EFFECTS OF FOREST MANAGEMENT PRACTICES AND FOREST-CUTTING HISTORY ON THE SONGBIRD COMMUNITIES OF MATURE HARDWOOD FOREST STANDS, LAKE OPINICON, LEEDS/FRONTENAC COS., ONTARIO.

Report on 1993 research.

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A project of the
Eastern Ontario Model Forest Program.

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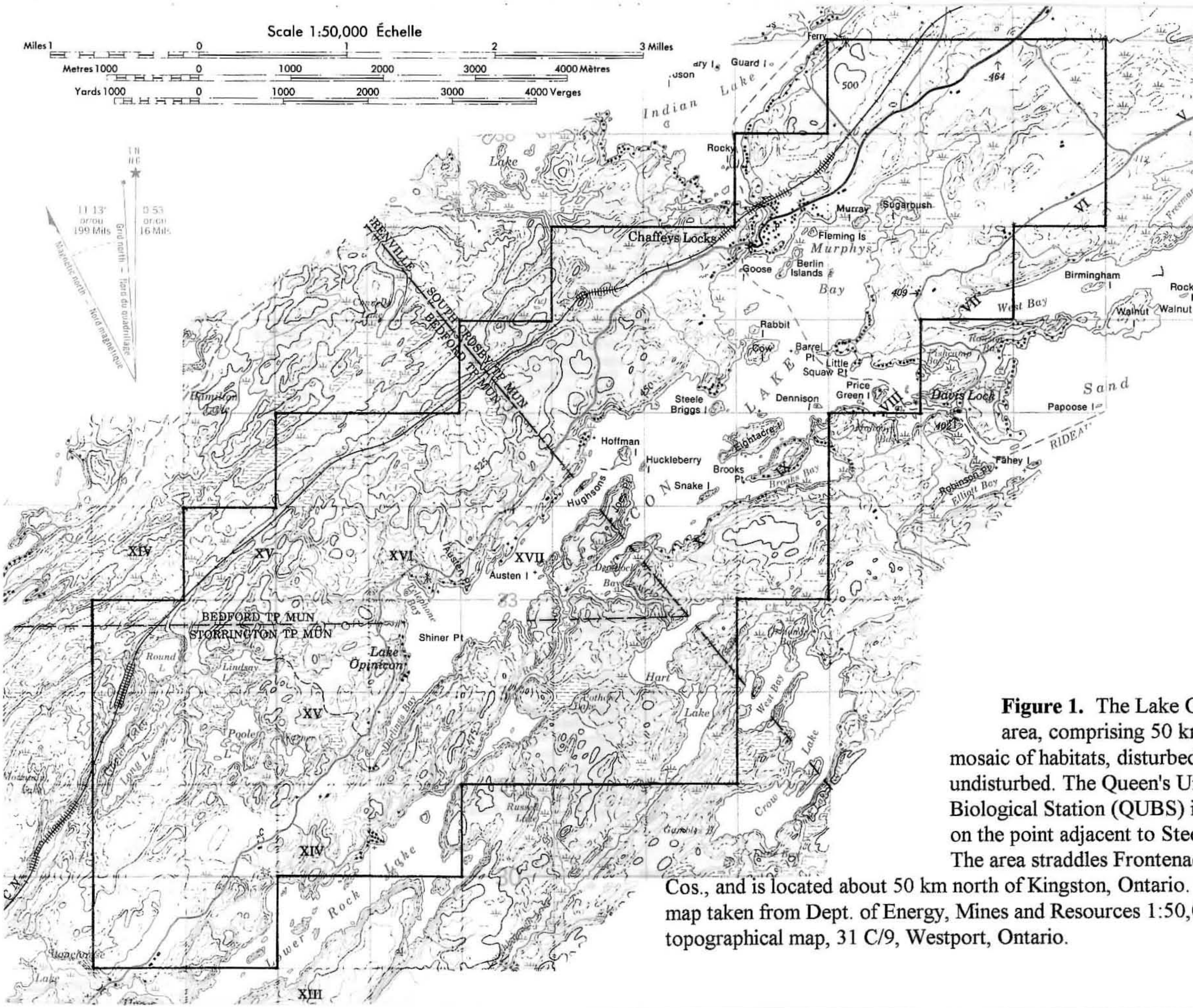

Figure 1. The Lake Opinicon area, comprising 50 km^2 of a mosaic of habitats, disturbed and undisturbed. The Queen's University Biological Station (QUBS) is located on the point adjacent to Steele Briggs I. The area straddles Frontenac and Leeds Cos., and is located about 50 km north of Kingston, Ontario. Section of map taken from Dept. of Energy, Mines and Resources 1:50,000 topographical map, 31 C/9, Westport, Ontario.

Executive Summary

Songbird decline in recent years has prompted focal attention on these species and the influence of forest management on their populations. The goal of this study is to provide preliminary work on the effects of forest management practices on the songbird community in the Eastern Ontario Model Forest region, with emphasis on mature hardwood forest stands in the area of Lake Opinicon. This report includes a description of the bird communities of the region, providing detailed information on populations and general habitat use. Microhabitat requirements of specific dominant songbird species inhabiting mature hardwood forest stands are described in detail and discussed in relation to forest management practices. Other aspects of songbird populations were examined in limited detail. These aspects include habitat use of avian songbird nest predators and brood parasites, and the suitability of current replanting strategies for songbird breeding habitat. This report serves as a stepping stone for further research to commence in 1994, and provides a discussion of possible future directions for research to come.

The Lake Opinicon Bird Community

The Lake Opinicon area (defined 50 km^2 region; Figure 1) is composed of a large variety of habitats, resulting from varied degrees of human disturbance and the natural mosaic nature of the landscape. A total of 143 bird species are known to breed or are suspected of breeding within the region, including eleven provincially or nationally rare/endangered species. Twelve additional species have recently been described as declining in Ontario, while many more, notably songbirds wintering in the Neotropics, appear to be suffering from larger scale declines over North America. Overall, the region supports significant breeding populations of important species, including Red-shouldered Hawk (among the highest Canadian densities), Wood Thrush, Golden-winged Warbler, Nashville Warbler, Cerulean Warbler (highest Canadian densities), Ovenbird, and Rose-breasted Grosbeak.

Mature Hardwood Forest; microhabitat requirements of songbird species

An examination of one of the prominent communities of the region, the songbird community of mature hardwood forest, provides species-specific microhabitat requirements of the key songbird species occurring there. Nineteen songbird species were examined in detail using song surveys and quantitative habitat measuring of 31, 50m-radius, circular forest plots.

Information obtained from this work provides insight into differential habitat use by key songbirds of mature hardwood forest. The complexity of bird-habitat relationships and bird community assemblages is vast, however, with habitat occupancy being complicated by various aspects of populations at all levels. In addition, habitat is only suitable if it is used by songbirds for *successful reproduction*, which was not measured in this study.

Despite these limitations, habitat use was described for 19 species using data from this study and incorporating data from other relevant studies. We

were able to describe parameters governing habitat use in these species which then served for discussion of forest management practices and preliminary management recommendations. Further work will require examination of the sustainability of the habitat for songbird populations (including differential reproductive success), and not just patterns of occurrence of songbirds in the habitat.

Results showed that aspects of vertical structure, tree species diversity, tree density, ground cover, and landscape, influence habitat use by hardwood forest songbirds. From this, habitat use by most species was shown to correlate with habitat parameters that may be influenced by forest management practices. These species include the Cerulean Warbler, Scarlet Tanager, Wood Thrush, American Redstart, Ovenbird, Black-and-white Warbler, Yellow-throated Vireo, Red-eyed Vireo, Pine Warbler, Least Flycatcher, Great Crested Flycatcher, and White-breasted Nuthatch. Aspects of mature forest stands suspected to influence such species include canopy density (Cerulean Warbler, Least Flycatcher), presence of nest cavities (Great Crested Flycatcher, White-breasted Nuthatch), mature tree component (Yellow-throated Vireo, White-breasted Nuthatch), understory component (American Redstart, Red-eyed Vireo), conifer component (Pine Warbler), tree species diversity (Scarlet Tanager), and notably the maintenance of extensive forest tracts, which may be one of the largest risks to songbird populations in general (Cerulean Warbler, Scarlet Tanager, Ovenbird, Black-and-white Warbler, Yellow-throated Vireo, Least Flycatcher).

It appears that forest management practices may affect different songbird species in different ways. Thus, moderation and variety in management techniques may be the best solution for incorporating songbird interests in integrated forest management. Avoidance of fragmentation of habitat, however, is one important factor that may affect a large proportion of forest songbirds. Protection of large continuous tracts of forested habitat, whether under management or not, seems vital for the maintenance of sustainable songbird populations in the Eastern Ontario Model Forest region.

Replanted Forest; suitability for songbird habitat

Replanting efforts in eastern Ontario frequently result in uniformly-aged conifer plantations, often with a low tree species diversity and only a limited resemblance to a natural forest ecosystem. Using 43, 25m-radius, circular plots, variation in songbird diversity was examined in conditions ranging from hardwood forest to mixed plantations to pure conifer plantations. No significant results were found relating bird species diversity to vegetational characteristics of forest/plantation plots. Differences in the bird communities in these habitats were evident, however, with more typically northern or conifer-specific songbird species occurring in plantation habitat.

Avian Nest Predator and Brood Parasite Habitat Use

The importance of varying reproductive success to Neotropical migrant songbird decline has been emphasized in recent literature, with aspects of nest predation and brood parasitism in the forefront of causes of reproductive failure.

Thus, examining habitat use of species that may greatly reduce songbird nesting success may be as important as the measurement of habitat use by the songbirds themselves.

Data was only available for avian predators, although reptilian and mammalian predators may be just as, or more, important with respect to songbird nesting success. Four bird species that may influence songbird nesting success in this region, the Blue Jay, American Crow, and Common Grackle (nest predators), and the Brown-headed Cowbird (brood parasite), were examined with respect to 5 habitat/landscape variables. Proximity to water, proximity to agricultural/suburban clearings, the density of foliage, and percent conifer composition of the habitat, all correlated with at least one of the potentially detrimental species. This implies that management decisions with respect to songbird habitat quality must take into account variation in songbird reproductive success and those species effecting success, in addition to simple songbird habitat use.

Directions for Future Research

Future research should aim to examine the ability of habitats to sustain populations of songbirds, which provides a more accurate assessment of habitat quality than does presence/absence of territorial males. Close examination of an appropriate focal species is essential to understanding the population dynamics and interactions of forest songbird species that could be disturbed by forest management practices. Songbirds must be viewed as populations, and not individual birds, as most have complex interactions outside of mated pairs that directly and indirectly influence reproductive success.

Experimental research would provide direct data on the proximate effects of forest management practices on songbird populations. Such experimental manipulation is possible through close work of foresters and forestry-based biologists involved in the Model Forest Program.

Reforestation and management of plantations for songbird habitat would provide another area of productive research that would be directly applicable to the eastern Ontario region. Work into the differential suitability of different replanting/thinning strategies would enable foresters to manage these sites for songbird habitat as well as for hardwood regeneration.

Finally, application of results obtained from studies of songbird monitoring to forest management practices in the Eastern Ontario Model Forest region would provide the best outcome from research efforts. Making information readily available to both private landowners and forest managers would enable informed decisions in forest management with respect to the maintenance of sustainable songbird populations.

Eastern Ontario Model Forest - Sustainable Forest Practices

Songbird Population Monitoring

PREFACE

We expect a lot from our forests - not only timber, fuel and fibre, but also, and with growing importance, secure habitat for wildlife, a natural filter and reservoir in the hydrologic cycle, a major sink in the carbon cycle, and serene environments for re-creation of the human spirit. In order for integrated forest management to accommodate these diverse forest values, it is essential to measure and understand the effects of different management practices on the many elements of the forest. The goal of the *Forest Songbird Monitoring Project* is to assess the impact of forest management practices on forest songbird populations. Recent evidence of population declines for many species of Neotropical migrant birds, widely held to be due to loss of habitat in both the breeding areas in the North, and wintering areas in the South, emphasize the urgency of coming to grips with the effects of how we use our forests on the well-being of the plant and animal communities they sustain.

This report provides the details of the approach and the results from the first year of study. The Songbird Population Monitoring Project [2.10/93 (2.3b/92)] was funded by the Eastern Ontario Model Forest Program, through the Ontario Ministry of Natural Resources, Contact Person Ross Cholmondeley. Field research was conducted by Queen's University student Paul Martin, under the supervision of Dr. Raleigh J. Robertson. Paul also did the data analysis and wrote the report. The Queen's University Biological Station, on Lake Opinicon, served as the base of operations and provided facilities. Logistical support in the form of transportation, accommodation, lab, library and computer facilities were provided through Infrastructure and Operating grants from NSERC to RJR.

In addition to the findings outlined in this report, our participation in the Eastern Ontario Model Forest has produced other tangible results, as reflected in the following activities:

Forestry Canada - Ontario Region Tour: On June 9, 1993, Queen's University Biological Station hosted a portion of this tour, including a "Discussion Session" on selected Eastern Ontario Model Forest projects. Participants heard about various programs at QUBS, and in turn many biologists at QUBS became familiar with the goals and the programs of the Model Forest. Paul Martin made a presentation on the *Forest Songbird Monitoring Project*.

Queen's University Biological Station Open House: On July 4, 1993, QUBS held its annual open house, which was attended by some 200+ local residents and cottagers. Paul Martin developed and attended a display which depicted both the *Forest Songbird Monitoring Project* and the *Eastern Ontario Model Forest Program* in general. This event contributed to the Public Information and Education goals of the Model Forest.

Forest Songbird Monitoring Workshop: On July 21, 1993, Paul Martin and I held an all-day workshop dealing with Forest Songbird Monitoring Programs at the Queen's University Biological Station. The workshop was attended by more than 25 people representing CWS, OMNR, Eastern Ontario Model Forest, Wildlife Habitat Canada, Forestry Canada, La Cite Collegiale, McGill University, Cariboo College, B.C., and Queen's University. Presentations and discussion fostered the exchange of information about songbird monitoring programs as well as the Eastern Ontario Model Forest objectives in general.

International Representatives Tour: On August 15, Paul Martin and I attended the round-table discussion at Kemptville with the Mexican Model Forest delegation. Our brief discussion served to emphasize the need for incorporating non-timber values into forest management, and suggested possibilities for cooperation with the International Model Forest Program in Mexico.

We look forward to continued participation in the Eastern Ontario Model Forest program.

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The incorporation of a songbird-related component into the Eastern Ontario Model Forest Project was proposed by foresters in the Leeds-Grenville Co. areas. The proposal was then written by Sylvest Muldal and Dave Bland, and given to Ross Cholmondeley to put into action. We thank all of these people above, and Ross for bringing Queen's University into the project.

Funding for this project was provided by the Eastern Ontario Model Forest. Encouragement was provided by all members of the Eastern Ontario Model Forest group, especially Brian Barkley and John Kerr-Wilson, and we thank all involved. Participants in the Forest Songbird Monitoring Workshop provided useful comments, especially with respect to future research directions. We thank all participants for attending and sharing information on their own projects.

More specifically, involvement and assistance by Dave Chapeskie and other area foresters have enhanced the forestry-biology component of this project. Advice and assistance in particular from Kelvin Conrad, Steve Lougheed, and Frank Phelan greatly improved this report. Other assistance and support was recieved from Floyd Connor, Mark Hovorka, James Fotheringham, Craig Morton, Janet Martin, Jessica Morrow, Sarah Rice, and Katherine Shields, as well as other researchers at the Queen's University Biological Station. Logistical support was provided by the Queen's University Biological Station at Lake Opinicon, Ontario, and by the manager Frank Phelan and assistant manager Floyd Connor.

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INTRODUCTION

Resource management in the past two decades has been characterized by profound and positive change. Overexploitation of resources in the past, and the growing public concern for more responsible resource management, has resulted in an integration of diverse and noneconomic goals into policies of natural resource use (Ruggiero *et al.* 1988; Jahn 1990; Kasten 1990; Roberts 1988). No longer is economic gain through natural resources viewed as independent of the environmental costs (Jahn 1990). Traditional economics involving "...habitual abstraction and fatal disregard for physical and biological principles..." (Kasten 1990) are now scorned. The desire for sustainable, rational, and responsible management of resources has become widespread.

With increasing public pressures, both resource and wildlife managers find themselves required to identify "...critical biological tolerances that determine habitat dependency of species..." (Ruggiero *et al.* 1988), and to integrate all aspects of non-timber and timber management into a wide-reaching integrated resource management plan. Even with increasing research in these areas, however, the complexities of integrated management, in addition to an incomplete knowledge base, make this task formidable.

Increasing research on both sustainable resource management, and sustainable wildlife management, is critical to meeting the current demands on natural resources. From the perspective of wildlife management alone, such research has lead to an increased appreciation of the complexities of underlying ecological concepts, which govern the requirements of populations (Ruggiero *et al.* 1988). Thus, as further research yields more information with regards to sustainable wildlife management, it also brings to light the need for more, and more specific, research in this area.

The current study marks the beginning of such research, whose goal is to examine the requirements of sustainable songbird populations and the impact of forest management practices in the Eastern Ontario Model Forest region. This research combines the aspects of sustainable timber management with sustainable wildlife management, towards an overall goal of providing an integrated management plan that will be applicable to this region.

The specific nature of this region is thus vital to the application of management goals. The high degree of private, non-industrial forest lands suggests the need for consultation and education to predominate with respect to local management implementation. Growing commitment by private land owners to noneconomic values, and their increasing openness to management of woodlots (Roberts 1988), provides an air of optimism. The combination of increased research and knowledge, and its use to formulate, implement, and promote broad-reaching education of management goals, will foster the most productive outcome for the natural resources of this region.

The Decline of Songbirds and Implications to Forest Management

A wealth of literature since the late 1970's has indicated significant decreases in migrant songbirds that breed in temperate North America and winter in the Neotropics (Central America, the Caribbean, and South America) (e.g. Holmes and Sherry 1988; Robbins *et al* 1989b; Hussell *et al.* 1992). Accounting for such declines has proved difficult, largely due to the complexities associated with all aspects of these species' natural history. In addition, reasons behind songbird declines are numerous, and originate from breeding grounds-, migration-, and wintering grounds-related factors (see Hutto 1988; Terborgh 1989; Hagan and Johnston 1992). Most recent information, however, suggests that aspects related to the breeding grounds and songbird reproductive success (especially predation rates) may well be the most significant factor reducing populations of neotropical migrants (Robinson 1992a;b; Martin 1992; Böhning-Gaese *et al.* 1993).

Both aspects of forest landscape and the forests themselves have been shown to affect songbird reproductive success (e.g. Robinson 1992b; Darveau *et al.* 1993). Both are heavily influenced by forest resource management practices which form the basis of this current research.

The goals of this report are:

1. To describe the bird community of the Lake Opinicon area (Figure 1), especially with respect to the forest songbird community of mature hardwood forest stands. (Part 1; Appendix 1))

2. To describe and discuss microhabitat requirements of certain dominant songbird species inhabiting mature hardwood forest stands. (Part 2)

3. Use the results obtained above to discuss concerns of forest management practices and suggest preliminary management recommendations. (Part 2)

4. Provide baseline information on current replanting strategies of conifer plantations and their suitability as songbird habitat. (Part 3)

5. Provide baseline information on differential habitat use by avian nest-predators and a brood parasite, and discuss their potential influences on the quality of songbird habitat. (Part 4)

Future research will further and more directly examine songbird-habitat relationships and the effects of forest management practices from the perspective of sustainable songbird populations. In addition, possible ways of improving songbird habitat through reforestation practices and education of private land owners will be topics of concern. Future research directions are discussed further in Part 5 of this report.

Part 1:

The breeding birds of Lake Opinicon, Leeds/Frontenac Cos., 1992-1993.

The area of Lake Opinicon has been defined as a 50 km^2 area surrounding the lake (Figure 1), encorporating land in both Storrington and Bedford Twps., Frontenac Co., and South Crosby Twp., Leeds Co. The physiography of the region can be described generally as shallow till and rock ridges (Chapman 1984), resulting in an undulating topography and a varied mosaic of habitats immediately surrounding the lake.

Much of the area was cleared for farming practices (hay especially) in the 1800's, however most of the land was gradually abandoned through the period of the 1930's through the 1970's. Today, only a small degree of logging still continues. Areas to the east of the lake itself, however, are still widely used for agricultural practices, and some bird species occurring in these open habitats have been included in the species accounts of Appendix 1.

Habitat Diversity and Bird Communities

Of the habitats within the Lake Opinicon region, many vary widely in the structure and composition of vegetation. Open rocky ridges and outcrops are common around the lake, and are dominated by stubby Red Oak (*Quercus rubra*), Eastern White Pine (*Pinus strobus*), and Red Juniper (*Juniperus virginiana*), as well as various mosses, grasses, and lichen-covered rock. These areas support a unique bird community which includes Field Sparrow (*Spizella pusilla*), Rufous-sided Towhee (*Pipilo erythrophthalmus*), Chipping Sparrow (*Spizella passerina*), and low densities of the nationally rare Prairie Warbler (*Dendroica discolor*).

The regrowth forest, in areas of agricultural abandonment, is at varying stages, but generally lacks the Eastern White Pine and Eastern Hemlock (*Tsuga canadensis*) component that was probably once present in the area. Instead, the regrowth forest is dominated by Sugar Maple (*Acer saccharum*) and Ironwood (*Ostrya virginiana*), with lesser degrees of Basswood (*Tilia americana*), ash spp. (*Fraximus* spp.), elm spp. (*Ulmus* spp.), hickory spp. (*Carya* spp.), and birch spp. (*Betula* spp.). This habitat may well account for the prominant southern 'Carolinian' bird species occurring at the northern limits of their ranges. These include Yellow-billed Cuckoo (*Coccyzus* *americanus*) (wet shrubby regrowth), Red-bellied Woodpecker (*Melanerpes carolinus*), Blue-gray Gnatcatcher (*Polioptila caerulea*), Yellow-throated Vireo (*Vireo flavifrons*), Golden-winged Warbler (*Vermivora chrysoptera*), (inhabiting more edge habitat), Cerulean Warbler (*Dendroica cerulea*), and Louisiana Waterthrush (*Seiurus motacilla*).

Pockets of wet woodland, dominated by Eastern White Cedar (*Thuja occidentalis*), White (*Betula papyrifera*) and Yellow (*B. alleghaniensis*) birch, and other associated species attract a collection of more typically northern bird species, including Winter Wren (*Troglodytes troglodytes*), Veery (*Catharus fuscescens*), and Northern Waterthrush (*Seiurus noveboracensis*). In addition to this habitat, sporatic bog habitat such as that located about 2 km to the west of the area, attract typical northern boreal species including Three-toed Woodpecker (*Picoides tridactylus*) (bred in 1984 only) and White-throated Sparrow (*Zonotrichia albicollis*).

Man-made habitat in the form of conifer plantations, also attracts a northern-type bird community. Most of these plantations (including those used in Part 3 of this study) are located outside of the defined area; however, the species accounts (Appendix 1) include birds from these areas (with note). Species that are characteristic of conifer-dominated habitats including Red-breasted Nuthatch (*Sitta canadensis*), Solitary Vireo (*Vireo solitarius*), and Pine Warbler (*Dendroica pinus*) are prominant in these plantations. Other species may use these woodlots more for the open structure of the habitat, such as certain flycatchers (Tyrannidae) and the American Robin (*Turdus migratorius*).

Mixed deciduous woods, with prominant Sugar Maple, Ironwood, Eastern Hemlock, and Eastern White Pine, may well be more typical habitat of what was once found in the area. This habitat harbours hardwood forest species typical of central Ontario, including Ovenbird (*Seiurus aurocapillus*), Red-eyed Vireo (*Vireo olivaceus*), Eastern Wood-Pewee (*Contopus virens*), and Blackburnian Warbler (*Dendroica fusca*) (particularly found in groves of Eastern White Pine and Eastern Hemlock). As the forest approaches more rocky lakeshore habitat, Eastern White Pine, Eastern Hemlock, and to a lesser extent Eastern White Cedar become more prominant, attracting other species characteristic of conifer-dominated habitats, including both Pine and Yellow-rumped (*Dendroica coronata*) warblers.

In addition to these forest-type habitats, open fields are maintained by a number of land owners, providing forest edge habitat as well. These field edges, along with edges of roadways, beaver ponds, and an abandoned railroad bed are utilized by yet another array of species which include Yellow Warbler (*Dendroica petechia*), Golden-winged Warbler, and Indigo Bunting (*Passerina cyanea*).

The open fields themselves support a remarkably different bird community. Savannah Sparrows (*Passerculus sandwichensis*), Bobolink (*Dolichonyx oryzivorus*), and Eastern Meadowlark (*Sturnella magna*) are characteristic of this habitat, but are better represented in the more open areas just to the east of the defined region.

Beaver ponds and flooded lakeshore habitats add diversity to the drier habitats discussed. Red-winged Blackbird (*Agelaius phoeniceus*), Common Grackle (*Quiscalus quiscula*), Common Yellowthroat (*Geothlypis trichas*), and Swamp Sparrow (*Melospiza georgiana*) are common species of such wet habitats. In addition, beaver ponds provide an abundance of nesting habitat used heavily by cavity-nesting species, including Downy (*Picoides pubescens*) and Red-headed (*Melanerpes erythrocephalus*) woodpeckers, Northern Flicker (*Colaptes auratus*), Tree Swallow (*Tachycineta bicolor*), Great Crested Flycatcher (*Myiarchus crinitus*), Wood Duck (*Aix sponsa*), and Hooded Merganser (*Lophodytes cucullatus*).

All in all, the varying degrees of disturbance in the area of Lake Opinicon coupled with the natural variation and mosaic nature of the habitats, supports a great diversity of avifauna. Both these habitats, and the avifauna that inhabit them, have changed greatly over the years, and continue to do so. The importance of this section (including Appendix 1) lies in its documentation of the bird species and habitat features of the Lake Opinicon area at this point in time, so that monitoring of important changes in these features is possible. Such monitoring better enables conservation efforts in both this area, and others like it, and is an important step in integrated management of local resources.

Appendix 1 provides species accounts of 143 known breeding or potentially breeding birds. Local habitats used for breeding as well as estimated population sizes (number of pairs) of each species within the 50 km^2 defined area (Figure 1) are provided. The list includes eleven species recognized as rare or endangered breeders in Ontario and/or Canada (ORBBA project), as well as twelve species recently described as declining (Long Point, Ontario study; Hussell *et al.*1992). Of the species designated as rare/endangered or declining, the following species have significant populations within the area: Red-shouldered Hawk (*Buteo lineatus*), Wood Thrush (*Hylocichla mustelina*), Gray Catbird (*Dumetella carolinensis*), Golden-winged Warbler, Nashville Warbler (*Vermivora ruticilla*), Cerulean Warbler, Ovenbird, Rose-breasted Grosbeak (*Pheucticus ludovicianus*), and Rufous-sided Towhee (*Pipilo erythrophthalmus*). Other neotropical migrant songbirds showing declines also breed within the area, making the Lake Opinicon area an important breeding grounds for a large number of threatened species.

Part 2:
Songbird Community of Mature Hardwood Forest; Species-Specific Microhabitat Requirements and Implications to Forest Resource Management Practices.

Introduction

Habitat selection by populations has been recommended as a valid basis for management decisions (Ruggiero *et al.* 1988). Such a perspective has been taken in this study, to provide information regarding microhabitat requirements of dominant songbird species in the mature hardwood forest habitat of the Lake Opinicon region.

In determining these habitat requirements, all aspects of the natural history of a species must be examined, including foraging behaviour, prey, predator, and competitor species presence, as well as specific requirements of nest sites, and other aspects associated with population dynamics. All requirements governing habitat use by a species must be considered with respect to forest resource management decisions if sustainable populations are to be protected. Recent province-wide guidelines suggest a trend towards implementing such requirements into an integrated forest management plan (Anderson and Rice 1993). The current province-wide guidelines, however, are lacking from the perspective of most forest-dwelling species (including songbird populations) (Anderson and Rice 1993), while local management plans are almost barren of attempts to integrate sustainable wildlife management goals (e.g. Van Dyke 1993).

This section discusses aspects governing habitat use by local songbird species, found in this study and others, and their possible relationship to forest resource management practices. It is designed to form a baseline of information from which more direct research efforts can be initiated, and from which an integrated management plan can eventually be drawn.

Methods

Study Site

The study was undertaken in forested areas surrounding Lake Opinicon, Ontario, which straddles South Crosby Twp., Leeds Co., as well as Bedford and Storrington Twps., Frontenac Co.. The study site was selected on the basis of its proximity to the Queen's University Biological Station, located on the NW shore of Lake Opinicon. The field station served as the origin of all research efforts, while the proximity of the study site enabled a more extensive sampling of the area.

Plot Selection and Characteristics

A total of 31 plots were selected at three different sites, all within a 6km radius of the biological station (Figure 2). Plots within a site were circular with a fixed 50m-radius. Selection was based on homogeneity (to the greatest extent possible) of habitat, which was characterized as predominately deciduous with a mature component (trees >15m in height). An additional plot was added to an original 30, which was composed of primarily Eastern White Pine (*Pinus strobus*) and maple spp. (*Acer* spp.), to add variation to the study. Spacing of the plots was also considered in plot selection, with an attempt to keep all plot centers 200m apart (although this was not always possible). Appendices 2-4 show locations of individual plots at each of the three sites used in the study. Example vegetation sampling data are included in Appendix 5.

Songbird Surveys

Surveys of territorial male songbirds present in each plot were carried out on three separate occasions per plot, once during each of the following periods: 25 May - 10 June, 11 June - 26 June, 27 June - 7 July, 1993. Each survey was 10 minutes in duration, and was conducted exclusively between 0445 - 0730 EST. During a survey, one observer situated in the center of the plot recorded the presence and location of any territorial male songbirds present within the estimated 50m-radius plot. In addition, their movements, countersinging behaviour, and location with respect to an estimated 25m-radius circle was also recorded. Females, nests, and family groups were all recorded as well, but were ignored with respect to the study unless they were within a 25m-radius of the observer where no territorial male had been recorded, despite territorial males being recorded within the plot. In this case, they were taken as evidence that a male's territory extended within the 25m radius circle (see implications for scoring below).

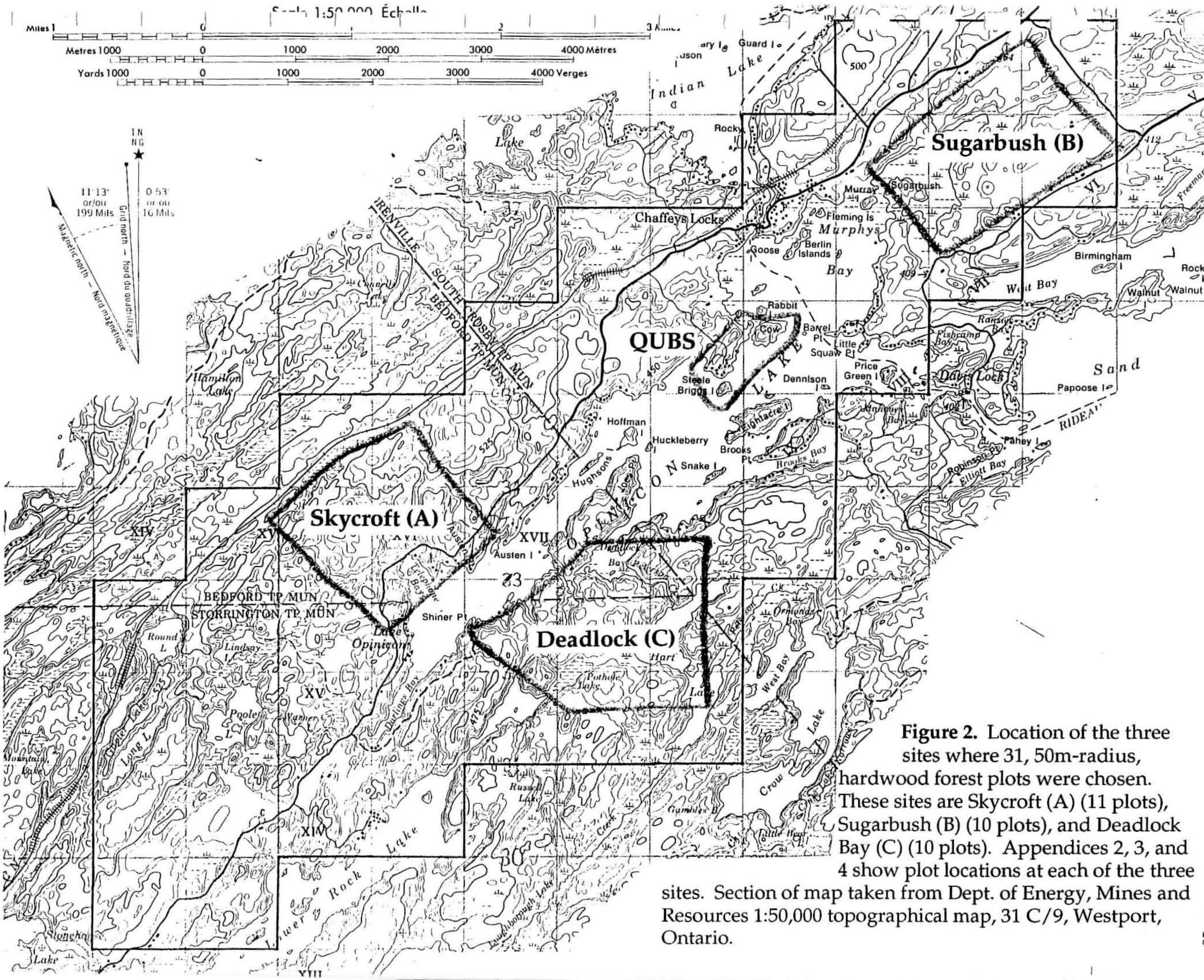


Figure 2. Location of the three sites where 31, 50m-radius, hardwood forest plots were chosen. These sites are Skycroft (A) (11 plots), Sugarbush (B) (10 plots), and Deadlock Bay (C) (10 plots). Appendices 2, 3, and 4 show plot locations at each of the three sites. Section of map taken from Dept. of Energy, Mines and Resources 1:50,000 topographical map, 31 C/9, Westport, Ontario.

Males that did not sing but were present within the plot provided no evidence of territoriality and thus were not recorded (These birds were not 'recorded' with respect to this study, however, all birds were actually recorded, including those falling outside of the 50m-radius and non-songbird species, for possible use in other ongoing monitoring projects) (see Ralph and Scott 1981 for discussion of various methodologies).

The plot order during surveying was based partly on randomization of plot order and partly on practicality and temporal spacing of plot surveys. Of the three sites (comprised of 31 plots), each was selected at random, one per morning. Five plots from this site were then selected in a random order; however, due to high travel times between plots (even those within sites), the order of the plots occasionally had to be altered. After all plots had been completed once, the procedure was repeated again, and once again after all plots had been surveyed twice.

Surveys were weather-dependent to avoid bias inflicted by harsh conditions. Thus, high winds or precipitation judged to have an effect on either singing rates or on the hearing ability of the observer resulted in surveys being postponed. Interobserver bias was avoided by using only one observer recording all surveys, thus decreasing distance estimation differences between observers. Sample songbird survey data are included in Appendix 6.

Quantitative Habitat Measurement

Habitat within the plots was measured during the period from mid-July - mid-August 1993, also by one individual to avoid interobserver error (see Discussion). A total of 17 plot characteristics were measured that can be grouped into five broad categories: vertical structure, tree density, tree species diversity characteristics, ground cover, and landscape characteristics (adapted from James and Shugart 1970; Willson 1974).

(i) Vertical Structure - The vertical structure and its species composition were measured at 16 points throughout each 50m-radius plot. At each point, vegetation density was scaled from 0-8, roughly representative of the number of 'full' foliaged branches (Sugar Maple, *Acer saccharum*, was used for comparison), for each vertical height range. Thus, the component species and their respective vegetation density scores were recorded for 11 vertical height intervals: 0-1.5m, 1.5-3m, 3-6m, 6-9m, ... 27-30m. These scores were representative of a 1.5m diameter circle that was estimated to extend vertically from the point of sampling. Distances of vegetation were calculated using a rangefinder (Model 620; Ranging Inc. Measuring Systems, East Rochester, NY).

Sampling points for vertical structure were selected on the basis of randomization and even-distribution of points. The 50m-radius circle was divided into 8 even portions (Figure 3), with two sampling points being selected at random distances from the center (between 0-50m) at random angles falling within each portion.

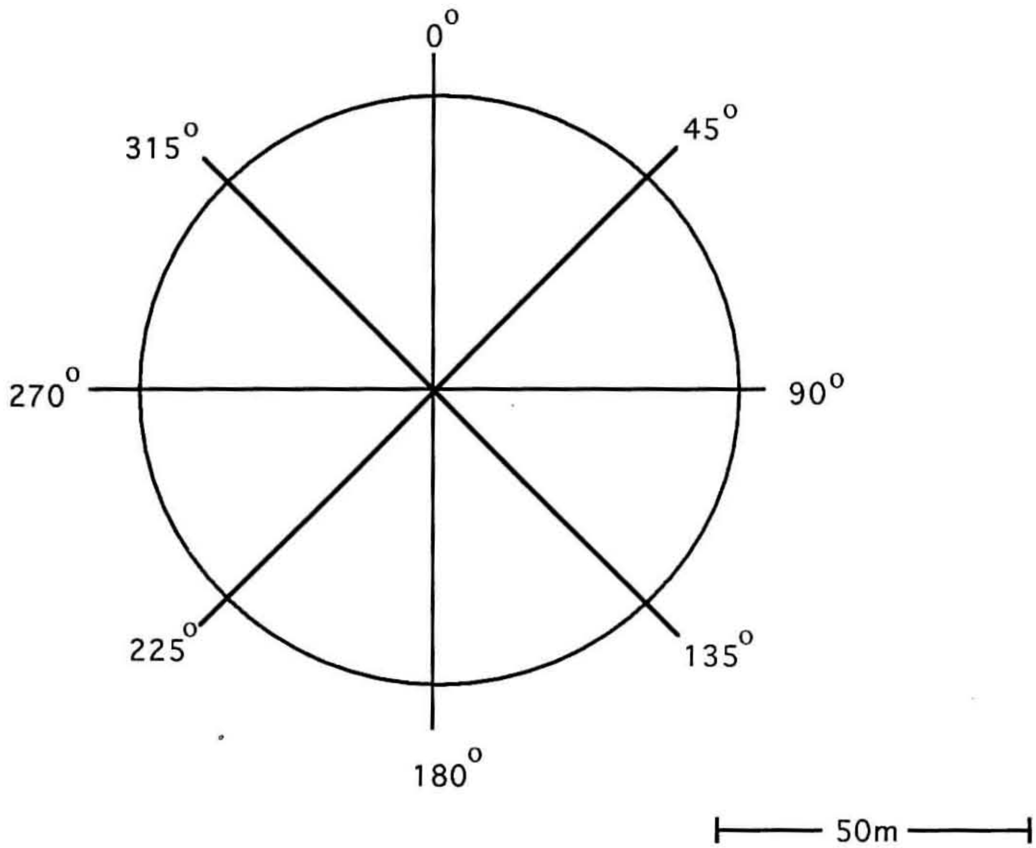


Figure 3. Division of 50m radius plots used for sampling vegetation. Vertical Structure was measured at random distances from the plot center (0m - 50m) for two randomly chosen angles within each plot section. Tree Density points were selected in a similar manner, with one density plot per section.

(ii) Tree Density - Tree density with respect to diameter at breast height (DBH) intervals, was recorded at 8 sample points within each plot. Using the same random/even-distribution method of point selection as for vertical structure sampling (Figure 3), one point per portion of plot was selected at a random distance from the center (between 0-50m) and at a random angle falling within each plot portion. At each point, a 5m X 5m square was set up using rope, always to the NW of each point. Within the defined 5m X 5m square, all trees of DBH≥2cm were recorded, with the species identity and DBH measurements. DBH measurements were calculated using a ruler modified as calipers (extensions at right angles to enable accurate measurement of tree diameter).

(iii) Tree Species Diversity - Tree species diversity of the foliage was recorded with vertical structure, while species identity of trees was also noted for the tree density measures. In addition, at each point of vertical structure measurement, the three closest trees of DBH≥20cm were measured (DBH) and identified to species. This enabled a more accurate estimate of the mature tree species composition of each plot. (Individual trees were only measured once, even if they were one of the three closest trees to more than one vertical habitat sample point.) A list of all tree species recorded in the plots is provided in Appendix 7.

(iv) Ground Cover - At each point of vertical structure assessment (n=16/plot), a 1m X 1m grid was placed on the ground and the % composition of ground cover was estimated and recorded. Percentage cover was grouped into the following categories: rock, moss, bare soil, fern spp., leaf litter, logs/dead branches, and herbaceous plants.

(v) Landscape - The contiguity of each plot was estimated using topographical maps, aerial photographs of the area (taken 1991; courtesy OMNR), and on site visits. See below for details of measurements.

Bird Abundance Scores

For each songbird species in each plot, an abundance score was obtained and used in the analysis described below. The reason for the use of abundance scores in this study was to alleviate problems associated with the mosaic nature of habitat in the area. Although plots were selected to be generally homogeneous with respect to habitat, there were frequent habitat changes near the 50m radius of plots. These habitat changes resulted in species being recorded within plots when the majority of their territories were in a different habitat adjacent to the plot. The use of abundance scores differentiated between birds relying on interior plot habitat characteristics (those measured in this study), and birds overlapping to a small extent with the plots, but relying on adjacent habitats not measured in this study.

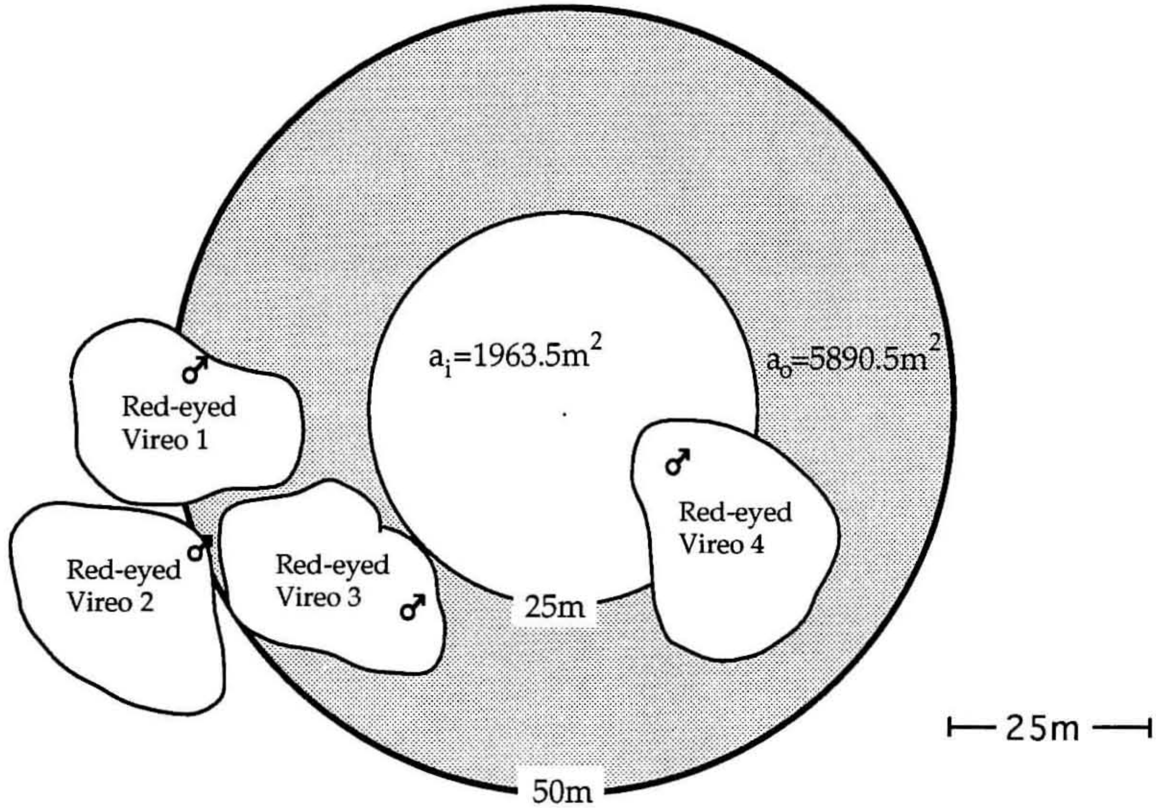
An additional advantage to the use of abundance scores, was the increased variation in the y values used in the analysis. Thus, they enabled more, and more statistically significant results to be obtained.

For the scoring of abundances, an attempt was made to equalize the importance of the inner 25m radius with the outer 25m-50m radii areas. This took the form of weighing the results obtained in the two areas of the plot differently, forming abundance scores based on the maximum number of territorial males within the plot, and the location of those territorial males relative to the 25m radius.

The scoring of songbird abundances took two steps. The first accounted for differences in the probability of finding a territorial males within the 25m of the plot center versus within the 25m-50m plot area. The goal was to weight the interior males higher, as the probability of finding a male here was statistically lower, simply based on differences in area between the inner and outer portions of the plots (see Figure 4). The second step involved assumptions of within plot habitat use, and its importance to a given territorial male. Males in the outer portion of the plot circle were less likely to have all of their territory described by habitat surveyed within the plot (see Figure 4). Calculations of abundance scores followed these two assumptions:

1. The area of the plot within the 25m radius was one third of that between the 25m and 50m radii (Figure 4). Therefore, the chances of recording a territorial male songbird within the 25m radius was lower than between the 25m and 50m radii, based on the differences in area of these two regions alone. Thus, there was 3x as great a chance of recording a territorial male within the 25m to 50m radius areas as within the 25m radius areas. To correct for this, the number of males within the 25m radius was multiplied by 3.

2. Territories defended by singing males were most likely 100% within the 50m plot if the male was recorded within the 25m radius. Males that were recorded outside of the 25m radius but inside the 50m radius defended territories that could include proportions (p) of the defined plot, where $0\% < p \leq 100\%$. Assuming even distribution of territory proportions within the defined plot, the mean proportion would be 50% (i.e. on average, one half of each territory, where the male was recorded between the 25m radius and 50m radius, overlapped the defined plot). To account for this average difference in plot habitat use, males between the 25m and 50m radii were weighted as half of a male within the 25m radius; thus, males within 25m were multiplied by two. This logic is based on the assumption that territory size is typical of many songbird species (e.g. Red-eyed Vireo, 1.3-1.7 acres; Williamson 1971); i.e. males within the 25m radius had 100% of their territories within the 50m-radius plot. For some species with larger territories (e.g. Great Crested Flycatcher), this may not hold true, however, other



♂ closest location of territorial male during 3 replicate censuses

1. The area of the outer portion of the circle ▩ (25m radius to 50m radius) equals three times the area of the inner circle □ . ($3x1963.5m^2$ (a_i) = $5890.5m^2$ (a_o)) Therefore, the chance of finding a territorial male within the outer portion of the circle is 3x as great as finding a territorial males songbird in the inner circle based on chance alone.

2. For most songbird sized territories (e.g. Red-eyed Vireo, *Vireo olivaceus*), a male within the 25m is likely to have 100% of its territory within the 50m sampled plot. A male within the outer portion of the circle may have a territory where x represents the percentage of the territory within the 50m plot circle: $0\% < x \leq 100\%$. Assuming even distribution of territories, the average territory would be 50% within and 50% outside of the plot circle.
For example, Red-eyed Vireo 4 found within the 25m radius has 100% of the territory within the plot. Red-eyed Vireo 1 has about 50%, while Red-eyed Vireos 2 and 3 have almost 0% and 100%, respectively, of their territories within the plot.

Figure 4. Illustration of two assumptions (1 & 2) involved in creating songbird abundance scores. The first assumption involves the greater liklihood of finding a bird within the 25m to 50m radii relative to within the 25m radius, based on differences in area alone. The second assumption involves differential use of the plot by birds in the outer portion of the plot (25m to 50m radii) relative to birds within the 25m radius. See text for reasoning and full explanation.

methodologies that adequately survey the songbird community on a larger scale are required to assess the habitat requirements of such species (see below, Biases and Assumptions).

Based on the logic and assumptions described in 1. and 2., the abundance score for each species within each plot was defined as:

abundance score = (max. no. of terr. males within 25m) x3 (section 1) x2 (section 2)+
(max. no. of terr. males between 25m and 50m radii)

Ecological Variables

Forty-two variables were measured for each plot, and are defined below in their appropriate groupings. Sample size (n) values indicate the number of points of sampling per plot.

(i) Vertical Structure

The following measurements are based on scoring of foliage density (0-8) (see habitat measurement), where 0-2 is 'low' density of foliage, 3-5 is 'medium' density of foliage, and 6-8 is 'high' density of foliage.

(1) Foliage Density 0m - 1.5m - the mean foliage density (n=16) between 0m and 1.5m (see above for habitat measurements).

(2) Foliage Density 1.5m - 6m - the mean foliage density (n=16) between 1.5m and 6m.

(3) Foliage Density 6m - 12m - the mean foliage density (n=16) between 6m and 12m.

(4) Foliage Density 12m - 18m - the mean foliage density (n=16) between 12m and 18m.

(5) Foliage Density 18m - 30m - the mean foliage density (n=16) between 18m and 30m.

(6) Maximum Tree Height - the mean of all maximum tree heights (n=16).

(7) Foliage >9m - Foliage <9m - the sum of all foliage densities (n=16) below 9m subtracted from the sum of all foliage densities (n=16) above 9m.

(8) Distinct High Canopy - the total number of points (out of the 16 measured/plot) where mid-high foliage densities (scores 3-8) over 12m are separated from vegetation below 12m by low density foliage (scores 0-2).

(9) Two Canopies - the total number of points (out of the 16 measured/plot) where a Distinct High Canopy is present, and mid-high foliage densities between 6m and 12m are separated from vegetation below 6m by low density foliage (scores 0-2).

(10) Mid Canopy - the total number of points (out of the 16 measured/plot) where mid-high density foliage (scores 3-8) was present between 6m and 12m.

(11) Continuous Ground Vegetation - the total number of points (out of the 16 measured/plot) where mid-high density foliage was present in both the 0m to 1.5m vertical range, and the 1.5m to 3m vertical range, and the 3m to 6m vertical range.

(12) Low Foliage Space - the sum of vertical space (in meters) where foliage densities of 0 were obtained between 1.5m and 6m (n=16)

(13) High Foliage Space - the sum of vertical space (in meters) where foliage densities of 0 were obtained between 6m and the top of the foliage (n=16)

(14) Mean Canopy Vertical Range - the mean of [the distance in meters from the top of the foliage to the height of low density foliage (scores of 0-2) occurring below 12m and above 3m] (n=16).

(15) Mean Canopy Maximum Density - the mean of [the maximum foliage density for the 3m vertical intervals found within the Mean Canopy Range] (n=16).

(16) Mean Canopy Height - the mean of [0.5 x Mean Canopy Vertical Range + the low vertical edge of the canopy] (n=16). Low end of canopy measured in Mean Canopy Vertical Range calculations.

(ii) Tree Species Diversity

(1) TSD index - calculated using the formula of MacArthur and MacArthur (1961) and MacArthur *et al.* (1966), where

$TSD = - \Sigma\ p_i \ln p_i$,

where p_i = the proportion of total foliage density of tree species i. (n=16)

(2) Conifer Component - % of coniferous foliage measured in Vertical Structure measurements (n=16).

(3) maple spp. Foliage Composition - % of maple spp. foliage measured in Vertical Structure measurements (n=16).

(4) White Pine Foliage Composition - % of White Pine foliage measured in Vertical Structure measurements (n=16).

(5) oak spp. Foliage Composition - % of oak spp. foliage measured in Vertical Structure measurements (n=16).

(6) White Birch Foliage Composition - % of White Birch foliage measured in Vertical Structure measurements (n=16).

(7) Basswood Foliage Composition - % of Basswood foliage measured in Vertical Structure measurements (n=16).

(8) ash spp. Foliage Composition - % of ash spp. foliage measured in Vertical Structure measurements (n=16).

(9) % Ironwood - % of trees measured in 5m x 5m tree density plots (n=8) that were < 20cm DBH and that were Ironwoods.

(iii) Tree Density

(1) Number of Trees DBH 2cm-5cm - the total number of trees measured in 5m x 5m tree density plots (n=8) that had DBH measurements from 2cm to 4.9cm.

(2) Number of Trees DBH 5cm-10cm - the total number of trees measured in 5m x 5m tree density plots (n=8) that had DBH measurements from 5cm to 9.9cm.

(3) Number of Trees DBH 10cm-15cm - the total number of trees measured in 5m x 5m tree density plots (n=8) that had DBH measurements from 10cm to 14.9cm.

(4) Number of Trees DBH 15cm-20cm - the total number of trees measured in 5m x 5m tree density plots (n=8) that had DBH measurements from 15cm to 19.9cm.

(5) Number of Trees DBH ≥ 20cm - the total number of trees measured in 5m x 5m tree density plots (n=8) that had DBH measurements ≥ 20cm.

(6) Mean DBH ≥ 20cm - the mean of the DBH measurements ≥ 20cm (n=8, 5m x 5m plots).

(7) Total Vegetation Density - the sum of all foliage density scores (from Vertical Structure measurements) (n=16).

(iv) Ground Cover

(1) Leaf Litter - mean % of leaf litter recorded on 1m x 1m plots (n=16).

(2) Herbaceous Plant Cover - [mean % of herbaceous plants recorded on 1m x 1m plots (n=16)] + [mean % of fern cover recorded on 1m x 1m plots (n=16)].

(3) Number of Logs ≥ 20cm - the total number of logs with diameters ≥ 20cm that were present in 5m x 5m Tree Density plots (n=8).

(4) Mean Log Size - the mean diameter (in centimeters) of logs ≥ 20cm that were present in 5m x 5m Tree Density plots (n=8).

(v) Landscape

(1) Contiguity - rough estimate (in hectares) of the size of unbroken forest within which a plot occurs. Forest was broken by developed land (roads not included), rocky outcrops, and water bodies, as well as less mature second growth habitat. Estimates based on topographical maps, aerial photographs (courtesy OMNR, 1991), and on site investigation.

(2) Distance to Water - Shortest distance (in meters) from the center of a plot to the edge of a body of water (not creek) (e.g. beaver pond, lake). Estimates based on topographical maps, aerial photographs (courtesy OMNR, 1991), and on site investigation.

(3) Distance to Agricultural/Suburban Clearing - Shortest distance (in meters) from the center of a plot to the edge of an actively managed clearing (e.g. cultivated field, mowed lawns, etc.). Estimates based on topographical maps, aerial photographs (courtesy OMNR, 1991), and on site investigation.

Statistical Methods

Habitat variables were first compared in a correlation matrix, which allowed a reduction in the total number of habitat variables included in the analysis. Out of all variables that correlated ≥ |0.70|, one was removed from the analysis. This decreased the number of habitat variables used from 39 to 30. From there, habitat variables were grouped into five groups, previously described in Habitat Measurements. Multivariate statistics in the form of a Principal Components Analysis (PCA) were then performed on each habitat variable group to further simplify the data. Oblique factor scores (obtained using a correlation matrix option and varimax rotation) were then saved, and each newly derived component was then plotted against scored songbird abundance values for each of the focus 19 species.

Biases and Assumptions

The results of this preliminary study provide useful baseline information that can be used to formulate hypotheses concerning variation in songbird abundance in relation to forest management practices. Such methods as used in this work (point count survey methods coupled with habitat assessment) have been recommended for use in the assessment of resource management effects on songbird abundance (Verner 1981); however, a full understanding of assumptions and limitations associated with such methodology, as well as key biases concerned with the present study, are essential to fully understand the implications of the results obtained.

Problems associated with biases and assumptions in a study such as this originate at all levels. The raw measuring of bird abundances and habitat characteristics, as well as manipulating and simplifying such raw data into variables, and especially statistical methodology and interpretation, are all sources of independent assumptions that require minimization, complete avoidance, and/or simple recognition.

The proximate biases associated with acoustic bird surveys in general, as well as habitat measurement of plots, are avoidable to varying degrees using techniques of experimental design. Such avoidance of unwanted biases was taken during this work, and has lead to more reliable results. Some of these proximate factors and their avoidance have been eluded to in the Methods section, and will not be discussed here. The following discussions of general assumptions and limitations associated with bird-habitat relationships, as well as statistical methodology, are more important to the interpretation of results obtained, and should shape the perception and context with which the results are viewed.

Assumptions, Limitations, and the Complexity of Songbird-Habitat Associations

The complexity of bird-habitat relationships and bird community assemblages is vast (Wiens 1989a;b). Habitat occupancy is complicated by various aspects of life history (e.g. migration patterns, mating systems), dynamics of populations at all levels (e.g. subpopulations, metapopulations), variations in scale (e.g. both aspects of temporal and spatial scales), as well as interspecific interactions which may range from outbreaks in prey species, to constraints of interspecific competition. The habitat occupancy of a species is truly an ecological event, influencing and being influenced by the complex nature of an interacting ecosystem.

Beginning with the method of songbird surveys used in the study, it becomes evident that such complexity must be taken into account when interpreting results such as those presented here. Many methods of surveying breeding songbird communities have been put forth, all of which have varying, and varying degrees, of limitations. The fixed-distance radius point count method used mostly in this work (Reynolds *et al.* 1980), was selected on the basis of its fairly accurate measuring of relative abundances of territorial male songbirds in a relatively homogeneous environment, whose habitat characteristics may also be measured fairly accurately and quantitatively. An emphasis on the measuring of *territorial males* must be made, as this method provides no information on the number of pairs of each species utilizing the habitat being measured, nor does it provide an estimate of the suitability of such habitat in supporting a sustainable population (i.e.. we do not know if these males successfully raise offspring, and contribute these offspring into the population) (e.g. Gibbs and Wenny 1993). In fact, such surveys provide only a relative abundance of territorial males between the plots selected. An absolute density of territorial male songbirds of a certain species utilizing a certain habitat is not obtainable using this method.

Although these restrictions may seem great to those seeking information concerning the quality or suitability of habitat to specific songbird species, fixed-radius point counts provide an accurate and general means of describing habitat use by songbird species in a given area. One must keep in mind, however, that a high relative abundance or even absolute density is not necessarily an indicator of the best habitat used by a songbird species (Van Horne 1983). In their study of Grasshopper (*Ammodramus savannarum*), Savannah (*Passerculus sandwichensis*), and Vesper (*Pooecetes gramineus*) sparrows, Vickery *et al.* (1992), in fact, found that none of the three species showed a clear correlation between high territory density and high reproductive success. Savannah Sparrows were surprisingly least successful at high density, illustrating how density data can be misleading with respect to influences of reproductive success and habitat quality.

Continuing with more general biases of the methodology, we are confronted with a variety of trends and patterns obtained from this study (Figures 9-50), that do not lend themselves to precise descriptions by 'tight' linear regressions or even nonlinear associations. This is not surprising when considering the scale and population dynamics that result in a complex 'background' of variation that obscures simple habitat occupancy results.

The focus of this study on a pre-selected and a narrowly-defined habitat in a local area limits the amount of 'obvious' or clear-cut (general) results we obtain. Work with a variety of habitats would enable larger and more coarse variation in the habitat components used in the analysis, and would result in clearer songbird-habitat relationships. For example, including plots of Black Spruce (*Picea mariana*) lowlands or even local open field conditions with our 31 hardwood forest plots, would result in a clear separation of species based on coarse habitat characteristics associated with the vastly different habitat conditions. This would lead to clearcut results: all Eastern Wood-Pewees use deciduous forest, while all Yellow-bellied Flycatchers (*Empidonax flaviventris*) use Black Spruce lowlands, and all Savannah Sparrows, open fields. The habitat specificity of this study, however, limits the clear cut results that would be expected, and increases the variation expected on the basis of "background" population dynamics associated with each species and with the community as a whole.

Such a variety of dynamics at various population levels have been described to influence habitat selection and use by many local songbird species. On the metapopulation scale, species have been shown to colonize and vacate eastern Ontario forest patches to some extent randomly, when other environmental conditions are held constant (Villard *et al.* 1992). This has also been shown for forest communities that are non-fragmented (e.g.. Tomialojác *et al.* 1984). This implies that suitable habitat that is occupied in one year, may be vacant the next, simply due to random chance and not the quality of the habitat for that species. This would result in increased variation in our results, obscuring abundance score-habitat variable associations. Fortunately, the amount of unoccupied but suitable habitat that occurs with species at higher densities (such as those used in the analysis) is low, and probably does not skew most of the results obtained. For many species showing large declines such as the Wood Thrush (Hussell *et al.* 1992), however, one must wonder if some suitable habitats are left unoccupied, especially if the population decline is not directly related to habitat loss on the breeding grounds.

On the population scale, presence or absence of species can be affected by a variety of factors, including habitat and landscape characteristics such as those measured here, or the presence or absence of other species (e.g. prey species, predator species, competitor species, or even the presence of other individuals of the same species) in that habitat. For example, in years of high spruce budworm (*Choristoneura fumiferana*) outbreaks, Bay-breasted Warblers (*Dendroica castanea*) have become superabundant in local areas, and Cape May Warblers (*Dendroica tigrina*) may breed in locales where they are otherwise absent (e.g. MacArthur 1958; Morse 1978). Such dynamics have hopefully been avoided in such a small study area, such as Lake Opinicon, however, even infestation of specific tree species in a region may alter the patterns of habitat use by local species.

Patterns of habitat occupancy in another species, the American Redstart, have been shown to be influenced by a sympatric songbird species, the Least Flycatcher (Sherry 1979; Bennett 1980; Sherry and Holmes 1988). Least Flycatchers appear to act as a competitor species, socially dominant to the redstart (Sherry 1979; Sherry and Holmes 1988), actively attacking American Redstarts more so than other local species (Sherry 1979; pers. obs.). Such interspecific aggression towards redstarts may result in the exclusion of this species from certain habitats and/or influence patterns of its selection of habitat.

Least Flycatchers in themselves are interesting in that they often behave in a semicolonial manner (e.g. DellaSala and Rabe 1987), and are apparently attracted in many cases to the presence of other individuals of their own species. Such an attraction to conspecifics may also influence habitat selection and use by a songbird species such as this.

Even the size of territories and thus the densities (or relative abundances) of a species, can be highly variable. Male American Redstarts in their first breeding season ('subadults') have smaller territories than their older conspecific males, and may thus occur at higher densities than the latter. However, these subadult males have also been shown to have a lower chance of mate attraction and may utilize habitat of "poorer quality" (Ficken and Ficken 1967; Howe 1974; Sherry 1979; Sherry and Holmes 1988; but see Morris and Lemon 1988). This would result in an inaccurate assessment of habitat quality if such a conclusion was based on the relative abundances or even absolute densities of territorial male redstarts alone.

The effects of territory size when using a fixed-size survey plot, may also lead to differential results for different species. Species with smaller territories (such as Red-eyed Vireo, *Vireo olivaceus*) are capable of having greater variation in abundance scores, which results in clearer trends with greater statistical significance when related to environmental variables. A species with larger territories relative to the fixed plot size (and consequently lower overall potential densities, such as the Yellow-throated Vireo, *Vireo flavifrons*), lack extreme variation in abundance scores and may have a maximum one territorial male per plot. In this case, more obscure results would be obtained with lower statistical significance, and a larger-sized plot would be required to achieve a greater variation in abundance scores.

A final bias of scale should be discussed, as it seems to be particularly applicable to the results obtained in this study. Temporal variation is not evident from this one-year study; however, such year to year variation appears to be potentially large within similar hardwood forest ecosystems (e.g. Holmes 1988; 1990; Sherry and Holmes 1992). The effects of spatial scale, however, are evident in this study, and can lead to the obtaining of entirely different results of habitat use in a single species.

One of the best examples of this is the Black-throated Green Warbler, a habitat generalist with a broad geographic breeding range (Collins 1983; Morse 1989). This species occupies the mature hardwood forest habitat characteristic of the plots used in this study, and appears to use more mature forest with a higher and distinct canopy (see later Discussion). On a larger spatial scale - say the entire Lake Opinicon region - this condition of habitat structure, however, does not hold true. Individual Black-throated Green Warblers may occupy a variety of vastly different habitat types, which include cedar swamps and regrowth hemlock stands. On the scale of the entire breeding range of this species, in fact, it appears that habitat cues similar to those used by other warblers are not used by Black-throated Greens, but instead this species appears to require only an available food resource and a multilayered leaf arrangement (Horn 1974; Holmes and Robinson 1981; Collins 1983).

With all of these factors complicating simple songbird-habitat relationships, it seems obvious that the results obtained from this study must be examined with caution. The complexity of songbird-habitat relationships should be kept in mind when reading the subsequent species discussions, and should go to influence the directions and methodology in future research efforts.

Context and Limitations of Statistical Analyses

The pathway from the raw data to obtaining the final results (Figures 9-50) has a great influence on the context and limitations which characterize the apparent songbird-habitat relationships. The statistics used in this study will be the focus of this discussion, which hopefully will provide a better understanding of the advantages and disadvantages of the methods used.

The large volume of habitat data obtained for the 31 plots was initially summarized into new variables, expected to affect differential habitat use by songbirds in the mature hardwood forest habitat. Any variable that might affect habitat use by songbird species, that was omitted at this step (and that did not correlate with variables that were included) would have resulted in misleading results. Thus, this step was a critical one.

In addition, variation in the variables used in habitat selection by a species had to vary noticeably between the 31 plots utilized, otherwise a lack of results would also be expected. This may be particularly prominent among habitat generalists such as the Ovenbird (see Discussion below).

From the habitat variables obtained, a Principal Components Analysis (PCA) was used to further reduce the number of the habitat variables prior to relating them to specific bird species abundance scores. PCA is a technique that summarizes the variability in the habitat, with components made up of linear combinations of weighted original habitat variables. In this case, these components, or axes, where chosen to be oblique (as opposed to orthogonal), as this better represented the baseline habitat variables. Thus, components within a given PCA were not necessarily independent of each other, although correlations between components remained low.

Limitations of this technique include the assumption of linear relationships between habitat variables. Thus, as one variable increases, another varies with it in a linear fashion (proportionately). This does not allow for threshold relationships which are commonplace in biological systems (see Ricklefs 1990). For example, in the relationship between canopy density and the density of vegetation from 1.5m - 6m, there could be a threshold amount of light that would permit rapid growth of the understory, but below which only limited understory growth would occur. In this case, PCA would unrealistically assume a linear relationship where, as light increases, undergrowth increases proportionately.

Such an assumption of linearity in habitat variables has drawbacks on the applicability of the derived components in explaining variations in habitat use by songbirds. Possibly an even greater drawback, however, would be the further assumption of a linear relationship between habitat components and the songbird's use of habitat itself (see Meents *et al.* 1983). Such assumptions have been common in previous literature (Wiens 1989a), and an attempt has been made to avoid it here.

Songbird abundance scores were first plotted against each derived habitat component (from PCA), and a linear test (nonparametric regression) of the null hypothesis where the slope of a fitted regression line is equal to zero ($Ho : \beta = \beta o$), was performed (Daniel 1990). In this technique, only values greater than the median y value and less than the median x value are used to reject the null hypothesis (Daniel 1990). Since this technique is restricted to only one quadrant of the data, it is not affected by nonlinearity. Thus, it was used to identify both linear and nonlinear relationships between the x and y variables, and no regression lines were fitted to the data.

Problems, in general, associated with using this nonparametric regression technique include a loss of accuracy due to ties in the y values (Daniel 1990). In particular, ties with the median y value result in a serious loss of accuracy. In an attempt to correct this, species' sample sizes were adjusted to the formula,

n=(number of y values > median y value but ≠ median value) x 2 + 1, which results in more conservative results better representative of the data.

The Bonferroni Correction

In this study, the same data set was used many times for many separate analyses. With each set of data points being used several times, the chance of a Type 1 error is artificially increased (i.e. the chance of p being "significant" is increased by chance alone). This increase may be accounted for by using a Bonferroni correction, where the desired p value to describe "significance" (0.05 in this case), is divided by the number of times each data point is used (in this case, habitat variables 20x + abundance scores 15x). The new p value obtained denotes the same significance of the overall results, taking into account the multiple use of data (in this case it would be $p = 0.05 / 35 = 0.001429$. Thus, using the Bonferroni correction, results should be significant only if $p \leq 0.0014$).

Although there is logic to this correction, it may be excessively conservative. Consequently, the decreased proportion of results which reject the null hypothesis often limits its practicality in biological investigations (Kleinbaum *et al.* 1988). For the purpose of this work, all values where $p < 0.001$ will be termed significant, and all those where $p < 0.05$ will be termed trends, however, both will be used in the discussion. In fact, values where $p < 0.10$ will also be discussed (but specified) if they provide possible insight into songbird-habitat utilization. An argument for inclusion of such values in the discussion is obvious considering the complexity of songbird-habitat relationships previously discussed.

The purpose of this discussion of biases and assumptions has been to put the results and subsequent discussions into context, enabling them to provide the most useful information possible without provoking misleading, generalized conclusions with regards to differential habitat use by songbirds. The results obtained provide a good baseline for hypotheses of habitat requirements of local songbird species, and serve useful for discussion to follow.

Results and Discussion

Habitat Components

The 39 habitat/landscape variables described in the methods were simplified using five separate Principal Component Analyses (PCA), one each for variables of vertical structure (16 variables), tree species diversity (9 variables), tree density (7 variables), ground cover (4 variables), and landscape (3 variables). The 5 separate PCA's described the variation in the habitat/landscape data in terms of 15 components (4,4,3,2,2 respectively for each group). The importance of each component (% variance contributed) to each group, as well as descriptions of each component in terms of composite environmental variables, are found in Table 1.

With variation in habitat/landscape characters of the 31 plots simplified to 15 components, an examination of conditions between components revealed possible interrelationships that could confound later analysis with respect to songbird abundance scores. No correlations between components were present where $r > |0.60|$ (Table 2). Implications of these intercomponent correlations are discussed below with regards to the songbird-habitat results obtained (see Species Accounts).

Songbird Surveys

Forty-nine species of birds (songbirds + nonsongbirds) were recorded within the 31, 50m-radius hardwood forest plots (Table 3). An additional 28 species were recorded during surveys, from outside the plots areas (Appendix 8; total of 77 species recorded during surveys). This represents a modest fraction of the 143 potential breeding birds of the Lake Opinicon region (Appendix 1).

Examining patterns of occurrence and abundance of the 49 bird species recorded within the plots, we find a great deal of variation. Two species, the Red-eyed Vireo (*Vireo olivaceus*) and Ovenbird (*Seiurus aurocapillus*), were recorded on every plot, and every plot but one, respectively. In addition, numbers of territorial males were the highest recorded: a respective 85 and 69 in total, or an average of 2.74 and 2.23 males per 50m-radius plot (Table 3).

Other species, including the Scarlet Tanager (*Piranga olivacea*) and Great Crested Flycatcher (*Myiarchus crinitus*), were found on over 60% of the plots, but were in relatively lower numbers. Only rarely was more than one

Table 1. Description of principal components in terms of important contributing habitat/ landscape parameters. Components separated into groups, representing the five independent Principal Components Analyses done. See also Figs. 5-8 (Vertical Components).

<u>Vertical Structure PC 1</u>
- high densities of vegetation, in particular from 1.5m - 6m; also from 6m - 12m (dense mid canopy
- relatively low vegetation density above 9m and low occurrence of two distinct canopies; also no distinct high canopy
- mean canopy height is low, while canopy range is large, stretching often with medium to high foliage density down to 3m height
- accounts for 33.74% of variation in vertical structure variables

<u>Vertical Structure PC 2</u>
- high foliage density between 12m and 18m with distinct high canopy
- relatively more vegetation above 9m than below 9m
- high amounts of space among foliage
- mean canopy height is high, while the canopy is composed of dense foliage
- total amount of vegetation (all vertical levels) is high
- maximum tree height high
- accounts for 32.56% of variation in vertical structure variables

<u>Vertical Structure PC 3</u>
- dense low undergrowth; high density of foliage from the ground to 1.5m
- often continuous vegetation from ground to 6m
- accounts for 13.01% of variation in vertical structure variables

<u>Vertical Structure PC 4</u>
- even height of forest with little above canopy space
- heavy mid-high canopy; dense foliage in 6m - 18m range
- total amount of vegetation (all vertical levels) is high
- accounts for 20.69% of variation in vertical structure variables

<u>Tree Species Diversity PC 1</u>
- coniferous component of foliage high
- high Eastern White Pine (*Pinus strobus*) foliage composition
- moderately low Ironwood (*Ostrya virginiana*) foliage composition
- accounts for 22.65% of variation in tree species diversity variables

<u>Tree Species Diversity PC 2</u>
- high maple (*Acer* spp.) and Ironwood foliage composition
- low tree species diversity (TSD)
- accounts for 44.85% of variation in tree species diversity variables

<u>Tree Species Diversity PC 3</u>
- high Basswood (*Tilia americana*) foliage composition
- low White Birch (*Betula papyrifera*) and moderately low Ironwood foliage composition
- accounts for 16.18% of variation in tre species diversity variables

Table 1. continued.

Tree Species Diversity PC 4
- high ash (*Fraxinus* spp.) foliage composition
- moderate Ironwood and Basswood foliage composition
- accounts for 16.33% of variation in tree species diversity variables

Tree Density PC 1
- High densities of 10-15cm DBH trees
- low densities of trees with DBH ≥ 20cm
- low sapling growth (DBH 2-5cm)
- accounts for 37.57% of variation in tree density variables

Tree Density PC 2
- high densities of 15-20cm DBH trees
- moderately high densities of trees with DBH ≥ 20cm, but these trees are relatively small - i.e. few overmature hardwoods
- accounts for 31.96% of variation in tree density variables

Tree Density PC 3
- high densities of trees with DBH 2-10cm
- trees with DBH ≥ 20cm are relatively small; few overmature hardwoods
- accounts for 30.48% of variation in tree density variables

Ground Cover PC 1
- high percentage leaf litter
- low percentage herbaceous growth
- accounts for 60.63% of variation in ground cover variables

Ground Cover PC 2
- high numbers of large logs (≥ 20cm in diameter) (i.e. mature forest)
- accounts for 39.37% of variation in ground cover variables

Landscape PC 1
- relatively large forest tracts (contiguity high)
- relatively short distance to water body (e.g. beaver pond, lake)
- accounts for 52.13% of variation in landscape varialbes

Landscape PC 2
- relatively far from agricultural/ suburban clearings
- accounts for 47.87% of variation in landscape variables

Table 2. Correlation matrix of the 15 principal components derived from five separate Principal Componenets Analyses. Values given are correlation coefficients.

	VH 1	VH 2	VH 3	VH 4	TSD 1	TSD 2	TSD 3	TSD 4
Vertical Height PC 1	1.000							
Vertical Height PC 2	-.077	1.000						
Vertical Height PC 3	.019	-.018	1.000					
Vertical Height PC 4	.003	.023	.018	1.000				
Tree Spp. Div. PC 1	-.060	.020	-.429	-.420	1.000			
Tree Spp. Div. PC 2	.202	-.191	-.058	-.438	.044	1.000		
Tree Spp. Div. PC 3	.160	-.010	-.481	-.013	.235	-.084	1.000	
Tree Spp. Div. PC 4	.261	.004	-.027	-.007	.426	.105	.235	1.000
Tree Density PC 1	.190	-.045	.093	-.434	.063	.147	.096	.130
Tree Density PC 2	-.024	-.047	.239	.349	.070	-.380	-.334	.106
Tree Density PC 3	.434	-.392	-.001	.170	-.238	-.227	.151	.003
Ground Cover PC 1	.170	.372	-.056	.303	.054	-.058	-.228	.235
Ground Cover PC 2	-.074	.335	-.112	-.114	.080	.366	.012	-.047
Landscape PC 1	.356	.294	.067	-.023	.102	.409	-.038	.245
Landscape PC 2	-.116	-.220	.296	.428	-.489	-.298	-.227	-.123

Table 2. continued.

	TD 1	TD 2	TD 3	GC 1	GC 2	LSC 1	LSC 2	
Tree Density PC 1	1.000							
Tree Density PC 2	-.146	1.000						
Tree Density PC 3	.057	-.134	1.000					
Ground Cover PC 1	-.215	.253	-.228	1.000				
Ground Cover PC 2	-.113	-.371	-.162	.201	1.000			
Landscape PC 1	-.061	-.009	-.007	.336	.290	1.000		
Landscape PC 2	-.233	.494	-.041	.141	-.463	-.347	1.000	

Table 3. All bird species recorded inside the 31 plots, the percentage of plots in which they occurred, the total number of territorial males, and the mean number of terr. males per plot.

bird species	% plots of occurrence (N=31)	total number of territorial males	mean number of territorial males per plot
Red-shouldered Hawk †	3.2	1	0.03
Black-billed Cuckoo	6.5	2	0.06
Great Horned Owl †	3.2	1	0.03
Ruby-thr. Hummingbird †	12.9	4	0.13
Red-bellied Woodpecker †	3.2	1	0.03
Yellow-bellied Sapsucker †	3.2	1	0.03
Downy Woodpecker †	25.8	8	0.26
Hairy Woodpecker †	9.7	3	0.10
Northern Flicker †	3.2	1	0.03
Pileated Woodpecker †	12.9	4	0.13
Eastern Wood Pewee	58.1	21	0.68
Least Flycatcher	25.8	13	0.42
Eastern Phoebe	6.5	2	0.06
Great Crested Flycatcher	64.5	20	0.65
Eastern Kingbird	3.2	1	0.03
Blue Jay †	9.7	3	0.10
American Crow †	6.5	2	0.06
Black-capped Chickadee	38.7	12	0.39
White-breasted Nuthatch	61.3	19	0.61
Brown Creeper	3.2	1	0.03
Winter Wren	3.2	1	0.03
Blue-gray Gnatcatcher	3.2	1	0.03
Veery	3.2	1	0.03
Swainson's Thrush	3.2	1	0.03
Wood Thrush	45.2	17	0.55
American Robin	29.0	9	0.29
Yellow-throated Vireo	19.4	6	0.19
Warbling Vireo	6.5	2	0.06
Red-eyed Vireo	100.0	85	2.74
Yellow Warbler	3.2	1	0.03
Yellow-rumped Warbler	6.5	2	0.06
Black-thr. Green Warbler	22.6	8	0.26
Blackburnian Warbler	3.2	1	0.03
Pine Warbler	12.9	5	0.16
Cerulean Warbler	58.1	31	1.00
Black-and-white Warbler	41.9	13	0.42
American Redstart	38.7	20	0.65
Ovenbird	96.8	69	2.23
Scarlet Tanager	74.2	25	0.81
Rose-breasted Grosbeak	22.6	7	0.23

* denotes species that were not territorial on the hardwood forest plots; therefore numbers reflect total number of birds seen or heard

† denotes species where males were not separated from females; therefore numbers reflect total number of birds seen or heard

Table 3. continued.

bird species	% plots of occurrence (N=31)	total number of territorial males	mean number of territorial males per plot
Indigo Bunting	6.5	2	0.06
Rufous-sided Towhee	6.5	2	0.06
Chipping Sparrow	35.5	13	0.42
Field Sparrow	3.2	1	0.03
Red-winged Blackbird*	16.1	9	0.29
Brown-headed Cowbird*	38.7	13	0.42
Northern Oriole	19.4	6	0.19
Purple Finch	3.2	1	0.03
American Goldfinch	3.2	1	0.03

* denotes species that were not territorial on the hardwood forest plots; therefore numbers reflect total number of birds seen or heard

† denotes species where males were not separated from females; therefore numbers reflect total number of birds seen or heard

territorial male recorded on a plot in these species, reflecting the relatively larger territory size. For species such as these, abundance score variation between plots was limited, making analysis of habitat use using 50m-radius sampling plots inappropriate.

Species showing more variation in both abundances and patterns of occurrence among plots, provided the best cases for habitat use determination. Such "clumped" species appear to use habitat based on microhabitat cues that were measurable using plots of 50m in radius. Such species included American Redstarts (*Setophaga ruticilla*), Least Flycatchers (*Empidonax minimus*) and Cerulean Warblers (*Dendroica cerulea*), all with territory sizes similar to those of Red-eyed Vireos and Ovenbirds.

Many species recorded on plots represented only one or two territorial males, possibly indicating appropriate habitat characteristics associated with only one or a few of the plots. An example of such a species is the Brown Creeper (*Certhia americana*), which requires suitable nesting habitat in the form of wetter woods with dead trees and loose bark.

In some instances, distribution of species both among and within forest plots may be indicators of the hardwood forest habitat providing only a fragment of the territory utilized by a species. In these cases, preferred habitat may occur in areas adjacent to plots, and may compose the bulk of those individual's territories. Chipping Sparrow (*Spizella passerina*) are an example of this, and are not truly characteristic of a mature hardwood forest, yet they frequently utilize bordering habitats and associated rocky outcrops.

The Red-winged Blackbird (*Agelaius phoeniceus*) was another interesting species occurring within the forest plots. This species was excluded from the analysis due to only non-territorial individuals occurring within plot boundaries. Red-winged Blackbirds were usually found in plots close in proximity to wetland habitat, and utilized the mid-upper canopies for foraging. Thus, despite defending territories outside of this habitat, this species regularly utilized mature hardwood forest habitat, and may well prove important to the ecology and songbird community of hardwood forest near wetlands.

The Songbird Community of Mature Hardwood Forest, Lake Opinicon

Aside from differences in patterns of abundance and occurrence, birds comprising the Lake Opinicon hardwood forest songbird community show vast ecological differences important to enabling their co-occurrence in this habitat. These species show a wide range of foraging behaviours and reproductive strategies, and thus utilize different food resources (primarily insects and other invertebrates). Other aspects of their natural history differ markedly, including patterns of migration and mating systems, the latter of which we still know very little about. (Keast 1988;1990 describes a similar bird community and its various components from the station point, within the Lake Opinicon area.)

While most songbird species breeding in the area winter further to the south (from southern Ontario to central South America), a few species are year round residents. The White-breasted Nuthatch (*Sitta carolinensis*) and Black-capped Chickadee (*Parus atricapillua*) were both fairly widespread on the plots, and may utilize non-insectivorous food outside of feeding young. These species both breed earlier than most migrant species, and are interestingly both single-brooded cavity nesters. Incidentally, the early breeding of these species resulted in lower singing rates by territorial males during the survey period of this study. This may explain poor results, in particular, with respect to Black-capped Chickadee habitat use.

Reproductive strategies are diverse in the songbird community, and represent varying tradeoffs and overall different strategies to maximize the number of offspring produced. American Robins (*Turdus migratorius*) may have three broods (three consecutive nests raising young) in a single season, compared with the single brooded Least Flycatcher which commences migration southward in July after having arrived in mid May. Other species may have six eggs in a clutch (e.g. Brown Creeper) as compared with a low of two eggs in the Least Flycatcher in years of poor food resource conditions (pers. obs.).

Foraging strategies of hardwood forest songbirds are even more diverse, and can be classified into "guilds," or groups of species with similar foraging behaviours. The most prominent species in hardwood forest plots, the Red-eyed Vireo, is a low vegetation to sub-canopy leaf-gleaning species, while the equally prominent Ovenbird specializes in using forest floor and ground vegetation as foraging substrate.

Other focal species include the Cerulean Warbler, which gleans invertebrates from the mid-upper canopies, while the Eastern Wood-Pewee (*Contopus virens*) is an aerial flycatcher, actively pursuing insects spotted from a stationary perch. Other distinct songbirds include the Black-and-white Warbler (*Mniotilta varis*) and White-breasted Nuthatch, both of which forage on the bark of trees. American Redstarts frequently use a "flush-chase" method of catching insects, where individuals flash their colourful and bold plumage, startling insects into flight and then actively chasing them through the subcanopy vegetation. Still other passerines, such as the Blue Jay (*Cyanocitta cristata*), feed on larger prey, including young songbird nestlings and other small vertebrates.

<u>Covariance in Songbird Species</u>

The diversity in ecology and behaviour of songbirds within the mature forest plots provides insight into their ability to coexist with one another. An examination into correlations between the songbirds themselves was examined to identify any patterns in the co-occurrence of these species.

Table 4 provides a correlation matrix of songbird abundances for the 19 species used in the subsequent analysis. Twenty significant results or trends in songbird abundance were found, most of which probably reflects differences in selected habitats.

Significant results were obtained for Wood Thrush (*Hylocichla mustelina*) and Great Crested Flycatcher (negative), Cerulean Warbler and Eastern Wood-Pewee (positive), Cerulean Warbler and Black-capped Chickadee (negative), American Redstart and Pine Warbler (*Dendroica pinus*) (negative), and Northern Oriole (*Icterus galbula*) and Rose-breasted Grosbeak (*Pheucticus ludovicianus*) (positive). All of these relationships appear to represent differences or similarities in habitat use, and no interspecific influences are suspected. See species account discussions for descriptions of habitat use for each of these species.

<u>Habitat Characteristics and Influences on Species Association Patterns</u>

As previously discussed, the PCAs that were performed enable a simplification of habitat data to only a few 'components' which described most of the variation in the data. Thus, variation in the hardwood forest plots can be described with respect to the various variable categories used:

Table 4. Correlation matrix of the absolute abundance values for the 19 focus songbird species (total number of territorial males). Values given are correlation coefficients.

	EWPE	LEFL	GCFL	BLCC	WBNU	WOTH	AMRO	YTVI
Eastern Wood-Pewee	1.000							
Least Flycatcher	.188	1.000						
Gr. Cr. Flycatcher	-.151	.222	1.000					
Black-c. Chickadee	-.300	-.253	.174	1.000				
White-br. Nuthatch	.204	**-.414**	-.174	-.048	1.000			
Wood Thrush	.174	-.130	**-.504***	-.257	.257			
American Robin	.299	.110	-.120	.075	.071	**.435**	1.000	
Yellow-thr. Vireo	.111	.255	.193	-.222	-.281	-.036	.046	1.000
Red-eyed Vireo	.333	.072	.103	**-.427**	.253	.280	.030	.059
Bl.-thr. Gr. Warbler	-.039	-.109	-.021	-.013	.144	.251	.236	-.250
Pine Warbler	**-.354**	-.009	.268	.306	-.158	-.189	.246	
Cerulean Warbler	**.464***	**.367**	.244	**-.479***	-.299	-.088	-.064	
Bl.-and-wh. Warbler	-.266	.210	.084	**.398**	**-.398**	-.308	-.256	
American Redstart	.127	-.017	.082	**-.423**	-.019	.056	-.143	-.079
Ovenbird	.117	-.042	-.038	-.344	.198	-.152	-.159	.148
Scarlet Tanager	-.082	.039	.236	**.412**	-.164	.026	**.365**	
Rose-br. Grosbeak	-.083	-.188	-.083	.204	.271	.251	.334	-.069
Chipping Sparrow	.091	.170	.289	.214	.112	-.329	-.090	-.069
Northern Oriole	-.126	-.259	-.149	.114	.054	.333	**.406**	

boldface indicates trends $0.05 \geq p > 0.001$ ($N = 31$; d.f. $= 29$); (using Bonferroni correction)
boldface * indicates significant relationships, $p < 0.001$ ($N = 31$; d.f. $= 29$)

Table 4.

	REVI	BTGW	PIWA	CEWA	BWWA	AMRE	OVEN	SCTA
Red-eyed Vireo	1.000							
Bl.-thr. Gr. Warbler	.188	1.000						
Pine Warbler	-.151	.222	1.000					
Cerulean Warbler	-.300	-.253	.174	1.000				
Bl.-and-wh. Warbler	.204	**-.414**	-.174	-.048	1.000			
American Redstart	.174	-.130	**-.504***	-.257	.257			
Ovenbird	.299	.110	-.120	.075	.071	**.435**	1.000	
Scarlet Tanager	.111	.255	.193	-.222	-.281	-.036	.046	1.000
Rose-br. Grosbeak	.333	.072	.103	**-.427**	.253	.280	.030	.059
Chipping Sparrow	-.039	-.109	-.021	-.013	.144	.251	.236	-.250
Northern Oriole	**-.354**	-.009	.268	.306	-.158	-.189	.246	

Table 4. continued.

	RBGR	CHSP	NOOR
Rose-br. Grosbeak	1.000		
Chipping Sparrow	-.118	1.000	
Northern Oriole	**.712***	-.203	1.000

boldface indicates trends $0.05 \geq p > 0.001$ ($N = 31$; d.f. = 29); (using Bonferroni correction)
boldface * indicates significant relationships, $p < 0.001$ ($N = 31$; d.f. = 29)

Vertical Structure, Tree Species Diversity, Tree Density, Ground Cover, and Landscape.

Within each category, we see components that describe differential portions of the variation, and furthermore, relate to different songbird species' abundance scores. These abundance scores describe the relative use of habitat with respect to the components, and will be referred to as indicating differential habitat use in the subsequent discussions. Figures 5-8 illustrate the dominant features of each of the vertical structure, and provide an indication of the importance of such components to songbird species, which will be the subject of more specific discussion in the following section.

Species Accounts

Eighteen species of passerines (called "songbirds" here although not all represent true oscines) occurred on at least 1/6 of the plots. These species were judged to comprise the dominant songbird species utilizing the mature hardwood forest habitat in the area, and were the focus of subsequent analysis and discussion in the Species Accounts section. An additional species, the Pine Warbler, was recorded on only four plots; however, the extreme habitat specificity of this species resulted in interesting results warranting inclusion in this discussion.

Regressions for songbird abundance scores versus environmental (habitat/landscape) components tested the null hypothesis of no relationship (H_0; slope = 0). Relationships between the PCA-derived environmental components and songbird abundance scores, where $p \leq 0.05$ (nonparametric regression) are plotted for each species (Figure 9-50). Significant relationships ($p \leq 0.001$ using Bonferroni correction - see above discussion) were found for eight bird species (total of 10 significant songbird-habitat relationships) (Table 5). A total of 34 trends ($p \leq 0.05$) were found for 16 songbird species, and are provided in Table 6. Trends where ($p \leq 0.10$) occurred in the cases of 11 species (26 occasions), and are shown in Appendix 9, primarily for purposes of later discussions and are not graphed.

Within the following accounts, a review of literature on habitat use, foraging behaviour, and nest site requirements was made, to provide background essential to interpreting the results of this study, as well as to discussing implications of forest management to each species. Following a review of literature, a discussion of each species with reference to the Lake

Figure 5. Vertical Structure PC1 habitat characteristics, illustrating relatively low, large and dense canopy (1.5-12m). This component accounted for 33.74% of the variation in habitat structure, and correlated significantly ($p<0.001$) with the abundance scores of Red-eyed Vireo (*Vireo olivaceus*) and Eastern Wood-Pewee (*Contopus virens*) (both positively), and showed trends ($p<0.05$) with abundance scores of Cerulean Warbler (*Dendroica cerulea*), White-breasted Nuthatch (*Sitta carolinensis*), American Redstart (*Setophaga ruticilla*), and Chipping Sparrow (*Spizella passerina*), (all positive), as well as Black-and-white Warbler (*Mniotilta varia*) (negative).

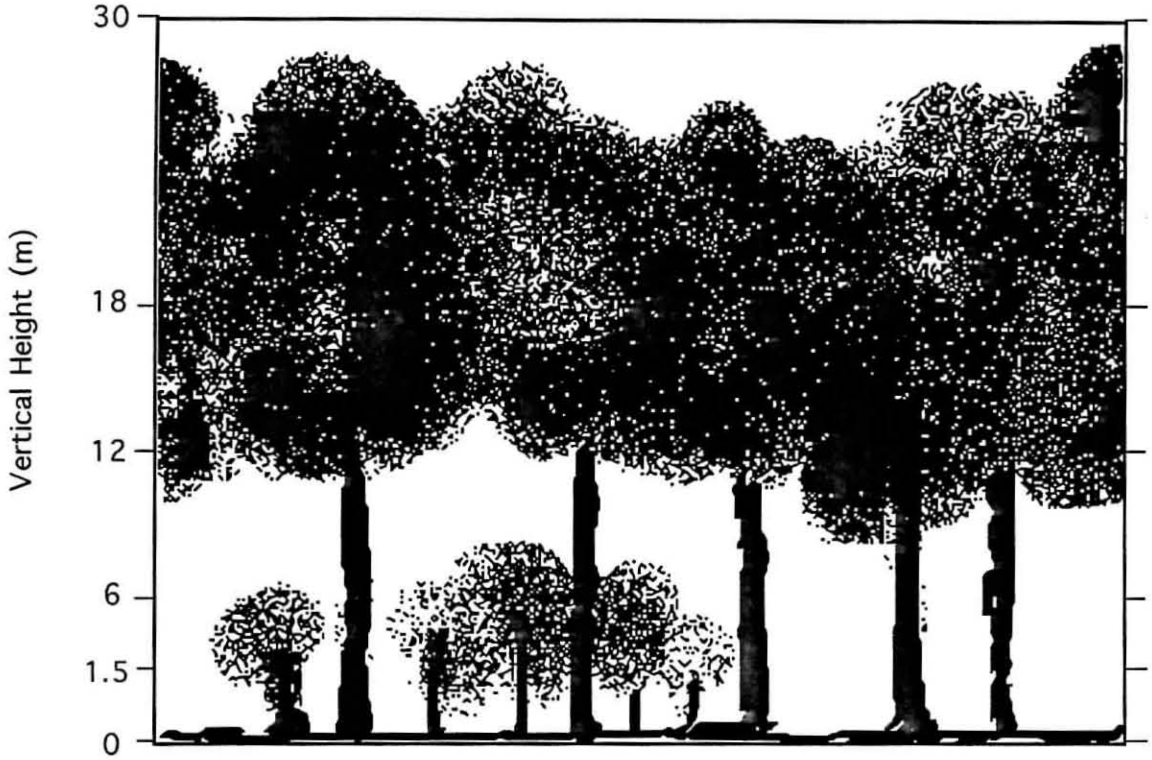


Figure 6. Vertical Structure PC2 habitat characteristics, illustrating high, dense, and distinct high canopy (12+m). This component accounted for 32.56% of the variation in habitat structure, and showed trends ($p<0.05$) with abundance scores of Northern Oriole (*Icterus galbula*) (positive), and Chipping Sparrow (*Spizella passerina*), (negative).

Figure 7. Vertical Structure PC3 habitat characteristics, illustrating dense, low undergrowth (up to 6m). This component accounted for 13.01 of the variation in habitat structure, and showed trends ($p<0.05$) with abundance scores of American Redstart (*Setophaga ruticilla*), and Great Crested Flycatcher (*Myiarchus crinitus*) (positive).

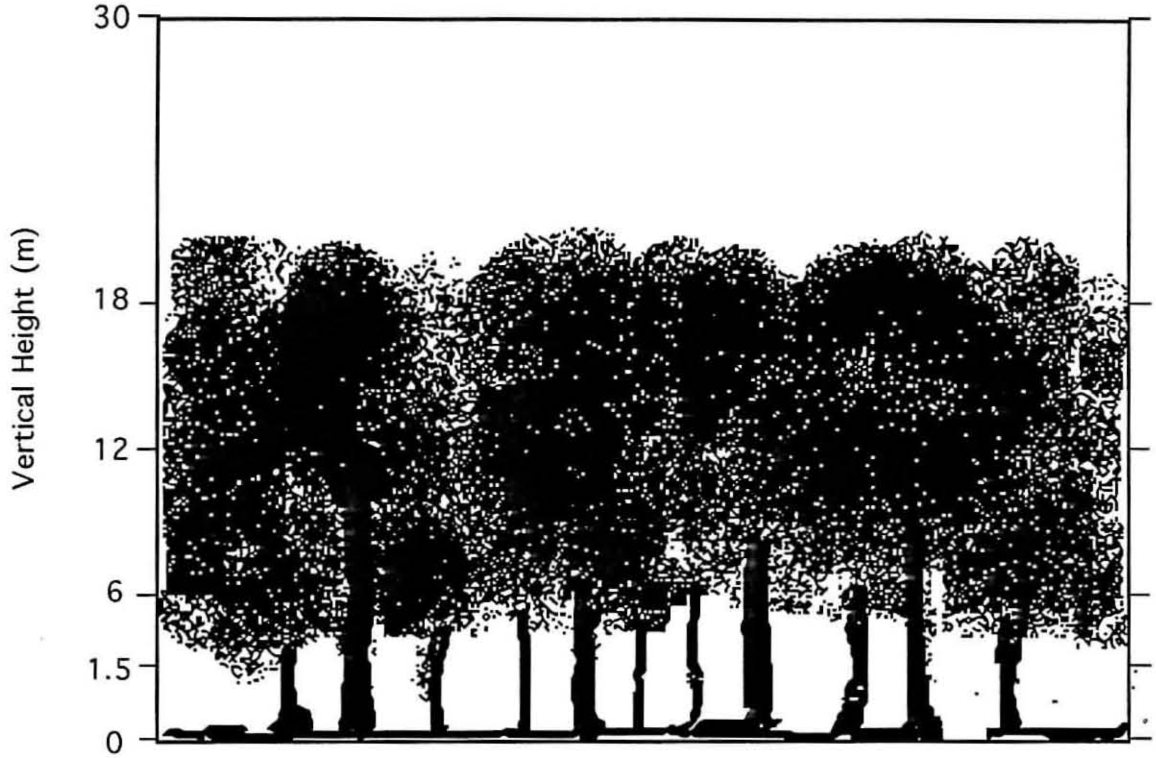


Figure 8. Vertical Structure PC4 habitat characteristics, illustrating relatively low, large and dense canopy (1.5-12m). This component accounted for 20.69 of the variation in habitat structure, and correlated significantly ($p<0.001$) with the abundance scores of Rose-breasted Grosbeak (*Pheucticus ludovicianus*) (negative), and showed trends ($p<0.05$) with abundance scores of White-breasted Nuthatch (*Sitta carolinensis*), and Least Flycatcher (*Empidonax minimus*) (both positive), as well as Northern Oriole (*Icterus galbula*) (negative).

Table 5. Significant relationships between songbird species abundance scores and environmental components derived from Principal Components Analyses.

Environmental Component	Songbird Species	χ^2	degrees of freedom	p value	adjusted sample size†
Vertical Structure PC1	E. Wood Pewee *Contopus virens*	12.99	1	<0.001	$n_1 = 13$
Vertical Structure PC1	Red-eyed Vireo *Vireo olivaceus*	15.05	1	<0.001	$n_1 = 15$
Vertical Structure PC4	Rose-br. Grosbeak *Pheucticus ludovicianus*	11.30	1	<0.001	$n_1 = 15$
Tree Species Diversity PC3	White-br. Nuthatch *Sitta carolinensis*	10.97	1	<0.001	$n_1 = 11$
Tree Species Diversity PC2	American Redstart *Setophaga ruticilla*	17.64	1	<0.001	$n_1 = 25$
Landscape PC1	American Redstart *Setophaga ruticilla*	11.56	1	<0.001	$n_1 = 25$
Landscape PC1	Rose-br. Grosbeak *Pheucticus ludovicianus*	15.05	1	<0.001	$n_1 = 15$
Landscape PC1	Northern Oriole *Icterus galbula*	12.99	1	<0.001	$n_1 = 13$

†see Methods for details with reference to original sample size

Opinicon area and the results obtained in this study is given. Using both these results, and the results of other work, the implications of forest management practices are discussed for each species. From this, preliminary recommendations are made, which usually consist of requests of more data concerning specific aspects of population dynamics of each species.

Table 6. Trends ($p \leq 0.05$) between songbird species abundance scores and environmental components derived from Principal Components Analyses.

Environmental Component	Songbird Species	χ^2	degrees of freedom	p value	adjusted sample size†
Vertical Structure PC4	Least Flycatcher *Empidonax minimus*	4.76	1	<0.025	$n_1 = 17$
Vertical Structure PC3	Gr. Cr. Flycatcher *Myiarchus crinitus*	6.23	1	<0.025	$n_1 = 13$
Vertical Structure PC1	White-br. Nuthatch *Sitta carolinensis*	4.44	1	<0.05	$n_1 = 11$
Vertical Structure PC4	White-br. Nuthatch *Sitta carolinensis*	4.44	1	<0.05	$n_1 = 11$
Vertical Structure PC1	Cerulean Warbler *Dendroica cerulea*	9.93	1	<0.005	$n_1 = 29$
Vertical Structure PC1	Bl.-and-wh. Warbler *Mniotilta varia*	10.70	1	<0.005	$n_1 = 27$
Vertical Structure PC1	American Redstart *Setophaga ruticilla*	6.76	1	<0.01	$n_1 = 25$
Vertical Structure PC3	American Redstart *Setophaga ruticilla*	6.76	1	<0.01	$n_1 = 25$
Vertical Structure PC1	Chipping Sparrow *Spizella passerina*	5.26	1	<0.025	$n_1 = 23$
Vertical Structure PC2	Chipping Sparrow *Spizella passerina*	7.35	1	<0.01	$n_1 = 23$
Vertical Structure PC2	Northern Oriole *Icterus galbula*	6.23	1	<0.025	$n_1 = 13$
Vertical Structure PC4	Northern Oriole *Icterus galbula*	9.30	1	<0.005	$n_1 = 13$
Tree Species Diversity PC2	Wood Thrush *Hylocichla mustelina*	9.93	1	<0.005	$n_1 = 29$

†see Methods for details with reference to original sample size

Table 6. continued.

Environmental Component	Songbird Species	χ^2	degrees of freedom	p value	adjusted sample size†
Tree Species Diversity PC3	Wood Thrush *Hylocichla mustelina*	5.81	1	<0.025	$n_1 = 29$
Tree Species Diversity PC4	American Robin *Turdus migratorius*	6.37	1	<0.025	$n_1 = 19$
Tree Species Diversity PC2	Red-eyed Vireo *Vireo olivaceous*	8.09	1	<0.005	$n_1 = 15$
Tree Species Diversity PC1	Pine Warbler *Dendroica pinus*	4.44	1	<0.005	$n_1 = 9$
Tree Species Diversity PC4	Pine Warbler *Dendroica pinus*	4.44	1	<0.005	$n_1 = 9$
Tree Species Diversity PC2	Bl.-and-wh. Warbler *Mniotilta varia*	6.26	1	<0.025	$n_1 = 27$
Tree Species Diversity PC1	Ovenbird *Seiurus aurocapillus*	5.26	1	<0.025	$n_1 = 23$
Tree Density PC1	White-br. Nuthatch *Sitta carolinensis*	4.44	1	<0.05	$n_1 = 11$
Tree Density PC3	Wood Thrush *Hylocichla mustelina*	7.73	1	<0.01	$n_1 = 29$
Tree Density PC3	Pine Warbler *Dendroica pinus*	5.45	1	<0.025	$n_1 = 9$
Tree Density PC3	Chipping Sparrow *Spizella passerina*	5.26	1	<0.025	$n_1 = 23$
Ground Cover PC1	Least Flycatcher *Empidonax minimus*	4.76	1	<0.025	$n_1 = 17$
Ground Cover PC2	Bl.-thr. Gr. Warbler *Dendroica virens*	8.09	1	<0.005	$n_1 = 15$
Landscape PC1	E. Wood-Pewee *Contopus virens*	6.23	1	<0.025	$n_1 = 13$

† see Methods for details with reference to original sample size

Table 6. continued.

Environmental Component	Songbird Species	χ^2	degrees of freedom	p value	adjusted sample size†
Landscape PC2	Least Flycatcher *Empidonax minimus*	9.94	1	<0.005	$n_1 = 17$
Landscape PC2	Wood Thrush *Hylocichla mustelina*	4.16	1	<0.05	$n_1 = 29$
Landscape PC1	American Robin *Turdus migratorius*	6.37	1	<0.025	$n_1 = 19$
Landscape PC1	Red-eyed Vireo *Vireo olivaceous*	8.09	1	<0.005	$n_1 = 15$
Landscape PC2	Pine Warbler *Dendroica pinus*	5.45	1	<0.025	$n_1 = 9$
Landscape PC2	Rose-br. Grosbeak *Pheucticus ludovicianus*	5.42	1	<0.025	$n_1 = 15$
Landscape PC2	Northern Oriole *Icterus galbula*	9.30	1	<0.005	$n_1 = 13$

†see Methods for details with reference to original sample size

Eastern Wood-Pewee (*Contopus virens*)

This neotropical migrant winters primarily in northwest-central South America, moving north to breed across the eastern United States (west to Texas) and southeastern Canada (west to Saskatchewan) (AOU 1983). On the breeding grounds, this species typically forages using a hawking behaviour, often sitting on an exposed perch, "passively searching" for flying insects which it pursues in an aerial attack (Johnston 1971; Robinson and Holmes 1982; Rising 1987). This characteristic foraging behaviour may well restrict this species to woodland openings, edges, and forest with an open subcanopy, where it can better search and actively pursue its insect prey (Hespenheide 1971; Johnston 1971; Robinson and Holmes 1982; Rising 1987).

The Eastern Wood-Pewee has been described in a variety of habitats ranging from sparse pine woods with undergrowing cane thickets (Virginia) to dense maple saplings with an open oak canopy (Wisconsin) (Hespenheide 1971). Contrary to Hespenheide (1971), however, denser forests do not exclude this species (Bond 1957; Sibley 1988), although a requirement of edge or an open subcanopy may be real (Johnston 1971). Sibley (1988) describes forest habitat used by this species to include mature beech-maple, oak-hickory, and river valley forest in New York state. In addition, more disturbed habitats occupied by pewees include fruit orchards and large shade trees in urban parks (Bull 1974; Peck and James 1987; Rising 1987; Sibley 1988).

Nests of this species are often associated with open areas as well, including forest edges, clearings, and water edge (Peck and James 1987). In addition, relatively dry deciduous woods may provide more suitable habitat than mixed woods, while coniferous woods are only rarely used (Peck and James 1987; Rising 1987). Nest heights most commonly range from 4.5m - 9m, with elm, oak, maple, birch, and apple being the most common nest trees (Peck and James 1987).

Lake Opinicon Mature Hardwood Forest Stands

The Eastern Wood Pewee is one of the most widespread species in the mature forests of Lake Opinicon, occurring on a large percentage of the plots surveyed. Territories appear to be relatively large compared with some of the smaller wood warblers, and abundance's (absolute number) were usually ≤ 2 territorial males per plot.

The significant degree to which Eastern Wood-Pewees use heavy-midcanopy, continuously dense, and relatively low regrowth habitat within the study plots (Figure 9) is difficult to explain. This species' need for openings in the forest seems clear from previous accounts in the literature, while the continuous canopy that seems to support so may individuals allows for relatively little space among the foliage. The negative correlation of abundance scores with respect to distance from water may provide some insight into this relationship.

A close proximity to water provides edge habitat that may be required for nesting and to some degree, foraging (see Figure 10). Although forest contiguity is negatively correlated to distance from water as well (see Figure 10), decreasing size of forest tracts have not been described to affect this species, except perhaps in a positive way (Clark *et al.* 1983; Robbins 1984; Rising 1987). Thus it appears that both a close proximity to water, and a dense, low regrowth habitat support greater use by Eastern Wood-Pewees, although there is also some correlation between these two variables (r=0.356 see Table 5).

The correlation between abundance scores and the relatively low and dense regrowth habitat proves interesting. The increased substrate at the subcanopy level may play a role in prey abundance that could not be measured in this study. In addition, the amount of canopy "space" required in a territory to allow active foraging and sustain an Eastern Wood-Pewee pair has not been described, and is probably heavily dependent on prey availability. Altering foraging behaviour, as has been described American Redstarts (*Setophaga ruticilla*) (Sherry 1979), may well occur in this species, as ell, and enable the utilization of more dense habitats such as described here.

In any case, the results obtained suggest the relationship between Eastern Wood-Pewees and their utilized habitat may not be as simplistic as has been previously described. For example, Hespenheide (1971) proposed the *Empidonax* flycatchers inhabited denser forests with no overlap in the open-preferring Eastern Wood-Pewee; a hypothesis that is not applicable to the Lake Opinicon area (nor to the study area of Johnston 1971), where both Least Flycatcher (*Empidonax minimus*) and Eastern Wood-Pewee territories overlap.

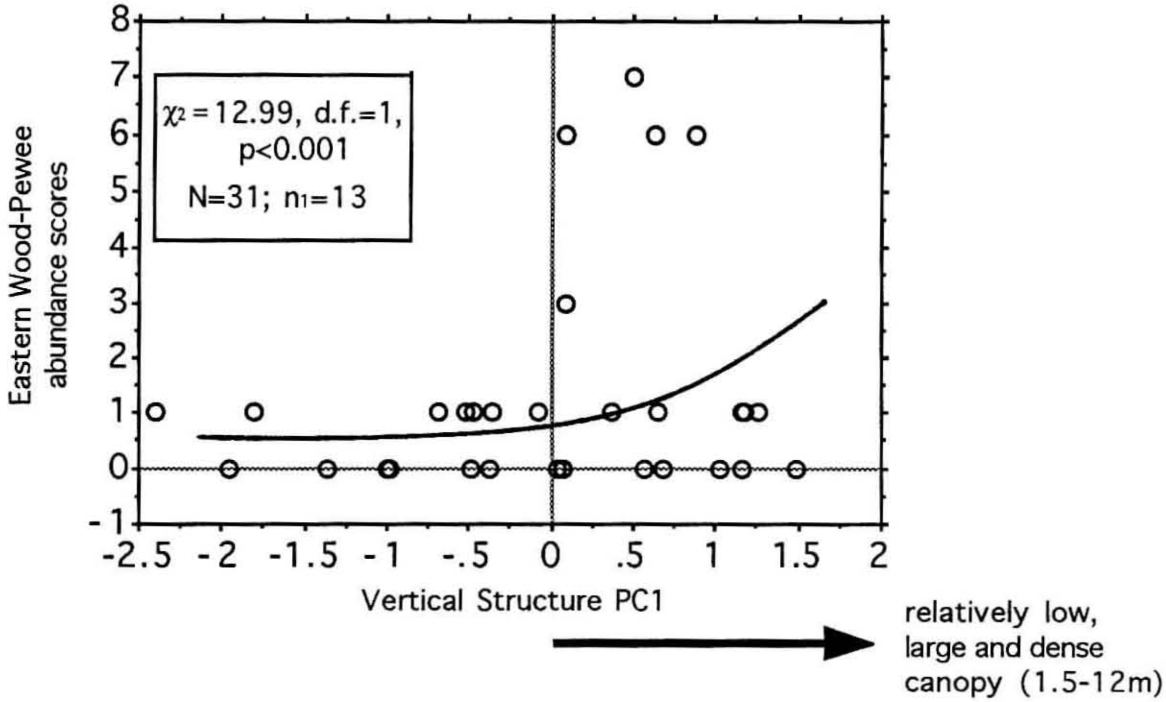


Figure 9. Relationship between Eastern Wood-Pewee (*Contopus virens*) abundance scores and Vertical Structure PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

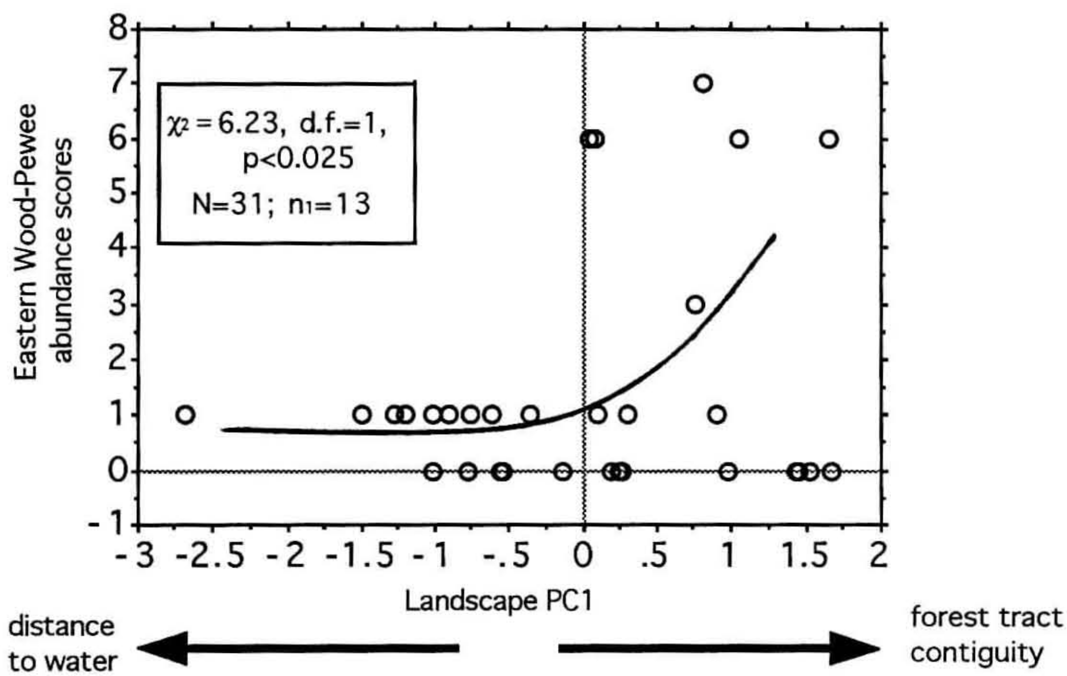


Figure 10. Relationship between Eastern Wood-Pewee (*Contopus virens*) abundance scores and Landscape PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

Concerns of Forest Management Practices

A variety of authors suggest that the Eastern Wood-Pewee may benefit from thinning of forest, especially with respect to clearing of the understory or thinning of the canopy (Hespenheide 1971; Clark *et al.* 1983; Robbins 1984; Rising 1987). In addition, forest tract size (effects of fragmentation) does not appear to influence the abundance of this species inhabiting these tracts (Robbins 1984). Without more extensive research regarding actual productivity of Eastern Wood-Pewees with respect to habitat and landscape variables, however, such suggestions and evidence provoke premature conclusions.

Should advantages to Eastern Wood-Pewees associated with denser forest tracts be real, as this preliminary study suggests, even selective cutting may have some population effects. Fortunately, this species appears to be highly adaptable, and capable of coping with such pressures, even if detrimental to wood-pewee habitat. More information on nest depredation and brood parasitism, however, may reveal differential reproductive success in different habitats. Populations appear to be relatively stable in both Ontario and eastern North America (Hussell *et al.* 1992; Robbins 1984), suggesting this species in not in serious jeopardy.

Preliminary Recommendations

None. The species appears to be highly adaptable to both forest alterations and fragmentation, although whether the former is in fact beneficial to the species, as many authors suggest (Hespenheide 1971; Clark *et al.* 1983; Robbins 1984; Rising 1987), is unclear. More research is required on the actual productivity of individuals and populations associated with different habitat and landscape conditions.

Least Flycatcher (*Empidonax minimus*)

This widespread flycatcher breeds across Canada to the rockies, and south into the Appalachians of the United States (AOU 1983). Wintering birds are found from northern Mexico to Panama (AOU 1983), making the Least Flycatcher a true neotropical migrant.

The broad geographic distribution of this species may in part be accounted for by its use of a wide range of habitats. Breckonridge (1956) found this species in woods dominated by Northern Pine Oak (*Quercus ellipsoidalis*), Bur Oak (*Quercus macrocarpa*), Jack Pine (*Pinus banksiana*), Eastern White Pine (*P. strobus*), White Birch (*Betula papyrifera*), and Red Maple (*Acer rubrum*) (Minnesota). Use of second growth woodland, such as that dominated by Large-tooth Aspen (*Populus grandidentata*) and Trembling Aspen (*Populus tremuloides*) (MacQueen 1950), and aspen beech-maple associations (Johnston 1971) have also been described. More open habitats include orchards, deciduous growth within pine forest, woodland edges, and urban parks with large shade trees (Norse and Kibbe 1985; MacQueen 1950; Davis 1959; Connor 1988). Less open habitats such as beech-maple mesophytic or Appalachian oak-hickory forests in New York state apparently lack this species (Connor 1988), supporting the many suggestions of an open habitat requirement.

From the perspective of tree species composition, the Least Flycatcher does not appear to be limited. Habitats range from those dominated by oak (*Quercus* spp.), Cucumber (*Magnolia acuminata*), Pitch Pine (*Pinus rigida*), and Sweet Birch (*Betula lenta*) (North Carolina) (Davis 1959), to beech-maple-Yellow Birch (*Betula alleghaniensis*) mature forest of New Hampshire, to sparse areas of poplar (*Populus* spp.) lining river banks along the Hudson Bay coast (Peck and James 1987), all supporting populations of Least Flycatcher.

Instead of specific tree species preference, evidence suggests this species to use habitat exhibiting favoured structural patterns in foliage. Many authors note an apparent preference for "open" woods (MacQueen 1950; Breckonridge 1956; Davis 1959; Johnston 1971; Fraser 1987; Connor 1988); while Breckonridge (1956) went on to suggest a requirement of openness just beneath the forest canopy (about 3m - 9m off the ground). This author suggests that limb density in this subcanopy region was a critical factor influencing habitat use in Least Flycatchers (a threshold relationship). Johnston (1971) provided some support for this view, while work in New Hampshire found Least Flycatchers to use habitat with low foliage density from 12m - 15m, where this species forages extensively (Sherry 1979).

Foraging behaviour of the Least Flycatcher is not simple flycatching, as the name suggests, but may implicate more complicated habitat requirements for this species. Hovering (hover-gleaning), and to a lesser extent, flycatching forms the bulk of its foraging behaviour (Sherry 1979; Robinson and Holmes 1982; Sabo and Holmes 1983). Thus, this species requires a vegetative substrate on which to catch insect prey, and although it may prefer less dense vegetation in its foraging height range, it does not prefer least dense areas for foraging (Sherry 1979).

Nest sites are frequently in the crotch of deciduous saplings or small trees (usually 3m - 8m above the ground) (Peck and James 1987), and are probably not limiting to this species. A complicating factor, however, is a competitor species, the American Redstart, which is actively attacked by Least Flycatchers (Sherry 1979; pers. obs.) and may well influence habitat selection and use in the latter species. In addition, semicoloniality has been described (e.g. DellaSala and Rabe 1987), which suggests the presence of conspecifics on the breeding grounds may also influence habitat selection and use.

Lake Opinicon Mature Hardwood Forest Stands

The Least Flycatcher shows a patchy distribution in the Lake Opinicon area, ranging from absent to abundant. The small territories and tight clustering groups of territorial males allowed for interesting variation in abundance scores with respect to habitat variables measured, and suggests that habitat parameters on the stand scale may influence habitat use.

A positive relationship between habitat use and even height, heavy mid-high canopy forest (6m+) (Figure 11) suggests that such foliage patterns may be conducive to foraging of this species. Surprisingly, vegetation in the 6m - 18m range is dense in such habitat conditions; however, open space below 6m may satisfy an open space requirement, while the dense canopy above may provide ample substrate for foraging and a source of potential prey.

Surprisingly, a trend towards increasing habitat use with increased leaf litter (decreased herbaceous ground cover) (Figure 12) was found for this species which seldom uses the ground layer. A positive correlation with the significant vertical component above may partially explain these findings (see Table 5), although similar results were obtained by Darveau *et al.* (1992) in similar habitat in Québec.

A positive relationship between abundance scores and distance to agricultural or suburban openings (Figure 13) may also be influenced by a high correlation with the same vertical structure pattern (Table 5); however, evidence from Michigan suggest that this trend is real. DellaSala and Rabe (1987) found Least Flycatchers in continuous hardwood forests to increase

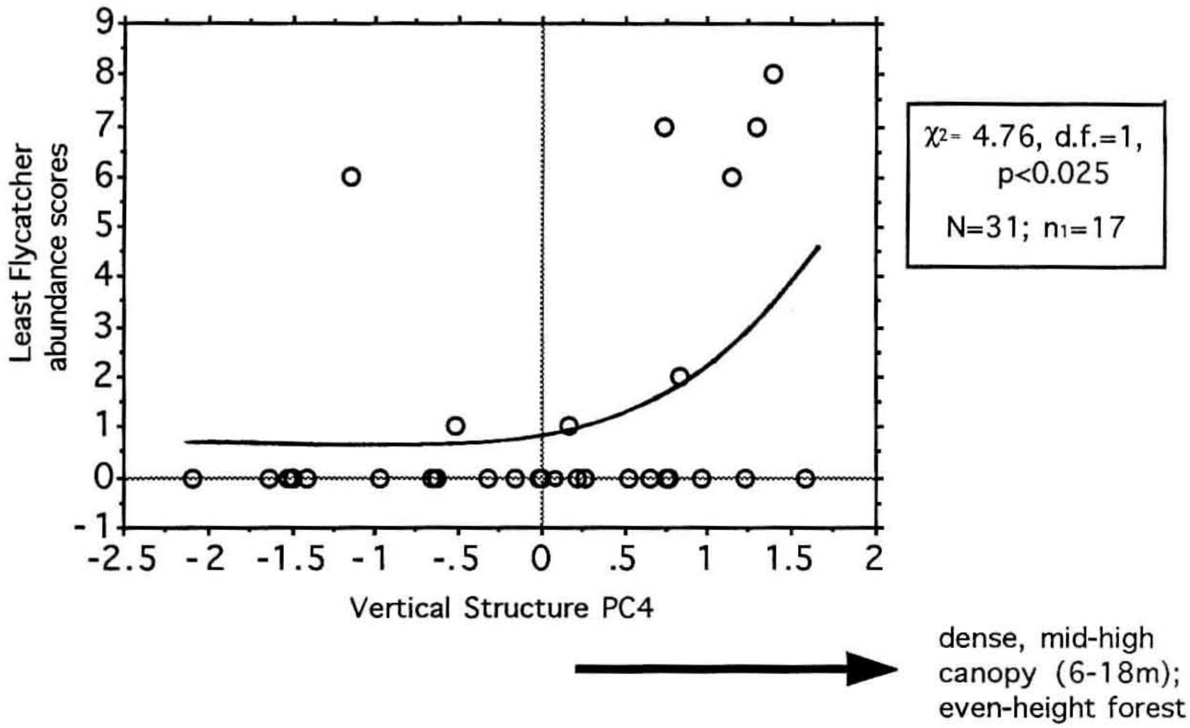


Figure 11. Relationship between Least Flycatcher (*Empidonax minimus*) abundance scores and Vertical Structure PC4. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

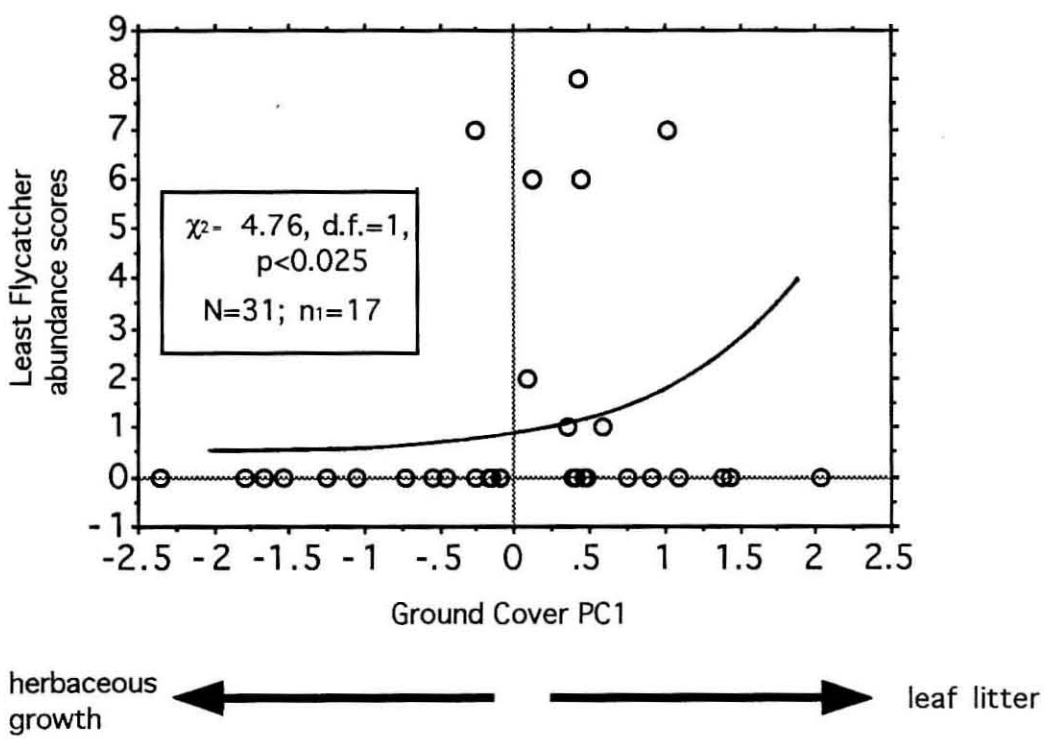


Figure 12. Relationship between Least Flycatcher (*Empidonax minimus*) abundance scores and Ground Cover PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

their distance from a forest disturbance (man-induced) with increasing size of the disturbance. This study supports a negative relationship between the proximity of such disturbances and the occurrence of Least Flycatchers, as in DellaSala and Rabe (1987), but seems to contradict previous descriptions of this species using disturbed habitats such as orchards and urban parks.

Interestingly, DellaSala and Rabe (1987) also describe habitat utilized by Least Flycatchers to include a well-developed canopy and large-tall trees, which were hypothesized to be important in habitat selection by this species. These requirements are supported by this study, which found almost the exact same requirements for Least Flycatcher habitat use.

A negative trend ($p<0.10$) of Least Flycatcher habitat use with increasing conifer/White Pine foliage composition (Appendix 9) may reflect the less suitable foliage profile conditions of mature White Pine-dominated forest. Many other habitats are used in the area, however, including wet areas dominated by Eastern White Cedar (*Thuja occidentalis*) (and other deciduous trees), suggesting that other coniferous habitats may not be entirely unsuitable to this species.

Concerns of Forest Management Practices

Despite utilizing some man-dominated habitats such as urban parks and orchards, the Least Flycatcher appears to be highly susceptible to the effects of forest management practices. Darveau *et al.* (1992) found this species to be affected by a 20% loss of maple crown foliage (due to acid rain), which was compared to a 20% thinning of canopy foliage by silvicultural practices. Six habitat variables, which included tree height, Sugar Maple composition, intermediate and upper canopy layers (10m+ in height), and decreasing herbaceous ground cover were associated with the occurrence of Least Flycatchers in maple forest of Québec. These data largely support the findings of this study as well as those of DellaSala and Rabe (1987).

Thus, it appears that contentions made by some authors (e.g. Fraser 1987) that forest thinning and fragmentation may provide more suitable habitat for this species as opposed to larger tracts of forest, are to a large degree false. Thinning of canopy and fragmenting of forests may well decrease the suitability or quality of habitat available to Least Flycatchers in mature hardwood forest stands.

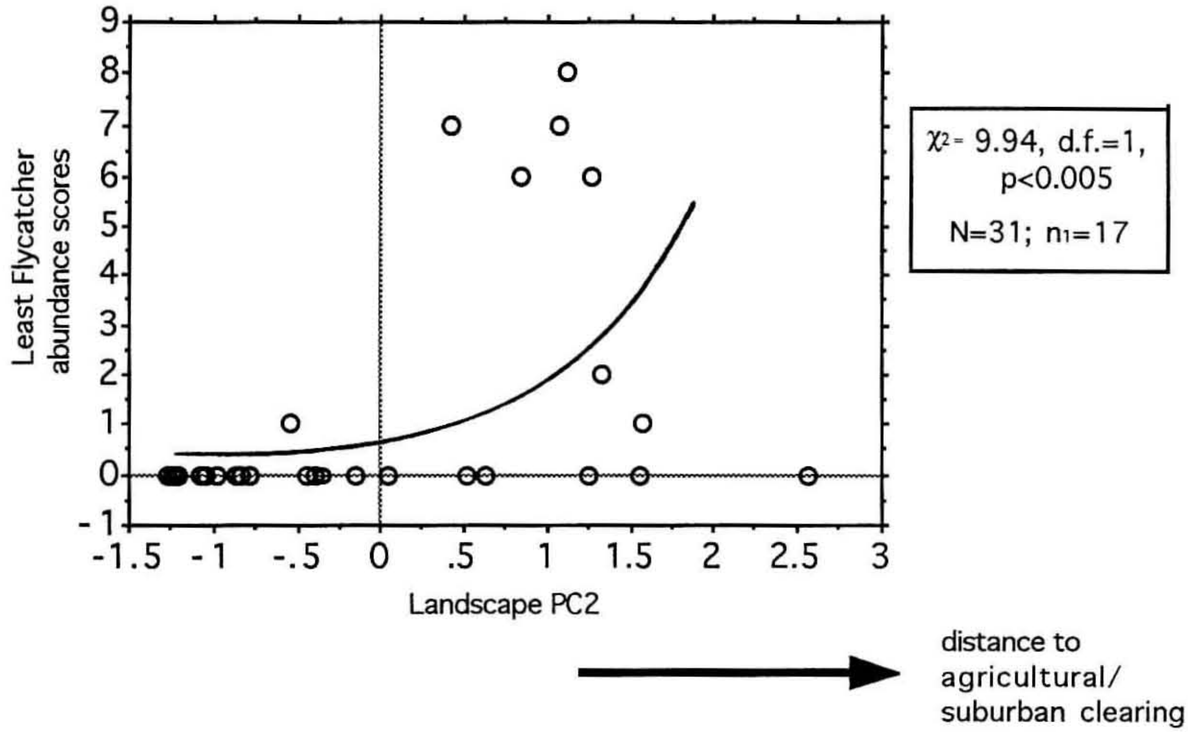


Figure 13. Relationship between Least Flycatcher (*Empidonax minimus*) abundance scores and Landscape PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

Preliminary Recommendations

Extensive thinning of hardwood forest canopies (6m - 18m) in the area may well have a serious impact on the habitat of this species. The Least Flycatcher, however, is semicolonial, and silvicultural thinning of canopy in areas supporting such "colonies" should be avoided. In addition, the fragmentation of this forest type appears to have negative effects on the occurrence of this species. Although many open and disturbed habitats may be used, mature hardwood forest that is subject to such fragmentation disturbances will likely have a decrease in Least Flycatcher populations. More research on the more proximate effects of both silvicultural practices and landscape alterations on this species are required, as well as factors governing general population dynamics, which are poorly understood.

Great Crested Flycatcher (*Myiarchus crinitus*)

The breeding range of the Great Crested Flycatcher encompasses southeastern Canada and most of the southeastern United States, west to Texas and the Great Plains (AOU 1983). Wintering range includes Central America, parts of the Caribbean and northern South America (AOU 1983).

Most authors describe this species occupying characteristically open-forested areas, ranging from clearings, edges, and wetlands, to more disturbed habitat of orchards, pastures and suburban parks (Norse and Ellison 1985; Bennett 1987; Peck and James 1987; Levine 1988). This species also uses more closed forest habitats, where individuals hawk for insects in the forest canopy (about 15m to 30m off the ground) (Johnston 1971). Bent (1942) suggests that the Great Crested Flycatcher was once a bird of the forest interior habitats; however, this species moved into more open habitats with the clearing and opening up of forested areas.

No species-specific habitat requirement has been described in the literature for this species, however, it seems restricted to deciduous and mixed forest types (Peck and James 1987; Bennett 1987; Levine 1988). Beehler (1978) believed this species to benefit from the replacement of cleared coniferous forest with regrowth deciduous forest in the Adirondack regions of New York, thus it appears this species may be limited geographically by the extent of deciduous and mixed forest available.

The Great Crested Flycatcher is unique among Canadian members of its family in using existing cavities as nest sites. Nest sites range from tree cavities, stumps, and nest boxes to fence posts (Peck and James 1987), with the height of the cavity being variable and apparently relatively unimportant (Johnston 1971). In most cases, however, nest sites range from 1.5m - 4.6m in height, and include both natural and woodpecker-excavated cavities.

The specific requirements of this species' nest sites suggests possible limitations with respect to habitat use. Both intraspecific and perhaps more importantly, interspecific competition for nest sites may influence reproductive success and perhaps habitat selection by this species (Peck and James 1987; Rendell and Robertson 1991).

Lake Opinicon Mature Hardwood Forest Stands

The Great Crested Flycatcher was one of the most widespread species found on plot surveys. In fact, Bennett (1987) describes the highest Ontario densities of this species (10km x 10km squares) from this region. Results obtained in this study, however, may have been limited by this species' relatively large territories which limited variation in abundance scores (there was never more than one bird per plot).

The only trend suggesting differential habitat use by this species, was with increasing dense, low undergrowth between 0m - 1.5m and often up to 6m (Figure 14). Considering previous accounts of this species utilizing canopy habitat for foraging, this trend seems difficult to explain. Possible influences of the ground layers on the abundance of insect prey that this species utilizes may account for these results. This species has been shown to take larger flying insect prey (Johnston 1971), which may utilize this low dense undergrowth habitat. More information, however, is needed on specific habitat requirements of this species, possibly using methodology better suited to its larger territory size.

Concerns of Forest Management Practices

Several references suggest this species may benefit from both fragmentation and selective silvicultural practices which result in more open habitat used by this species (Norse and Ellison 1985; Bennett 1987). Such speculation is unsupported, and the suggestion that this species originally occupied denser deciduous and mixed forest (Bent 1942) suggests a need for more information on Great Crested Flycatcher reproductive success in disturbed habitats.

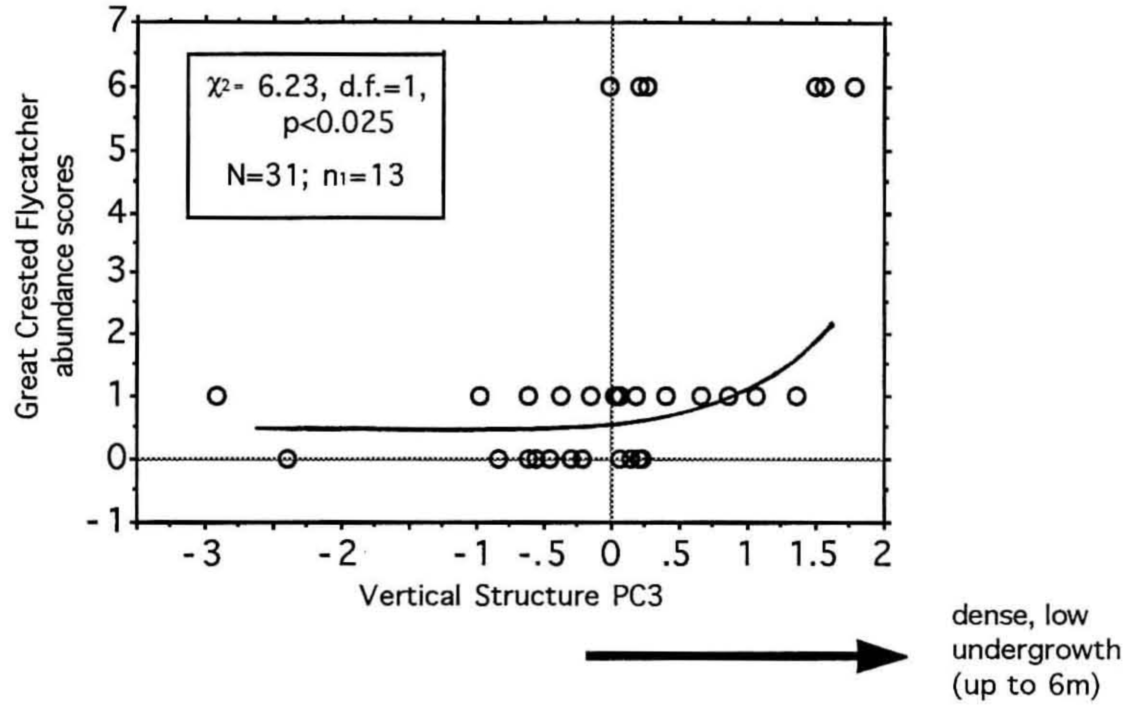


Figure 59. Relationship between Great Crested Flycatcher (*Myiarchus crinitus*) abundance scores and Vertical Structure PC3. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

The requirement for cavities by this species may be a notable constraint on reproductive success; thus, taking steps to avoid the cutting of cavity trees (as is currently practice -Anderson and Rice 1993) may limit silvicultural effects. More information on the number of required cavities per given area, and especially on population dynamics of associated competitor species is required to better assess this situation. Nest boxes are another possibility that should be considered from the perspective of silvicultural managers.

Preliminary Recommendations

Ensuring a sufficient supply of suitable nest cavities is the only recommendation. More information is required on the effects of silvicultural practices on this species, as well as possible nest competitor species.

Black-capped Chickadee (*Parus atricapillus*)

The Black-capped Chickadee is largely a permanent resident across North America, from the treeline south to the central United States (AOU 1983). This species is one of a few unique passerines that can sustain themselves throughout the winter months without migrating.

A wide range of habitats are used by the Black-capped Chickadee across its broad geographical range. Sibley (1988) describes a preference for mixed-deciduous and coniferous forest, while a similar preference for a coniferous component to this species' habitat was suggested by Peck and James (1987) and Sherry and Holmes (1985). All forest types, however, may be occupied by this species, including pure deciduous woods, urban and second growth habitats, orchards, hedgerows, and conifer plantations (McLaren 1987; Peck and James 1987; Sibley 1988). Even within territories, there may be significant variation in habitat, with a range of mature and second growth habitat often included in one territory (Odum 1941).

The Black-capped Chickadee predominately gleans prey items (Sabo and Holmes 1983), enabling broad use of forested habitats at all times of the year. Robinson and Holmes (1982) found it to be unique among other songbirds in the chickadee's flexibility in its use of foraging substrate. Chickadees in New Hampshire selected specific substrate such as dead, damaged, or curled leaves, and twig tips, instead of using a generalized substrate such as leaves or tree bark (Robinson and Holmes 1982). This flexibility may enable differential habitat use by this species.

In addition to their use of specific substrates in a variety of habitats, the Black-capped Chickadee caches food, and often uses artificial sources of food in winter months. The ability to use a wide variety of non-insectivorous food items may prove adaptive with respect to other insectivorous species discussed; however, invertebrate food is fed to young and is heavily used during the nesting season (Smith 1991).

This species nests earlier in the season than many migrant insectivores, especially those wintering in the Neotropics (Peck and James 1987). Nests are usually excavated cavities, most often in birch tree stumps, 0.9m - 3.7m off the ground (Peck and James 1987). Other tree species and even nest boxes may be used, with a supply of appropriate nest sites potentially playing a role in habitat quality, especially since more than one cavity may be excavated before one is selected for nesting (Smith 1991).

Lake Opinicon Mature Hardwood Forest Stands

The Black-capped Chickadee is one of the most widespread species in the Lake Opinicon area. Breeding in this area, however, occurs earlier than most other songbirds monitored in this study; thus, the timing of surveys was late with respect to singing territorial males. This timing as well as the different approach to foraging substrate and habitat use of this species, may underlie the lack of results obtained in this study. No trends or significant results were found between chickadee abundance scores and environmental variables, suggesting work more suited to this species' unique characteristics is required to better describe its habitat use.

Concerns of Forest Management Practices

This species is able to take advantage of a variety of forest habitats, suggesting that influences of selective silvicultural practices may be relatively low. A requirement for dead, soft, wood (often White Birch and other soft tree stumps) for nest cavity excavation, however, should be kept in mind by forest resource managers, as Black-capped Chickadees in this region do not use nest boxes as readily as other cavity nesting species.

Preliminary Recommendation

Leaving an assortment of dead, soft stumps, in particular, White Birch, is recommended for nest sites. More than one cavity is often excavated before one is selected for nesting, thus, many suitable nest sites are required for each territory (average territory size of 5ha - Odum 1941; Smith 1967). As far as general habitat considerations, this species appears to be highly adaptable to a wide range of forest types. More information on different habitat qualities with regards to reproductive success is needed, however, before recommendations can be made.

White-breasted Nuthatch (*Sitta carolinensis*)

This permanent resident is found throughout the eastern United States, north to southeastern Canada, as well as the southwestern provinces south to Mexico (AOU 1983). Like the Black-capped Chickadee, this species uses a variety of non-invertebrate food during the non-breeding season, and in particular, uses food caches and bird feeders in winter.

The White-breasted Nuthatch is characteristic of mature deciduous forest, also uses mixed woods, orchards, and suburban areas with shade trees (Bull 1974; Ellison 1985; Mills 1987; Peck and James 1987; Bonney 1988). Heavier use of pure deciduous forest over mixed has been described by Peck and James (1987), who also found nest sites most often proximate to woodland edges and open areas.

Nest sites are in pre-existing tree cavities, most often in living trees and most often in natural cavities (as opposed to woodpecker-excavated holes) (Peck and James 1987). More specifically, nest sites were most commonly found in the main trunk of fairly large trees, often in splits and knot holes of maple, oak, elm, and pine, 1.8m - 9m above the ground (Peck and James 1987).

The foraging behaviour of this species is fairly unique to its genus. It is primarily a bark gleaner (Holmes *et al.* 1979b; Sabo and Holmes 1983), often hopping upside down along the trunks of mid-large deciduous trees.

Lake Opinicon Mature Hardwood Forest Stands

The White-breasted Nuthatch is a low density, but widespread species in the Lake Opinicon area, and like the Black-capped Chickadee, it breeds earlier than most migrant insectivorous songbirds. Results obtained from this study reveal a variety of relationships suggesting differential habitat use by this nuthatch (Figures 15-18). A significant relationship was found between habitat use and Basswood composition, suggesting that this tree species may be important, either for foraging substrate or for nest cavities.

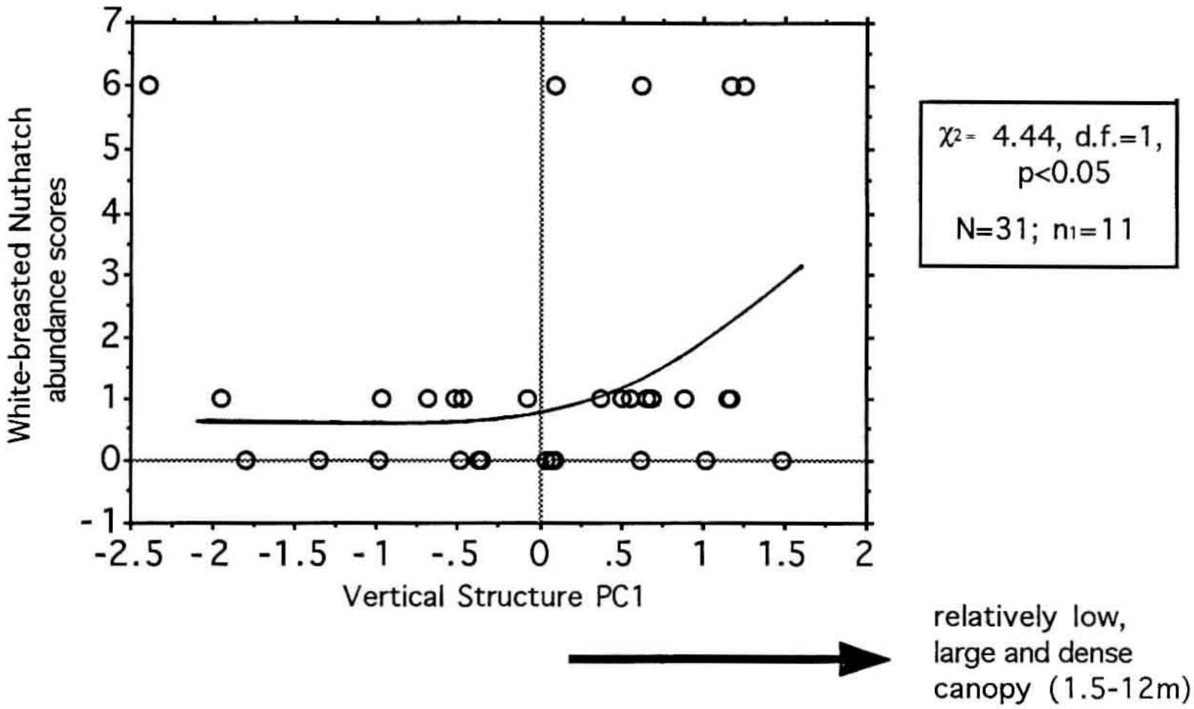


Figure 15. Relationship between White-breasted Nuthatch (*Sitta carolinensis*) abundance scores and Vertical Structure PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

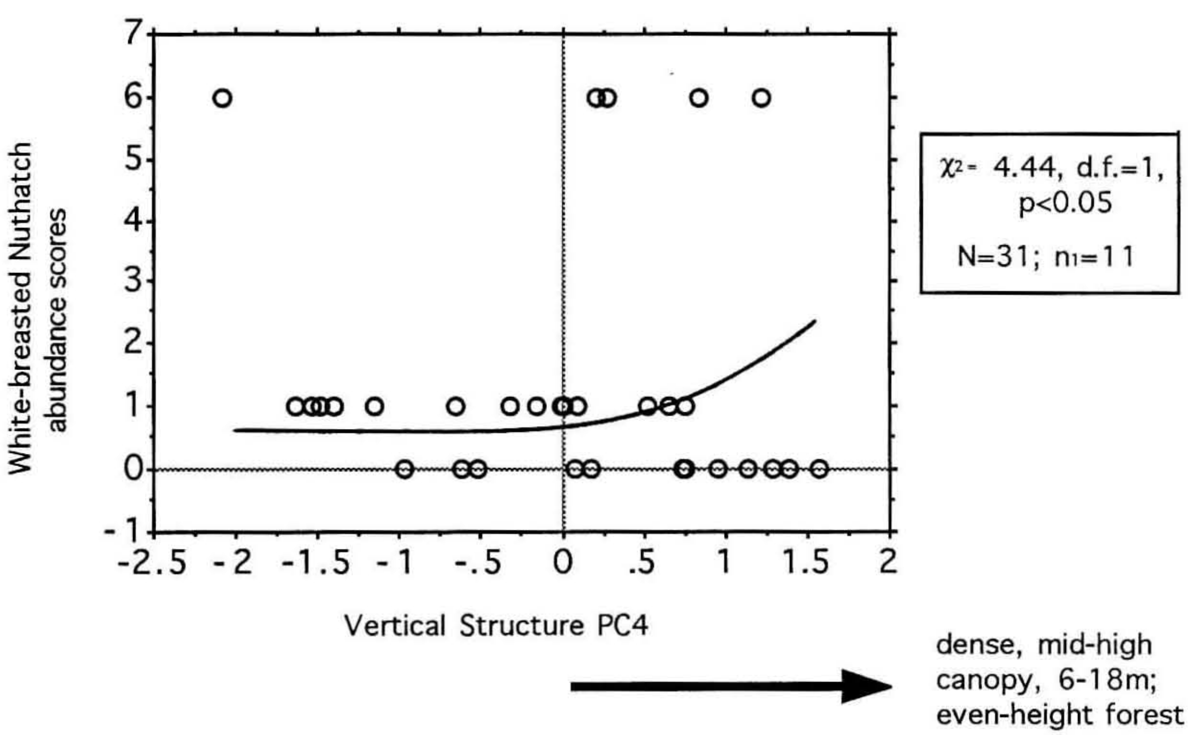


Figure 16. Relationship between White-breasted Nuthatch (*Sitta carolinensis*) abundance scores and Vertical Structure PC4. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

The large size of Basswood trees found on the plots may well have played a role in its relationship with nuthatch habitat use, as may have a negative association with White Birch (see Figure 17). Positive trends were also found between nuthatch habitat use and relatively low, large and dense canopy habitat (1.5m - 12m) (Figure 15), as well as dense mid-high canopy (6m - 18m), even height forest (Figure 16). Since foliage is not directly used by this species as foraging substrate, these trends probably reflect indirect relationships with these habitat components; possibly reflecting increased food abundance or more suitable foraging conditions (e.g. bark substrate) with these habitat characters.

An additional positive trend was found between habitat use and high densities of 10cm - 15cm DBH trees, with few but overmature (very large) trees with DBH ≥ 20cm (Figure 18). The few overmature trees may well have been an important aspect of this component, providing a relatively large proportion of suitable nest sites and foraging substrate for this species.

Concerns of Forest Management Practices

The White-breasted Nuthatch may well be a species prone to influences by silvicultural practices. Its use of mature deciduous forest, and possible requirement of overmature, large trees make it susceptible to silvicultural practices that remove such trees. Thinning of deciduous forest, creating overmature trees may actually improve habitat for this species, as open habitat appear to be well-suited to nuthatch use (see above).

Nest cavity availability in the form of knot holes and other main-trunk natural cavities in fairly mature trees may well be influenced by silvicultural practices that remove important trees. The specific nature of these nest sites, and the low degree of artificial nest box use, suggest resource managers should incorporate the nesting requirements of this species into silvicultural management practices.

Preliminary Recommendations

Silvicultural thinning of deciduous forest may well prove beneficial to this species; however, removal of large deciduous trees could well result in a decrease in nuthatch habitat quality. In particular, suitable nest sites in the form of natural, main-trunk cavities (knot holes, splits; not woodpecker-excavated holes), in mature, live trees should be maintained within nuthatch

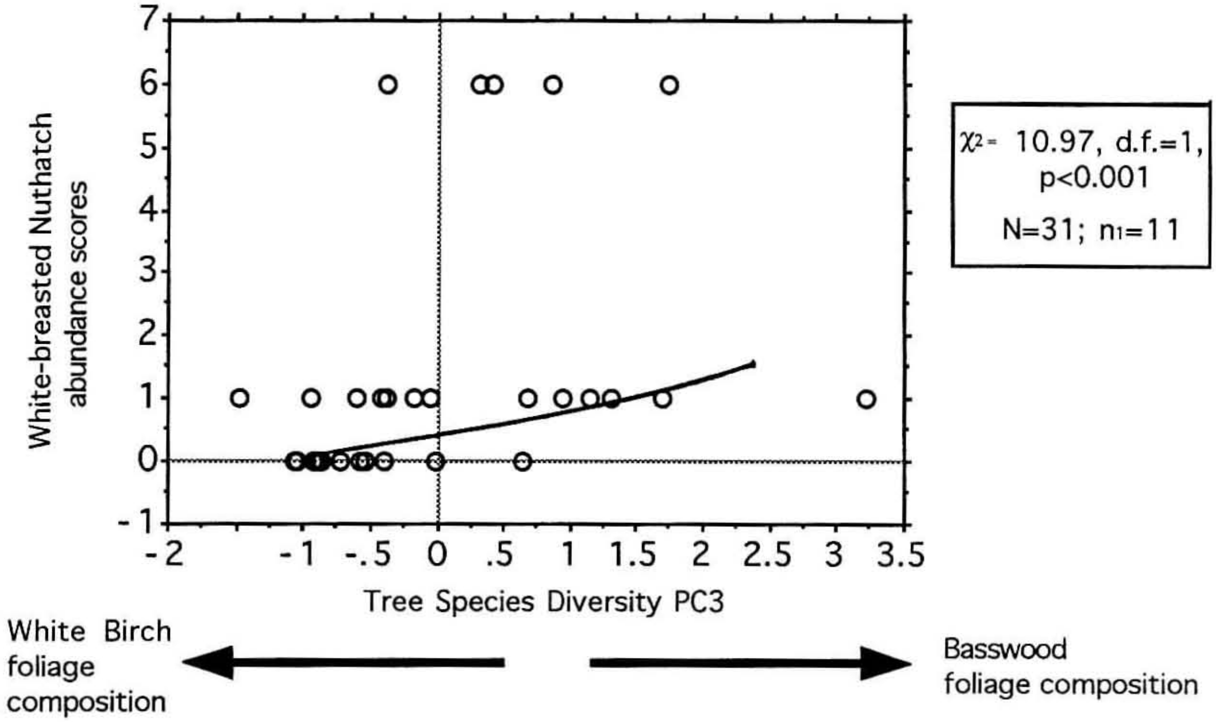


Figure 17. Relationship between White-breasted Nuthatch (*Sitta carolinensis*) abundance scores and Tree Species Diversity PC3. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

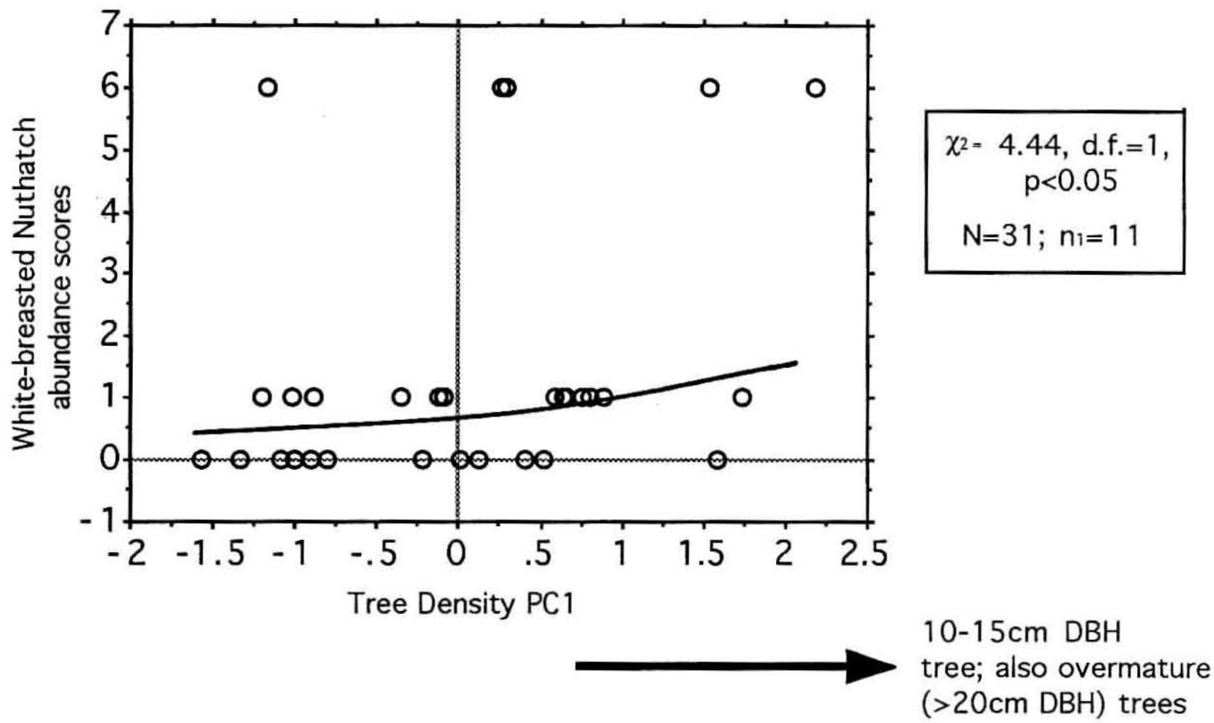


Figure 18. Relationship between White-breasted Nuthatch (*Sitta carolinensis*) abundance scores and Tree Density PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

habitat by resource managers. Low use of nest boxes may well be improved with boxes designed to be more specific to this species' usage.

Wood Thrush (*Hylocichla mustelina*)

Winter months find this species from Mexico to Panama, wintering in more mature and second growth forest (AOU 1983; Ridgely and Gwynne 1989). The breeding grounds include habitat fitting a similar description, and extend from the southeastern provinces of Canada to the Gulf Coast of the southeastern United States (AOU 1983). Interestingly, this species may well have taken advantage of the predominately deciduous regrowth forest that has become common in the northeastern states and eastern provinces since settlement. Populations in these regions may represent population expansions of this species in response to these changes in habitat (Weaver 1949; Morse 1971; Bull 1974; Erskine 1978; James *et al.* 1984; Kibbe 1985; Peck and James 1987; Sadler 1987).

James *et al.* (1984) describe geographic variations in the habitat used by this species. Suitable habitats range from tulip tree- (*Liriodendron* spp.) and sweet gum- (*Liquidambar* spp.) dominated forest of the central and southern states, to mesic oak forests (Tennessee-Pennsylvania), to mature northern hardwoods (Sugar Maple, Yellow Birch, Beech) of the northern United States and Canada. These authors found the Wood Thrush to be limited geographically by mesic deciduous sites, while this species was absent from more coniferous regions to the west, from the prairie peninsula of Illinois, Indiana and Ohio, and from the cedar glades of Tennessee (James *et al.* 1984).

More specific habitat requirements of this species appear to be deciduous foliage, although a preference for deciduous woods over mixed has not been suggested (except perhaps by Kibbe 1985). James *et al.* (1984) describe geographic variation in habitat structure used by this species; however, a general restriction to close-canopy forest seems more prevalent in this species than for other thrushes (e.g. Veery, *Catharus fuscescens*) (James *et al.* 1984). In addition, a well-shaded understory with few small trees and low exposed branches, as well as an open forest floor with moist decaying leaf litter, may be the ideal habitat of the Wood Thrush and may well represent the primary habitat feature governing the distribution and abundance of this species (James *et al.* 1984). Such habitat requirements are supported by many authors (e.g. James 1971; Sadler 1987; Bonney and Burrill 1988).

Aspects of the life history of the Wood Thrush may well underlie habitat requirements of this species (James *et al.* 1984). The foraging behaviour of the Wood Thrush is characterized by walking along the forest floor probing and pecking decaying leaf litter, etc. (Sabo and Holmes 1983; James *et al.* 1984). Additional requirements of territories include nest sites, which are typically 1.8m - 3m off the ground, in saplings (most often deciduous) (Peck and James 1987). Bertin (1977) suggested that males may require trees of 12m in height or greater for song perches. A closed canopy may also be required indirectly, as this may influence the nature of the ground cover and its invertebrate prey, as has been suggested for the Ovenbird (*Seiurus aurocapillus*) (Smith and Shugart 1987).

Lake Opinicon Mature Hardwood Forest Stands

The Wood Thrush may well be a newcomer to this region since the settlement and clearing of the land by Europeans. Weir (1989) describes records from the Kingston region since 1858, but does not elude to whether this species was historically native or not. Further discussion by Weaver (1949), Morse (1971), Bull (1974), Erskine (1978), James *et al.* (1984), Godfrey (1986), Peck and James (1987), and Sadler (1987) provide more insight into the historical and current range expansions of this species.

Currently, the Wood Thrush is a low density breeder in the Lake Opinicon area, suffering from extremely high predation rates (pers. obs.), possibly associated with its nesting habits. Other observers have found this species to be particularly hard hit by cowbird parasitism (Robinson 1992b; D. Bland, pers. comm. 1993), suggesting that the effects of such parasitism should be closely examined in this area. It should be noted that Hussell *et al.* (1992) found significant declines in Wood Thrushes at Long Point, Ontario (migration trends), while other authors have described similar, large scale population declines (e.g. Sherry and Holmes 1988; Robbins *et al.* 1989a;b).

The results of this study provide some insight into important habitat variables associated with habitat used by this species. Four components showed associations with Wood Thrush abundance scores (Figures 19-22), with all of these components showing correlations with each other ($r > |0.30|$) (see Table 5). Thus, it appears that increased habitat use is associated with all of these variables interacting to form suitable environmental conditions.

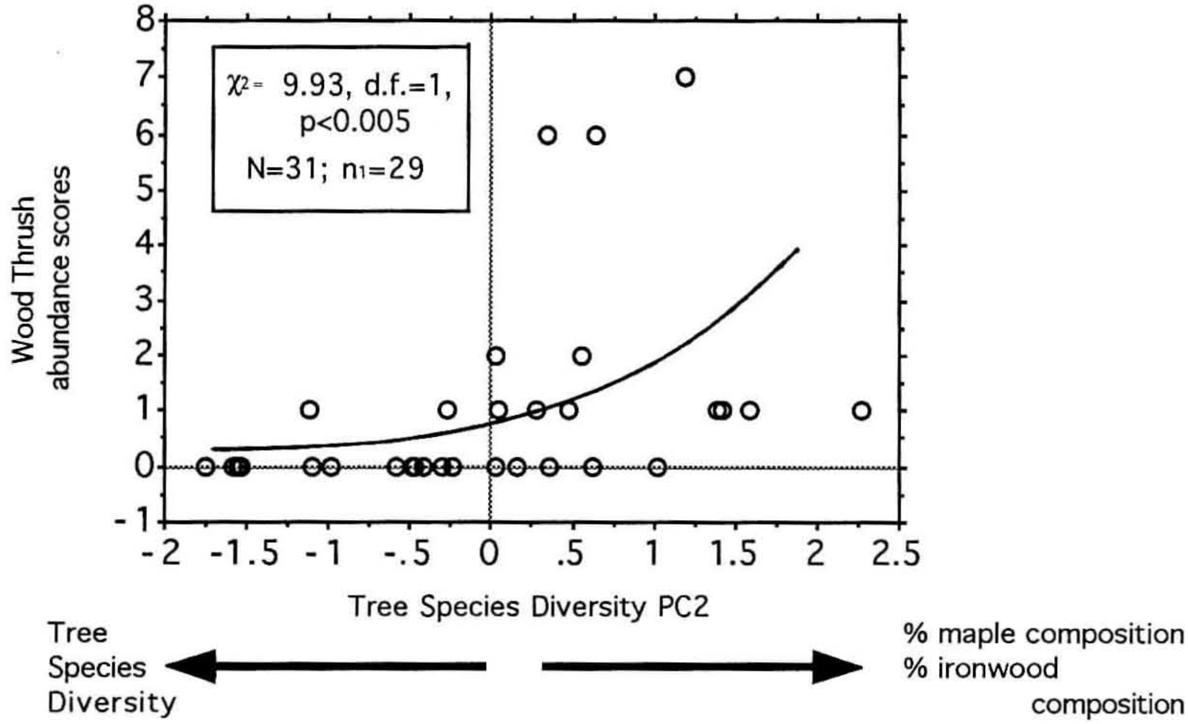


Figure 19. Relationship between Wood Thrush (*Hylocichla mustelina*) abundance scores and Tree Species Diversity PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

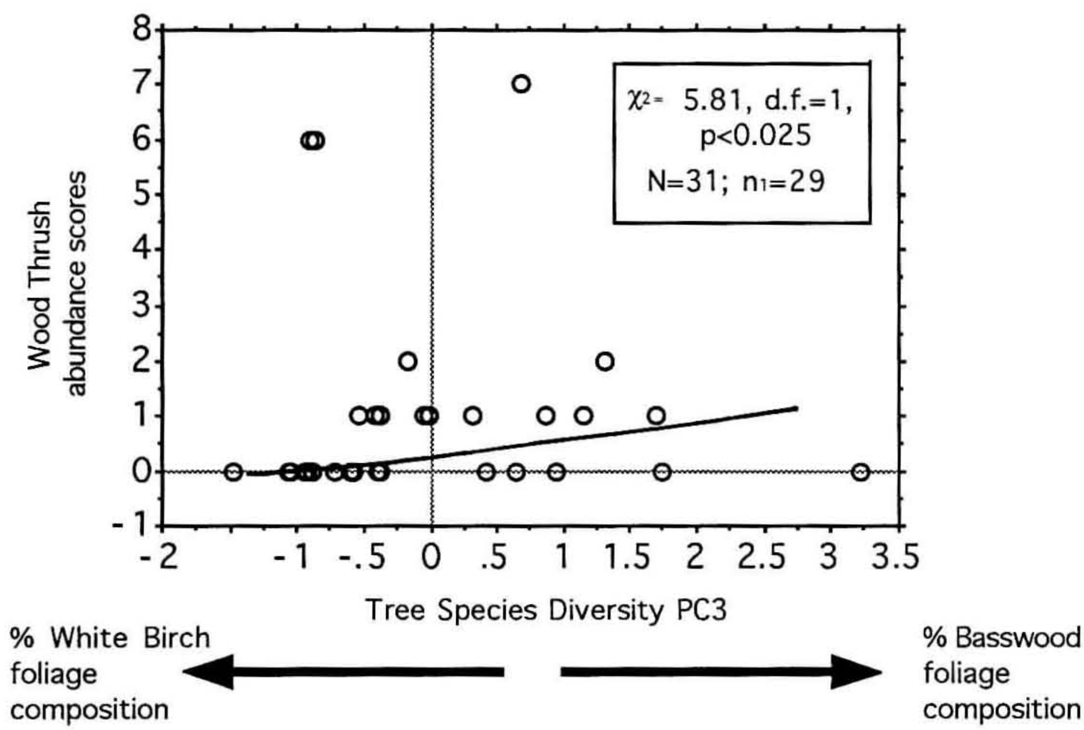


Figure 20. Relationship between Wood Thrush (*Hylocichla mustelina*) abundance scores and Tree Species Diversity PC3. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

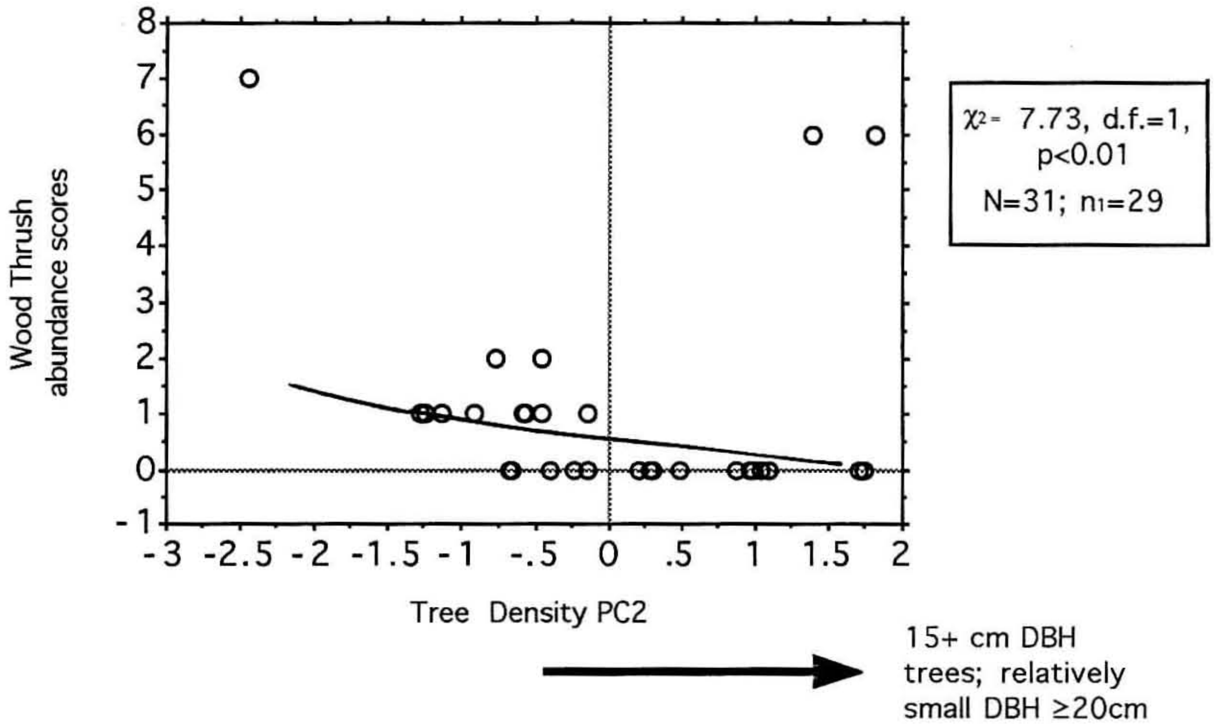


Figure 21. Relationship between Wood Thrush (*Hylocichla mustelina*) abundance scores and Tree Density PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

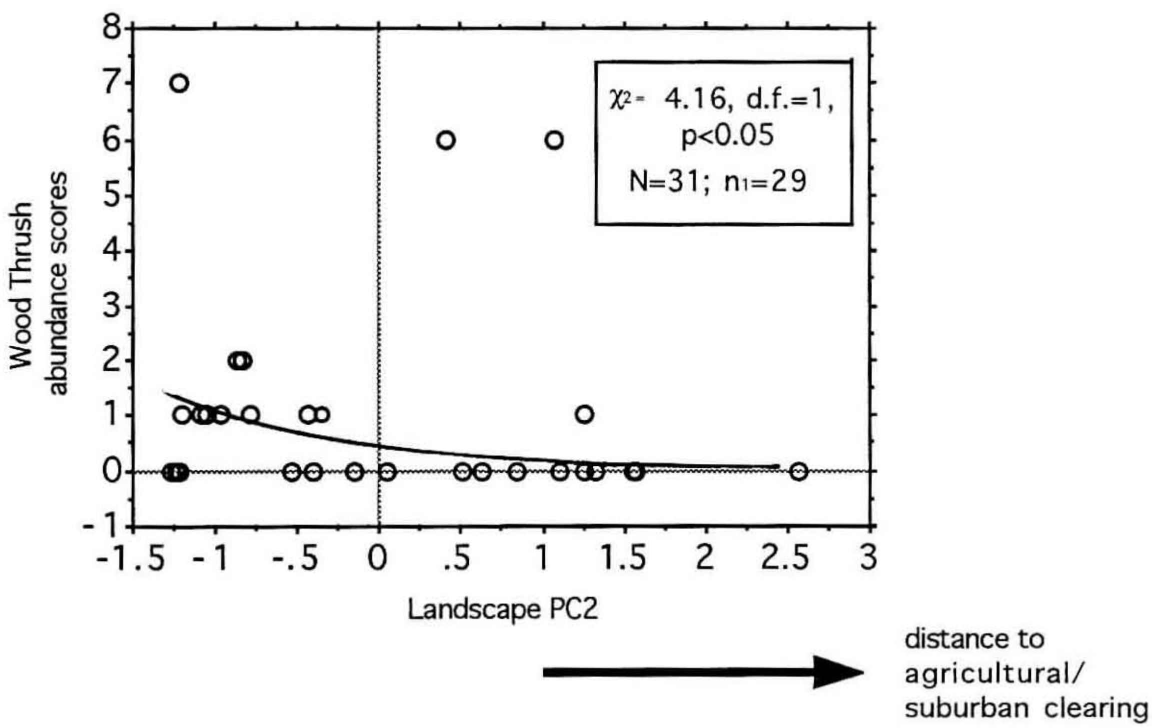


Figure 22. Relationship between Wood Thrush (*Hylocichla mustelina*) abundance scores and Landscape PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

These habitat/landscape conditions include increased maple-ironwood composition (decreased tree species diversity), decreased densities of trees 15cm DBH and larger (accompanied by fewer larger trees over 20cm DBH), and decreased distance of habitat to agricultural/suburban clearings. An additional positive relationship between Basswood composition (decreased White Birch composition) and Wood Thrush abundance scores appears to be an artifact of the statistics, as more plots on the negative side of the component score contradict the implied trend (see Figure 20).

The parameters associated with increased habitat use from this study correspond to those suggested by previous authors. A variety of authors have noted this species to use edge habitats (Bertin 1977; Dilger 1956) as well as more disturbed and urban sites (Weaver 1949; Bull 1974). The negative association with moderate-sized tree densities is more difficult to interpret; however, it suggests that such densities do not provide the requirements of this species which include saplings for nesting and characteristics associated with ground foraging substrate. A preference for maple-ironwood forest in this region may also be interpreted with respect to indirect influences on ground cover, or perhaps influences of the leaf litter resulting from these tree species.

It seems clear that in this region, more information is required to corroborate or dismiss the findings of other authors with respect to habitat requirements of the Wood Thrush .

Concerns of Forest Management Practices

The results of this study provide little to formulate hypotheses as to the effects and concerns of forest management practices with respect to this species. Using primarily the findings of James *et al.* (1984), the maturity of the forest and structure of the understory appear to be the main factors that can predict Wood Thrush density irrespective of geographic region. Alterations to these characteristics may have implications to decreased Wood Thrush habitat quality .

Probably more important than habitat variables at the stand level may be nest depredation, brood parasitism, and the varying effects of these two factors with respect to habitat and landscape parameters. Wood Thrushes seem to be somewhat adaptable to a variety of edge and disturbed habitats (see above); however, whether these habitats are overall detrimental to Wood Thrush nesting success is not clear.

Wilcove's (1985) classic paper documents increased predation rates on nests near woodland edge. Furthermore, marked declines in this species reproductive success have been recently documented in fragmented landscape in Illinois (Robinson 1992b), largely due to cowbird parasitism. Other authors have warned about this species susceptibility to forest fragmentation (e.g. Robbins *et al.* 1989a), although recent evidence suggests that long-term population dynamics of this species in forest fragments may be more complex (Roth and Johnson 1993).

Preliminary Recommendations

Variation in aspects of predation and brood parasitism throughout the range of this species (Robinson 1992a) suggest a need for local information on the effects of these factors on Wood Thrush reproductive success. More information on variation in these factors with respect to silvicultural practices and, more importantly, forest fragmentation, are needed before management recommendations can be made.

American Robin (*Turdus migratorius*)

The American Robin is a widespread breeding species, found from the southern limits of the arctic tundra south through Central America (AOU 1983). In winter, this species is widespread across the central and southern United States and Central America, north to extreme southern Canada (AOU 1983). The heavy use of suburban and urban habitats by this species has made it a conspicuous and widely recognized member of the thrush family.

The American Robin has been reported using a multitude of habitats from tundra to bogs, burned over areas to mature hardwood forest (James and Long 1987; Peck and James 1987; Bonney 1988). It is an abundant and widespread species over most of North America, probably increasing in response to colonization of North America by Europeans (James and Long 1987).

In New Hampshire, the occurrence of this species in mature hardwood forests was largely attributed to an overflow of populations in nearby forest edge habitat and pasture land (Holmes and Sturges 1975; Sabo and Holmes 1983). These authors believed this species may act as an opportunist, responding to increased availability of certain food in hardwood forest habitats. Other authors, however, suggest that this species may have had an original preference for forested habitats, shifting to more disturbed habitats with European colonization (Bonney 1988).

Within forested habitats, Peck and James (1987) suggested a preference for coniferous over deciduous or mixed forest, as well as dry habitats over wet. James *et al.* (1984) suggested limited understory to support the highest densities of this species in eastern North American forests, while James and Long (1987) suggested that forest edges and openings are important to this species.

The American Robin is largely a ground forager, and may well be directly influenced more by forest floor characteristics and prey abundance than other habitat parameters. Nests are often in both coniferous and deciduous trees, bushes, and on man-made structures, often 1.4m - 3m off the ground (Peck and James 1987). In the Lake Opinicon region, however, natural nest sites away from disturbed habitats are frequently high (e.g. 6m - 20m off the ground); higher than those described by Peck and James (1987) (pers. obs.).

Lake Opinicon Mature Hardwood Forest Stands

In this region, the American Robin is characteristic of a variety of suburban habitats, as well as open forests, and rocky outcrop edges, and to a lesser extent, mature hardwood forest sites. Frequent use of residential areas and pine plantations is also apparent. From the perspective of mature hardwood forest sites, this species does not appear to be a dominant species. Differential habitat use suggested by this study is limited, and provides little insight into the specifics of habitat use by this species.

A positive relationship between ash component and American Robin habitat use (Figure 23) was interesting, as ash has a unique structure (see Robinson and Holmes 1982) with lower density of foliage relative to some other tree species (e.g. Basswood). Thus, more light penetration may be permitted through the canopy, which may indirectly affect habitat quality for American Robins. This trend, however, is not entirely convincing, and more information on specific habitat requirements is needed. In particular, the widespread habitat use by this species suggests that habitat selection may occur on a broader scale that would not be apparent in the results of this study. Thus, results obtained should be interpreted loosely.

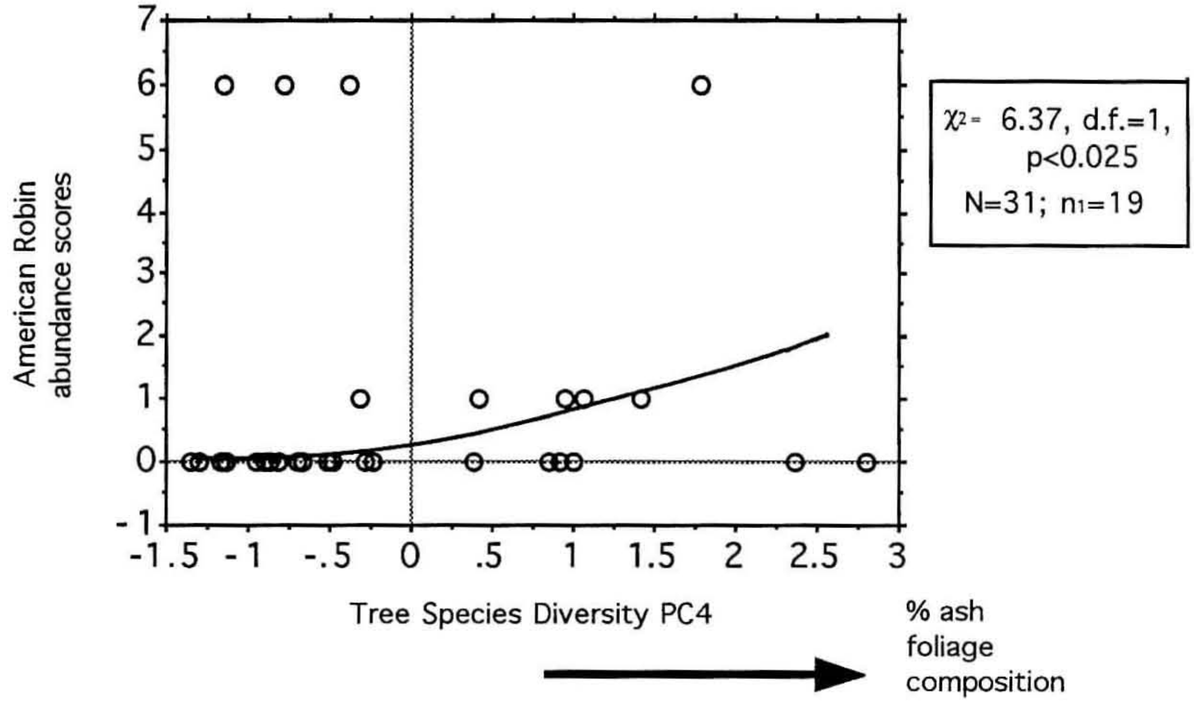


Figure 23. Relationship between American Robin (*Turdus migratorius*) abundance scores and Tree Species Diversity PC4. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

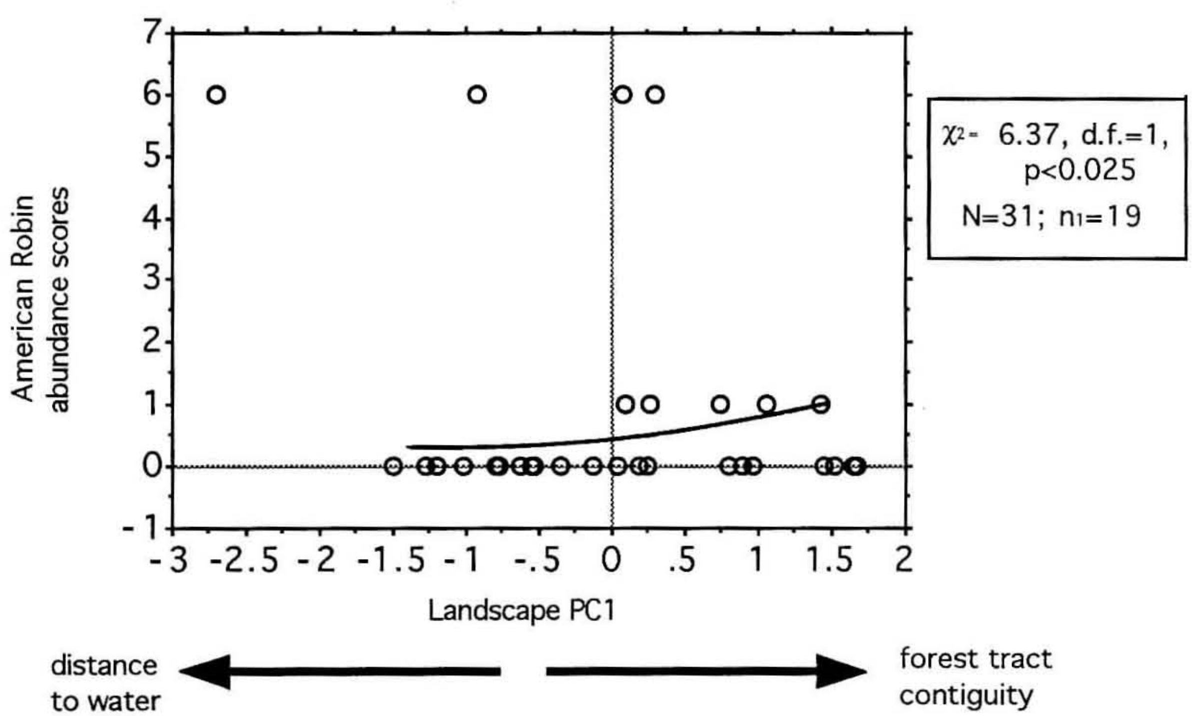


Figure 24. Relationship between American Robin (*Turdus migratorius*) abundance scores and Landscape PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

A positive relationship between American Robin abundance scores and contiguity of habitat as well as proximity of water (Figure 24) is interesting and suggests large forest tracts may support relatively greater densities of this species, and/or that waters edge may prove to be an important feature. The use of mud in the nests may support the latter case, with other authors suggesting that this requirement may limit habitat use by some thrush species (James *et al.* 1984).

Concerns of Forest Management Practices

From the perspective of forest resource management, little can be drawn to suggest possible influences on American Robin habitat quality. A wide range of nest sites are used, as are a wide range of habitats with incredibly variable habitat characteristics. Thus, the obvious adaptable nature of this species as well as stable populations (Hussell *et al.* 1992), suggest that the American Robin should not be a concern to silvicultural practices.

Preliminary Recommendations

The wide range of habitats used by this species, the apparently stable population, and the relatively low use of mature hardwood forest, suggests that management practices should not be based on or altered by habitat requirements of this species.

Yellow-throated Vireo (*Vireo flavifrons*)

The Yellow-throated Vireo breeds across the eastern United States, north to southern Ontario and southwestern Québec (AOU 1983). Throughout its range, this species occurs at fairly low densities relative to many vireos and wood warblers, and inhabits almost exclusively deciduous forest (James 1987). In winter, this species inhabits Central America south to northern South America (AOU 1983).

This vireo is characteristic of large, full-canopy deciduous trees (James 1971; Williamson 1971; James 1987; Nichols 1985), in which it gleans insects from the leaves of the upper canopy (Williamson 1971). Thus, relatively mature trees with large canopies appear to be a habitat requirement. Both open and more closed forest may be occupied (James 1979), while a preference for the former more open condition being proposed by some authors (Peck and James 1987). Other more disturbed habitats may also be occupied, including fruit orchards and large shade trees in suburban areas (Bull 1974).

Nests are frequently high (7.5m - 13.5m off the ground), and are almost always confined to large, mature, deciduous trees, including maples, oaks, poplars, and elms (Peck and James 1987). Temple and Temple (1976) noted greater use of elm trees as nest sites, and suggested that elm decline (due to Dutch Elm disease) may have contributed to a decline in Yellow-throated Vireos in their study area (Cayuga Lake Basin, New York).

Lake Opinicon Mature Hardwood Forest Stands

James (1987) noted the highest Ontario densities of this species (per 10km x 10km squares) from this area, and attributed such concentrations to maturing second growth forest habitats in the region. Indeed, this species has relatively large numbers in this region, utilizing typical habitat described above, which includes some of the survey plots in this study.

Unfortunately, only a few plots supported Yellow-throated Vireos, with abundances never exceeding one territorial male per plot (see Table 1). The low abundances may be partly attributable to this species' larger territories (about 10 acres per territory - Williamson 1971), and lower overall densities (James 1987). The low occurrence of this species in the study plots suggests heavier use of habitats not well represented here. Many overmature and open-forested habitats that were not characteristic of study plots, support Yellow-throated Vireos. In addition, heavy use of large, oak-dominated habitat seems apparent; however, only when this habitat occurs in large forest tracts (pers. obs.).

From this study, there were no significant results obtained for this species; however, one notable trend did occur ($p<0.10$) (see Appendix 9). Yellow-throated Vireo abundance scores were negatively associated with decreasing densities of trees of >20cm DBH. This supports widespread observations of this species' heavy utilization of large trees. More research catered to the specific habitat and aspects of this species' life history is needed to provide more proximate answers to such apparent habitat relationships.

Concerns of Forest Management Practices

Probst (1979) (cited in Smith 1988) describes this species occurring in forested areas where incomplete timber harvest had resulted in openly spaced, heavy canopied, and mature trees. Thus, it appears that silvicultural practices may even improve habitat for this species. A definite requirement of mature, large-crowned, deciduous trees, however, seems evident, and management of areas hosting Yellow-throated Vireos should take this requirement into account. More information on differential use of specific tree species will provide insight into potential oak-vireo relations in the area.

More important than stand-scale silvicultural practices appears to be landscape alterations to this species' habitat. The Yellow-throated Vireo appears to be especially susceptible to the negative effects of forest fragmentation (Whitcomb *et al.* 1981; Ambuel and Temple 1982), perhaps in part due to its large territory size and characteristic lower densities. In Ontario, James (1987) described highest densities of this species to occur in larger forested tracts, and speculated land clearing and fragmentation to contribute to this species' population decline. Such decline was noted by several authors (e.g. Temple and Temple 1976), and may be in part due to this species' high susceptibility to Brown-headed Cowbird parasitism (Whitcomb *et al.* 1981).

Preliminary Recommendations

Yellow-throated Vireos have a definite requirement of mature, broad-canopied, deciduous trees which may be openly spaced or in a closed-canopy forest. Forest managers in Yellow-throated Vireo habitat should keep this requirement in mind. More information on the varying extent to which loss of such trees affects habitat use by this species, as well as any tree species preferences that may exist in this region, is required.

The protection of large forest tracts may prove much more vital to this species than the consequences of smaller-scale silvicultural practices This is due to this species' high susceptibility to forest fragmentation and to brood parasitism by the Brown-headed Cowbird.

Red-eyed Vireo (*Vireo olivaceous*)

One of the most numerous songbird in eastern North America (Kibbe 1985; James 1987), the Red-eyed Vireo inhabits a broad range of habitats across the Canadian provinces (north to MacKenzie, southern Northwest Territories, central Québec), and south to Oregon, Texas, and Florida (AOU 1983). It is a true neotropical migrant, spending its winters in northern South America to southern Central America (AOU 1983).

On the breeding grounds, the Red-eyed Vireo appears to require only a small percentage of broad-leaved trees (James 1971). Habitats used by this species range from hardwood maple-beech-Yellow Birch forest (New Hampshire) (Robinson 1981), to aspen-birch forest, as well as riparian elm-ash (Rice 1978), groves of deciduous trees within coniferous woods (including plantations) (James 1987), beech-maple-hemlock forest (Kendeigh 1946), open deciduous forest, second growth woodland, and large shade trees in urban parks (Bull 1974), wooded clearings, borders of burns, and residential areas, as well as oak-hickory, cherry-aspen, and beech-maple mesic habitats (Bonney 1988). Red-eyed Vireos were described as absent from dense hemlock tracts and alder thickets in New York state, as well as from some dense mixed woods (Bonney 1988). Peck and James (1987), however suggest no clear difference between suitability of deciduous versus mixed woods for this species (Ontario).

Specific habitat requirements appear to include deciduous foliage (Sherry and Holmes 1985); however, no preference for specific tree species has been described, in contrast to its close relative, the Philadelphia Vireo (*Vireo philadelphia*) (Robinson 1981). Robinson (1981) failed to find preferences for any microhabitat by this species, with contiguous territories throughout the maple-beech-birch forests of New Hampshire. Kendeigh (1946) also found it abundant and uniformly distributed throughout beech-maple-hemlock forest in New York state.

A more specific "preference" by this species for an undergrowth of saplings (1.8m - 4.6m)(James 1987; Bonney 1988) has been described, which corresponds to this species nesting and foraging requirements. Red-eyed Vireos typically consume large proportions of Lepidoptera (Williamson 1971; Robinson 1981; Robinson and Holmes 1982), hovering and gleaning to capture prey found while searching leaves in the outer portions of trees (Holmes *et al.* 1979a; Robinson and Holmes 1982; Sabo and Holmes 1983). This species frequently forages from the forest canopy to low understory (sapling/subcanopy to shrub layer - Robinson 1981), and may require such a vertical height diversity to decrease intersexual competition within a pair (males forage higher than females - Williamson 1971). Thus, despite inhabiting second growth habitats, increased intersexual overlap due to decreased vertical height diversity may result in decreased reproductive success. A "preference" for shaded undergrowth (Bonney 1988) may reflect the need for such vertical stratum separation in a foraging pair.

Nest site requirements are few; however, a preference for small sapling trees and bushes over larger trees is evident (Peck and James 1987). Nests are usually 1.8m - 3.7m off the ground, most often in maple, but also in birch, poplar, oak, alder, and white cedar (Peck and James 1987).

Lake Opinicon Mature Hardwood Forest Stands

Red-eyed Vireos were found on all study plots within the region, and were the most numerous species present in this habitat (see Table 1). With territories small (1.3-1.7 acres - Williamson 1971), abundance scores were variable, and significant results were obtained showing differential habitat use.

A significant increase in abundance scores with respect to increasing relatively low, large and heavy-canopy regrowth forest (Figure 25) is not surprising considering the foraging behaviour and basic habitat requirements of this species. The dense but moderately low forest provides an abundance of substrate (leaves) on which this species forages. In addition, the height of the forest would permit ample foraging substrate distributed vertically, allowing vertical separation of foraging males and females. Lower saplings characteristic of this habitat would also provide nest sites and dense cover for nesting.

Increasing maple and ironwood composition indicated increased habitat use as well (Figure 26), suggesting that a preference for those tree species over other deciduous species may be present. A small correlation between maple-ironwood composition (Tree Species Diveristy PC2) and relatively low, large and heavy-canopy regrowth forests (Vertical Structure PC1) (r= 0.202; see Table 5), does not suggest that maple and Ironwood more commonly result in the preferred vegetation structure. Thus it appears that maple-ironwood forest may well be better suited to Red-eyed Vireo's use.

This is not really surprising as this species uses leaves as a foraging substrate, and different leaf morphology and susceptibility to hosting Lepidoptera may lead to differences in suitability for foraging Red-eyed Vireos. Variation in forest Lepidopteran composition and populations may also be important, as tree species preference by insectivorous birds

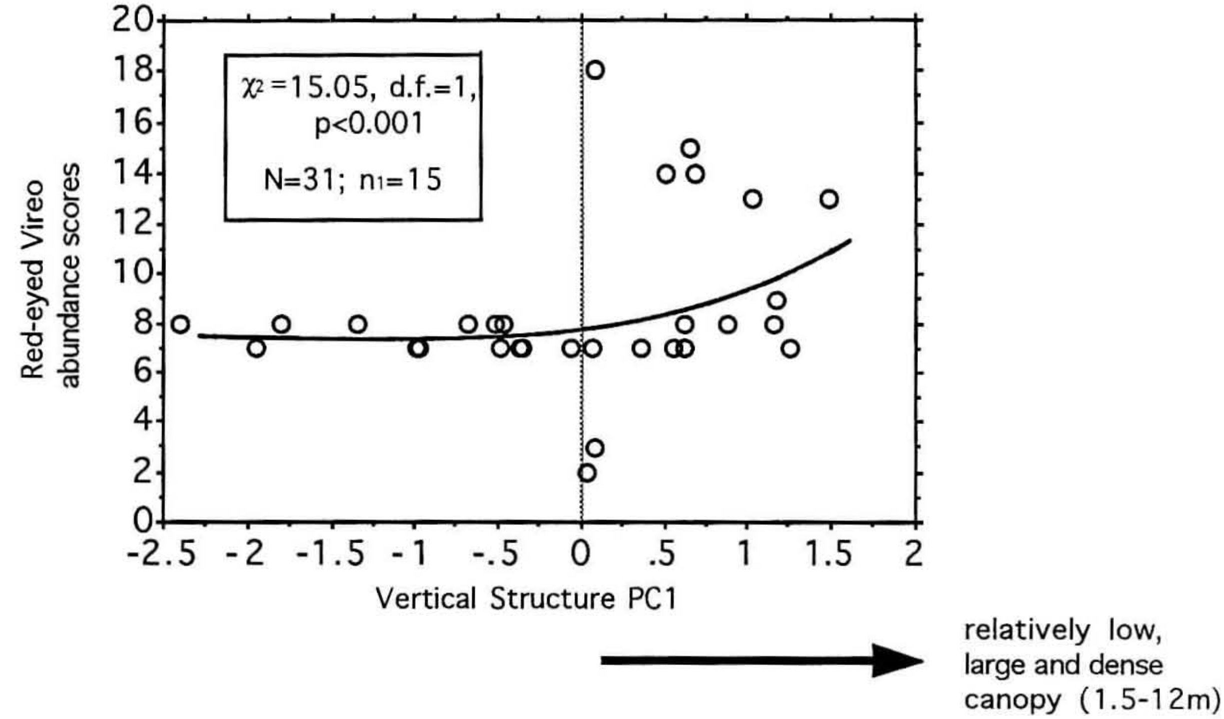


Figure 25. Relationship between Red-eyed Vireo (*Vireo olivaceus*) abundance scores and Vertical Structure PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

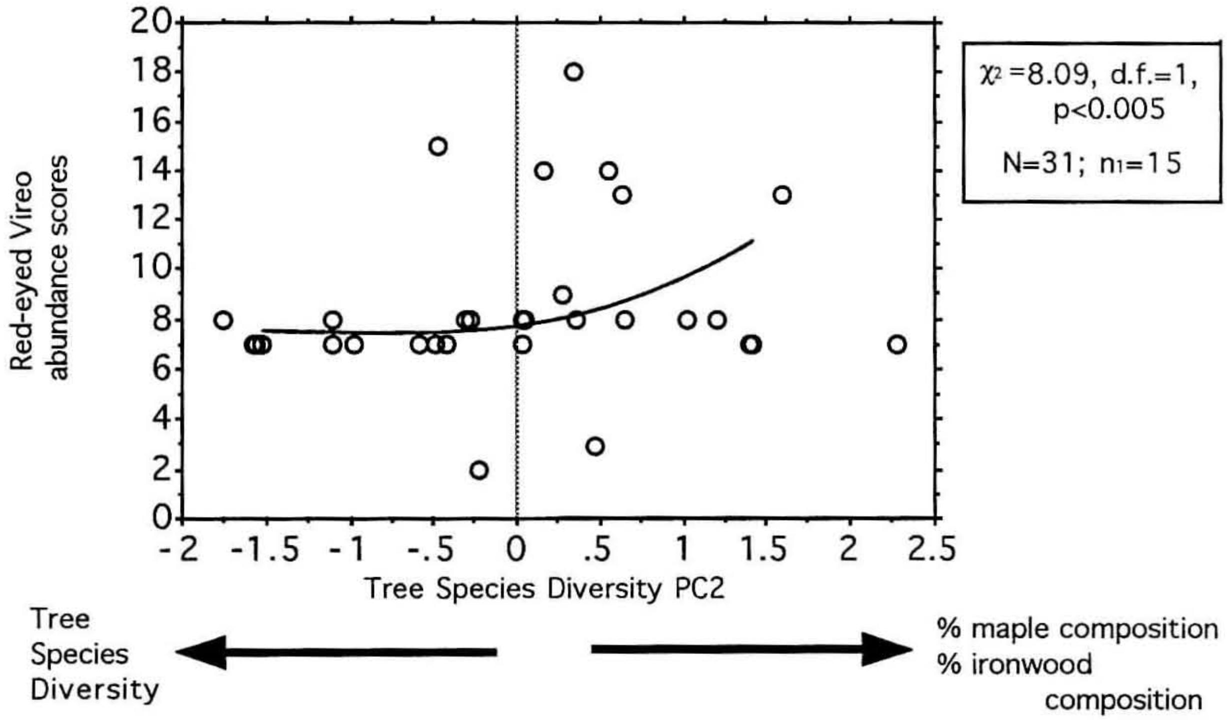


Figure 26. Relationship between Red-eyed Vireo (*Vireo olivaceus*) abundance scores and Tree Species Diversity PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

undoubtedly changes with outbreaks and declines in species of Lepidoptera that may feed on different tree species (Holmes 1988).

A positive association between abundance scores and increase in contiguity of plots with decrease in distance to water (Figure 27), is more difficult to explain. No preference for edge, be it waters edge or otherwise, has been described in the literature; however, James (1987) suggested a preference for larger tracts of forest by this species. This suggests that increased forest contiguity is a factor in habitat use by Red-eyed Vireos, although a positive correlation (r= 0.409; see Table 5) between dense low regrowth forest and increased contiguity may confound the results.

Concerns of Forest Management Practices

It seems clear that this species may excel under conditions of dense and continuous deciduous forest that occurs in the Lake Opinicon region. Thus, silvicultural practices that thin such vegetation may well decrease the suitability of habitat for Red-eyed Vireos. This species, however, is highly adaptable and may be able to sustain a population under a number of habitat conditions (although research is needed to confirm this).

Darveau *et al.* (1992), for example, found no decrease in occurrence of this species on among forest plots suffering a 20% reduction in crown cover due to maple dieback. They compared such a decline to a silvicultural reduction of crown cover by the same percentage. Unfortunately, their study did not examine changes in abundance of vireos, nor did it examine reproductive success. Holmes *et al.* (1979a) described great variation in nesting success of this species, which may be an important measure of habitat influences such as maple dieback or silvicultural practices.

From a landscape perspective, James (1987) described 0.5ha forest tract as the minimum tract size to attract this species. The small territory size may enable this species to utilize smaller forest tracts that other species (e.g. Yellow-throated Vireo) may not. Aspects of success with respect to forest tract size and isolation are lacking, however, and territorial males in smaller tracts may well suffer lower reproductive success (e.g. Robinson 1992b). than in contiguous tracts. The Red-eyed Vireos susceptibility to Brown-headed Cowbird parasitism may well play a key role in differential nesting success in this species (Kibbe 1985; Bonney 1988). This study suggest that more contiguous tracts are more suited to Red-eyed Vireo use, which is not

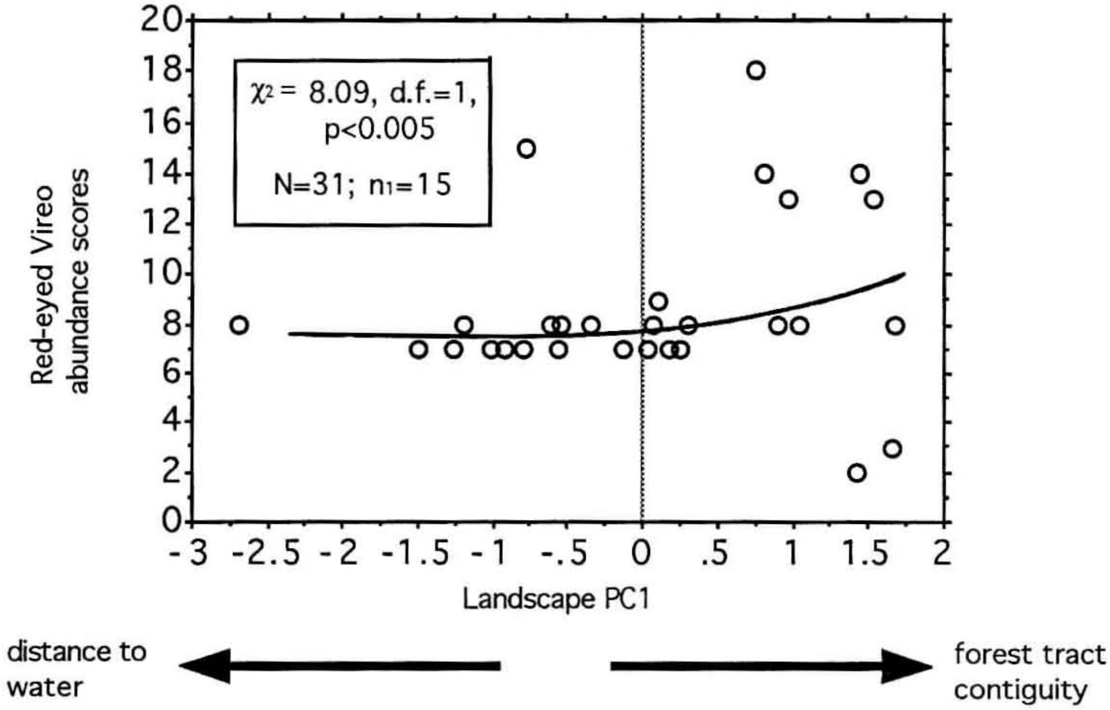


Figure 27. Relationship between Red-eyed Vireo (*Vireo olivaceus*) abundance scores and Landscape PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

surprising considering similar situations with other neotropical migrant songbirds.

Preliminary Recommendations

Vertical diversity of foliage and denser lower vegetation (≤ 12m) appears to be beneficial to this species, as may be maple and ironwood composition and increased forest tract size. This species is highly adaptable to a variety of forest and landscape conditions, with a requirement only of a low level of deciduous subcanopy growth. This species is, however, susceptible to fluctuations in nesting success, in addition to Brown-headed Cowbird parasitism; two factors that should be considered in management decisions. More information on variations in reproductive success with respect to varying habitat and landscape conditions is needed.

Black-throated Green Warbler (*Dendroica virens*)

The Black-throated Green Warbler is a widespread breeding species east of the rockies, wintering primarily in Mexico and Central America (AOU 1983). Habitat use by this species is perplexing, with a wide range of vastly different habitats occupied across its breeding range (Collins *et al.* 1982; Collins 1983; Morse 1989). General habitats include both mixed, pure coniferous, and pure deciduous forest, as well as a wide variety of habitat structures associated with these habitat types (Collins 1983; Morse 1989).

More specifically, Collins *et al.* (1982) and Collins (1983) describe the use of pine (Red, White, and Jack), spruce-arbor vitae, mixed spruce-fir-deciduous, beech-maple-birch, and Balsam Fir (*Abies balsamea*) habitats by this species. Crins (1987) describes habitat used in Ontario to include pine-, spruce-, Eastern White Cedar-, Eastern Hemlock-, and Balsam Fir-dominated forests, as well as deciduous beech-maple-birch habitat. Sherry and Holmes (1985) found a "preference" by this species for areas with conifers (New Hampshire), however, Morse (1989) also describes exclusively deciduous habitat including cypress from Virginia and South Carolina. In Maine alone, this species occupies White Pine- and Eastern Hemlock-dominated forests inland, mixed coniferous-deciduous in the northwest, and Red (*Picea rubens*) and White spruce forest in coastal areas (MacArthur 1958; Morse 1989).

In the latter areas of Red and White spruce, Morse (1976) found this species to be more abundant in Red Spruce, where the pattern of needles was more conducive to this species' foraging behaviour. In northern Maine and New Hampshire, Black-throated Green Warblers were more abundant in mixed coniferous-deciduous forests than in nearby spruce-fir forest, where Bay-breasted Warblers (*Dendroica castanea*) may restrict Black-throated Greens (Morse 1978; 1979).

Specific widespread habitat requirements by this species are difficult to define. Collins (1983) examined a variety of habitats across a broad geographic range and found no structural or tree-species parameters governing habitat use. A combination of habitat variables, the inability of variables to detect subtle patterns of structural similarities between habitats (Anderson 1981), or perhaps habitat selection on a broader scale (e.g. Wiens 1981; Wiens *et al.* 1987) may underlie the perplexity of habitat selection by this species.

The foraging behaviour of this species, suggests an opportunistic foraging strategy which may influence habitat selection and use (Horn 1974; Holmes and Robinson 1981). Typical Black-throated Green Warbler foraging behaviour consists of gleaning and hover-gleaning in a variety of habitats (MacArthur 1958; Sabo and Holmes 1983; Holmes and Robinson 1981). Sabo and Holmes (1983) describe this species niche as almost identical in both conifer and deciduous-mixed hardwood forest. Thus, this species may well be a wide ranging habitat generalist (Collins 1983); an opportunistic species responding to variable food resources and preferring only multilayered leaf arrangements - not specific habitat variables (Horn 1974; Holmes and Robinson 1981).

Lake Opinicon Mature Hardwood Forest Stands

Even within the Lake Opinicon region, the Black-throated Green Warbler utilizes a variety of habitat types. Individuals can be found in mixed plantations, cedar swamps, hemlock-dominated forest, mixed White Pine-maple forest, and pure deciduous maple-ironwood habitats. This species is widespread but in low numbers, and shows no evidence of interspecific influences, as have been suggested for New Hampshire (Morse 1978; 1979) (see Table 2). Not surprisingly, this species also provided few results with respect to habitat variables of the plots.

The only significant association was a positive relationship between Black-throated Green Warbler abundance scores and the number of logs

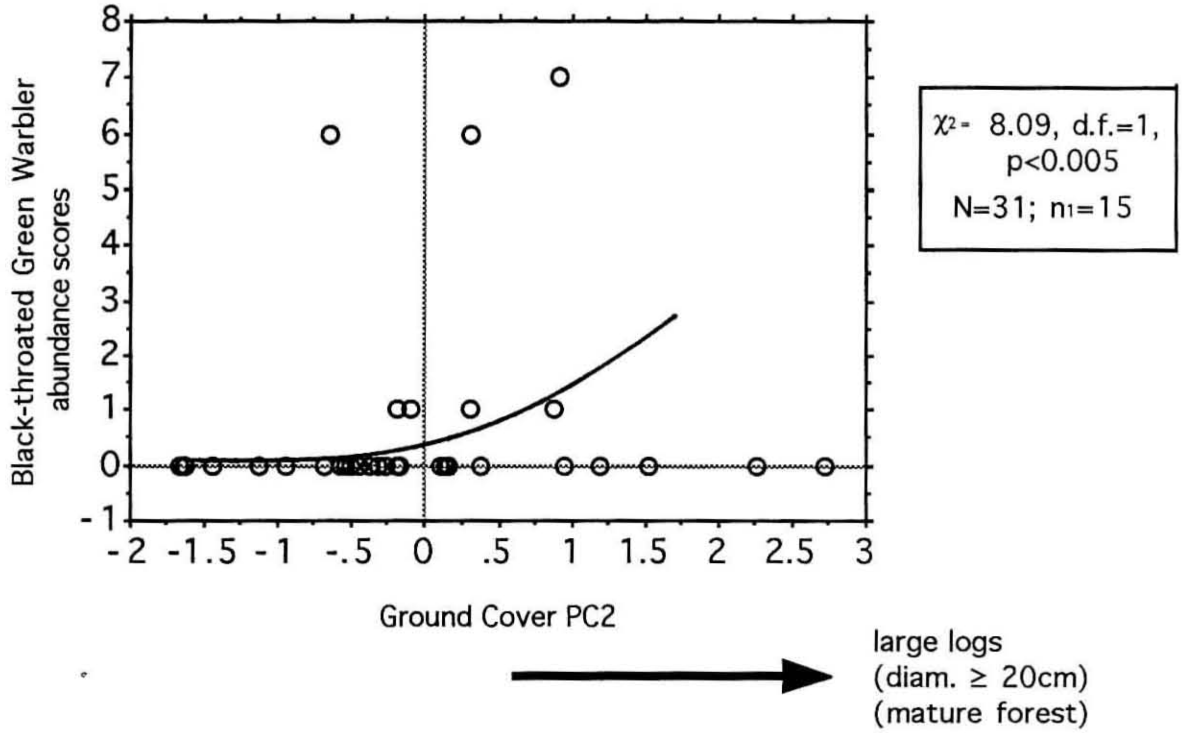


Figure 28. Relationship between Black-throated Green Warbler (*Dendroica virens*) abundance scores and Ground Cover PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

≥20cm in diameter (Figure 28). This suggests a preference for more mature forest by this species, which is supported by a trend ($p<0.10$) of increasing habitat use with tall, high canopy forests (canopy 12m+) (Appendix 9). An additional trend ($p<0.10$) was also found with increasing maple-ironwood composition (decreasing tree species diversity) (Appendix 9). All of these results may well represent real habitat variables that characterize habitat more suitable for this species; however, these trends appear to be restricted to the specific mature hardwood forest habitat type. These same habitat conditions are not applicable to other habitats in the area (e.g. cedar swamp), and may be restricted geographically as well.

Concerns of Forest Management Practices

Collins (1983) proposed that regional analysis, even within a single habitat-type, may be of limited value with respect to habitat management for this species. In this study, a requirement of a mature forest, with a distinct, tall canopy layer (12m+) appears to exist; however, such requirements are not even applicable to variations in this habitat. For example, a relatively low patch of regrowth Eastern Hemlock occurring within mature hardwood forest, may be enough to attract this species, irrespective of the requirements suggested above. Thus, suggestions for forest management with regards to this species are difficult at best.

Morse (1977;1989) describes this species as being extremely area sensitive, having larger territories than other related wood warblers. Clark *et al.* (1983) also describe this species as sensitive to disturbance, limited to undisturbed forests in central Ontario. Thus, at a landscape scale, this species appears to require contiguous forest tracts and may be negatively affected by forest fragmentation. Protection of large tracts of forest (irrespective of habitat characteristics) will probably benefit this species moreso than specific silvicultural, within-stand practices.

Preliminary Recommendations

Protection of large forest tracts and alleviating fragmentation may be the only recommendation possible. This species appears to act as an opportunist, requiring no specific habitat type or condition, but only a multi-layered leaf arrangement (Horn 1974; Holmes and Robinson 1981) that could not be managed for. More research is required, however, to better understand habitat selection and use in this species.

Pine Warbler (*Dendroica pinus*)

The Pine Warbler is a temperate wintering species, heading north from its wintering grounds in the southeastern United States to breed in southeastern Canada and the eastern U.S. (AOU 1983). As its name suggests, this species is a habitat specialist, adept at gleaning food from thin needles of a variety of pine species, and foraging primarily in the outer shell of pine canopy (Emlen 1977).

The Pine Warbler is not restricted to any particular species of pine, but may be found in a wide range of pine species. Peterson (1988) describes the use of Pitch Pine (*Pinus rigida*) in the pine-scrub oak barrens of coastal New York. Upstate, and in Ontario, Eastern White and Red pine are the most frequent habitat (Peck and James 1987; Eagles 1987; Peterson 1988), with Eastern White Pine apparently used more heavily than Red (and Jack Pine) (Eagles 1987).

This species' strong selectivity for pine forest has been noted by most authors (Anderson and Shugart 1974; Smith 1977; Emlen 1977; Collins *et al.* 1982; Ellison 1985; Morse 1989; Eagles 1987; Peck and James 1987; Peterson 1988). In fact, Morse (1974a) describes this species treating mixed habitats as if they were just "dilute pine forests", ignoring all deciduous trees and foraging only in the pines. Several authors have noted other requirements of this species to include aspects of tree size, spacing, and density, as well as tree species preferences described above. Collins *et al.* (1982) described a habitat with large conifers and fewer medium deciduous trees to be more suitable, while Anderson and Shugart (1974) and Conner *et al.* (1983) found areas with closed canopies, high mature pine composition, and sparse undergrowth to be differentially selected by this species. Peterson (1988) included that almost any species of pine may be used, provided trees are well-spaced, while Capen (1979) (cited in Peterson 1988) suggested that maturity of the forest is also a factor governing habitat selection and/or use.

Nests of this species are invariably in coniferous trees, and at that, almost always in pines (Peck and James 1987). White and Red pines were the most frequent nest trees in Ontario, with nests being placed quite high, commonly from 8.5m - 15m off the ground (Peck and James 1987).

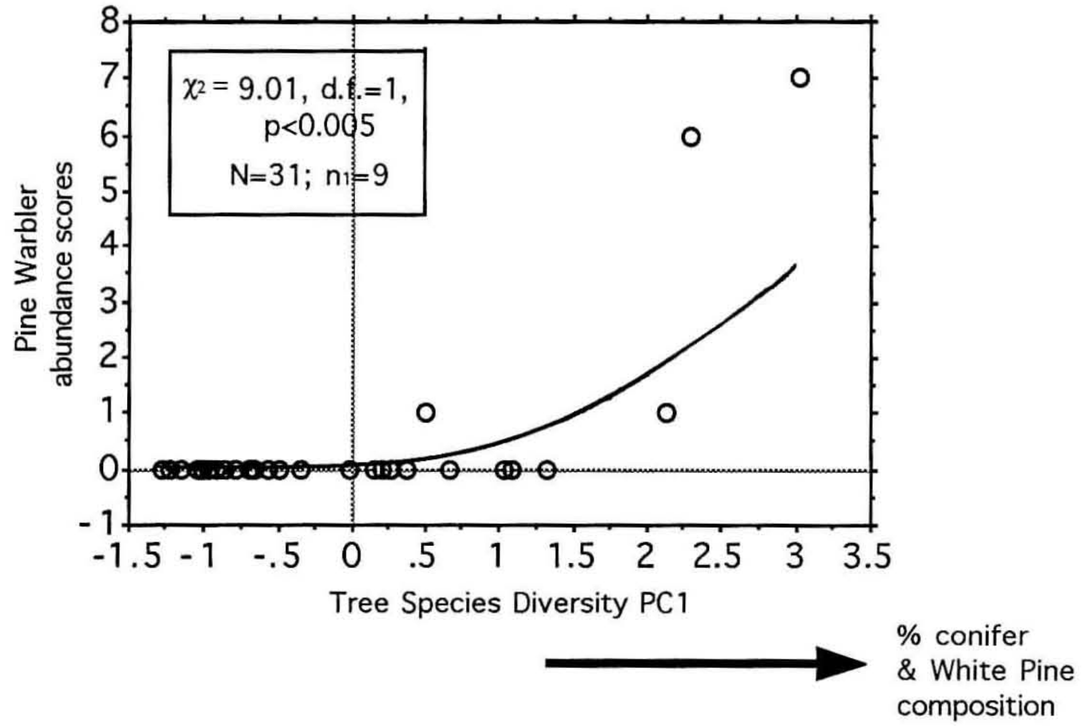


Figure 29. Relationship between Pine Warbler (*Dendroica pinus*) abundance scores and Tree Species Diversity PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

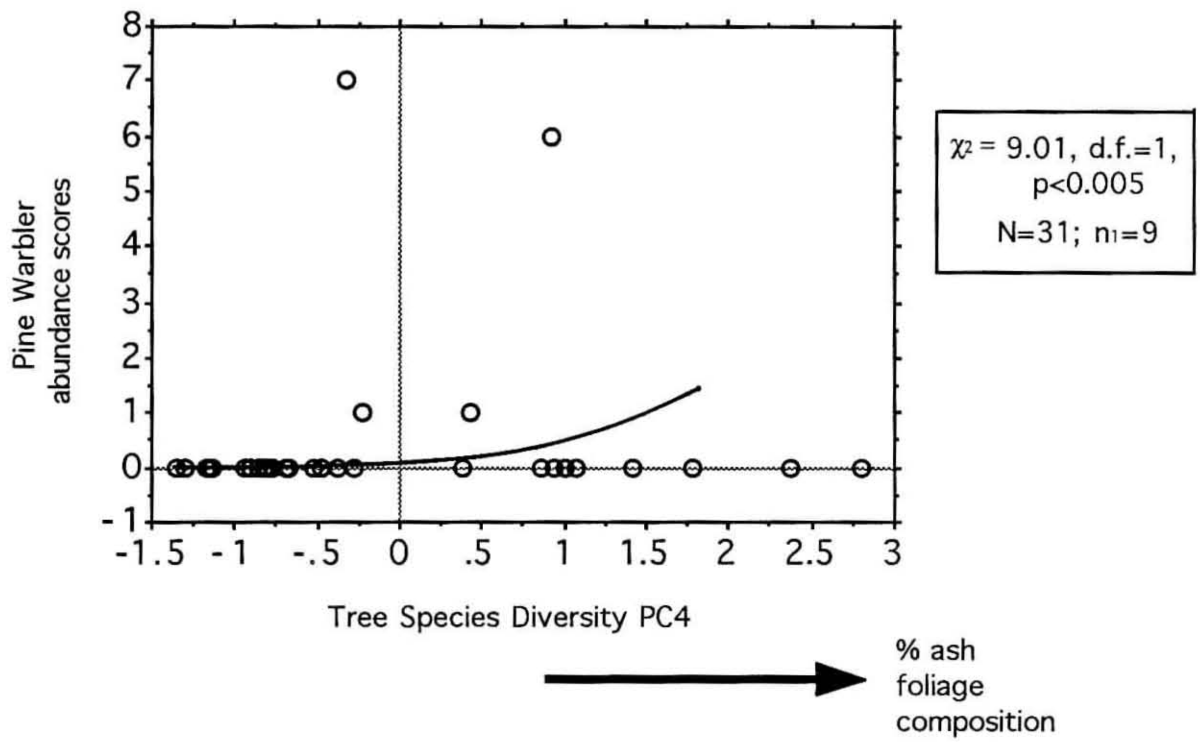


Figure 30. Relationship between Pine Warbler (*Dendroica pinus*) abundance scores and Tree Species Diversity PC4. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

Lake Opinicon Mature Hardwood Forest Stands

Despite having a large population in the Lake Opinicon region, this species was not well represented in the surveys of the present study. The selection of plots and the predominance of deciduous habitat in these study plots, are the underlying reasons for this. In actual fact, the Canadian Shield, including areas north of Kingston and Brockville, supports the highest densities of this species in all of Ontario (10km x 10km squares) (Eagles 1987).

Despite the low number of plots where Pine Warblers were found (4 plots), some significant results were obtained. Coniferous foliage and notably White Pine supported all populations found on the surveys (Figure 29). A trend showing increased abundance scores with respect to White Ash is merely an artifact of the low sample size, with only half of the plots occurring on the positive side of the component (see Figure 30). A correlation between coniferous/White Pine habitat and the presence of White Ash (*Fraxinus americana*) ($r=0.425$; Table 5) may have also contributed to this result.

High densities of low DBH trees (<10cm DBH) showed a negative relationship with Pine Warbler abundance scores (Figure 31), supporting this species' need for large trees. Interestingly, a trend ($p<0.10$) (Appendix 9) towards "top-heavy" plots with denser foliage in the 12-18m range and taller maximum tree height and canopy height, supports a heavier use of more closed canopy and mature forest (Anderson and Shugart 1974; Conner *et al.* 1983).

Finally a negative relationship between abundance scores and distance to agriculture or suburban edge (Figure 32) may only reflect the chance location of the four plots that held Pine Warblers. Incidentally, this species' specific habitat requirements and the often patchy nature of its preferred habitat, may better enable it to cope with fragmentation of habitat.

Concerns of Forest Management Practices

The destruction of Eastern White Pine forest and selective cutting of this species in Ontario has undoubtedly had its negative effects on the Pine Warbler (Eagles 1987). This warbler's requirement of mature and dense-canopy stands of pine seriously limit its ability to adapt to such selective, species-specific silvicultural practices. Fortunately, Pine Warblers are able to

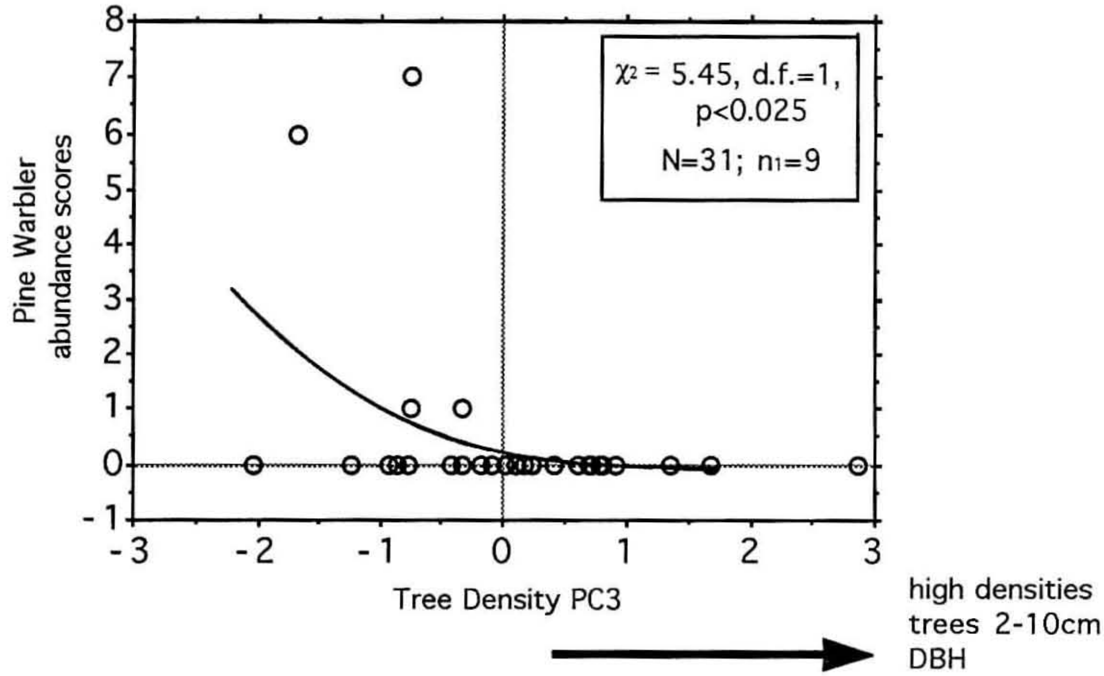


Figure 31. Relationship between Pine Warbler (*Dendroica pinus*) abundance scores and Tree Density PC3. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

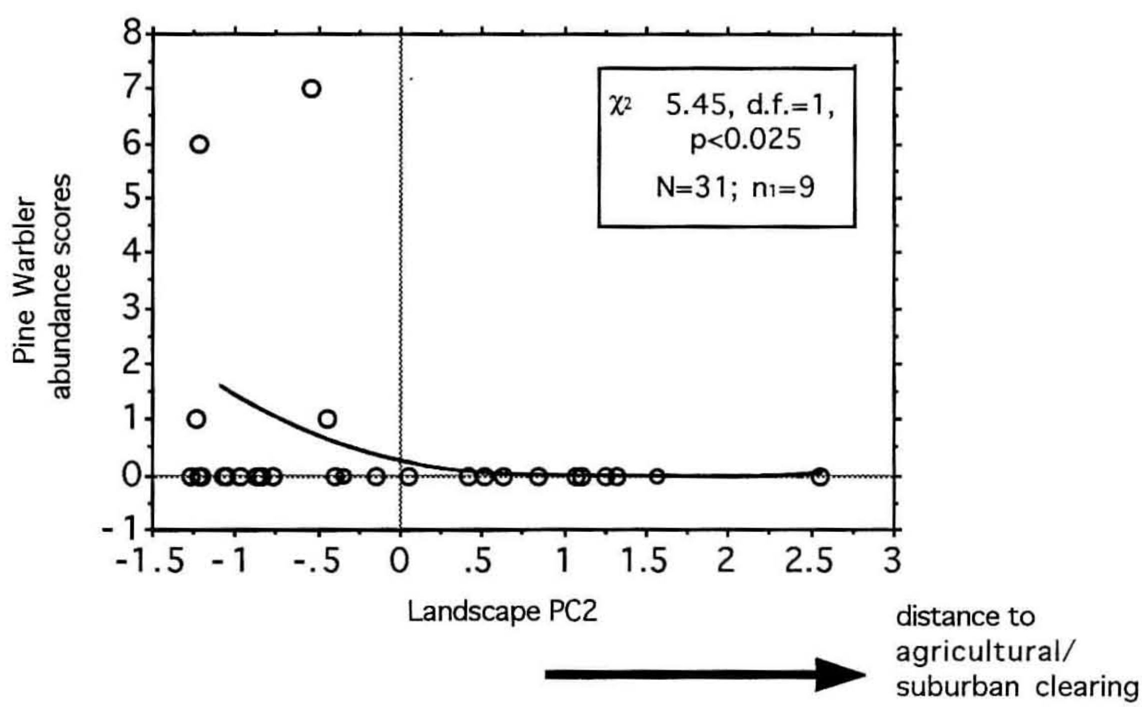


Figure 32. Relationship between Pine Warbler (*Dendroica pinus*) abundance scores and Landscape PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

take advantage of pine plantations (Appendix 10), although this may be limited by the spacing and maturity of the trees.

Currently, in the Lake Opinicon area, this species is in relatively large numbers, inhabiting the mature Eastern White Pines that are especially characteristic of lake shore, dry, rocky habitat ('poor' soil conditions). Protection of this habitat is a must for this species, while the management of current mature pine plantations (e.g. through thinning) could further increase availability of suitable habitat. The regrowth forest typical of the abandoned farmland in the region, is also typically absent of Eastern White Pine. Similar situations have been reported from upstate New York (Kendeigh 1946), where regrowth forest has a greater deciduous component and can not sustain the bird communities that were once characteristic of the region. It seems the Pine Warbler may have suffered a similar fate, and may have been originally more common in the area, as was once Eastern White Pine.

Preliminary Recommendations

Protection of mature pine stands and management of maturing pine plantations will probably benefit this species most. More information on management practices that improve plantation habitat for this species are needed. In addition, silvicultural practices that selectively cut mature pines should be avoided, while incorporating Eastern White Pines (and perhaps Eastern Hemlock for Blackburnian Warblers) in regrowth deciduous forest is encouraged.

Cerulean Warbler (*Dendroica cerulea*)

The Canadian portion of the Cerulean Warbler's breeding range is restricted to southern Ontario (rarely southwestern Québec), with the bulk of the population occurring in the eastern United States (Robbins *et al.* 1992). This species has become a central example of a declining neotropical migrant, suffering from habitat loss on both the breeding grounds and in its wintering grounds, which is restricted to the mature and humid evergreen forests of the Andean foothills (Robbins *et al.* 1992). Data from the North American-wide breeding bird survey document a long-term decline of this species, with populations declining an average of 3.4% per year from 1966-1987 (Robbins *et al.* 1992).

Habitat destruction has been the key factor in this species' marked decline. Some authors suggest populations to be strictly limited to tall deciduous forests with little subcanopy growth (e.g. Ellison 1985). Further investigation, however, proves this assumption to be incorrect, with Cerulean Warblers occupying a range of habitats which vary in aspects of both vertical structure and tree species composition.

Robbins *et al.* (1992) describe the principal nesting habitat of Cerulean Warblers as extensive, tall, mature, deciduous floodplain forest. In addition, they describe the use of mixed hardwoods, maturing climax forest (oak-hickory), and lowland floodplain forest. Lynch (1981) found this species in old-growth floodplain forest dominated by Sycamore (*Platanus occidentalis*), Green Ash (*Fraxinus pennsylvanica*), and Sugarberry (*Celtis laevigata*). In New York state, Connor (1988) describes other habitats occupied by this species, including wooded swamps, cottonwood-dominated forest, oak-Silver Maple (*Acer saccharinum*) forest, drier, open upland forest (oak or oak-maple), and black locust-dominated woods. Riparian forest dominated by Silver Maple and Eastern Cottonwood (*Populus deltoides*) support a small population of Cerulean Warblers in Vermont (Ellison 1985), while in Ontario, Peck and James (1987) include second growth deciduous woods to the list of habitats occupied by this species.

More specific habitat requirements of this species include aspects of foliage structure. Lynch (1981) describes the highest densities of Cerulean Warblers in North Carolina in forest with a closed canopy of 24m - 30m in height, with a distinct shrub layer and 100% ground cover. Even-aged timber, lacking old-growth trees, contained few if any Ceruleans (Lynch 1981). In Maryland, this species' abundance is correlated with % ground cover and tree size (DBH), and is negatively correlated with coniferous foliage in the canopy (Robbins *et al.* 1989). Kahl *et al.* (1985) (cited in Robbins *et al.* 1992) found Cerulean Warblers to be restricted to tall forest (>18m), with large live trees (>30cm DBH), closed canopy (>85% vegetation), intermediate to closed subcanopy, few dead stems, and an intermediate number of small woody stems (<2.5cm DBH).

All of these habitat conditions appear to suit the characteristic behaviour of this species. Cerulean Warblers are typical canopy dwellers, foraging in larger trees at about 75% of the forest height (17m in 22m tall trees; Tennessee) (Robbins *et al.* 1992). Foraging appears to be largely by gleaning (pers. obs.), although there is little information on details of foraging behaviour and prey taken. Singing males may require large canopy trees for singing perches (Lynch 1981), and similarly medium to large deciduous trees are required for nest sites (Peck and James 1987). Nests were commonly near forest edges at 9m - 12m above the ground (Peck and James 1987). A variety of deciduous trees were used for nesting, including oak, maple, basswood, and elm (Ontario) (Peck and James 1987).

Lake Opinicon Mature Hardwood Forest Stands

The historical range of the Cerulean Warbler in eastern North America is not especially clear. It appears to have been native to Carolinian forest extending up to southwestern Ontario. Recent discoveries of populations in Vermont, southwestern Québec, parts of New York state, and notably north of Kingston (including this area), have been attributed largely to range extensions, although most authors agree that this is not entirely clear (Connor 1988; Robbins *et al.* 1992). The low observability of this species makes conclusions about the history of these 'new' populations difficult.

Specifically in the Lake Opinicon region, this species may well be a newcomer. Regrowth deciduous forest lacking a strong coniferous component which may have historically been present, has resulted in an extension of suitable habitat for this species, both in this area, and in upstate New York (e.g. Kendeigh 1946). In any case, as populations decline in the central portions of its breeding range (Robbins *et al.* 1992), the Cerulean Warbler appears to be prospering in the extensive regrowth forest tracts of the area, at the northern edge of its range.

Results from this study suggest a greater use of dense and low regrowth habitat in the 1.5m - 12m vertical range by this species (Figure 33). Interestingly, trends ($p<0.10$) also suggest heavier use of habitats with heavy undergrowth (0m - 1.5m) and heavy canopy (6m -18m) (Appendix 9). All of these observations seem to support previous reports of dense foliage requirements at the canopy and subcanopy levels; however, the requirement of a distinct and specifically high canopy is not supported by these data. This is not surprising, since Cerulean Warblers do not require canopy space for flycatching, as may some species of flycatcher. Instead, dense deciduous foliage provides ample foraging substrate to support high populations of this species.

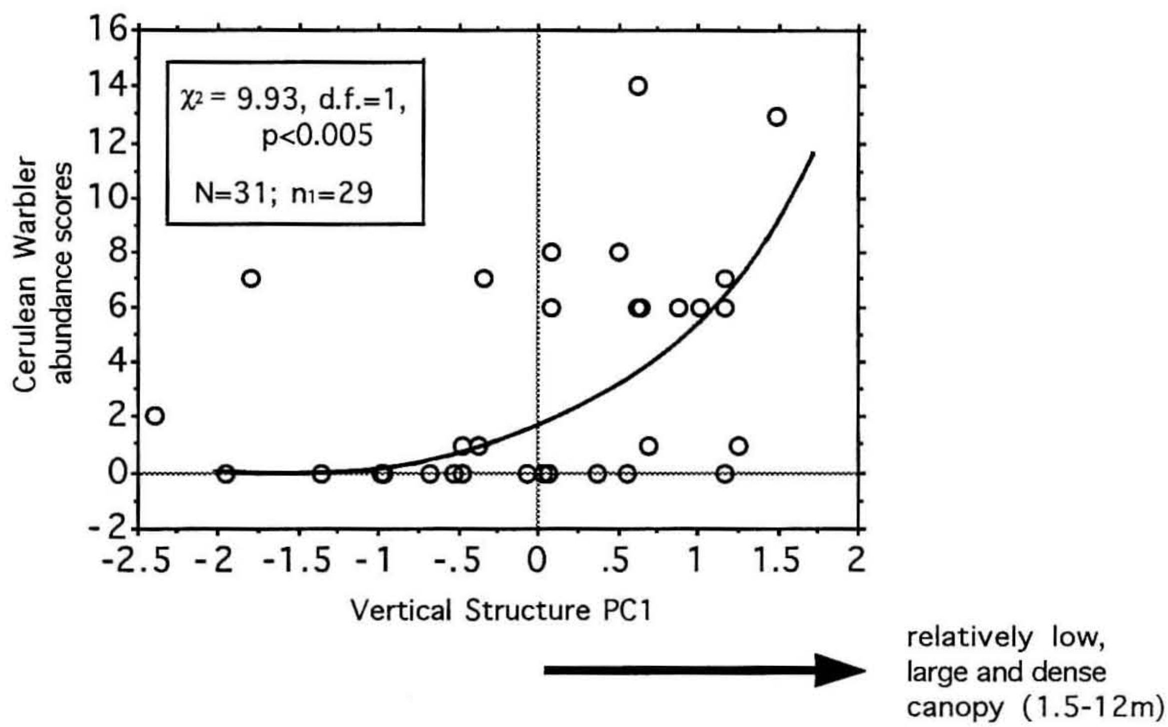


Figure 33. Relationship between Cerulean Warbler (*Dendroica cerulea*) abundance scores and Vertical Structure PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

Indeed, this species was found to be the third most abundant songbird in the mature hardwood forest habitats of the region (Table 1), while this area supports the highest Canadian densities, and among the highest densities anywhere, of this endangered species (PRM, unpublished data). Within this area, a trend towards increased habitat use of maple-ironwood dominated areas ($p<0.10$) (Appendix 9) suggests a preference for these species. Individuals, however, were found in Red Oak- dominated forest, with a subcanopy of predominately Sugar Maple, as well as in tall Sugar Maple-Bitternut Hickory-White Ash habitat (the latter with a well defined high canopy).

Concerns of Forest Management Practices

Lynch (1981) warned that forests managed for timber production were not permitted to grow large enough to sustain Cerulean Warbler populations. Such a dependence on old-growth forests is not supported by data from this region, where these birds utilize approximately 50-60 year old regrowth forest, averaging about 18m in height. The destruction of canopy trees is a major concern, however, and information is needed concerning the effects of varying degrees of canopy thinning on habitat quality for Cerulean Warblers. These birds appear to occupy surprisingly open habitat in this region, provided broad-canopied trees are present. These individuals may well be spilling over from nearby denser forests, however, and it would not be safe to assess the effects of canopy opening without measuring the productivity of individuals in these habitats.

One of the major concerns related to management practices of Cerulean Warbler habitat may not be at the stand level, but instead on the landscape scale. Robbins *et al.* (1989a) rarely found this species to occupy forest tracts <250ha in size. Maximum densities were found in tracts of 3000ha or larger, while forest tracts of 700ha had only a 50% probability of hosting Cerulean Warblers at all (Robbins *et al.* 1989a). Thus, the extensive forest tracts of the Lake Opinicon region, may well be the reason for such a large population of this species, and not so much specific habitat characteristics previously discussed. For this species more so than most, the protection of vast tracts of contiguous forest is crucial to its continuing occurrence in the Lake Opinicon area and elsewhere.

Preliminary Recommendations

More information is clearly required on the extent to which silvicultural thinning of canopy trees can be carried out without a serious effect on the suitability of habitat for this species. Canopy and subcanopy foliage is important to Cerulean Warblers, thus careful management of Cerulean habitat is a must. Specific recommendations could only be made after more information is attained; however, this species does not appear to be as dependent on "old-growth" deciduous woods as has been described in the southeast.

Possibly more important is this species' requirement of extensive forest tracts. Protection of vast contiguous tracts of forest is needed to safeguard habitat degradation by fragmentation.

Black-and-white Warbler (*Mniotilta varia*)

The broad breeding range of this species encompasses regions from the MacKenzie River valley through Newfoundland, south to the southeastern United States (west to Texas) (AOU 1983). In fall, this species migrants to Central America and the Caribbean where it winters (south to northern South America) (AOU 1983).

On the breeding grounds, Black-and-white Warblers typically inhabit dry deciduous and mixed forests, with variable canopy cover (Collins *et al.* 1982). Noon *et al.* (1980) found this species to inhabit forests with taller trees and more open understory in the south than in the north, which was attributed to differences in habitat availability. Peck and James (1987) suggested this species may utilize mixed woods in Ontario to a greater extent than either pure deciduous or coniferous woods. Such a preference has not been suggested by other authors, however, and Eaton (1988) describes a wide range of habitats in which this species may be found (New York), including mature or second-growth deciduous or mixed woodland, alpine krummholz (Adirondacks), and coastal deciduous lowlands including predominately oak woods.

Specific habitat requirements by this species have been seldom described. Ellison (1985), suggested that in Vermont, this species may occur in higher densities in stands of medium-aged second growth habitats with well-developed understories, as opposed to more mature, closed-canopy forests. Other literature, however, fail to support such differential habitat use.

Among wood-warblers, this species is unique in its foraging behaviour and primary substrate. Eaton *et al.* (1963) found it more structurally like a nuthatch, to which its foraging behaviour also resembles. The Black-and-white Warbler forages primarily by gleaning insects from the bark of trees, including limbs, branches and trunks (Eaton 1988). In addition, this species is able to catch insects on the wing, showing adaptable foraging behaviour that may assist it in utilizing a broad array of habitats (Eaton 1988).

Nest sites are located on the ground, often at the base of trees, stumps, or under logs and bushes (rarely elevated) (Peck and James 1987), and probably do not play a major role in habitat selection.

Lake Opinicon Mature Hardwood Forest Stands

In the Lake Opinicon area, this species is widespread and quite common, moreso than is indicated by its occurrence in the sampled plots. This suggests that other habitat types may provide more suitable habitat than the bulk of those which were sampled here. Of these plots, however, trends associated with habitat variables were evident and provide insight into varying suitability of habitat types.

A negative association with relatively low and dense regrowth forest (Figure 34) contradicts Ellison (1985) who suggested that such habitat may be preferred. Thus it appears that regrowth forest with dense foliage between 1.5m - 12m is not the most suitable for this warbler, and a more mature-structured forest, fairly open up to 12m, may be more suitable habitat.

The diversity of tree species, in addition, may influence habitat use by this species in the area. A negative association between maple-ironwood composition and decreasing tree species diversity was evident (Figure 35), while trends ($p<0.10$) suggest similar negative trends associated with increasing conifer and Eastern White Pine composition, as well as ash composition (Appendix 9). Together, these results suggest an overall greater habitat use with an increasing diversity of tree species.

Such a conclusion is not surprising when considering the substrate and foraging behaviour of this species. Insect species and abundance undoubtedly vary with respect to the bark of various tree species, and an increase in the number of tree species may well provide a greater diversity, and perhaps a better food resource, for Black-and-white Warblers. Preferences for bark-substrate of specific species, or specific tree sizes (e.g. differences in basal area),

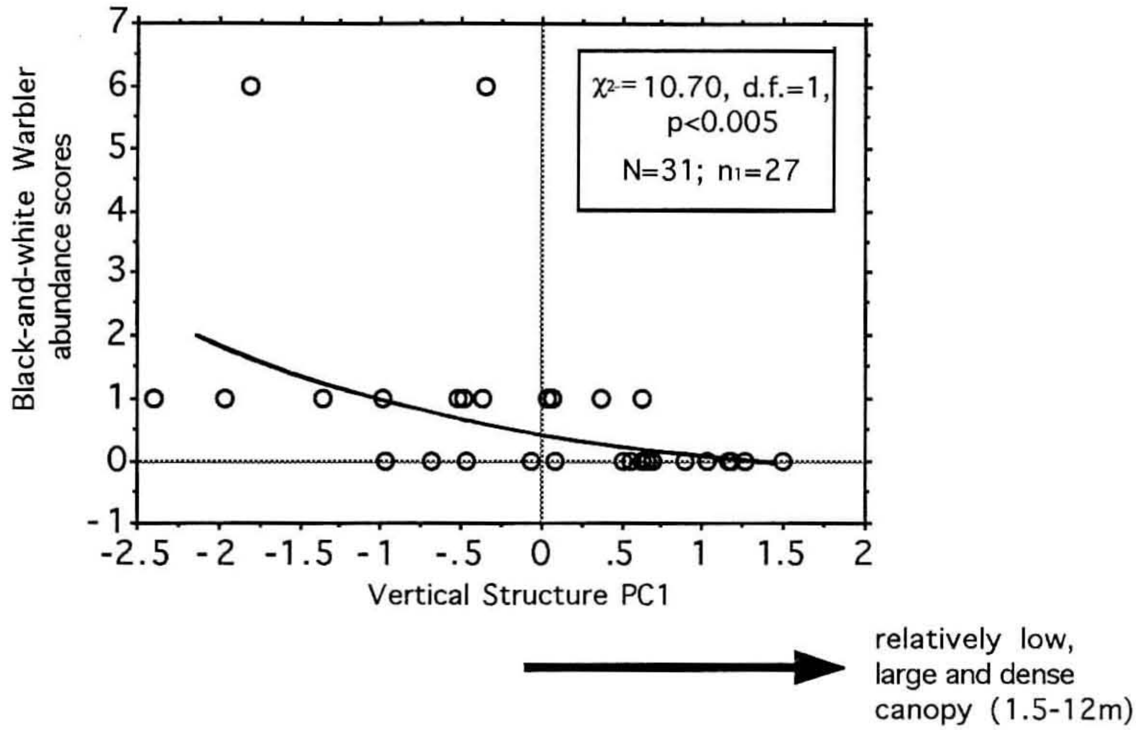


Figure 34. Relationship between Black-and-white Warbler (*Mniotilta varia*) abundance scores and Vertical Structure PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

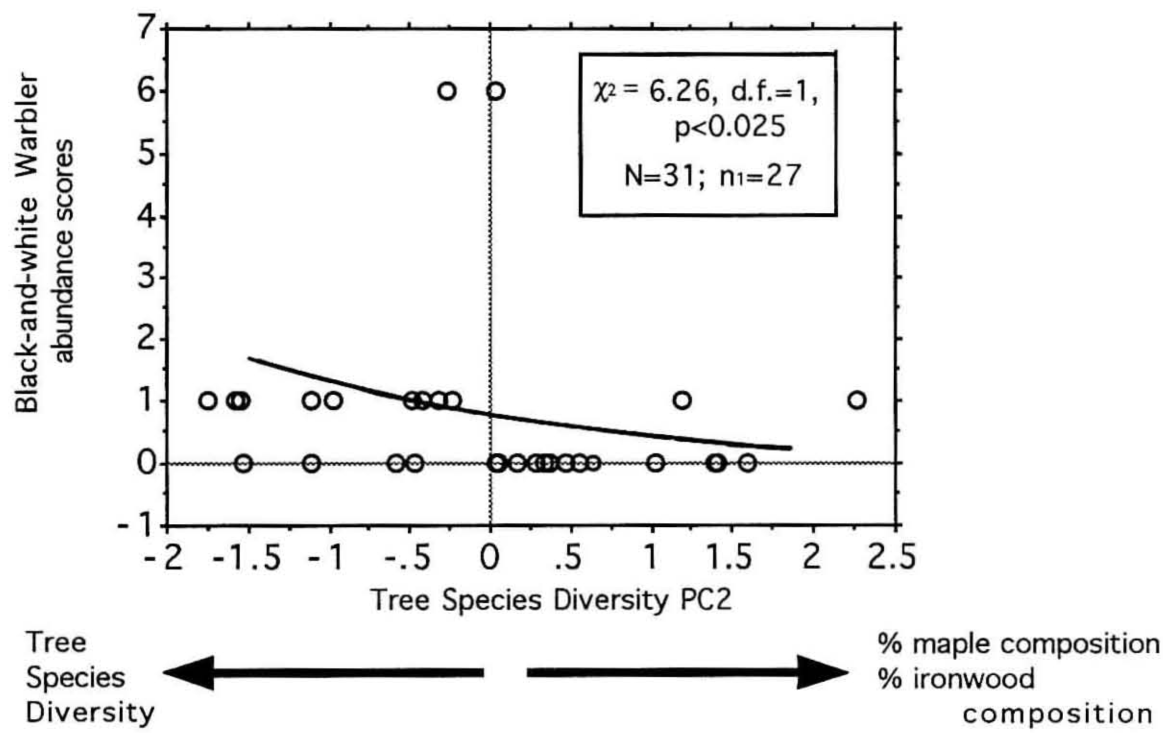


Figure 35. Relationship between Black-and-white Warbler (*Mniotilta varia*) abundance scores and Tree Species Diversity PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

may also underlie these results. Research appears to be sparse on this species, and more is needed on aspects of its behaviour and habitat use.

Concerns of Forest Management Practices

From this study, the maintenance of tree species diversity within forest stands appears to be of importance to this species. In addition, more mature habitat lacking the dense, continuous and low canopy may prove more suited to this species. The lower occurrence of this species on surveys relative to the general population in the area may be due to the large numbers of maple-ironwood-dominated plots that lack high tree species diversity. If Peck and James (1987) are correct, the absence of mixed woods among this regrowth may also play a role. More information on specific habitat requirements, however, are required before conclusions can be drawn.

At the landscape scale, several authors have noted this species decline with respect to fragmentation of forest (Galli *et al.* 1976; Whitcomb *et al.* 1977). The area-sensitive nature of this species may require the protection of larger tracts of forest as well as specific management practices at the stand scale.

Preliminary Recommendations

The maintenance of tree species diversity within a forest stand appears to be an important parameter for this species, while this requirement may extend to mixed habitats over pure deciduous. Black-and-white Warblers showed lower habitat usage of low and dense regrowth habitats which may suggest more open or perhaps more mature habitat is favored. More information is needed on such specific requirements of habitat structure.

Extensive tracts of forest are also vital to this species, with fragmentation having detrimental effects on populations. This may prove to be more important than habitat aspects at the stand level, with the latter less susceptable to degradation.

American Redstart (*Setophaga ruticilla*)

The widespread breeding range of the American Redstart spans Alaska east to Newfoundland, and south to the southeastern United States (AOU 1983). The ability to occupy such a widespread range may be at least partly attributable to the adaptable characteristics of this species, which include varying foraging behaviour in response to differences in habitat (Sherry 1979). Although this species may well be one of the most numerous songbird species in North America (Holmes and Sherry 1992), recent work indicates threatening habitat loss on its wintering grounds (Sherry and Holmes 1992), which include the Caribbean, parts of Central America, and northern South America (AOU 1983).

Not surprisingly, the American Redstart occupies a variety of habitats over its broad geographic range. These include a variety of mature and regrowth deciduous habitats, and even primarily coniferous habitats, with only a small deciduous component (Bent 1953; Morse 1973). Bent (1953) also describes willow and alder thickets as suitable redstart habitat, while Eaton (1988) lists second growth forest, Red Maple - hardwood swamps, upland deciduous forests, mature beech-spruce-hemlock forests (Adirondacks), Black Spruce-beech-maple forest, White Ash-Basswood (St. Lawrence Co.), and shrub swamps, forested uplands, and wetlands as all comprising suitable habitat for American Redstarts in New York state. Even in one locale, Morris and Lemon (1988) describe marked differences in the floristics features of American Redstart territories (New Brunswick), with cherry and aspens, and Eastern White Cedar representative at different sites.

In Ontario, Cartwright (1987) incorrectly states that "... the American Redstart is a bird of maturing rather than fully mature woods,..." On the contrary, this species inhabits mature woods and regrowth as well as forest edge habitats (e.g. Ficken 1962; Ficken and Ficken 1967). Peck and James (1987) do not suggest a preference between mixed or deciduous woods by this species; however, second growth, shrub growth, and forest with a dense sapling understory were more heavily utilized than mature woods lacking the latter.

More specifically, Morse (1973) describes a requirement for deciduous growth by American Redstarts in Maine. Those individuals that inhabited small spruce-clad islands seldom fledged young, while those in mixed vegetation foraged primarily in deciduous foliage (Morse 1973). A similar preference was found by Sabo and Holmes (1983) in the subalpine forest of New Hampshire, while Sherry and Holmes (1985) documented a preference for deciduous vegetation within territories.

Within habitat, this species occurs most frequently where vegetation is dense within the redstart's vertical foraging range (Ficken and Ficken 1967;

described by Sherry (1979) as 12m to 15m range in hardwood forests of New Hampshire). This habitat proves conducive to the general foraging behaviour of this species, which includes hovering, capturing insects on vegetative substrates, as well as hawking for insects, and flushing with subsequent chase (Sherry 1979; Robinson and Holmes 1982; Sabo and Holmes 1983).

Nest sites are usually low, described as commonly 1.8m - 3.7m off the ground by Peck and James (1987), and as averaging 5.1m off the ground by Sherry (1979). Saplings and shrubs were more frequent nest sites than were mature trees, with nests being reported from a variety of tree species, including maples, birchs, ashes, and Eastern White Cedar (Peck and James 1987).

Complications concerning habitat use and selection with American Redstarts include aspects of habitat use with respect to the age of males, influences of a possible dominant competitor species, and differential foraging behaviours of males and females on a territory. There has been some debate as the whether year-old male redstarts defend territories that are "inferior" or "less suitable" than those defended by older males (Ficken and Ficken 1967; Howe 1974; Procter-Gray and Holmes 1981; Morris and Lemon 1988; Sherry and Holmes 1989). Part of this argument suggests habitat quality to differ between age classes, with this difference contributing to the lower reproductive success of the subadult males. Another complicating factor is a competitor species, the Least Flycatcher, which may directly or indirectly influence habitat selection and/or reproductive success of redstarts (Sherry 1979; Bennett 1980; Sherry and Holmes 1988). In addition, male and female redstarts forage at different heights on the breeding territories (Holmes *et al.* 1978), suggesting that vertical diversity of foliage may play an important role in habitat selection and alleviating intraspecific competition within a pair.

Lake Opinicon Mature Hardwood Forest Stands

The American Redstart had a patchy distribution among the forest plots of this study. Abundances varied with up to three territorial males per plot. This suggests nonrandom use of this hardwood forest habitat, and selection at a microhabitat scale; two hypotheses that are supported by the relatively large number of significant results obtained.

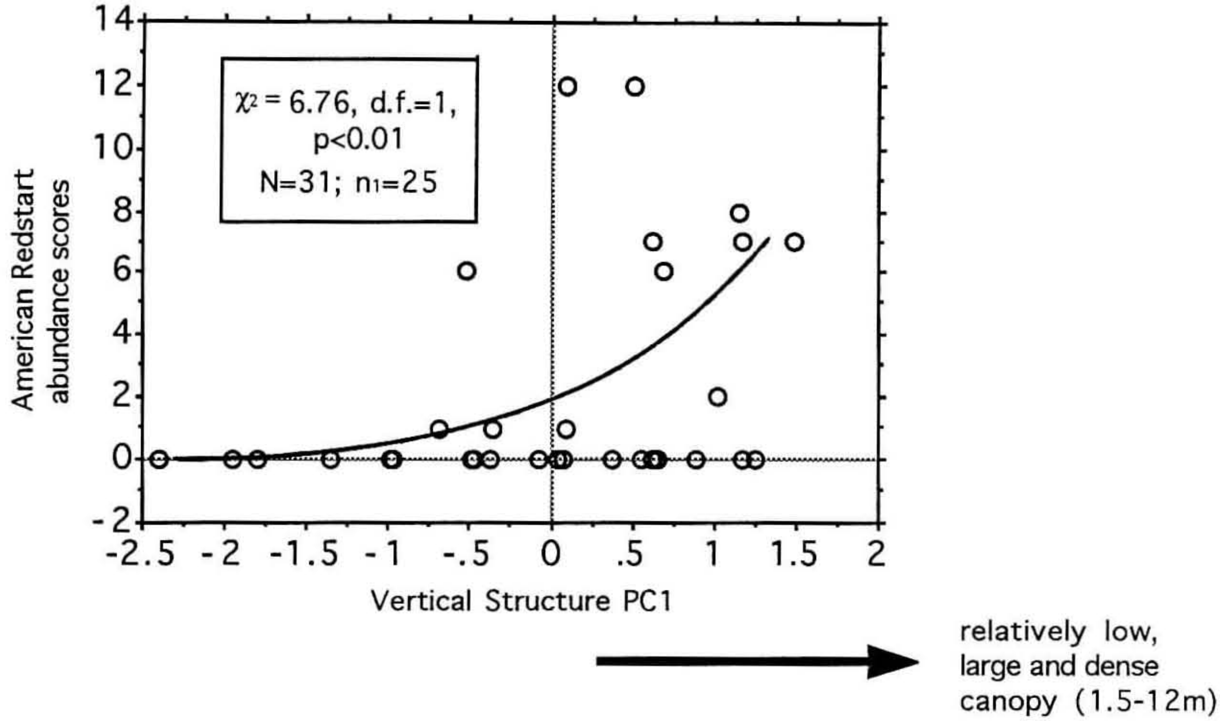


Figure 36. Relationship between American Redstart (*Setophaga ruticilla*) abundance scores and Vertical Structure PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

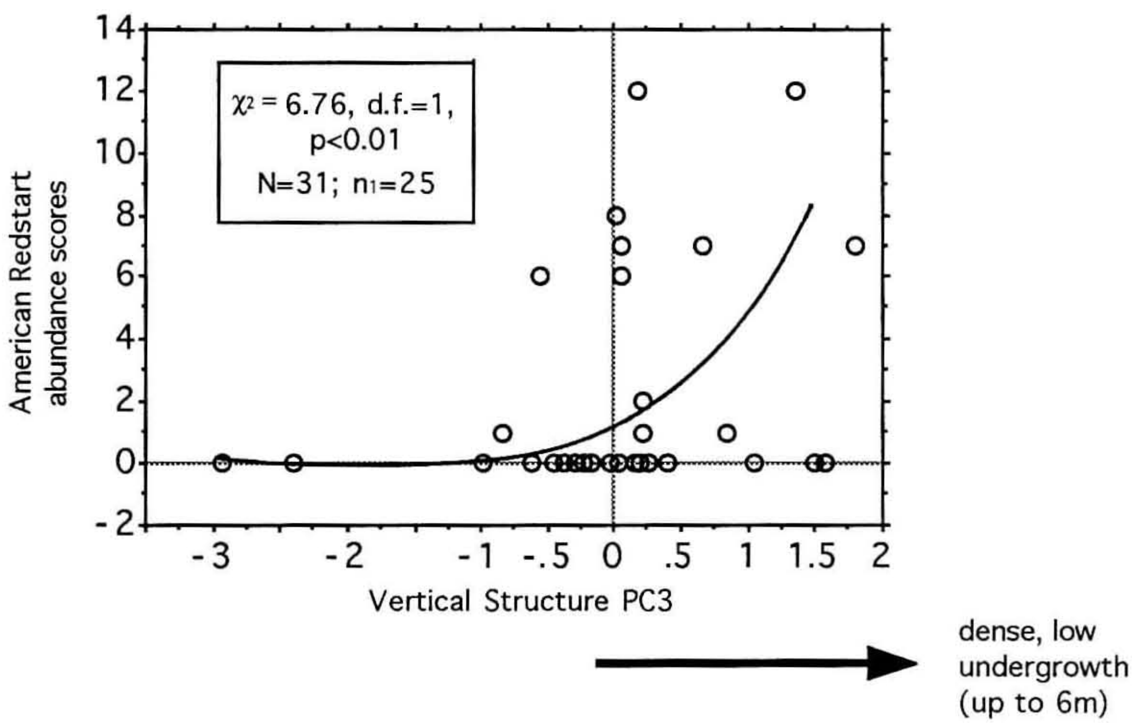


Figure 37. Relationship between American Redstart (*Setophaga ruticilla*) abundance scores and Vertical Structure PC3. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

Both relatively low and dense regrowth habitat (1.5m - 12m) (Figure 35) and dense low undergrowth habitat (0m - 1.5m) (Figure 36) proved to support more territorial male American Redstarts than did other habitat conditions. This suggests that dense vegetation from the ground up to about 12m provides suitable foraging substrate, a suggestion supported by Sherry (1979). The diversity of foliage would provide ample vertical space for vertical foraging separation of the sexes, while a dense sapling layer would provide numerous sites for nesting.

A significant positive relationship was also found between redstart abundance scores and increasing maple and ironwood composition of the plots (negatively associated with tree species diversity) (Figure 38). This suggests that these tree species may provide superior foraging substrate for redstarts , although the possibility that maple-ironwood habitat may simply provide the most suitable habitat structure may underlie these results. In support of this theory, negative correlations between the vertical structure apparently used by redstarts (Vertical Structure PC 3; see Figure 37), and high coniferous composition (Tree Species Diversity PC1) as well as high Basswood composition (Tree Species Diversity PC3), suggest other dominant tree species lack suitable habitat structure for redstarts (see Table 5). The use of a diversity of habitats by American Redstarts across their range, also supports this last hypothesis.

Finally, a significant positive relationship between habitat contiguity, and negative relationship with distance to water was shown for redstart abundance scores (Figure 39). Although both high densities of maple-ironwood as well as relatively low, dense regrowth habitat correlate positively with contiguity and low distance to water ($r= 0.356$, $r= 0.409$, respectively; see Table 5), the significance of the relationship with landscape variables suggests a real influence on habitat use by territorial males. Since redstarts in the Lake Opinicon region regularly use habitats at a variety of distances from water bodies, the contiguity of plots appears to be the important factor in habitat use. This suggests detrimental effects of fragmentation and small tract size, which remain to be substantiated.

Concerns of Forest Management Practices

Cartwright (1987) suggested that control of forest fires decreased the number of regenerating forest stands, thus decreasing habitat used by this

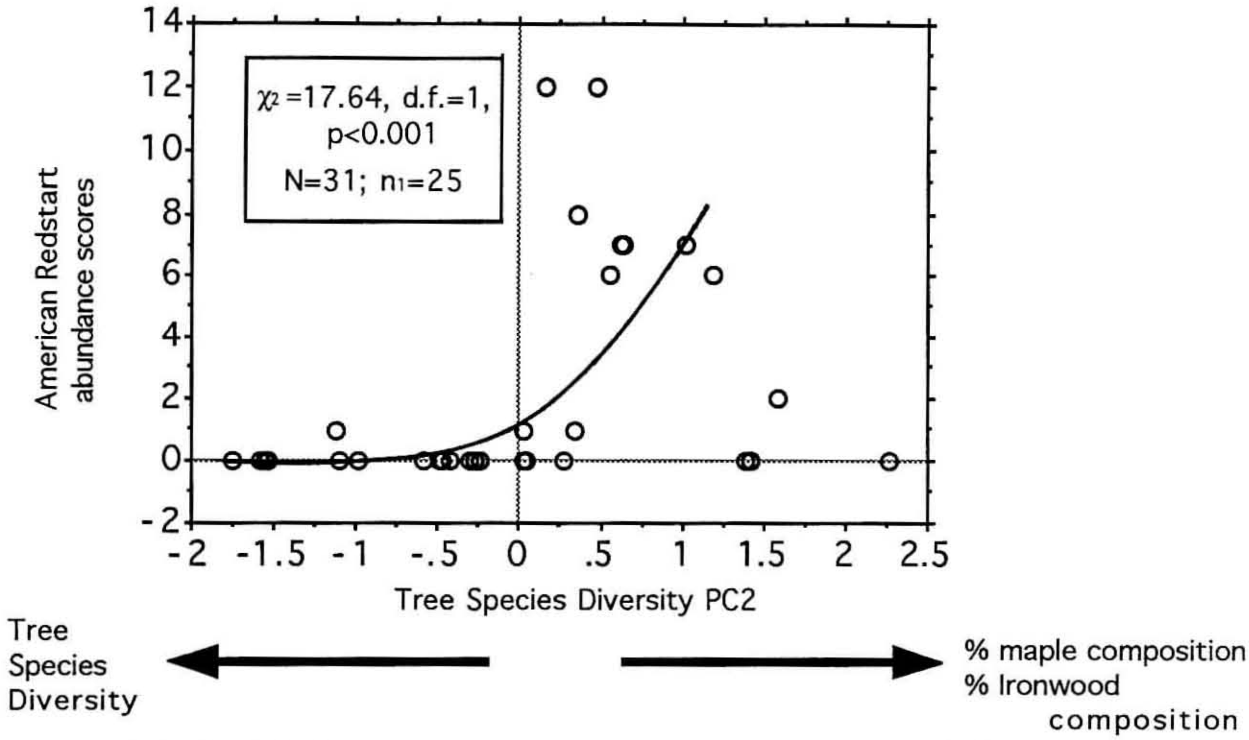


Figure 38. Relationship between American Redstart (*Setophaga ruticilla*) abundance scores and Tree Species Diversity PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

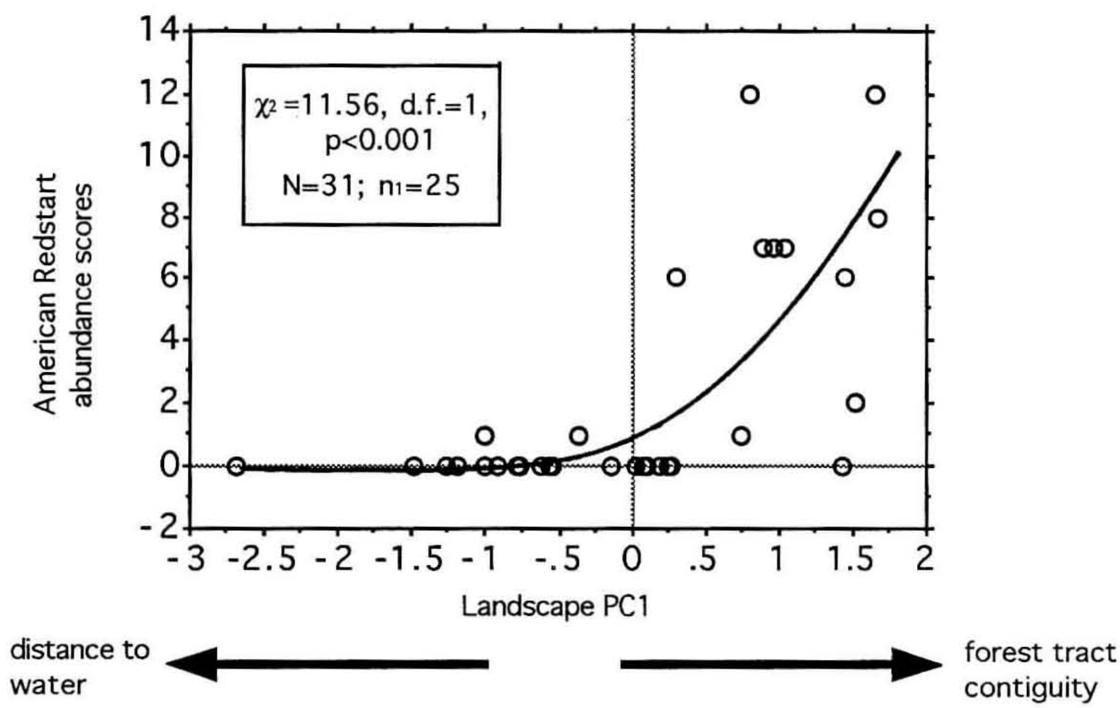


Figure 39. Relationship between American Redstart (*Setophaga ruticilla*) abundance scores and Landscape PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

species. Regrowth forest, however, proves to be common in the Lake Opinicon area, and is indeed heavily used by the American Redstart. In mature forest, tree falls, pond edges, and various areas of subcanopy growth provide habitat for redstarts as well. Silvicultural practices that thin canopies, allowing heavier understory growth could very well increase suitably of habitat for this species. In addition, plantations where thinning allows deciduous undergrowth to prosper could increase redstart habitat.

The small size of most plantations, however, may not be able to attract or sustain a population of American Redstarts, even if habitat is suitable. This is based on evidence that habitat contiguity is associated with redstart habitat use, which further suggests that management on a landscape scale could influence populations of this species. More evidence is needed on the proximate effects of such fragmentation and isolation of forest tracts.

Preliminary Recommendations

At the stand scale, silvicultural practices may well increase habitat suitability by increasing undergrowth and subcanopy growth in forest stands. Removal of foliage up to approximately 12m may reduce the suitability of this habitat. More information on the effects of conifer plantation management promoting deciduous undergrowth and regrowth, and use by American Redstarts is needed. In addition, negative effects of forest fragmentation on habitat use are suggested, although more information on the proximate causes and effects of such landscape alterations are required before specific recommendations can be made.

Ovenbird (*Seiurus aurocapillus*)

This wood warbler spans a broad geographical breeding range, extending across Canada and south through the eastern United States (AOU 1983). Its wintering range is also large, extending from Central America and the Caribbean, south to northern South America (AOU 1983).

Not surprisingly, the Ovenbird occupies a broad range of habitats throughout its breeding range. These include all types of mature deciduous, mixed, and coniferous forest, with little regard for tree species composition (Hann 1937; Kendeigh 1946; Martin 1960; Collins *et al.* 1983; Ellison 1985; Peck and James 1987; Armstrong 1987; Eaton 1988). Extreme habitats include Pitch Pine-oak forest (Eaton 1988), young aspen stands (Ellison 1985), spruce-fir forest (Collins *et al.* 1983; Ellison 1985), and typical mature hardwood forest (e.g. beech-maple-hemlock forest - Kendeigh 1946).

A preference for deciduous vegetation was suggested by Sherry and Holmes (1985) in New Hampshire; however, this may represent lower abundances in the spruce-fir forests of the area. Collins *et al.* (1983), however, contend that the Ovenbird's association with conifers may be a secondary one, as they occur only in mixed coniferous-deciduous vegetation. While technically deciduous vegetation may be present in all Ovenbird habitat, some habitats, such as spruce-pine forest of the Adirondacks (Eaton 1988), have only a few deciduous trees intermingled, suggesting that the suitability of habitat for use by Ovenbirds may not be as largely influenced by the conifer composition as Collins *et al.* (1983) suggest.

Eaton (1988) describes habitats where Ovenbirds does not occur, which include cherry-aspen successional woods, as well as pure conifer stands in the Adirondack mountains of New York. Ellison (1985) echoed a similar absence of Ovenbirds from stunted coniferous alpine forests of Vermont. In addition, smaller numbers of this species were described from denser aspen groves (old burn sites) in New York (Eaton 1988).

With such a variation in habitats used, parameters that may govern Ovenbird habitat selection are difficult to assess. Armstrong (1987) suggested a preference for closed canopy forest with little ground vegetation in Ontario, while James (1971) suggested greater use of well-developed, shaded forests in Arkansas. In New York state, Temple *et al.* (1979) (cited in Eaton 1988) found Ovenbird abundance to increase with density of trees; however, Eaton(1988) described suitable habitat to include more open forest, with little underbrush and an abundance of fallen leaves, logs, and rocks. James *et al.* (1984), while examining habitat associations of the Wood Thrush (which shares similar foraging habits to the Ovenbird), found the Ovenbird to use more dense understory, and often occupied different habitats than the Wood Thrush, despite the fact that the two species were found to frequently co-occur.

Several authors have taken a different approach to examining the quality of habitat for this species. Smith and Shugart (1987) found Ovenbird territories to vary in both habitat characteristics, and prey abundance (Tennessee). Prey abundance increased from a pure conifer, or mixed conifer-deciduous habitat, to a pure deciduous habitat, which they attributed to differences in the microclimate patterns and chemistry of the forest litter layer

(Smith and Shugart 1987). Stenger (1958) found different results in Ontario, which suggested prey abundance to increase as a forest matured from an early successional stage to a late stage, with fewer more shade tolerant trees.

All of these studies together, fail to draw any definite and widespread conclusions as to habitat variables that may provide better quality habitat for Ovenbirds. The uniqueness of this wood warbler makes this question particularly interesting, as Ovenbirds spend most of their foraging time gleaning invertebrates from the ground and low vegetation (Hann 1937; Sabo and Holmes 1983). Nests are uniquely dome-shaped, and are located on the ground, often in a variety of situations, and usually hidden to some degree in surrounding vegetation (Peck and James 1987). Kendeigh (1945) suggested that a supply of dead deciduous leaves used in the building of these dome-shaped nests may be a factor limiting habitat use by this species; however, Ovenbirds readily use thick-leafed grasses and a variable assortment of readily available leaves (pers. obs.), that would probably not play a major role, if any, in the selection of habitat.

Lake Opinicon Mature Hardwood Forest Stands

Second to the Red-eyed Vireo, the Ovenbird was the most abundant and widespread songbird on the forest plots. This species occurs in a variety of forest habitats throughout the Lake Opinicon area; however, this study suggests that habitat use is governed by factors either not measured in this study, factors too subtle to be evident or possibly obscured by other dynamics of the population, or perhaps Ovenbirds select habitat on a broader scale than some of the other songbird species.

Results showed almost no variation in Ovenbird habitat use with respect to habitat variables measured. Trends associated with conifer composition and Eastern White Pine foliage are unclear and obscure (see Figure 40). Ovenbird abundance was notably low in mature dominant Eastern White Pine stands, however, which may reflect lower prey abundance in this habitat, as suggested by Smith and Shugart (1987).

Concerns of Forest Management Practices

The widespread nature of Ovenbird occurrence within this forest habitat type (mature hardwood forest), suggests that other factors of population dynamics and prey abundance must be examined to predict the

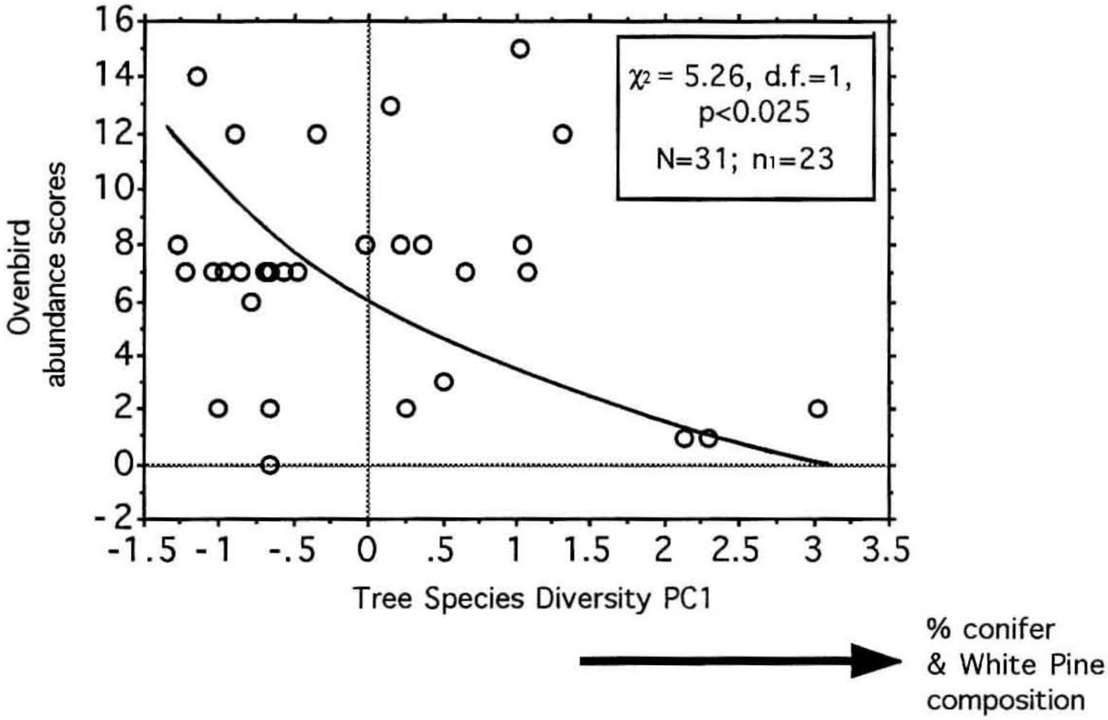


Figure 40. Relationship between Ovenbird (*Seiurus aurocapillus*) abundance scores and Tree Species Diversity PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

effects of silvicultural management practices on this species. The findings of Stenger (1958), where the maintenance of mature shade tolerant trees may be important to prey abundance, suggest that the maturity of forests may pose a concern for management with respect to Ovenbird habitat quality.

More importantly, are the findings of Villard *et al.* (1993) of decreased pairing success of Ovenbirds in fragmented forest tracts. Further implications of reduced reproductive success of those birds that do nest, due to higher predation rates of nests in forest tracts (Witcomb *et al.* 1981), and higher brood parasitism rates by cowbirds (Robinson 1992b), suggest fragmentation of forests may have an enormous impact on this species; more so than most moderate silvicultural practices at the stand level.

Hussell *et al.* (1992) found significant declines in this species at Long Point, Ontario (migration trends), while other authors note similar declines elsewhere (e.g. Robbins *et al.* 1989b). The various negative effects of forest fragmentation, as well as this species high susceptibility to cowbird parasitism (Hann 1937; Eaton 1988) may well be the agents causing such decline.

Preliminary Recommendations

From the stand level, populations are widespread throughout all variations of the mature hardwood forest type. Higher prey abundances may be evident in more mature forest conditions. More work on the population dynamics and specific parameters governing habitat use are required before recommendations may be made.

More important are the implications of forest fragmentation and cowbird parasitism in the decline of this species. All aspects of pairing success from chance of occurrence (Villard *et al* 1992) and pairing success, to rate of nest depredation and cowbird parasitism may well be affected by landscape parameters and forest fragmentation. Protection of large tracts of forest are needed to protect this species from severe population decline.

Scarlet Tanager (*Piranga olivacea*)

The Scarlet Tanager breeds through east-central Canada and the eastern United States, wintering far to the south, from Columbia to Bolivia (AOU 1983). The specific habitat requirements of this species are not well described relative to other songbirds, and may reflect habitat selection on a larger scale (see Wiens 1981; Wiens *et al.* 1987). The larger territories relative to other forest songbirds (e.g. wood warblers) do not lend this species to studies which involve varying abundances (densities) such as this study. Instead, pairs (territorial males) are evenly and moderately dispersed over forest habitat, as was reflected by the high percentage of plots where this species was found, but correspondingly low abundances (see Table 1; Figure 4).

What has been described for this species has been general "preferences" for habitat, which include fairly mature deciduous or mixed forest (Cadman 1987), with the deciduous habitat supporting tanagers more often than mixed (Peck and James 1987). Bull (1974) describes a preference for oak forest in southern New York state, which corresponds to the foraging tactics of hover-gleaning, well suited to the foliage structures of both oaks and beeches (Holmes and Robinson 1981). These foraging tactics often include the open inner branches of large canopy trees from which Scarlet Tanagers search outward from a fixed perch (Robinson and Holmes 1982).

In addition to foraging requirements, Scarlet Tanager nest sites may play a role in habitat selection and use. Prescott (1965) (cited in Smith 1988) describes a typical nest which surprisingly fits nests observed in this region. Nests are typically found in mature deciduous trees, "usually midway out on a nearly horizontal branch with an unobstructed view to the ground below and with open flyways from adjacent trees to the nest" (Prescott 1965). Nests are typically 4m - 9m off the ground, most often in mature maples, beeches and hemlocks (Peck and James 1987).

The Scarlet Tanager has been a central example of a neotropical migrant songbird highly susceptible to habitat alterations with respect to landscape. Minimum forest patch size required for this species is relatively large in comparison to many other songbirds, and has been described as 10ha (Galli *et al.* 1976), with a distinct preference for forested areas ≥ 20ha in size (Robbins 1984). In addition to patch size requirements, Villard *et al.* (1992) suggested patch isolation (from extensive tracts of forest) may also play a role in the use of forest tracts by this species in eastern Ontario. Thus, there is no doubt that extensive forested areas are essential to this species.

Lake Opinicon Mature Hardwood Forest Stands

Cadman (1987) describes the highest abundances (densities per 10km x 10km square) to include the forests of this area, stretching across to Algonquin Provincial Park (Canadian Shield). The extensive forest tracts of this area are undoubtedly key to these populations, and thus it proves disappointing that no results obtained from this study provide insight into the tanager's specific habitat requirements.

One negative trend ($p<0.10$) was found with regards to tree species diversity (Appendix 9), which supports the claim of Peck and James (1987) that deciduous woods are more heavily utilized than are mixed. Scarlet Tanagers appear to utilize forest plots with a lower coniferous and Eastern White Pine foliage component more frequently than other mixed habitat. Other than this trend, territorial male tanagers were widely dispersed among plots, in low numbers (always ≤ 2, and usually only 1 per plot) (Table 1).

Concerns for Forest Management Practices

The use of larger trees by this species suggests that this may be a factor to consider with respect to forest management practices. Oaks and beeches may prove important foraging trees (Holmes and Robinson 1981). The specific nesting requirements of tanagers may require some heterogeneity of habitat so that appropriate nesting situations may be found that maintain a degree of nest concealment. Nests are particularly vulnerable to Brown-headed Cowbird parasitism (Whitcomb *et al* 1981; Ambuel and Temple 1982), thus management practices influencing the latter species should be considered carefully.

On the whole, the Scarlet Tanager populations may well be able to cope with selective cutting within the habitat used. Of greater concern, is the landscape perspective of forest management, as this species appears to be more susceptible than most to negative impacts of forest fragmentation (Whitcomb *et al* 1981; Ambuel and Temple 1982).

Large forest tract preservation and increased research into the proximate effects of forest fragmentation and population/metapopulation dynamics are particularly needed for this species. In addition, assessing sustainability of Scarlet Tanager populations in all forest tracts, and the effects of predation, parasitism, and edge is a priority. Scarlet Tanager populations are known to oscillate, with heavy mortality associated with varying year to year environmental conditions (Zumeta and Holmes 1978), thus a population that cannot sustain such population fluctuations may not protect this species from population bottlenecks or local extinctions due to chance.

Preliminary Recommendations

The maintenance and protection of extensive forest tracts (in particular deciduous tracts) is essential to this species. Selective silvicultural practices must maintain some large canopy trees, as well as species diversity among them (notably oak and beech). A heterogeneous habitat with nest-site opportunities may also be a requirement of this species that should be incorporated into forest management practices. Much more information on specific habitat requirements and population dynamics on all scales are required for this species, as well as information on the proximate influences of forest fragmentation which impact this species so heavily.

Rose-breasted Grosbeak (*Pheucticus ludovicianus*)

The Rose-breasted Grosbeak breeds in the northeastern and eastcentral United States, north into eastern and much of western Canada to British Columbia and southern Northwest Territories (AOU 1983). This species was found by Hussell *et al.* (1992) to have declined significantly (migration counts at Long Point, Ontario), suggesting that it is a species to monitor in the future.

A range of deciduous habitats are used by this species across its range. Peck and James (1987) described second growth and open forests as more frequently used habitats in Ontario versus more mature and dense forest. Bonney (1988) described this species as thriving in cutover and disturbed habitats, using rich, moist, second growth deciduous forest, including areas close to stream edges and forested swamps. Pough (1946) describes the habitat used most often by this species as the interface between tall trees and low shrubs, often along streams, ponds, and marshes. Other habitats used by the Rose-breasted Grosbeak include suburban areas with shade trees and thickets (shrubbery) as well as mixed woods with similar characteristics mentioned above (Bull 1974; Bonney 1988).

Foraging behaviour of this species can be characterized as gleaning or hover-gleaning (Sabo and Holmes 1983). Such behaviour appears variable, however, with a broad range of vertical heights used (Robinson and Holmes 1982; Sabo and Holmes 1983). Use of taller trees for both foraging (Sabo and Holmes 1983; Ellison 1985), as well as singing perches (Ellison 1985), may be an important habitat component for this species. In addition, Sherry and Holmes (1985) describes use of cutover vegetation (feeding on fruits)

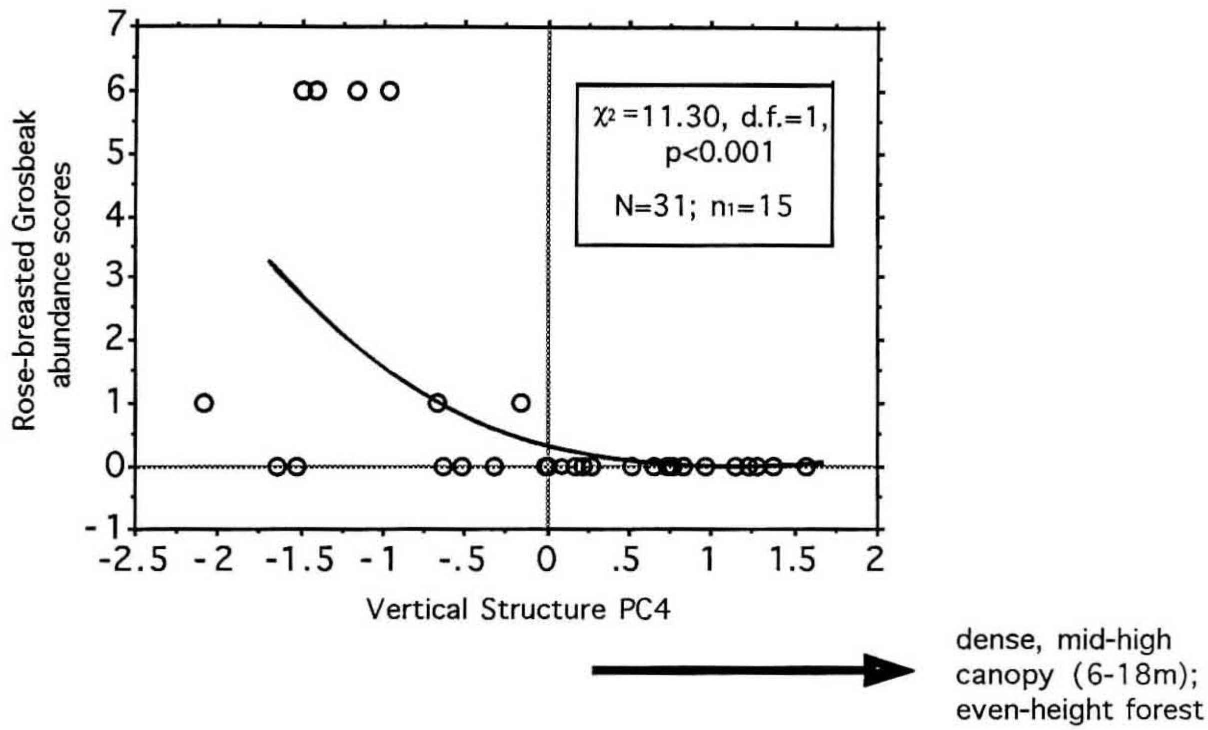


Figure 41. Relationship between Rose-breasted Grosbeak (*Pheucticus ludovicianus*) abundance scores and Vertical Structure PC4. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

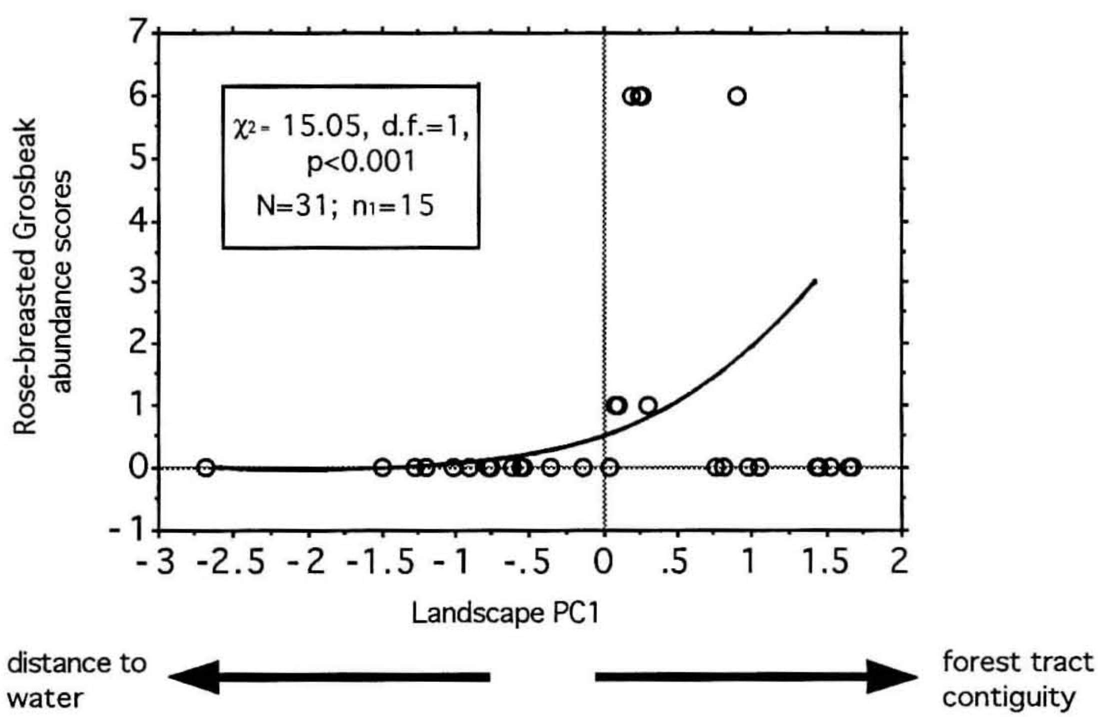


Figure 42. Relationship between Rose-breasted Grosbeak (*Pheucticus ludovicianus*) abundance scores and Landscape PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

immediately following breeding, suggesting that proximity of suitable areas for post-breeding foraging may be important.

Nests are frequently at woodland edges, often in saplings of bushes 1.8m - 3.7m in height (Peck and James 1987). Other than these general characteristics, no other important habitat components appear to be required for nesting.

Lake Opinicon Mature Hardwood Forest Stands

The Rose-breasted Grosbeak is fairly common in the Lake Opinicon area; however, it appears to have declined in recent years (pers. obs.). In the study plots, this species was not common or evenly distributed, suggesting differential habitat use and perhaps that hardwood forest habitat is not the primary habitat used by this species.

Significant results were obtained for two environmental components. The first was a negative association between even height and fairly tall forest and habitat use by this species (Figure 41), suggesting that more diversified habitat structure is required. The location of this even, tall forest relative to edge habitat may indirectly result in a lower use of mature forest, frequently found in the interior of forest tracts.

A significant relationship between Rose-breasted Grosbeak habitat use and decreased distance to water/increased contiguity of forest was also found (Figure 42); the former aspect supporting previous literature. Contiguity of forest tracts, however, is probably not a factor influencing this relationship, as Eagles (1987) describes this species as capable of breeding in relatively small blocks of forest. On the other hand, high use of habitat proximate to streams, ponds, and other water sources have been described in literature (see above) and is likely supported by these results. The availability of both mature trees and bushy second growth bordering water is probably the underlying relationship between habitat use and proximity to water.

A trend between proximity to agricultural/suburban clearings and habitat use by this species was also found (Figure 43), probably indicating the presence of large trees with second growth habitat along terrestrial edge habitat as along waters edge above. A preference for nest sites near forest edge described by Peck and James (1987) is supported by habitat use in the Lake Opinicon area; however, whether this reflects more suitable nest sites in this

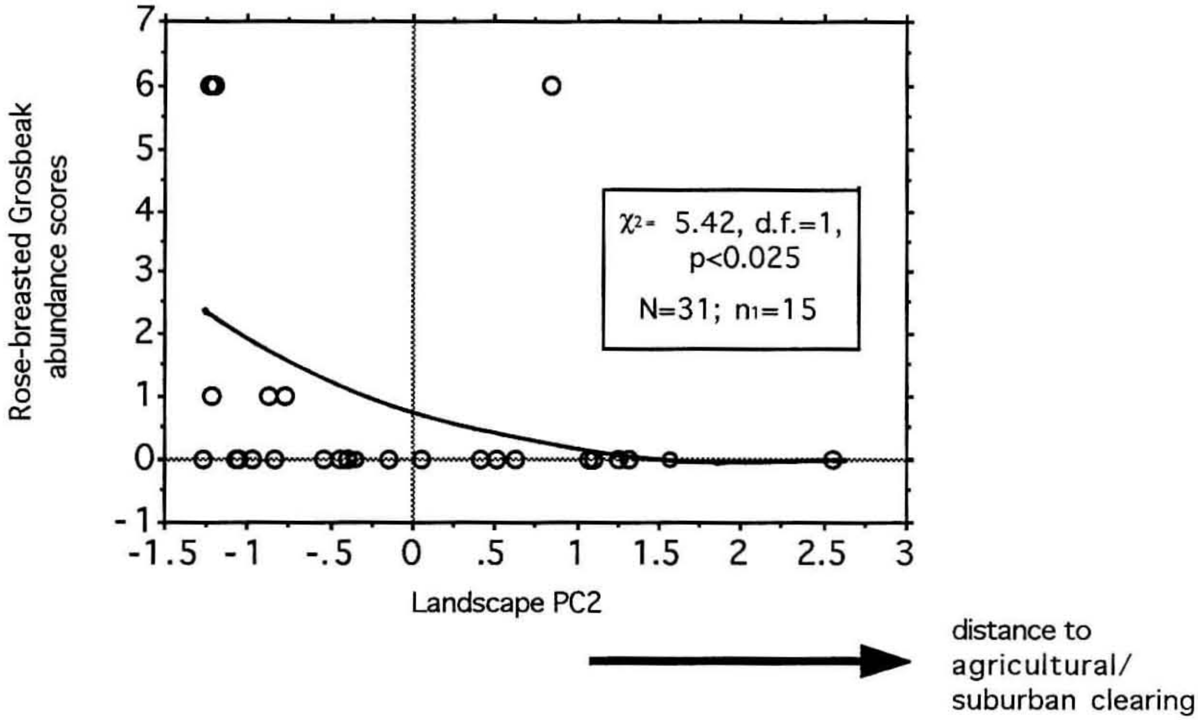


Figure 43. Relationship between Rose-breasted Grosbeak (*Pheucticus ludovicianus*) abundance scores and Landscape PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

edge habitat, important fruit sources for after breeding, or other influencing factors, remains unclear.

Concerns of Forest Management Practices

As far as silvicultural practices are concerned, little can be advised with respect to this species. Use of second growth and mature trees suggest that both should be maintained in silvicultural practices; however, to what degree this species requires these characteristics is unclear. In addition, significant declines in this species (Hussell *et al.* 1992) suggest more detailed information is required, especially in relation to differential reproductive success in different habitats. This includes information on nest predation and cowbird parasitism which are known to affect edge-nesting species (Wilcove 1985; Yahner and Scott 1988).

Preliminary Recommendations

Much more information is needed on differential reproductive success in different habitats before recommendations can be made. The use of edge habitat by this species suggests selective silvicultural practices may be unimportant; however, the recent population declines warrant increased investigation.

Chipping Sparrow (*Spizella passerina*)

This small sparrow breeds throughout North America, migrating a relatively short distance to winter across the United States (AOU 1983). Ground foraging is common for this species, with open, dry habitats most suitable. In fact, the Chipping Sparrow's reliance on open habitat enabled it to prosper with the clearing and settlement of North America by Europeans (Reilly 1964; Stull 1968; Ellison 1985; Arbib 1988). While previously occupied habitats include open grassy areas and clearings, woodland edges, and more open forest, this species now frequents an assortment of urban, suburban, and rural habitats, including farms, city parks, roadsides, and suburban lawns (Stull 1968; Ellison 1985; Middleton 1987; Arbib 1988). Nesting requirements of this species are few, with most nests being 0.9m - 2.2m off the ground, most often in coniferous vegetation (Peck and James 1987). Thus, it appears that the Chipping Sparrow is only restricted by the openness of the habitat, with some preference for drier areas (Peck and James 1987).

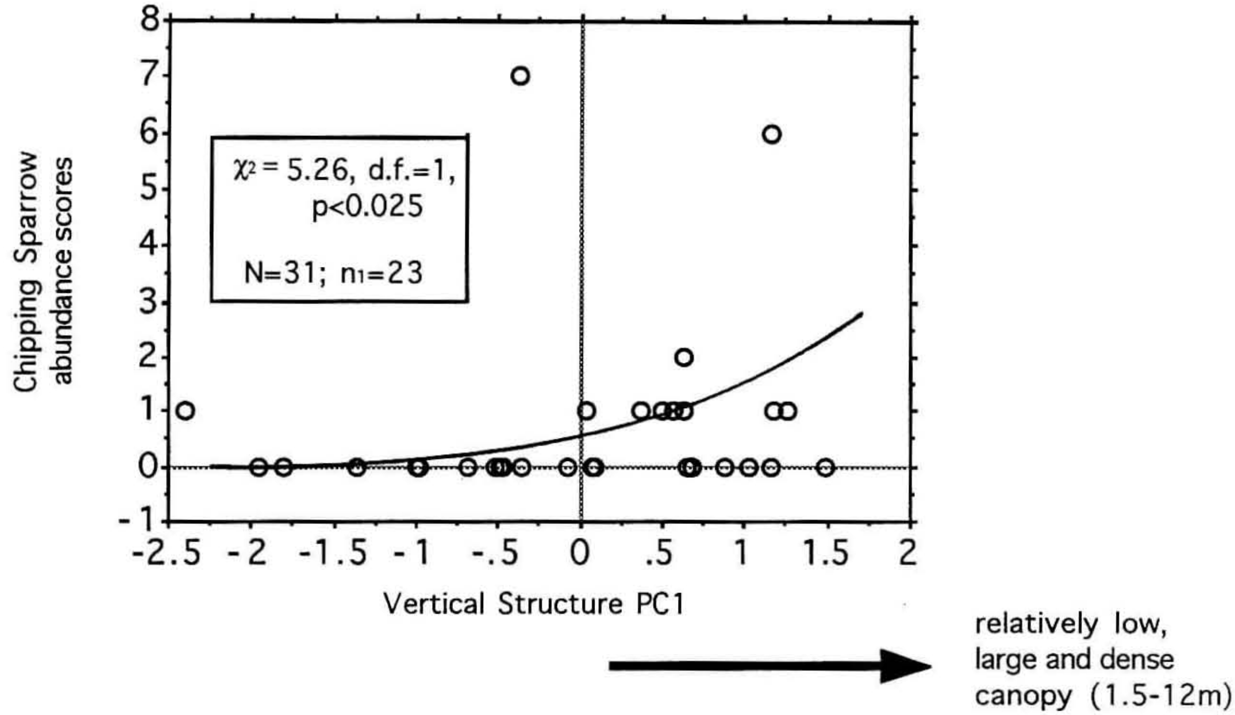


Figure 44. Relationship between Chipping Sparrow (*Spizella passerina*) abundance scores and Vertical Structure PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

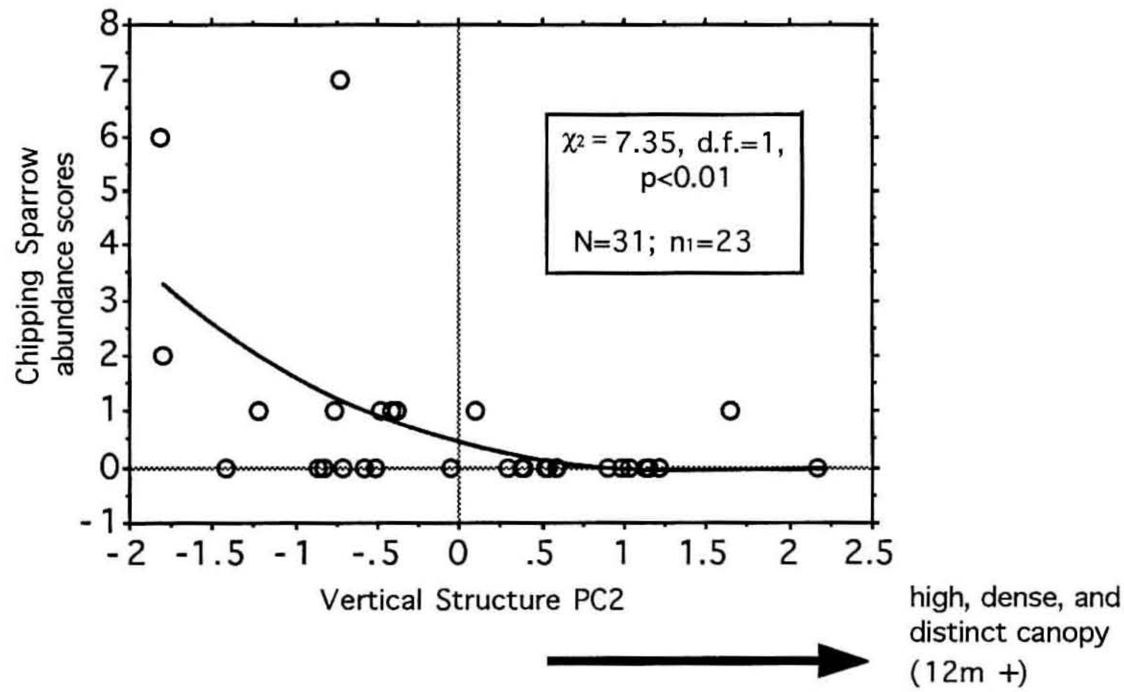


Figure 45. Relationship between Chipping Sparrow (*Spizella passerina*) abundance scores and Vertical Structure PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

In Ontario, this species is common, reaching its peak densities (per 10km x 10km square) in the region of Frontenac Provincial Park, just west of the Lake Opinicon study site (Middleton 1987). In both areas, this species was probably always found in high numbers, inhabiting the open rocky outcrops characteristic of the shield area. These rocky outcrops provide edge habitat and stunted Eastern White Pines and Red (and to a lesser extent, White (*Quercus alba*)) oaks which are used as singing perches. In addition, an abundance of Red Juniper (*Juniperus virginiana*) provides ample nesting sites, while the grassy, moss- and lichen-covered rock provides substrate for foraging. Chipping Sparrows can also be found in Eastern White Pine-dominated habitats, where mature trees with little undergrowth provide the open habitat required.

Lake Opinicon Mature Hardwood Forest Stands

As the previous discussion suggests, the Chipping Sparrow is not characteristic of the mature deciduous forest of the survey sites. It instead was recorded on the outskirts of the plots, especially where they came in close proximity to the rocky outcrops described above.

The trends observed in Chipping Sparrow habitat utilization indeed relate to the close proximity of open areas, which probably form the bulk of the territories of these individuals. Both the large relatively low, large and heavy canopy (Figure 44), and the high density of small DBH trees (<10cm DBH) (Figure 46) are common characteristics of deciduous forest in close proximity to rocky outcrops. In addition, a positive correlation between these two habitat characteristics ($r=0.434$, Table 5), suggest these parameters to often be characteristic of a common habitat.

The negative association between Chipping Sparrow abundance scores, and high, dense-canopy habitat (Figure 45), and a high density of logs (≥ 20cm diameter) ($p<0.10$) (Appendix 9), continue to support low use of deeper, more mature forest by this species. Incidentally, no trends with respect to landscape components is largely due to the lack of measurements on the distance of plot centers to naturally open areas such as rocky outcrops and open, dry woodland (see Methods).

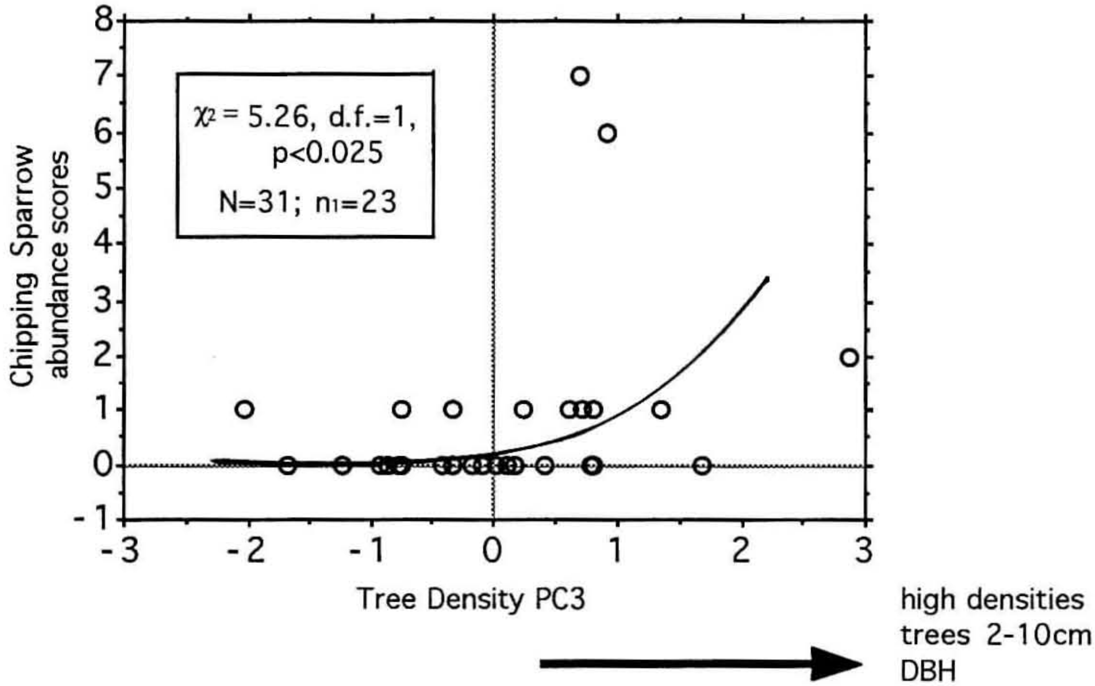


Figure 46. Relationship between Chipping Sparrow (*Spizella passerina*) abundance scores and Tree Density PC3. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

Concerns of Forest Management Practices

Silvicultural practices on mature hardwood stands could only increase habitat for this species, whose populations are stable and under no immediate threat. This stability is in spite of cowbird parasitism, which may significantly affect this species (Arbib 1988). Although extensive clearing of forest tracts for agriculture may decrease the availability of suitable habitat (Middleton 1987), any management practice that would increase edge and/or open forest habitats to the extent required by this species, would result in increased suitable habitat. To date, there is no evidence of detrimental effects of Chipping Sparrows on more typical forest species, thus, detrimental effects of past increasing Chipping Sparrow populations do not appear themselves to be detrimental.

Preliminary Recommendations

None. No management practices should be based on or altered by habitat requirements of this species.

Northern Oriole (*Icterus galbula*)

The Northern Oriole breeds across North America, north to southern Canada and south to Mexico (AOU 1983). The eastern subspecies, the "Baltimore" Oriole is found east of the Great Plains. In winter, both subspecies can be found from Mexico through northern South America, making this species a typical Neotropical migrant songbird.

Breeding habitat used by the Northern Oriole is characteristically tall but open deciduous forest, often along edge bordering water or open terrestrial habitat (James 1971; Flood 1987; Peck and James 1987; Connor 1988). Open deciduous habitats are frequently used, including fields with shade trees, orchards, and suburban areas (Bull 1974; Flood 1987; Peck and James 1987).

James (1971) further described habitat use of this species to be restricted to areas of large trees with clearings below. Ellison (1985) also described this species absence from dense forests, which lack the characteristics described by James (1971).

The dependence on large trees may partly reflect the requirements of nest sites, which are most commonly 5.5m - 10.7m above the ground in tall trees (Peck and James 1987; Connor 1988). Nests are woven pockets, often

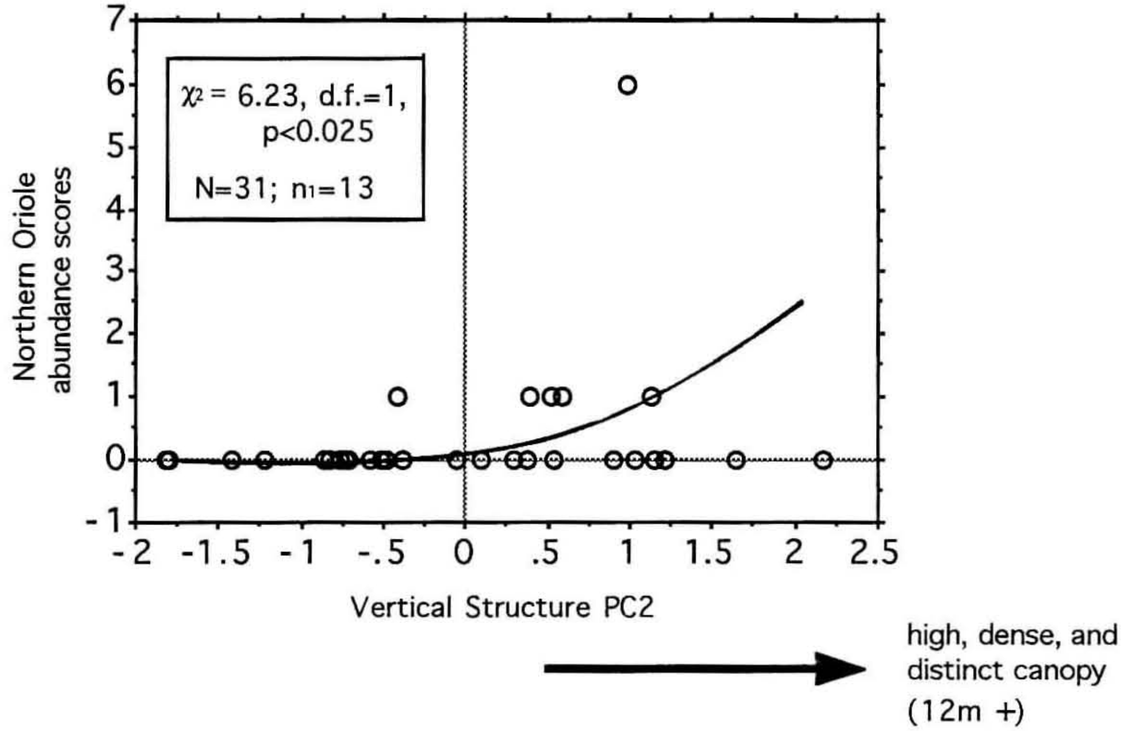


Figure 47. Relationship between Northern Oriole (*Icterus galbula*) abundance scores and Vertical Structure PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

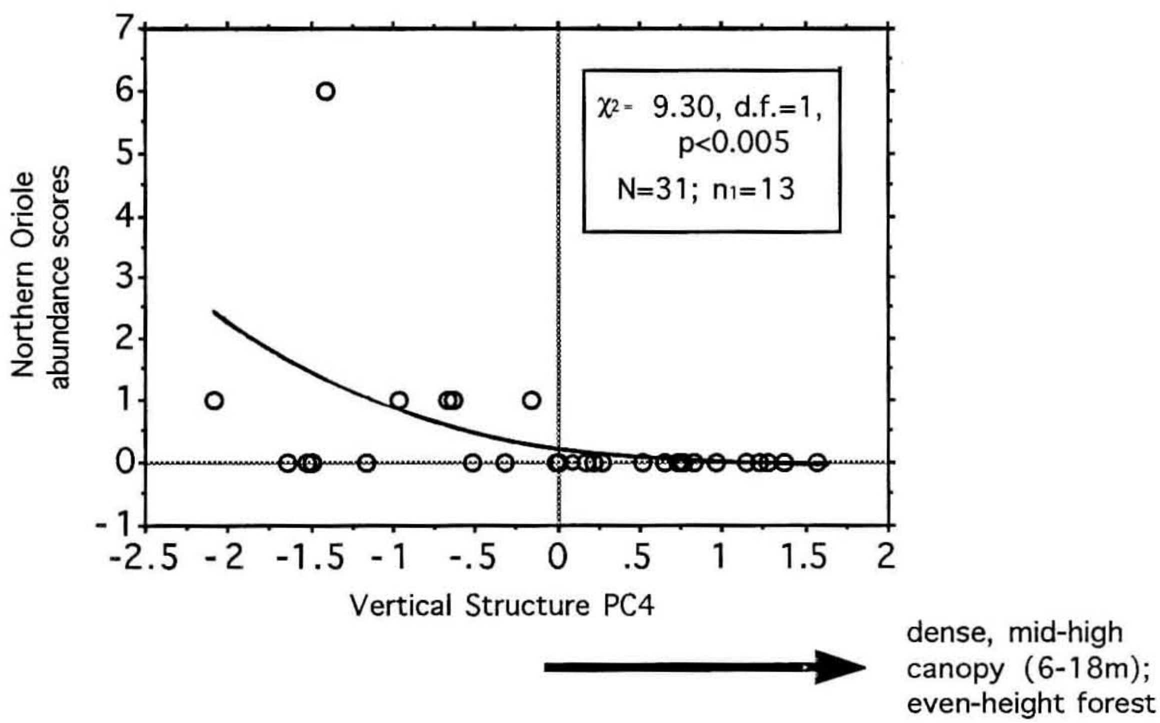


Figure 48. Relationship between Northern Oriole (*Icterus galbula*) abundance scores and Vertical Structure PC4. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

placed near the edge of woodlands at clearings or bodies of water (Peck and James 1987; Connor 1988). Deciduous trees are exclusively used; however, tree species are variable, and include elm, maple, poplar, willow, birch, and oak (Peck and James 1987).

Lake Opinicon Mature Hardwood Forest Stands

The Northern Oriole is a common and widespread species in the Lake Opinicon area, however, it is not a dominant one within the mature hardwood forest of this study. In this habitat, its occurrence is not evenly spread, suggesting differential habitat use with respect to hardwood forest.

Heavy use of high, distinct canopy habitat (Figure 47), supports the literature which suggests a requirement of large deciduous trees by this species, and supports James (1971) who suggested fairly open area below the canopy to be a feature of Northern Oriole habitat. A negative relationship between habitat use and even height, mature forest (Figure 48) may reflect less open habitat, more distant from edge, and thus overall less appropriate for use by this species.

Increased use of edge habitat is also supported by landscape relationships with oriole abundance scores (Figures 49 & 50). Only habitats relatively near to water and agricultural/suburban clearings were used by this species. A positive relationship with contiguity of plots is probably an artifact of its negative relationship with distance from water (see Figure 49), as this species regularly uses small patches of trees, including large shade trees in fields and urban parks.

Concerns of Forest Management Practices

The Northern Oriole is not an interior forest species, prone to disturbance from selective silvicultural practices. In fact, both Flood (1987) and Connor (1988) suggested that this species increased in abundance with increased disturbance of habitat. The heavy use of suburban-type habitat also suggests that this species is well adapted to thinning of forest. Nests, however, are prone to high predation rates by a wide variety of predator species, including American Crow (*Corvus brachyrhynchos*) and squirrels (Sciuridae) (Connor 1988). Thus, management practices that increase the susceptibility of oriole nests to predators should be carefully monitored.

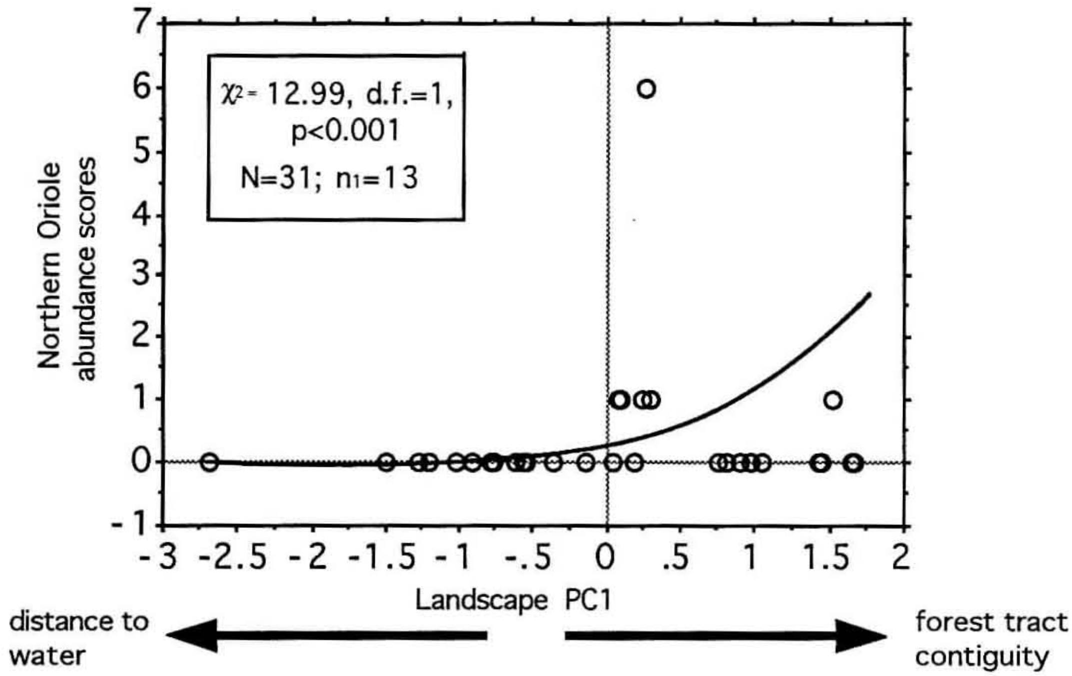


Figure 49. Relationship between Northern Oriole (*Icterus galbula*) abundance scores and Landscape PC1. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

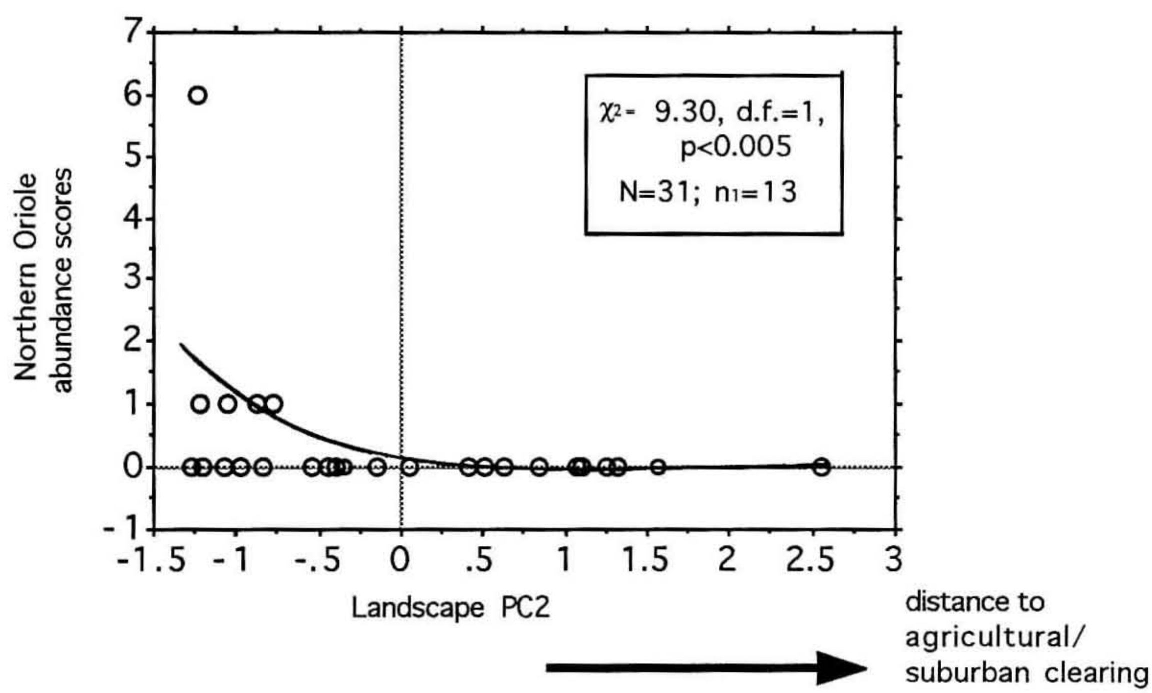


Figure 50. Relationship between Northern Oriole (*Icterus galbula*) abundance scores and Landscape PC2. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

Preliminary Recommendations

None. The Northern Oriole appears to be highly adaptable to forest disturbances, and may even benefit from them. More information of influences of management practices on predation rates of oriole nests, however, is needed to better assess silvicultural effects.

Conclusions

From these results, we can see that most forest songbirds may be affected by forest management practices in some way. If this is the case, then a compromise must be reached between management practices and conservation of songbird biodiversity. With the exception of fragmentation of habitat, different management practices appear to affect different songbirds in different ways. Thus, moderation and variety in management techniques may be the best solution to encorporating songbird interests in integrated forest management. Avoidance of fragmentation of habitat, however, is one important factor that may affect a large proportion of forest songbirds. Protection of large sections of forested habitat, whether under management or not, seems vital for the maintenance of sustainable songbird populations in the Eastern Ontario Model Forest region.

Part 3:

Trends in Songbird Diversity with Habitat Variables in Conifer Plantation to Mature Hardwood Forest Gradient.

Introduction

Replanting efforts using structured, uniformly-aged conifers often include a low tree species diversity and suggest only a limited resemblance to natural forest ecosystems. Depending on management practices, forest floors may be barren, foliage height diversity limited, and the songbird community markedly different than that of more typical hardwood forest stands. The aim of this part of the study was to examine some of the relationships between bird species diversity and habitat characteristics across a range of plantation ages and compositions through to more typical hardwood forest types of the region.

Methods

Study Site

Study sites (plantations) were within 10km of the Queen's University Biological Station, Lake Opinicon, to facilitate access and decrease travel time to and from sites. A total of three sites were chosen, all in the area to the north-east of Chaffey's Lock, where agriculture and White Pine forest along with fragmented woodlots dominate the landscape (Figure 51). At each site, four 25m-radius plots were selected (except on one site where only three could be placed). In addition to these plots, one plot on the biology station point surveyed in 1992 was included in the study.

Plot Selection and Characteristics

A total of 12, 25m-radius plots were selected on the basis of the presence of planted coniferous trees (see Figure 51). The first site which contained four plots, was located along Chaffeys Lock Rd., just west of Hwy 15. This plantation forms part of the Limerick Forest managed by the OMNR (Brockville Area Office), and consists of mixed White and Red (*Pinus resinosa*) pine along with White Spruce (*Picea glauca*). The site is surrounded primarily by farmland, while deciduous growth is prominent within the site, especially in wet areas.

The second site is located on private land just to the north of the first site. This location was also surrounded primarily by farmland, with some overgrown and wet fields to the south. Habitat was mixed with planted White Pine (up to 10m), White Spruce as well as Red Maple, American Elm (*Ulmus americana*), and Black Cherry (*Prunus serotina*) mixed in.

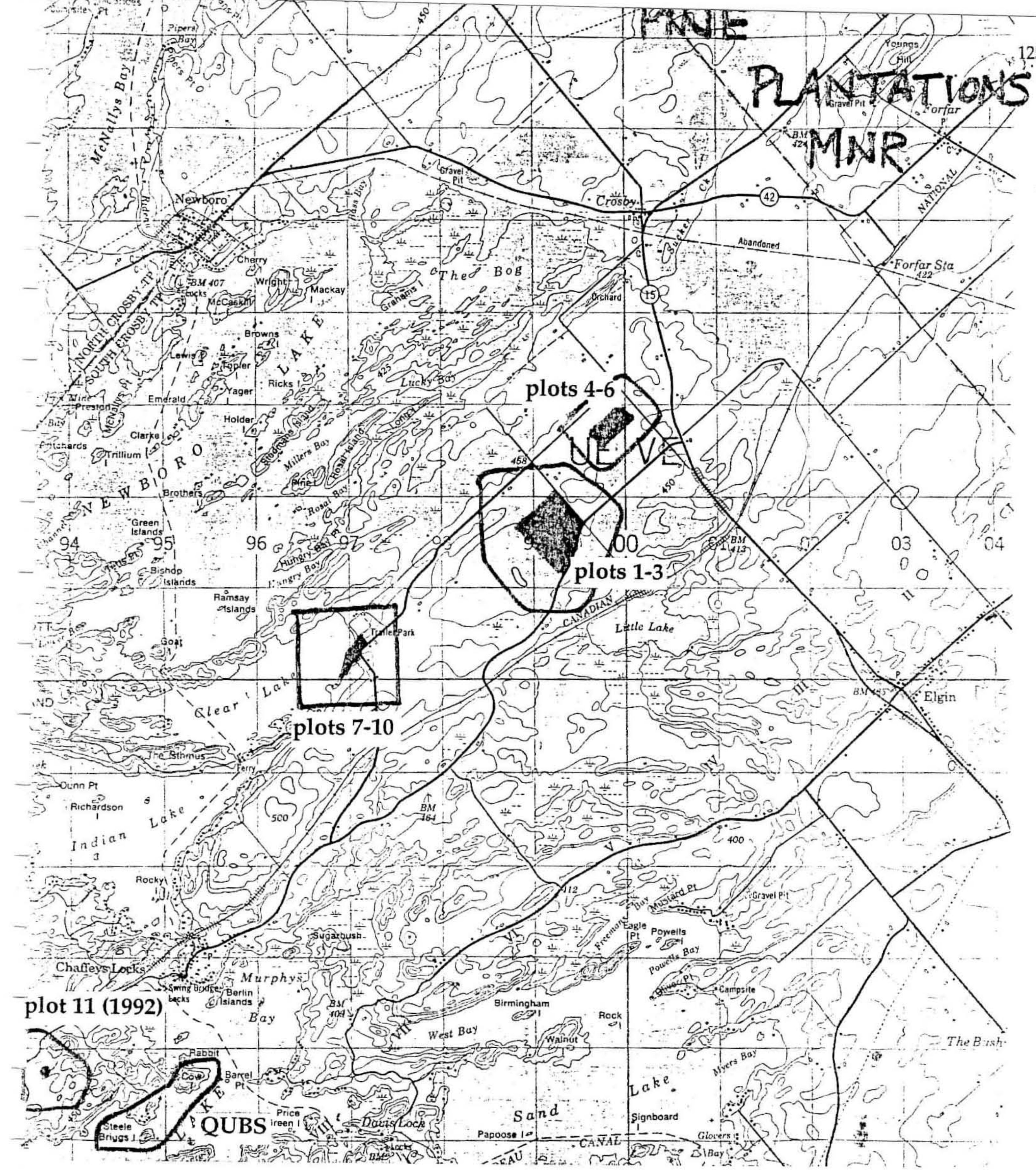


Figure 51. Location of 12, 25m-radius, pine plantation plots at four different sites northeast of Lake Opinicon.

The third site was located on Scouts Canada property (Camp Folly), and was located along the same road as the second site, to the west. This site was characterized by rows of White, Red, and Jack pine, with varying degrees of deciduous regeneration. This regeneration took place in the form of White (*Fraxinus americana*) and Red (*F. pennsylvanica*) ash, Red and Sugar maple, Basswood, Black Cherry, American Elm, and other less prominent species. Forest height ranged from 9m - 15m, while surrounding areas included farmland, deciduous woodland, natural White Pine stands (along Clear, Indian, and Newboro lake shorelines), and other planted conifers (e.g.. White Spruce).

The last site, included from 1992, was a mature and pure Red Pine stand (18-19m in height), surrounded by Sugar Maple- and Red Oak (*Quercus rubra*) -dominated deciduous forest. Unlike the other plots, undergrowth was totally absent, as were tree species other than Red Pine.

Plots were selected for their homogeneity of habitat, and for this reason, only 25m-radius plots could be accommodated by the characteristically small plantation sites. Thus, as in Part 2, plots were fixed-radius and circular, and were spaced out with centers preferably 150m apart or greater.

The subset of the birds recorded within a 25m-radius of the deciduous plot centers (Part 2) were included in this analysis (n=31). This provided a range of habitat variables to be examined with respect to effects on bird species diversity. See Part 2 (methods) for details of plot selection and characteristics.

Songbird Surveys

For plantation sites, surveys of territorial males within the 25m-radius plots were conducted as described in Part 2, the only difference being the radius of the plot. While this enabled results useful in this study, it did not adequately describe species that utilize the plantation sites, thus a list of these species is included in Appendix 10. Surveys were done in rotation with the hardwood forest plots, and the order of plots and sites follows that described in Part 2.

Unlike survey data in Part 2, the number of individual territorial males, their frequency of occurrence, and their species identity were used in the analysis. This enabled both an index of bird species diversity (BSD) using occurrence data to be calculated for these plots (see Variable Selection and Calculation below).

Habitat Measurement

Habitat was measured as in Part 2, with fewer replications due to the smaller plot size. Vertical habitat was measured 8X per plot, and was spaced out with one sample per portion (see Figure 3) at random distances (0-25m) from the center of the plot. Tree density and ground cover variables were not required for the analysis.

For the deciduous plots of Part 2, a subset of the habitat measurements within a 25m-radius of the plot center was used in this analysis. This corresponded to the replications of the plantation plots and roughly to their spacing as well.

Variable Selection and Calculation

(i) Bird Population Variables - A Bird Species Diversity index (BSD) was calculated for each plot using the equation adapted from MacArthur and MacArthur (1961) and MacArthur *et al.* (1966)

$$BSD = -\sum p_i \ln p_i$$

where p_i =the proportion of an individual species i to the total number of occurrences of territorial male songbirds. This differs from the use of this equation by MacArthur and MacArthur (1961) and MacArthur *et al.* (1966) who use abundance proportions for each species in the equation. In this case, the occurrence of the same individual territorial male within the plot on three different occasion would be given a value of 3, to provide a value of the relative use of the plots, and not the relative abundance of species
(as in Part 2).

(ii) Habitat Variables - Habitat variables used in the analysis and the calculations done to obtain them are listed below.

Tree Species Diversity (TSD) - calculated using the same equation for BSD, where $TSD = -\sum p_i \ln p_i$, and p_i = the proportion of an individual tree species i in the foliage of the plot. Thus, the vertical height data are used to calculate this variable.

Vertical Height Diversity (VHD) - calculated using the equation above, where p_i = the proportion of total foliage measured in the vertical height sampling that falls into a specific vertical height range i. The vertical height ranges were defined as 0-1.5m, 1.5-6m, 6-12m, 12-18m, and 18-30m.

Percentage Deciduous Foliage - calculated using the vertical height data, where the % deciduous vegetation = [$\sum$ deciduous foliage $\div$ $\sum$ all foliage].

Total Foliage Density- simply the sum of all foliage calculated in the vertical height sampling.

Statistical Methods

A multiple regression analysis was performed, with BSD as the dependent variable (y), and the four habitat varibles as independent (x). All variables were tested for normality, and one (deciduous composition) was transformed using the equation of Anscombe (1948) described in Zar (1984):

$$p' = (\sqrt{n}+0.5) \arcsin \frac{x+0.375}{n+0.75}$$

where n is the total foliage density, and x is the total deciduous foliage density.
Thus, with all variables relatively normal in distribution, the parametric multiple regression was an appropriate statistical test.

Results

The multiple regression analysis examining relationships between bird species diversity and the habitat components (tree species diversity (TSD), vertical foliage height diversity (VHD), % deciduous foliage composition (% dec.), and total foliage density (tot. fol.)) was not significant (F-test, F=0.25229, p=0.9065, n=43). T-tests performed for each habitat variable, examined relationships of each variable with bird species diversity. No significant relationships were found (TSD, t=0.50819, p=0.6143, n=43; VHD, t=0.5086, p=0.614, n=43; % dec., t=0.75391, p=0.4555, n=43; tot. fol., t=0.36049, p=0.7205, n=43). A plot of residual values versus expected y values showed fairly even distribution of points, with only one outlier (where BSD=0).

Discussion

The absence of significant results suggests that relationships between the habitat variables, which seem to characterize differences between plantation sites and hardwood forest sites, are not the primary influence on songbird species diversity. On the contrary, it seems that factors governing bird species diversity are more complex than simple effects of habitat variables.

An obvious test not performed here would be to compare bird species diversity between the two groups of plots: the plantations, and the hardwood forest plots. This was not done due to the fact that plantation sites were chosen, not to represent typical plantations, but instead to provide a gradient of habitat characteristics that would allow tests for relationships between BSD and habitat variables associated with plantations. Thus, plantation sites were highly variable in nature, ranging from a predominately deciduous plot with thin Jack Pine, to tall, mature and pure Red Pine stands with absolutely no deciduous foliage.

The results obtained from this study are not too surprising considering the many variables that affect bird communities and bird species diversity that were not controlled for in this investigation. Both the size and distance of tracts of forest have been shown to influence songbird occurrence in eastern Ontario plots (Freemark and Collins 1992; Villard *et al.* 1992; Villard *et al.* 1993). Other aspects such as predation has been suggested to influence habitat selection (e.g. Martin 1988; Kelly 1993), while adjacent habitats, including the proximity of edge, may increase bird species diversity even though the habitat being measured is not sustaining all bird species recorded.

Future research that controls more of these variables, and that takes this project a step further to investigate reproductive rates of songbird species, is required. Previous work suggests that vertical foliage height diversity may influence bird species diversity (MacArthur *et al.* 1966), while some species such as the Red-eyed Vireo, may utilize coniferous habitats, only if there is a small percentage of deciduous foliage intermixed (James 1987). This suggests that there may be relationships between plantation sites and BSD, especially with respect to plantation sites with low vertical foliage height diversity and with no deciduous foliage.

One final note regards the differences in songbird communities found in plantation sites versus mature hardwood sites. Appendix 10 lists all the bird species found in conifer plantation habitat, as well as those recorded outside plantation habitat on surveys. Species found within plantation sites are frequently different from those typical of mature hardwood forest sites, with many more conifer-specific, often more typically northern, songbirds inhabiting plantations. These differences in songbird communities between habitats may prove important if policy decisions regarding management of plantations for songbirds were to be made (i.e. which songbird community should be managed for).

A detailed follow-up study on the suitability of different plantation management practices on suitability for songbird habitat is underway for the 1994 season, undertaken by Dale Kristensen and Dr. Raleigh Robertson.

Part 4:

Avian Nest Predator and Brood Parasite Habitat Use

Introduction

Recent work has suggested pressures forcing the decline of many neotropical migrant songbirds to predominate on the breeding grounds, and more importantly, focus on aspects of reproductive success (Robinson 1992a;b; Martin 1992; Böhning-Gaese *et al.* 1993). Considering appropriate habitat features for management, Martin (1992) suggests nest predation to be the most important feature for four species of migrant songbirds, directly influencing these species' fitness components and thus the sustainability of their populations. Previous work has eluded to large effects of human land management on nest predation pressures on many songbird species (e.g. Wilcove 1985; Yahner and Scott 1988). Thus, examining variation in nest predator abundance with respect to habitat variables may be as important as the measurement of habitat use by the songbirds themselves.

In recent years, another complicating factor for breeding songbirds has been introduced to eastern North America, in the form of the Brown-headed Cowbird (*Molothrus ater*). Prior to European settlement, the cowbird followed herds of Bison (*Bison bison*) in the central plains, laying eggs in other birds nests and continuing to follow the nomadic herds. Today, the cowbirds have expanded and flourished in the newly cleared lands of the east, and have become a serious problem for many species of songbirds, parasitizing nests in such numbers as to become a potentially large factor in many songbird species' declines (Brittingham and Temple 1983; Robinson 1992b).

The goal of this section is to examine habitat relationships with three avian nest predators and the one avian brood parasite. Data obtained from surveys enabled ready assessment of such relationships; however, data from mammalian and reptilian nest predators, which are prominant in the Lake Opinicon area, was not available for analysis.

Methods

Study Site and Plot Selection

The plots used in both Part 2 and Part 3 were used in this analysis. Thus, a total of 43 plots were used, 31 from Part 2 (mature hardwood forest sites) and 12 from Part 3 (plantation sites).

Bird Surveys and Variable Definitions

Four species were surveyed for this analysis, three being avian predators of songbird nests, and one being an obligate brood parasite on a variety of forest songbird species. These species are, respectively, American Crow (*Corvus brachyrhynchus*), Blue Jay (*Cyanocitta cristata*), Common Grackle (*Quiscalus quiscula*) and Brown-headed Cowbird (*Molothrus ater*).

Surveys followed a different methodology than that used in Parts 2 and 3. Instead of fixed-radius plot surveys (Reynolds *et al.* 1980), unlimited distance point counts (Blondel *et al.* 1970; 1981) were used. The reasoning for using this method of surveying is that we were not interested in habitat use by these species *per se*, but instead were interested in their presence near the plot to be used as an indicator of potential nest predation and parasitism by the respective species.

The actual variables used in the analysis were indices of occurrance taken from the three surveys. The index of occurrance for each species was the sum of individuals recorded on all three surveys with no reference to distance from the point of observation.

Ecological Variables

Five variables were measured to test specific hypotheses for each of the four species. These variables are defined below.

Contiguity of Site - a relatively arbitrary estimated area in hectares of continuous forest that includes the point of observation (defined as above); estimated from ground surveys, aerial photographs (courtesy OMNR), and topographical maps.

Distance to Active Agricultural Site or Urban Site (eg. houses with lawns) - estimated in meters from the point of observation (ie. plot center with respect to plots defined in Parts 2 and 3).

Distance to Body of Water (ie. beaver pond, lake; not creek, small river) - estimated in meters from the point of observation (as above).

Percentage Coniferous Foliage - calculated using the equation (1- Percentage Deciduous Foliage) where the latter value was obtained directly from Part 3.

Total Foliage Density - taken directly from Part 3.

The five variables were tested against the following bird species:

American Crow occurrance index vs. - distance to active agric./urban
- total foliage density
-contiguity of site

Blue Jay occurrance index vs. - % conifer. foliage
- total foliage density
- contiguity of site

Common Grackle occurrance index vs. - distance to water body
- total folige density

Brown-headed Cowbird occur. index vs. - distance to active agric./urban
- % conifer. foliage
- total foliage density
- contiguity of site

Statistical Analysis

Each species was analysed separately, comparing each environmental variable (x) with the species occurrence index (y). Simple linear regression lines were then fit to the data using a non-parametric method of line fitting described by Brown and Mood and outlined in Daniel (1990). A test of the null hypothesis of $H_0 : ß = ß_0$ using the Brown-Mood method outlined in Daniel (1990) was carried out to test for a significant (a = 0.95) relationship between the environmental variable and individual species occurrence indices (see Discussion for reference to Bon Ferroni's correction). For cases where Ho was rejected, ß was calculated more precisely using Theil's method (Daniel 1990) and regressions were plotted with their respective confidence intervals, calculated using Theil's method also (Daniel 1990).

Results and Discussion

The results obtained suggest that the occurrence of several birds potentially detrimental to songbird nesting success, use habitat differently with respect to the habitat/landscape parameters examined (Table 7). Although these results provide no direct evidence regarding differential predation rates with respect to these environmental variables, the relative abundance of predators and brood parasites may provide a clue to differential reproductive success (e.g. as in Angelstam 1986). From the perspective of management for songbird habitat, it is important to examine each of these factors in detail.

Habitat Contiguity

Fragmentation of habitat has been of major concern, not only to the disruption of songbird populations themselves (e.g. Villard *et al.* 1992), but also to increased nest predation and brood parasitism rates (e.g. Robinson 1992b). No relationships were found, however, between the occurrence of potential detrimental avian species and the contiguity of forest tracts where plots were located.

Reasons governing these results may lie in the naturally mosaic nature of the habitat of Lake Opinicon, or more probably, other aspects such as the proximity to edge and amount of edge being the proximate factor associated with increased nest predation and brood parasitism (e.g. Wilcove 1985; Yahner and Scott 1988).

Distance to Agricultural or Suburban Clearing

Distance to agricultural or suburban clearing provides an index to artificial edge as well as the distance to these artificial habitats, and has been shown to affect nest predation and brood parasitism rates in songbirds (Wilcove 1985; Yahner and Wright 1985). Results from this work revealed negative relationships with both Blue Jay (Figure 52) occurrence and American Crow occurrence (Figure 53), two species which frequently utilize such habitats to a large extent.

American Crow frequently use agricultural resources and similar artificial habitats, and thus may be disproportionately common in these areas. Blue Jays are a species that has adapted well to suburban areas, especially where bird feeders provide supplemental resources (see Terborgh 1989).

Table 7. Significant relationships ($p < 0.001$) and trends ($p \leq 0.05$) between avian nest predator/brood parasite occurrence and landscape/habitat variables.

Landscape/ Habitat Variable	Avian Nest Predator /Brood Parasite	χ^2	degrees of freedom	p value	adjusted sample size†
Distance to Water Body	Brown-h. Cowbird *Molothrus ater*	9.26	1	<0.005	$n_1 = 39$
Foliage Density	Brown-h. Cowbird *Molothrus ater*	4.33	1	<0.05	$n_1 = 39$
Distance to Water Body	Blue Jay *Cyanocitta cristata*	8.40	1	<0.005	$n_1 = 43$
Distance to Agricult./Suburb. Clearing	Blue Jay *Cyanocitta cristata*	3.93	1	<0.05	$n_1 = 43$
% Conifer Composition	Blue Jay *Cyanocitta cristata*	2.81	1	<0.10	$n_1 = 43$
Distance to Water Body	American Crow *Corvus brachyrhynchos*	18.94	1	<0.001	$n_1 = 33$
Distance to Agricult./Suburb. Clearing	American Crow *Corvus brachyrhynchos*	16.03	1	<0.001	$n_1 = 33$
Foliage Density	American Crow *Corvus brachyrhynchos*	10.94	1	<0.001	$n_1 = 33$
% Conifer Composition	American Crow *Corvus brachyrhynchos*	8.76	1	<0.005	$n_1 = 33$

†see Methods for details with reference to original sample size

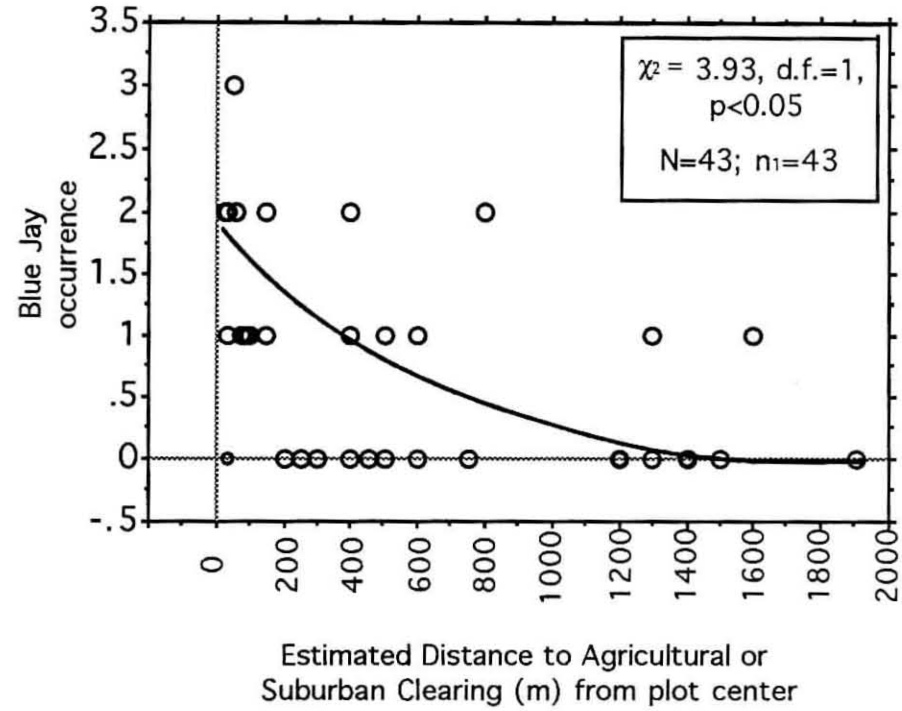


Figure 52. Relationship between Blue Jay (*Cyanocitta cristata*) occurrence and the estimated distance to an agriculture or suburban clearing from plot centers (m). See text for interpretation. Curve fitted by eye to aid in interpreting graph.

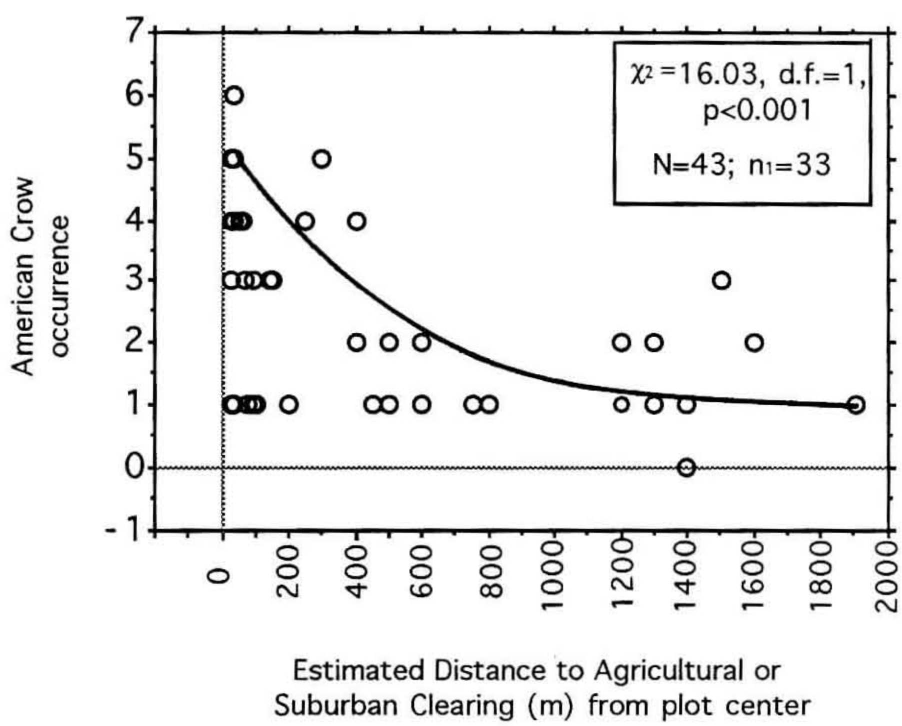


Figure 53. Relationship between American Crow (*Corvus brachyrhynchos*) occurrence and the estimated distance to agricultural or suburban clearing (m) from plot centers. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

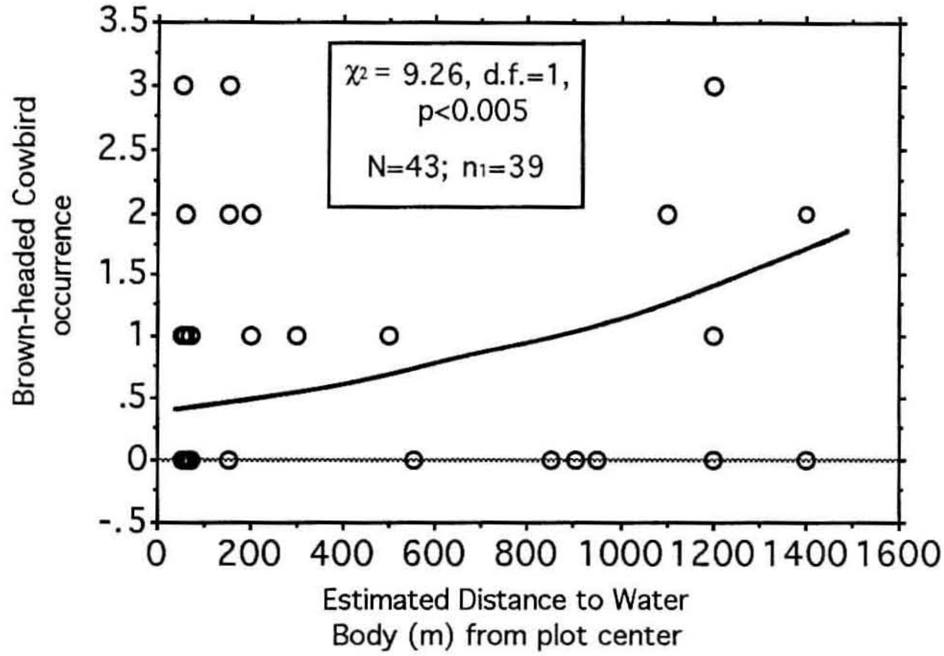


Figure 54. Relationship between Brown-headed Cowbird (*Molothrus ater*) occurrence and the estimated distance to a water body from plot centers (m). See text for interpretation. Curve fitted by eye to aid in interpreting graph.

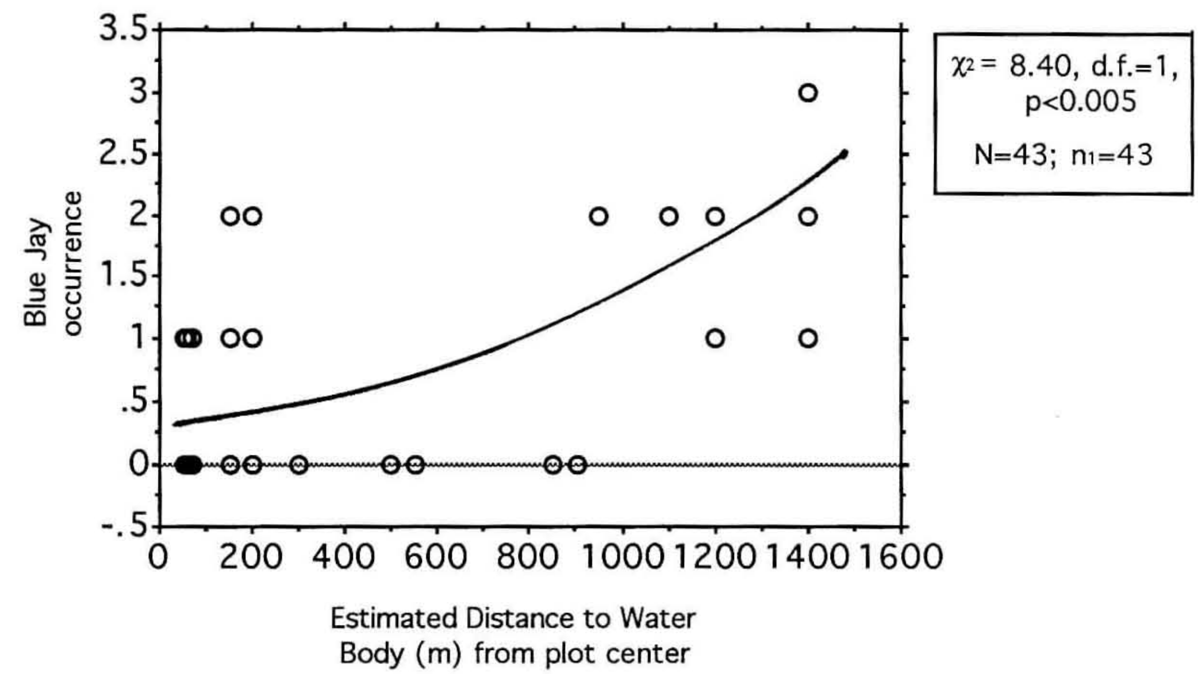


Figure 55. Relationship between Blue Jay (*Cyanocitta cristata*) occurrence and the estimated distance to a water body from plot centers (m). See text for interpretation. Curve fitted by eye to aid in interpreting graph.

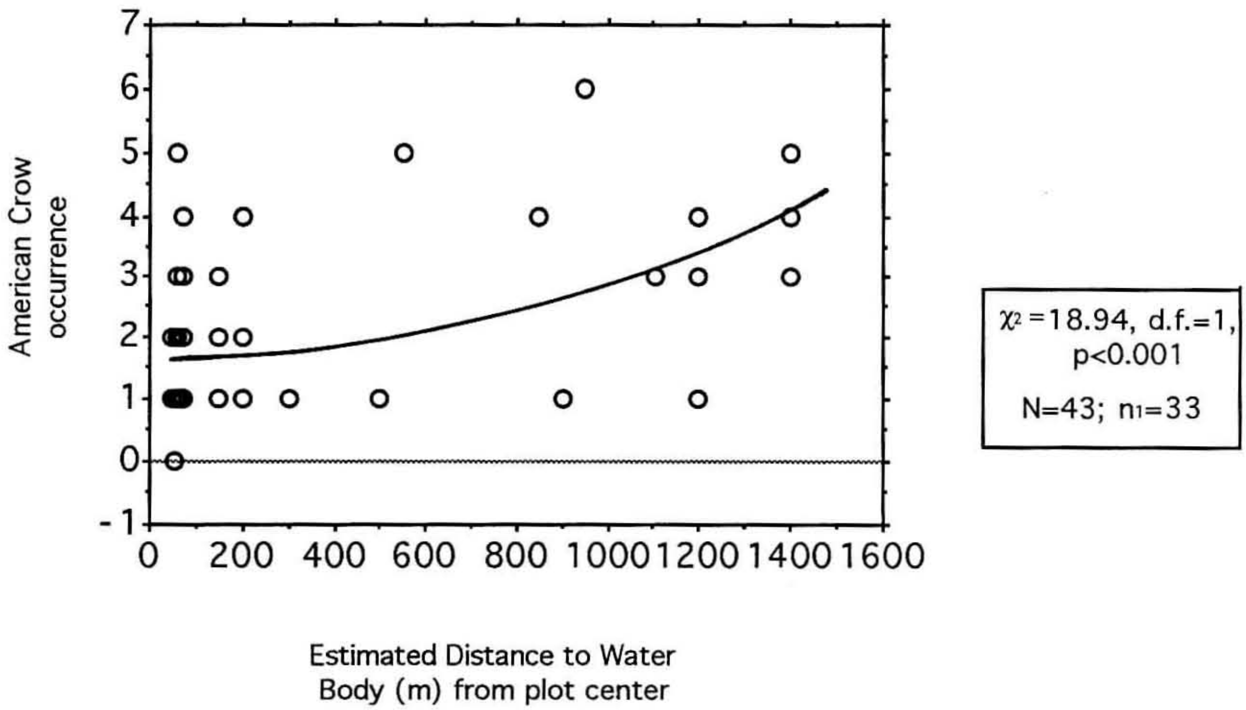


Figure 56. Relationship between American Crow (*Corvus brachyrhynchos*) occurrence and the estimated distance to water body (m) from plot centers. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

Thus, these two species may be in disproportionately large numbers proximate to disturbed agricultural/suburban clearings and exert heavier predation pressures on songbirds nesting here.

Distance to Water Body

Proximity to a body of water (e.g. lake, beaver pond) was also found to influence the occurrence of several focal species, including Brown-headed Cowbirds (Figure 54), Blue Jay (Figure 55), and American Crow (Figure 56). In all cases, the occurrence of these species decreased as distance to water bodies decreased. Reasons for these results are difficult to determine, but suggest natural edge related to water bodies and adjacent forest habitat have the opposite effects of artificial agricultural/suburban clearings on these three species.

Surprisingly, no relationship was found with Common Grackle occurrence, despite the fact that this species frequently uses beaver ponds and shallow bays of lakes for nesting (pers. obs.). The low occurrence of grackles on plots may account for the lack of results.

Foliage Density

Density of foliage associated with plots showed a negative relationship with both Brown-headed Cowbird occurrence (Figure 57) and American Crow occurrence (Figure 58). These two species are typical of open habitat, and it appears to extend to more open forested habitat as well. Such trends may have implications to thinning practices, which may allow increased numbers of these species to penetrate into forested areas and reduce songbird nesting success.

Percent Coniferous Foliage Composition

Two species, the Blue Jay and American Crow, were found to increase with increasing conifer composition of plots (Figures 59 and 60 respectively). With American Crows often nesting in coniferous trees, and Blue Jays often associated with mixed forests, it if not surprising to find these relationships. Such results, however, have important implications to management practices that alter conifer composition of songbird habitat, especially concerning conifer replantation efforts. More information on nesting success in areas of

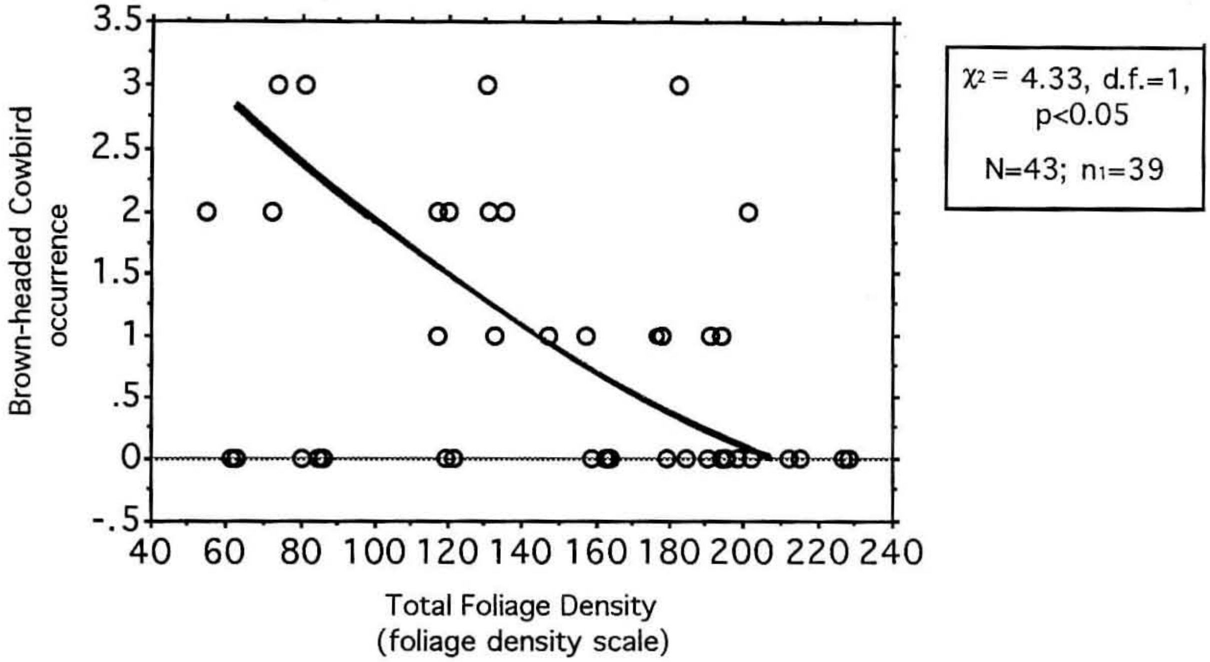


Figure 57. Relationship between Brown-headed Cowbird (*Molothrus ater*) occurrence and the total foliage density of the plots. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

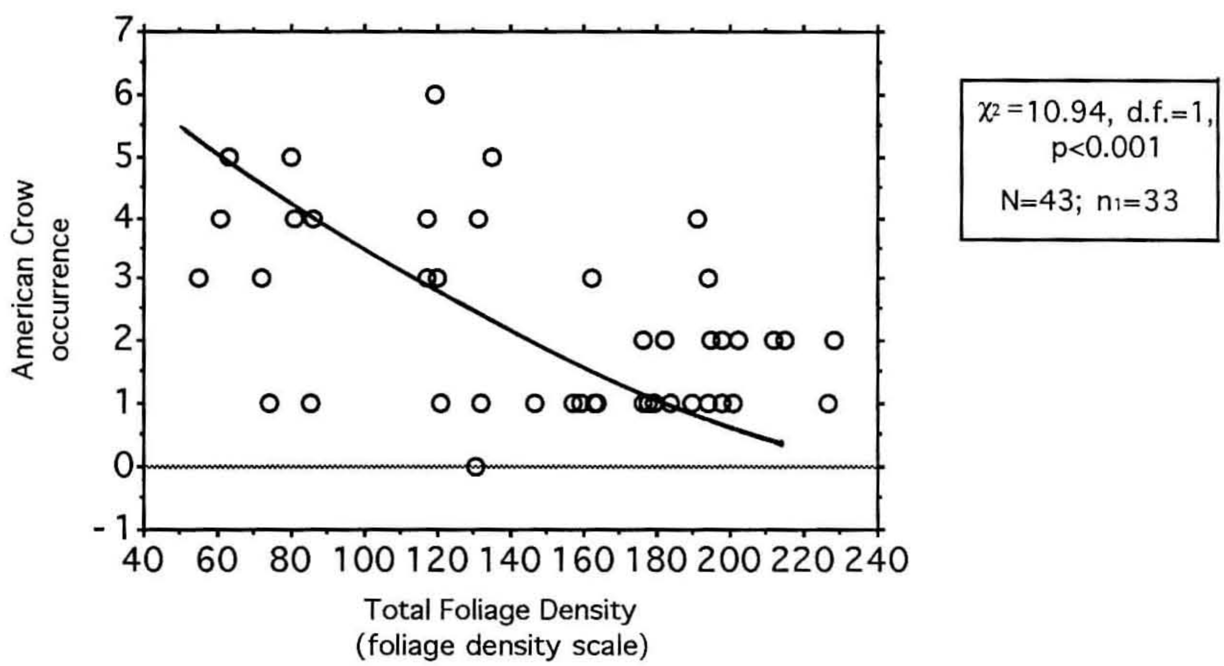


Figure 58. Relationship between American Crow (*Corvus brachyrhynchos*) occurrence and the total foliage density of the plots. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

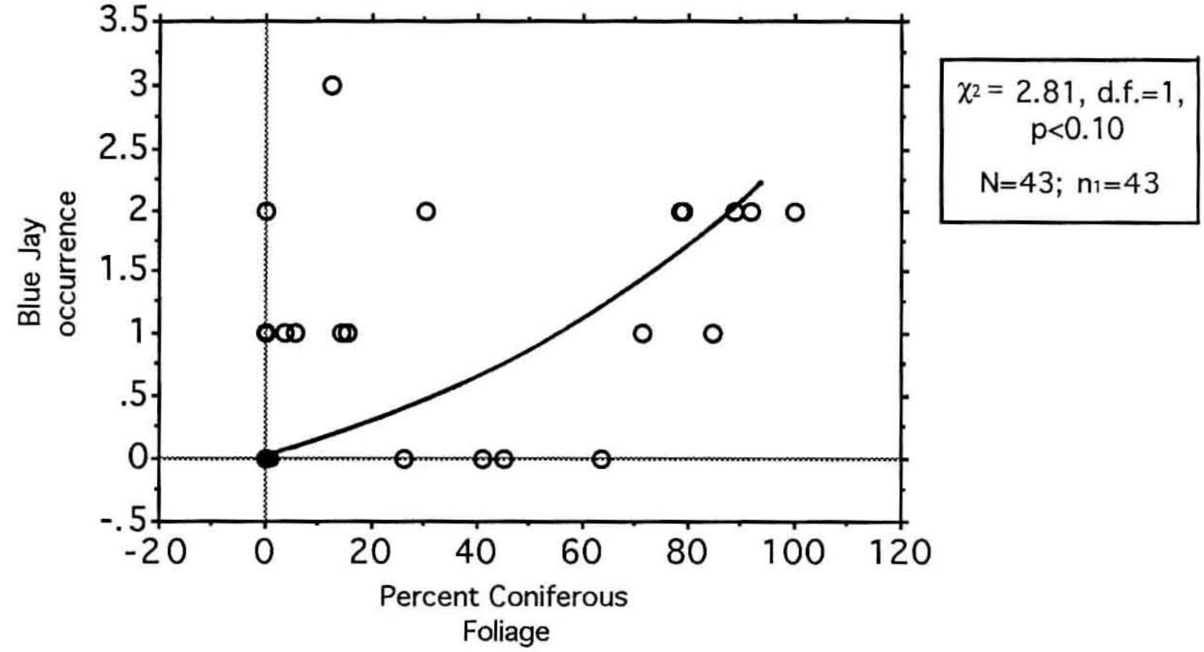


Figure 59. Relationship between Blue Jay (*Cyanocitta cristata*) occurrence and the percent coniferous foliage composition of plots. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

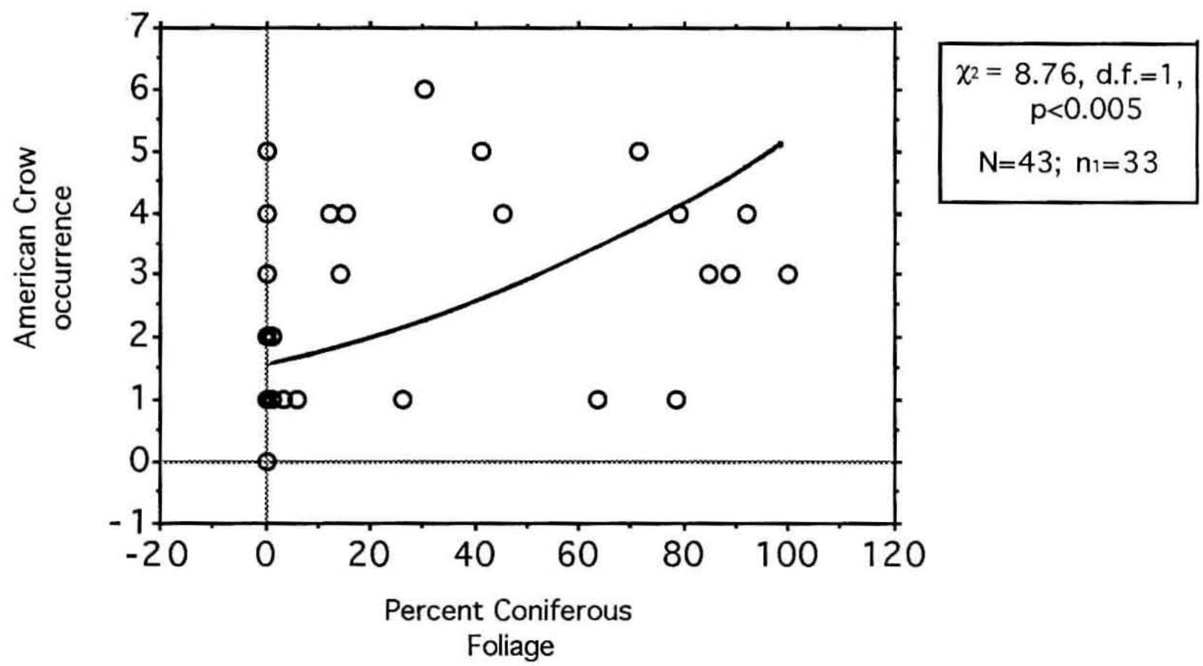


Figure 60. Relationship between American Crow (*Corvus brachyrhynchos*) occurrence and the percent coniferous foliage composition of plots. See text for interpretation. Curve fitted by eye to aid in interpreting graph.

conifer plantations planned for 1994 should provide more insight into these relationships.

Conclusions

From this preliminary work, it appears that habitat and landscape parameters affect the abundance of nest predators and brood parasites, which can result in adverse effects on nesting songbirds. More information to connect predator/parasite occurrence to actual nest depredation/parasitism rates is required to properly assess these relationships. It is safe to conclude, however, that management practices must take into account effects on songbird nest predation and parasitism rates, which may play vital roles in the maintenance of sustainable songbird populations in the Eastern Ontario Model Forest region.

Part 5:

Directions for Future Research

The limitations of the methodology used in this preliminary study, described in Part 2, reflect the complexities of songbird communities in forest habitats. Addressing these complexities to identify real relationships of habitat quality for important songbird species is thus a goal of future research. Defining habitat quality as habitat that results in the greatest reproductive success per unit area of habitat, it becomes evident that more detailed work is required.

In addition to more detailed work, research examining direct influences of forest resource management practices is the next step following this preliminary study. Experimental manipulations of habitat, and comparisons to control plots, should provide more applicable information. Further examination of replanting practices and their suitability for songbird use would also provide useful information from a forest management perspective.

Keeping in mind the end goal of applying information gained in regards to the influences of management practices on songbirds, brings us to the final direction of this work. As discussed in the Introduction, the bulk of forest in the Eastern Ontario Model Forest region is privately owned; thus, education and consultation should be the end result of this work, to promote applications of our findings to the improvement of songbird habitat.

Provided funding persists, all of these directions should lead to a very profitable outcome, both from the perspective of songbird habitat improvement, and from the perspective of forestry, with more responsible management practices and improved public image.

More Specific Work - focus species for research

In all research efforts, a compromise must be accepted between research effort (including funds), sample size, and the detail of results to be obtained. A variety of strategies combining different degrees of these factors can be used, and different researchers recommend different combinations. For example, Verner (1981) and others (e.g. Anderson 1979) suggest the point count method used in this study to be the best methodology for measuring the effects of resource management practices on bird communities. The broad array of limitations to this procedure, however, have been discussed in Part 2, and suggest that results obtained by this method miss the real measures of habitat quality as defined above.

The perspective taken here is in accordance with other authors (e.g. Ruggiero *et al.*1988; Robinson 1992b), where more detailed information on a smaller number of species provides more useful and applicable, results on reproductive success and other aspects of breeding biology important to management considerations. Choosing the species on which to focus is not random (see Block *et al.* 1987; Ruggiero *et al.* 1988), however, using the results of this preliminary report may assist in choosing such focus species.

Focus species for detailed study

From this study, a variety of songbird species have shown a dependence on specific characteristics of the hardwood forest habitat. Using these species as focus species would be most suitable, as these are more dependent on the mature hardwood forest than are more generalist species (e.g. Cerulean Warbler vs. Black-throated Green Warbler). From here, it seems appropriate to choose prominent species utilizing this habitat (e.g. Scarlet Tanager vs. Yellow-throated Vireo), and to focus on species that may well be detrimentally affected by forestry practices, and that are in need of more research (e.g. declining species or poorly studied species). Using these criteria, the following list of potential study species is proposed.

Least Flycatcher
Red-eyed Vireo
Cerulean Warbler
American Redstart
Ovenbird
Scarlet Tanager

The Ovenbird and Red-eyed Vireo, although habitat generalists relative to many other species, were included on the basis of their prominence in the forest bird community.

The more specific work on one or a few focus species would entail examination of detailed aspects of the life history of these species, especially with respect to breeding biology. This would include mating systems, reproductive success, predation and brood parasitism rates, food utilized, foraging behaviour, community relations, specific habitat requirements based on reproductive success, return rates, etc.

Experimental Manipulation and Direct Tests of Management Practices

With preliminary research suggesting possible effects of silvicultural practices, it is now appropriate to test these hypotheses through experimental manipulation of habitat, and comparison to control forest plots. Measuring important characteristics of reproductive success and thus relative habitat quality is a must, while controlling for other variables is also critical. Using these constraints, the following proposal has been drawn.

A control and experimental plot adjacent to each other but with a buffer area in between, would alleviate spatial variation in habitat characteristics. Measuring the reproductive success of all individuals of key songbird species would enable more accurate measurement of habitat quality for each species. In addition, focusing on other species such as woodpeckers (Piciformes) that were not suited to a point count survey method, is now possible. These species may be affected by silvicultural practices more so than other species due to their dependence on dead and dying cull trees that take up important productive tree space from the perspectives of silviculturalists (Crawford and Frank 1987).

Two years of study, one before all management practices, and one subsequent to experimental manipulation of one plot, would alleviate temporal variation in songbird reproductive success. Thus, the analysis would entail comparing differences between years of the control and experimental plots to test for effects of management practices on songbird species.

Reforestation and Management of Plantations for Songbirds

In addition to examining direct effects of habitat manipulation, further investigation of reforestation strategies currently in practice, and their suitability as songbird habitat would provide another productive approach to songbird research. Previous suggestions of conifer plantations as poor habitat for songbirds is a broad generalization that is not applicable to all cases. Better management of existing plantations and strategies to incorporate deciduous components, and eventually cut out the majority of the dominant conifer, may restore forest conditions to those typical of the region.

Examining a wide range of existing plantation sites and relating different conditions to either habitat use or reproductive success of songbirds using this habitat, would provide applicable information. From this study, it is apparent that factors governing songbird use of such habitat is complex, thus controlling for a variety of factors including plot size, age, adjacent habitat, etc. would enhance the clarity of results.

Application of Results - Education of private land owners

The final goal of the songbird project is to apply the findings obtained, while incorporating the ever-increasing number of other relevant studies, into an integrated forest management plan. It is hoped that such a plan would be welcomed and readily applied by government resource managers to government-managed lands in eastern Ontario, while further applications of such plans would be aimed at privately owned lands in the region.

The final form of the results (aside from potential scientific publication) could take the form of a readable booklet covering all key forest species and important information related to habitat requirements of each species. Management practices that on the whole, supplement habitat requirements of neotropical migrant songbirds could be recommended. A stewardship program, or perhaps some other active participation by landowners could be encouraged. This final goal is still a ways off, and more discussion about such a final format for education/consultation purposes is encouraged.

This section of proposed directions for future research is designed to provoke discussion and further refinements for future research efforts. It is hoped with sufficient funding, at least one of these research directions, or perhaps even others not discussed, may take place.

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Appendix 1

The following are species accounts of 143 known breeding or potentially breeding birds. Local habitats occupied by each species are described qualitatively, acompanied by estimated densities of each species within the defined area. Density estimates are based on estimates of the amount of occupied habitat within the area (50 km^2; Figure 1), and the estimated densities within those habitats based on observations from the 1992 and 1993 breeding seasons. The densities are in 100 km^2 instead of the 50 km^2 of the defined area, to allow direct comparison with similar density descriptions for all of Ontario (Cadman *et al.* 1987; Ontario Breeding Bird Atlas). Densities (abundance estimates) generally follow those of Cadman *et al.* (1987).

Species recognized as rare or endangered breeders in Ontario and/or Canada have been provided in boldface. Additional species recently described by Hussell *et al.* (1992) as showing significant declines in migrating populations through Long Point, Ontario, have been marked with an asterisk, as has one other species, the Golden-winged Warbler, which has been recognized as a seriously threatened species by a number of authors (e.g. Graham 1990). See discussions in Part 2 of this report for other declining and threatened species found within the Lake Opinicon area. Initials refer to the following observers: Floyd Connor (FC), Kelvin Conrad (KFC), Kevin Teather (KT), Raleigh Robertson (RJR), Michael Runtz (MR), and Pat Weatherhead (PJW).

Species Accounts

Common Loon (*Gavia immer*)
Present on most freshwater lakes in area. Several pairs on Lake Opinicon (4-8 prs.).

Pied-billed Grebe (*Podilymbus podiceps*)
Small numbers in larger beaver ponds, especially where cattail marsh is present. 11-50 prs./100 km^2.

American Bittern (*Botaurus lentiginosus*)
Low density in wet meadow (alder/willow shrubs) and in cattail marshes. More prominant in areas to east of defined area.

Least Bittern (*Ixobrychus exilis*)

Single nests in a couple years (1980's) in a small beaver pond dominated by willows (*Salix* spp.) and other bushes (FP).

Great Blue Heron (*Ardea herodias*)

Widespread and prominant species in all wet habitats, especially lakeshores and beaver ponds. One well-known colony of about 25-35 active nests per year. Number of nests may vary from year to year.

Green-backed Heron (*Butorides striatus*)

Individuals seen flying periodically. Probably nest either within the area, or just outside, using one of the many beaver ponds. Less than 10 prs./100 km^2.

Canada Goose (*Branta canadensis*)

Probably does not breed. Flocks present May through July in immediate area of Opinicon. May well breed nearby; perhaps Newboro Lake or a local sewage lagoon.

Wood Duck (*Aix sponsa*)

Probably the most numerous breeding species of waterfowl in the area. Found in most beaver ponds and shallow, swampy areas of lakes where tree cavities are available. 11-100 prs./100 km^2.

American Black Duck (*Anas rubripes*)

Only single sightings in June, 1993. May breed in beaver ponds in area, but no suggestive evidence beyond sightings of flying pairs. Weir (1989) describes a dramitic decline in the population of this species in the Kingston region (including Lake Opinicon). Dennis (1987) describes a widespread 80% decline in southern Ontario between 1951 and 1981. A decrease in habitat and an increase in the closely related Mallard (with which it hybridizes) have been suspected causes of decline, although reasons for decline in the Lake Opinicon region are not obvious.

Mallard (*Anas platyrhynchos*)

Small numbers in shallow areas of lakes (e.g. bays) and occasional beaver ponds. May be more common to the east in the more agricultural areas. Linked to the decline of the American Black Duck, although the latter species appears to have declined in the area without large numbers of the Mallard present. 11-100 prs./100 km^2.

Blue-winged Teal (*Anas discors*)

Present in cattail marshes of lakes and beaver ponds. Only low numbers in the area due to scarcity of habitat. 11-100 prs./100 km^2.

Hooded Merganser (*Lophodytes cucullatus*)

Another cavity-nesting species frequent in beaver ponds, although in smaller numbers than the Wood Duck. 11-50prs./100 km^2.

Common Merganser (*Mergus merganser*)

Individuals seen periodically on Lake Opinicon throughout the summer. May breed, however, no evidence present.

Turkey Vulture (*Cathartes aura*)

A new species to this area since the turn of the century; now the most prominant raptor in the area. Roosts commonly host 5 to 25 individuals (prior to nestling fledge). Soaring birds cover all terrestrial habitats of the area; however, they are largely absent from the larger expanses of agricultural fields to the east. 51-100 prs./100 km^2.

Osprey (*Pandion haliaetus*)

Associated with lakes in the area where fish are the primary source of food. At least two pairs on Lake Opinicon. Probably under 10 pairs within the defined 50 km^2 area.

Bald Eagle (*Haliaeetus leucocephalus*)

Apparently a former breeder in the area, up into the early 1970's. Has not bred since; however, individuals winter on Lake Opinicon, where open water attracts small numbers of diving ducks (FP). Two birds in full adult plumage remained roosting in an area of mature Eastern White Pine on Lake Opinicon into late April, 1992, but were not seen afterwards. Other recent reports of summering birds may indicate future breeding within the area.

Northern Harrier (*Circus cyaneus*)

Individuals seen periodically throughout the spring-summer period. These birds probably represent breeders from outside the defined area. Pairs commonly seen in larger cattail marshes/agricultural areas to the east and northeast (e.g. east end of Newboro Lake).

Sharp-shinned Hawk (*Accipiter striatus*)

Individuals present throughout the breeding season in a variety of mixed forest habitats. One pair suspected of breeding near base of station point in 1992. Another present near Sugarbush Island through July, 1993. No direct breeding evidence; however, and it should be noted that this species is a common migrant through the area, regularly visiting Tree Swallow nest box grids used for research on the latter species.

Cooper's Hawk (*Accipiter cooperii*)

One individual present in late May, 1992, at the base of the station point. This individual was probably not breeding, and there is no other information to suggest breeding by this species within the area. Suitable habitat suggests possible breeding in the future.

Northern Goshawk (*Accipiter gentilis*)

Regularly breeds in mixed and Eastern White Pine-dominated woods. May also use mature plantations just outside of the defined area. Probably no more than 5 pairs in the 50 km^2 area.

Red-shouldered Hawk (*Buteo lineatus*)

Prominant in dense, closed, and mature deciduous woods, dominated by Sugar Maple and Ironwood. At highest densities in Canada in this region. 11-20 prs./100 km^2.

Broad-winged Hawk (*Buteo platypterus*)

Widespread in mixed mature woods. Does not appear to use the pure deciduous habitats. Probably 11-20 prs./100 km^2.

Red-tailed Hawk (*Buteo jamaicensis*)

Uses more open habitat than Red-shouldered Hawk. Fields, forest edges, and open woods (e.g. rocky stunted habitats). Also, open mixed woods and various stages of regrowth forest. Under 10 prs./100 km^2.

American Kestrel (*Falco sparverius*)

Not known to occur within the defined area; however, breeds in small numbers in the agricultural areas to the east.

Ring-necked Pheasant (*Phaisianus colchicus*)

Low density in open areas (fields) within the Lake Opinicon area. Under 50 prs./100 km^2.

Ruffed Grouse (*Bonasa umbellus*)

Large numbers in all forest types, including pine plantations to the east. 501-1000 prs./100 km^2.

Wild Turkey (*Meleagris gallopavo*)

Introduced into the area. Individuals seen and heard periodically in 1992. Last bird apparently depredated during winter (1992-93) on station point (FC). It had been visiting a feeding station there. No birds seen in spring-summer 1993.

Virginia Rail (*Rallus limicola*)

Present in most small to large cattail marshes, in beaver ponds and lake edges. 101-500 prs./100 km . More common in larger expanses of cattails to the east (e.g. Portland Marsh off Hwy 15).

Sora (*Porzana carolina*)

Also present in cattail marshes, however, this species may be restricted to larger expanses of habitat. 51-100 prs./100 km . More common in larger expanses of cattails to the east (e.g. Portland Marsh).

Killdeer (*Charadrius vociferus*)

Frequently uses open cultivated field habitat. Thus, it is more common to the east of the Lake Opinicon area; however, small numbers can be found in suitable habitat within the region. 11-50 prs./100 km^2.

Spotted Sandpiper (*Actitis macularia*)

May occur in shoreline habitat along the larger lakes (Opinicon, Lower Rock); however, little evidence present. 1-10 prs. /100 km^2.

Upland Sandpiper (*Bartramia longicauda*)

Individuals seen just south of Perth Road Village in June, 1993. Probably occurs in similar open-field habitat to the east of the area, also. Appears to be entirely absent from the defined area, and probably in low densities just outside of the area as well.

Common Snipe (*Gallinago gallinago*)

Breeds in wet meadow/field habitat within the region. Conspicuous flight display a prominant feature of these habitats during the courting-breeding season. 51-100 prs./100 km^2.

American Woodcock (*Scolopax minor*)

Uses regrowth edge habitat; particularly saplings or other edge habitat adjacent to fields. 11-50 prs./100 km^2.

Ring-billed Gull (*Larus delawarensis*)

Increasing numbers are present as the summer progresses. The lack of breeding evidence suggests these birds originate from colonies found elsewhere.

Herring Gull (*Larus argentatus*)

No breeding evidence for this species. Increasing numbers as the summer progresses, suggests individuals breed elsewhere. Less common than the Ring-billed Gull.

Caspian Tern (*Sterna caspia*)

Individuals seen regularly, but not frequently, on Lake Opinicon from early July onwards. Probably originate from breeding colonies to the south (east end of Lake Ontario - see Weir 1989).

Common Tern (*Sterna hirundo*)

Individuals seen occasionally on Lake Opinicon in early July, 1992, but almost definitely represent birds from colonies elsewhere.

Black Tern (*Chlidonias niger*)

Individuals present at two locations: one within the defined area (northeast sanctuary, Lake Opinicon), and one to the east (across from Folly Scout Camp, near southeast end of Newboro Lake. Both sites appear to have only one pair each (no more than two pairs). Sites are both open, large, flooded swamps, with sections of cattail marshes.

Rock Dove (*Columba livia*)

Present only near agricultural areas to the east of the region. Occasionally seen flying within the defined area.

Mourning Dove (*Zenaida macroura*)

Often present foraging in open areas along an abandoned railroad line, roadways adjacent to fields, and in actively cultivated fields. More prominant in agricultural areas to the east. 101-500 prs./100 km^2.

Black-billed Cuckoo (*Coccyzus erythropthalmus*)

Low density in second growth deciduous forest; both within extensive mature forest tracts and in more open regrowth habitat and edge.
101-500 prs./100 km^2.

Yellow-billed Cuckoo (*Coccyzus americanus*)

Present in wet, low, and often shrubby deciduous woods. Also in some dry habitats similar in structure. 11-50 prs./100 km^2.

Great Horned Owl (*Bubo virginianus*)

Uses mature mixed forests, which include Eastern White Pine. Apparently absent from pure deciduous forest. Probably under 5 pairs in 50 km^2 area.

Barred Owl (*Strix varia*)

Probably the most numerous species of owl in the area. Uses a variety of habitats including pure deciduous forest, cedar swamps, and some low mixed woods (not found in the mature pine-mixed forests used by the previous species). Uses moderate-sized cavities for nesting. 11-50 prs./100 km^2.

Common Nighthawk (*Chordeiles minor*)

Nests on open, rocky ridges dominated by Red Oak, mosses, lichen, and grasses. Forages overhead, catching insects in the air. 26-100 prs./100 km^2.

Whip-poor-will (*Caprimulgus vociferus*)

Uses forested habitats with prominant leaf litter for nesting, although more specific habitat requirements are difficult to assess. Roosting birds appear to avoid mature and especially over-mature stands of forest, and may show a preference for sapling-dominated sections of forest as well as areas proximate to streams. Also an aerial insectivore like the previous species.
26-100 prs./100 km^2.

Chimney Swift (*Chaetura pelagica*)

Small numbers (under 8) seen over Lake Opinicon in May-June, 1993, may have bred on one of the forested islands there. No other records.

Ruby-throated Hummingbird (*Archilochus colubris*)

A widespread and conspicuous species in low densities in most forested habitats in the region. High densities appear to occur where feeders or an artificial source of food (e.g. flower garden) is present. 501-1000 prs./100 km^2.

Belted Kingfisher (*Ceryle alcyon*)

Present on most lakes and some beaver ponds. Low density. May be limited by nest sites requirements, as this species often burrows into vertical banks. 11-50 prs./100 km^2.

Red-headed Woodpecker (*Melanerpes erythrocephalus*)

A single pair successfully hatched young in a small beaver pond bordered by fairly mature deciduous forest, more open, dry deciduous woods, and mixed, wet woods. Previous reports of individuals of this species in previous years suggests that breeding is regular in small numbers. 1-10 prs./100 km^2.

Red-bellied Woodpecker (*Melanerpes carolinus*)

One male was present June (92) at Lindsay Lake Road (MR,PJW) and was seen and heard periodically through July. In 1993, at least three different individuals were present at five different sites off and on during June and July. The birds appear to use fairly mature deciduous (maple) forest and notably adjacent beaver ponds. The increasing abundance of this southern bird appears to coincide with the maturation of the regrowth forest in the area. The first record for this species in the area dates back to the late 1980's (KT); however, it seems quite likely that it now breeds in small numbers (under 5 pairs) in the Lake Opinicon area.

Yellow-bellied Sapsucker (*Sphyrapicus varius*)

Pairs seen in mature mixed woods but absent from pure deciduous (Carolinean type) forest. 11-100 prs./100 km^2.

Downy Woodpecker (*Picoides pubescens*)

Present in most fairly mature to mature forest habitats except perhaps for pure coniferous stands (plantations). 101-500 prs./100 km^2.

Hairy Woodpecker (*Picoides villosus*)

Present in most fairly mature to mature forest habitats except perhaps for pure coniferous stands (plantations). 101-500 prs./100 km^2.

Northern Flicker (*Colaptes auratus*)

Uses more open habitat, including woodland edges and open woods. Frequently nests in beaver ponds. 101-500 prs./100 km^2.

Pileated Woodpecker (*Dryocopus pileatus*)

Widespread in mature predominately deciduous and mixed woods. 11-100 prs./100 km^2.

Eastern Wood-Pewee (*Contopus virens*)

Widespread in both deciduous and mixed forest types, usually fairly mature. Also along edges of rocky outcrops, and occasionally uses pine plantations adjacent to deciduous woods. 501-1000 prs./100 km^2.

Acadian Flycatcher (*Empidonax virescens*)

One male along station road 6 June (92) was very vocal but did not remain in the area. Suitable habitat may allow expansion into the area.

Alder Flycatcher (*Empidonax alnorum*)

In generally wet/moist open fields with moderate to thick alder shrubs. Has not been observed within the defined area, but present just to the east.

Willow Flycatcher (*Empidonax traillii*)

Wet shrubby fields or pond edges, containing thick willow and sometimes alder bushes. 11-50 prs./100 km^2 .

Least Flycatcher (*Empidonax minimus*)

Apparently semicolonial in a variety of forested habitats, including pure deciduous, mixed, wet forest, and pine plantations with undergrowth deciduous saplings. 501-1000 prs./100 km^2.

Eastern Phoebe (*Sayornis phoebe*)

Uses both deciduous and mixed forest habitats. Prominant in disturbed, suburban-type habitat where it frequently nests on buildings. Lacking such buildings, this species may be restricted by appropriate nest sites (vertical rock ledges). Also uses open pine plantations to the east. 501-1000 prs./100 km^2 .

Great Crested Flycatcher (*Myiarchus crinitus*)

Widespread in deciduous and mixed forest habitats, as well as beaver ponds and edges. May be restricted by dependency on existing cavities for nesting. 501-1000 prs./100 km^2.

Eastern Kingbird (*Tyrannus tyrannus*)

Inhabits open habitats such as lake shoreline, beaver ponds and marsh edges, and open fields and field/forest borders. 501-1000 prs./100 km^2.

Horned Lark (*Eremophila alpestris*)

Open cultivated field habitat. Restricted to agricultural areas to the east of the defined area.

Purple Martin (*Progne subis*)

Breeds in man-made "colony" boxes at a few locations in the area. Probably fewer than 150 pairs in total. Later in summer, these aerial insectivores become prominant, especially above lakeshore habitats.

Tree Swallow (*Tachycineta bicolor*)

Inhabits open field habitat as well as beaver ponds. Breeding restricted by the availability of existing cavities for nesting. Grids of nest boxes support good populations which are the focus of study by some researchers. 1001-10,000 prs./100 km^2.

Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)

One pair in beaver pond along Chaffey's Locks Rd. probably bred. One pair previously bred in an abandoned sand pit along the edge of forest/open field (RJR). Further examination of other suitable habitat in the area would probably reveal other pairs, but low density nonetheless. 1-10 prs./100 km^2.

Bank Swallow (*Riparia riparia*)

May be present where suitable nesting habitat exists, but in low numbers. 11-50 prs./100 km^2.

Barn Swallow (*Hirundo rustica*)

Inhabits both lakeshore habitat and open agricultural habitat, frequently nesting on buildings. Only one natural site was found, located on a vertical rock face just above the water on a rocky island in Lake Opinicon (Hump I.). 151-500 prs./100 km^2.

Blue Jay (*Cyanocitta cristata*)

In low densities in mixed woods, as well as in pine plantations to the east. 11-100 prs./100 km^2.

American Crow (*Corvus brachyrhynchos*).

Widespread and conspicuous, except when breeding. Uses most habitats, however, nests often in pine plantations and in conifers in general. 11-100 prs./100 km^2.

Common Raven (*Corvus corax*)

Present all year and probably breeds in low density. Most prominant in mixed forest habitat and areas with open rocky outcrops. 6-20 prs./100 km^2.

Black-capped Chickadee (*Parus atricapillus*)

Widespread, covering all wooded and regrowth habitats. 1001-4,000 prs./100 km^2.

Red-breasted Nuthatch (*Sitta canadensis*)

In several White and Red pine plantations in area. Probably <15 prs./100 km^2.

White-breasted Nuthatch (*Sitta carolinensis*)

In mixed and predominately deciduous woods, both open and closed, with a mature deciduous component. 201-700 prs./100 km^2.

Brown Creeper (*Certhia americana*)

Found in forest surrounding wet woodland, often with standing water. 11-100 prs./100 km^2.

Carolina Wren (*Thryothorus ludovicianus*)

One migrant remained in the area of the point for several days in early May, 1991, but did not remain to set up a territory.

House Wren (*Troglodytes aedon*)

Present along forest edge habitat (e.g. field edge, edges of beaver ponds and lakes), and in second growth habitats. Nests often in man-made nest boxes as well as in White Birch stumps. 101-500 prs./100 km^2.

Winter Wren (*Troglodytes troglodytes*)

Associated with coniferous or mixed, often wet woods, with an abundance of fallen logs. 11-50 prs./100 km^2.

Marsh Wren (*Cistothorus palustris*)

Uses cattail marshes. 6-20 prs./100 km^2.

Blue-gray Gnatcatcher (*Polioptila caerulea*)

Inhabits open, dry forest and forest edges. 51-100 prs./100 km^2.

Eastern Bluebird (*Sialia sialis*)

Found in open field habitat, often bordering woodland, and to a lesser extent in beaver ponds. 11-50 prs./100 km^2.

*Veery (*Catharus fuscescens*)

Inhabits wet deciduous and mixed woods, often with standing water. 11-100 prs./100 km^2.

*Swainson's Thrush (*Catharus ustulatus*)

A single male was present for the entire breeding season (May through July) in 1993 in predominately Sugar Maple-Ironwood deciduous woods at Telephone Bay. Singing behaviour suggests pairing, however, no level of reproductive success was confirmed.

Hermit Thrush (*Catharus guttatus*)

Low density in mixed and often dry woods. 11-100 prs./100 km^2.

*Wood Thrush (*Hylocichla mustelina*)

Present in mature forested areas through to young regrowth. Often associated with edge habitat. 201-800 prs./100 km^2.

American Robin (*Turdus americana*)

Most numerous in disturbed open habitats, including mowed lawns and other suburban areas (e.g. cottages, Chaffeys Lock); also open forested areas, including rocky outcrops and pine plantations, as well as forest edge with agricultural fields and some deciduous forest. 501-1000 prs./100 km^2.

*Gray Catbird (*Dumetella carolinensis*)

Uses scrubby second growth habitats, often along edges of more mature forest as well as beaver ponds. 201-800 prs./100 km^2.

Northern Mockingbird (*Mimus polyglottos*)

One individual present in June, 1993, at the edge of forest and open field along Opinicon Rd. (KFC)

*Brown Thrasher (*Toxostoma rufum*)

Once more common, but now fairly low densities; present in recently regrown field edges. Loss of habitat may be responsible for the decline. 6-25 prs./100 km^2.

Cedar Waxwing (*Bombycilla cedrorum*)

Widespread, inhabiting Eastern White Cedar-dominated forest, as well as open rocky outcrops, open regrowth fields and forest, and in various conifer plantations. 501-1500 prs./100 km^2.

European Starling (*Sturnus vulgaris*)

Small numbers found in some beaver ponds with a supply of nest cavities and open areas nearby. Also in fields, especially cultivated. More common to the east of the defined region. 51-100 prs./100 km^2.

Solitary Vireo (*Vireo solitarius*)

Territorial birds in small Red Pine plantation with bordering regrowth Sugar Maple and mixed Balsam Fir plantation. Nested in previous years in another area of similar habitat on station point. 1-10 prs./100 km^2.

Yellow-throated Vireo (*Vireo flavifrons*)

Inhabits predominately deciduous woods (Red Oak, Sugar Maple, Beech, Ironwood) with a mature component (>15m tall trees); both open and closed forest. 101-500 prs./100 km^2.

Warbling Vireo (*Vireo gilvus*)

Inhabits woodland borders with field, lakeshore and beaver ponds. Usually trees of <40cm diameter (DBH) (ie. tall thin trees) dominate habitat. 101-500 prs./100 km^2.

Red-eyed Vireo (*Vireo olivaceus*)

High density in most forest with subcanopy (up to 10m). Also in younger regrowth >5m in height. Forest tree species makeup varies from predominately deciduous to cedar swamp. 1001-10 000 prs./100 km^2.

Blue-winged x Golden-winged Warbler hybrids (*Vermivora pinus x V. chrysoptera*)

One or possibly two Brewster's Warblers (males) present at station point in early May 1991. A backcross Blue-winged Warbler (Brewster's x Blue-winged Warbler) male has defended a territory along Lindsay Lake Road for three years since 1991. Its pairing success is unknown.

*Golden-winged Warbler (*Vermivora chrysoptera*)

High densities in deciduous/mixed forest borders with fields, beaver ponds, and cutting disturbance regrowth. 101-500 prs./100 km^2.

*Nashville Warbler (*Vermivora ruficapilla*)

Inhabits open habitat with stunted White Pine, Red Oak, Red Juniper, and other deciduous growth; often rocky, always with thick mosses covering parts of the ground. Also in local bogs and tamarack stands. 101-500 prs./100 km^2.

Yellow Warbler (*Dendroica petechia*)

Widespread and prominant in wet meadows and wet marsh/beaver pond edges as well as forest borders with shrubby to sapling regrowth. 1001-10,000 prs./100 km^2.

Chestnut-sided Warbler (*Dendroica pensylvanica*)

Forest edge where small deciduous saplings (1-4m tall) dominate. Spaced out and low density. 11-100 prs./100 km^2.

Black-throated Blue Warbler (*Dendroica caerulescens*)

Migrants through to June and periodic birds in June, but no evidence of potential breeding, despite the presence of fairly extensive mature maple-beech forest.

Yellow-rumped Warbler (*Dendroica coronata*)

Predominantly distributed around lake shoreline where White Pine, White Cedar, Eastern Hemlock, and a lesser extent of deciduous trees mixed in. 101-500 prs./100 km^2.

Black-throated Green Warbler (*Dendroica virens*)

Uses a variety of habitats including predominately deciduous beech-maple-ironwood mature woods, mature mixed woods with Eastern Hemlock and White Pine, as well as cedar swamp and predominately coniferous habitat. 101-500 prs./100 km^2.

Blackburnian Warbler (*Dendroica fusca*)

Scattered pairs in pockets of White Pine and Eastern Hemlock in mature mixed forest. 11-100 prs./ 100 km^2.

Pine Warbler (*Dendroica pinus*)

Prominate in all pine forest (both natural and plantations). 501-1000 prs./100 km^2.

Cerulean Warbler (*Dendroica cerulea*)

High densities in mature deciduous woods (>15m in height), both in open and closed canopy forests. 101-500 prs./100 km^2.

Prairie Warbler (*Dendroica discolor*)

Small numbers bred in rocky, open habitat, dominated by Red Juniper, and stunted Red Oaks, and White Pines at two locations near Hart and Round Lakes. Records from the 1980's but there have been no recent investigations of these areas since (FP).

Black-and-white Warbler (*Mniotilta varia*)

Prominant in mixed and coniferous woods (including pine plantations). Usually rocky areas. 501-1000 prs./100 km^2.

American Redstart (*Setophaga ruticilla*)

High densities in regrowth deciduous woods as well as in regrowth habitats within mature woods (eg. regrowth after tree fall). Less common in subcanopy of mature woods. 501-1000 prs./100 km^2.

*Ovenbird (*Seiurus aurocapillus*)

One of the most prominant forest species, inhabiting a broad range of regrowth (>8m in height) to mature deciduous, and mixed moist to dry woods. 1001-10 000 prs./100 km^2.

*Northern Waterthrush (*Seiurus noveboracensis*)

Inhabits forested areas of standing water with thick fallen logs and varied thick ground vegetation (mosses, ferns). 101-500 prs./100 km^2.

Louisiana Waterthrush (*Seiurus motacilla*)

One male on territory in mature deciduous beech-maple-ironwood forest along a small creek with many fallen logs and thick mosses (1993).

Common Yellowthroat (*Geothlypis trichas*)

Breeds in wet shrubby areas, often at edges of lakes, beaver ponds, in wet fields, cattail marsh edges, along streams, and in dense large ferns associated with wet swampy forest. 501-1000 prs./100 km^2.

Canada Warbler (*Wilsonia canadensis*)

Small numbers found in wet forested areas, with prominent fern and other deciduous ground vegetation. 1-10 prs./100 km^2. No definite breeding evidence.

Scarlet Tanager (*Piranga olivacea*)

Present in deciduous and mixed forested habitats, often with a mature component, and often dry. 301-1000 prs./100 km^2.

Northern Cardinal (*Cardinalis cardinalis*)

Most often in areas dominated by Eastern White Cedar. Also in conifer plantations. 11-50 prs./100 km^2.

*Rose-breasted Grosbeak (*Pheucticus ludovicianus*)

Often associated with edge of forest and open forest with both a mature component and shrubby second growth below. 101-500 prs./100 km^2.

Indigo Bunting (*Passerina cyanea*)

Prominent along forest/field edge and in any dry shrubby habitats (e.g. along roadways, railroad beds, etc.) 401-800 prs./100 km^2.

*Rufous-sided Towhee (*Pipilo erythrophthalmus*)

Occurs in rocky, open habitat where stunted Red Oak, White Pine, and in particular, Red Juniper, are found. 101-500 prs./100 km^2.

Chipping Sparrow (*Spizella passerina*)

Widespread in a variety of open and edge habitats. Inhabits open suburban habitat (e.g. towns), as well as open rocky outcrop habitat, conifer plantations and White Pine stands, and edge habitat and open mixed and deciduous woods. 1001-10 000 prs./100 km^2.

Field Sparrow (*Spizella pusilla*)

Prominant in rocky outcrop habitat with open, stunted Red Oak, White Pine, and Red Juniper. Also found in dry, bushy fields. 501-1500 prs./100 km^2

Vesper Sparrow (*Pooecetes gramineus*)

Low density immediately to the east of the defined area, using cultivated and non-cultivated fields.

Savannah Sparrow (*Passerculus sandwichensis*)

High densities in cultivated and non-cultivated fields to the east of the area; lower densities in similar habitat within the area. 11-80 prs./100 km^2.

Song Sparrow (*Melospiza melodia*)

Widespread in a variety of habitats. Prominent in lake shoreline habitat and rocky islands, using predominantly Red Juniper, deciduous shrubs, and White Cedar for nesting. Also found in wet shrubby habitats, often associated with beaver ponds and creeks. Forest-field edges and open rocky outcrop habitat also support this species, but Song Sparrows appear most prominant near water. 1001-10 000 prs./100 km^2.

Swamp Sparrow (*Melospiza georgiana*)

Inhabits wet, shrubby areas, often associated with beaver ponds and edges of cattail marshes, as well as wet fields. 101-500 prs./100 km^2.

*White-throated Sparrow (*Zonotrichia albicollis*)

Small numbers of males present within the area, usually in habitat dominated by conifers (although absent from plantation sites). One male sang from an area of Tamarack/Larch at the base of the station point, May-July, 1992 and 1993. Another sang from forested habitat near the Tree Swallow grids along Lake Opinicon Rd. in May-June, 1993. Birds are known to breed in local small bogs just outside the region (FP). 1-10 prs./100 km^2. It is unknown, however, whether or not lone males attract mates and/or successfully reproduce.

Bobolink (*Dolichonyx oryzivorus*)

Small numbers use open fields within defined area. Larger numbers are found to the east of the region, in open field habitat. 11-50 prs./100 km^2.

Red-winged Blackbird (*Agelaius phoeniceus*)

A prominent and widespread, semicolonial species, inhabiting a range of habitats. Uses bushy second growth and cattails, often associated with beaver ponds, cattail and other marshes, and wet fields. Also uses shrubby wet habitats along roadways (e.g. ditches), and will forage in a variety of habitats from cultivated fields to mature deciduous and mixed forest. 5001-10 000 prs./100 km^2.

Eastern Meadowlark (*Sturnella magna*)

Small numbers use open fields within defined area. Larger numbers are found to the east of the region, in open field habitat. 6-30 prs./100 km^2.

Common Grackle (*Quiscalus quiscula*)

Somewhat colonial, often associated with water. Colonies frequently in beaver ponds where nests built in cattails and other shrubs, as well as in the base of Great Blue Heron nests (including active nests). Other nesting locations include stumps surrounded by water, open structures (marinas), and suburban areas with cedars. 501-1500 prs./100 km^2.

Brown-headed Cowbird (*Molothrus ater*)

Known to parasitize Least Flycatcher, Warbling Vireo, Red-eyed Vireo, Yellow Warbler, Yellow-rumped Warbler, American Redstart, Ovenbird, and Song Sparrow within the region. Inhabitats open disturbed areas including suburban habitats (towns), cultivated and non-cultivated fields, and forest habitats near openings. 501-1000 prs./100 km^2.

Northern Oriole (*Icterus galbula*)

Associated with forest edge and open forest with a mature deciduous component. Often along shoreline and edges of fields as well as open suburban habitats (e.g. cottages) where open area and large shade trees are found. 501-1500 prs./100 km^2.

Purple Finch (*Carpodacus purpureus*)

Low density in dry, mixed forest throughout area. Also occurs in fairly mature conifer plantations. 51-300 prs./100 km^2.

House Finch (*Carpodacus mexicanus*)

Small numbers found in the town of Chaffeys Lock; also in Elgin and in urban yards in between.

Pine Siskin (*Carduelis pinus*)

Present in small numbers in 1992 into June, and probably bred, but erratic; absent in 1993. In 1992, associated with conifers, including pine plantations and Easter White Cedar-dominated forest. Also observed in mixed forest.

American Goldfinch (*Carduelis tristis*)

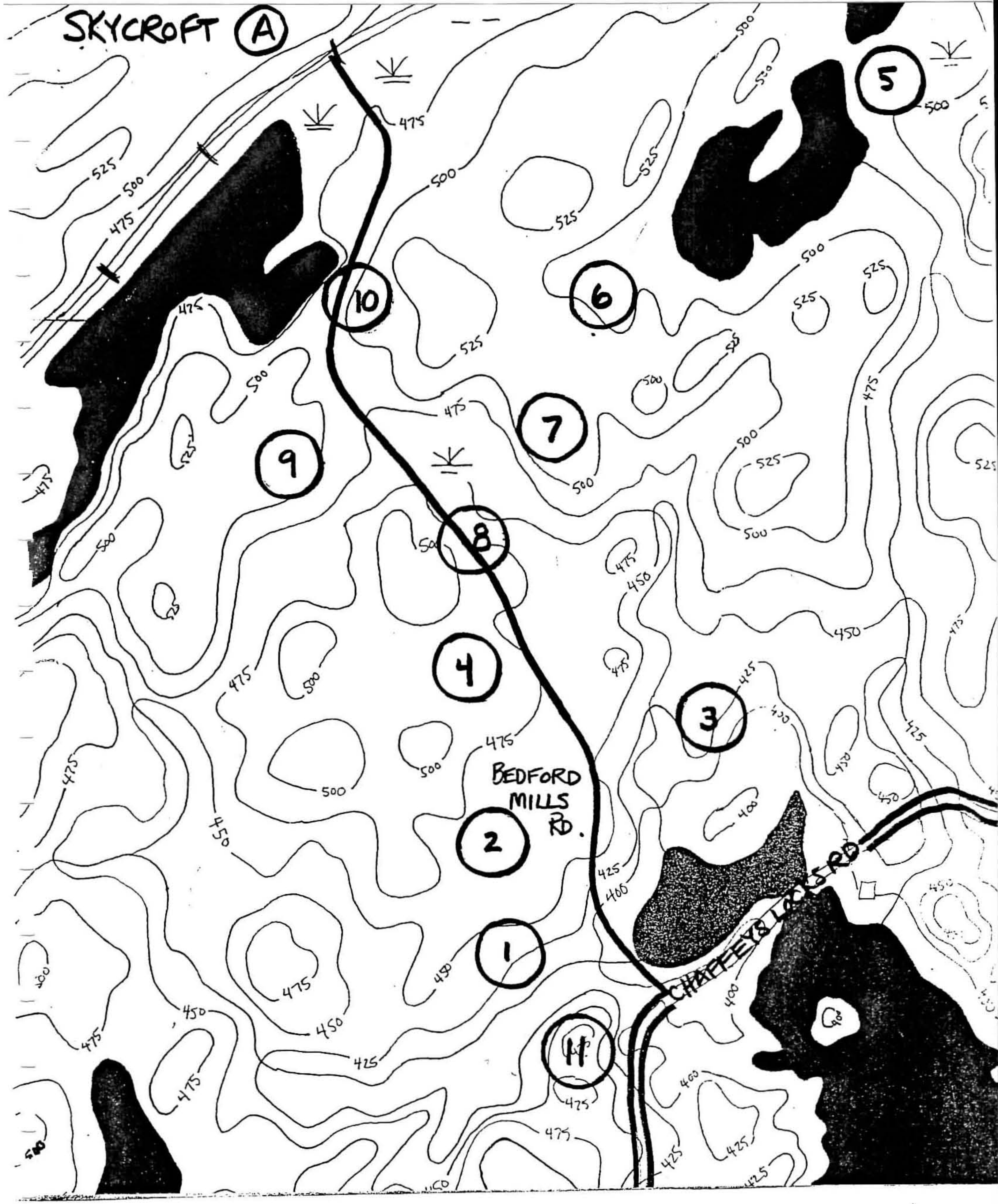
A late nesting species, frequently found in open, uncultivated fields and field edges. Breeding birds most often occur in regrowth fields with dispersed small-medium deciduous trees (often elm spp.). 101-800 prs./100 km^2.

Evening Grosbeak (*Coccothraustes vespertinus*)

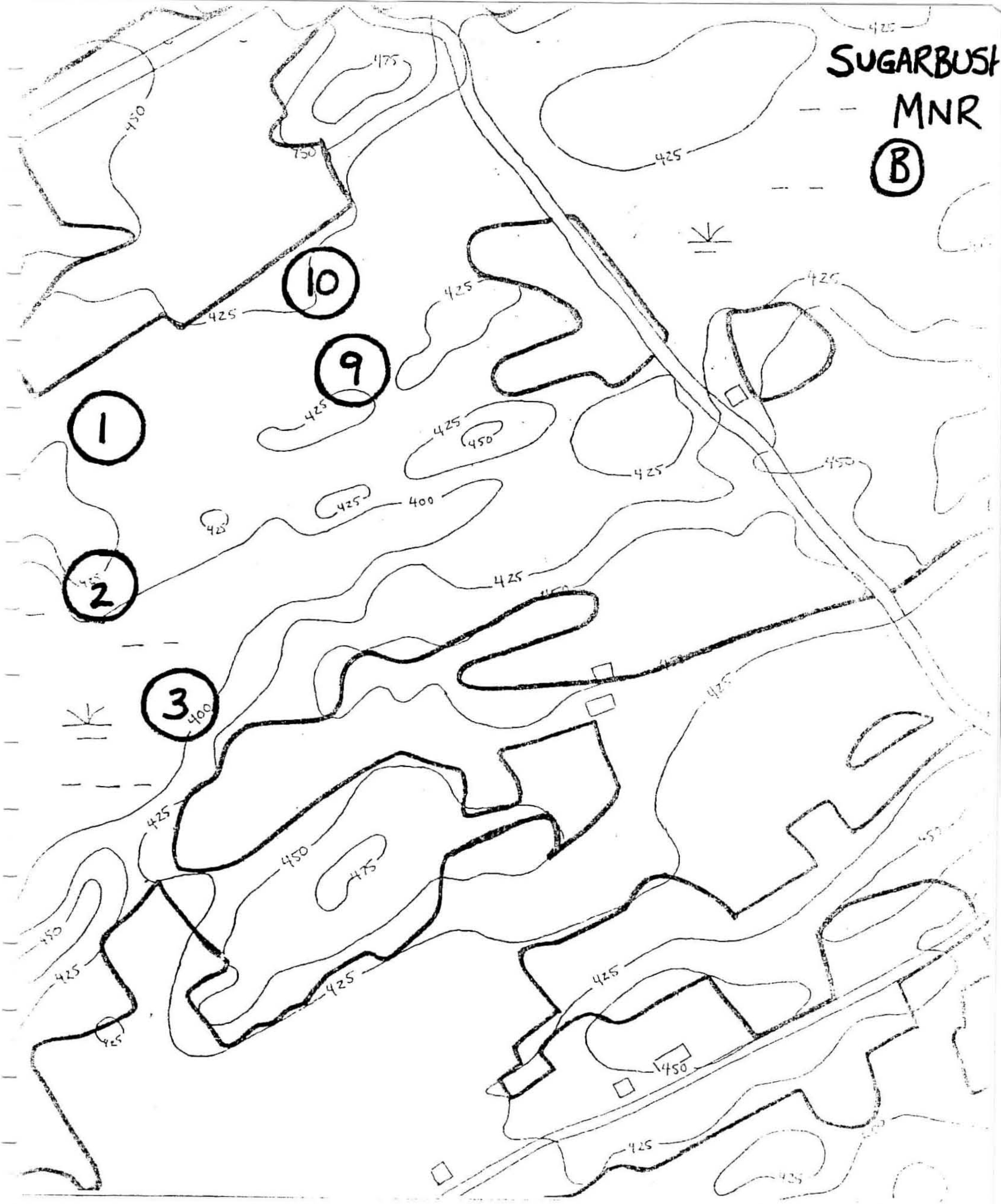
Numbers present through May (common winter visitant) and individuals again seen flying over from mid July onward. These individuals, however, probably do not represent breeders. Only one pair probably bred just outside the defined area, in a mixed pine plantation (Jack, Red, and White pine) with prominent deciduous undergrowth and more mature regrowth. The pair was observed foraging together on June 24, 1993.

House Sparrow (*Passer domesticus*)

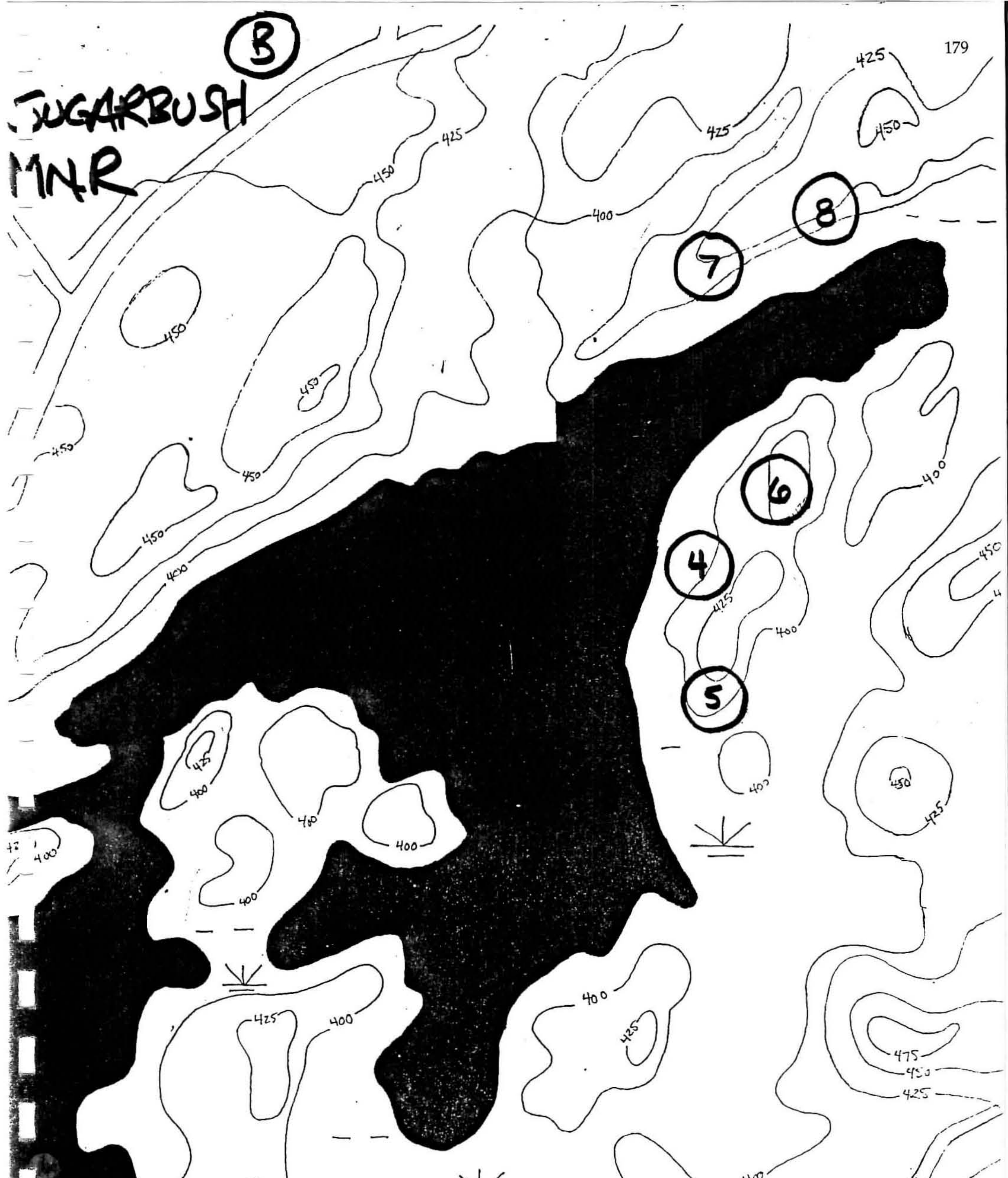
Only small numbers within the area, associated with active farms and more urban sites (e.g. Chaffeys Lock). More common to the east of the defined region, in the agricultural areas and especially in small towns (e.g. Elgin). 21-100 prs./100 km^2.



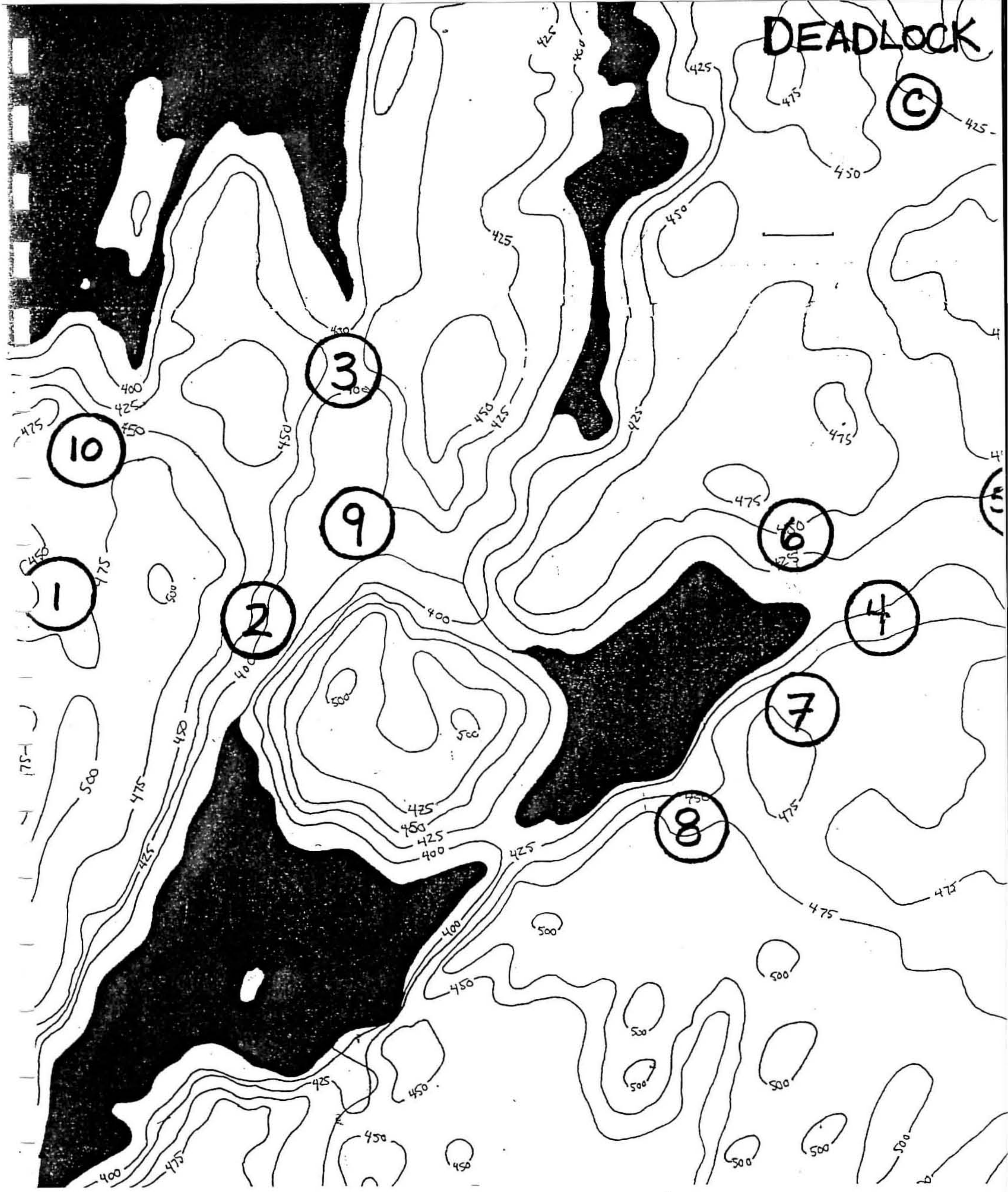
Appendix 2. Location of 11, 50m-radius, hardwood forest plots at the Skycroft site (A) (one of three sites; see Figure 2). Plot 11 was dominated by mature Eastern White Pine (*Pinus strobus*).



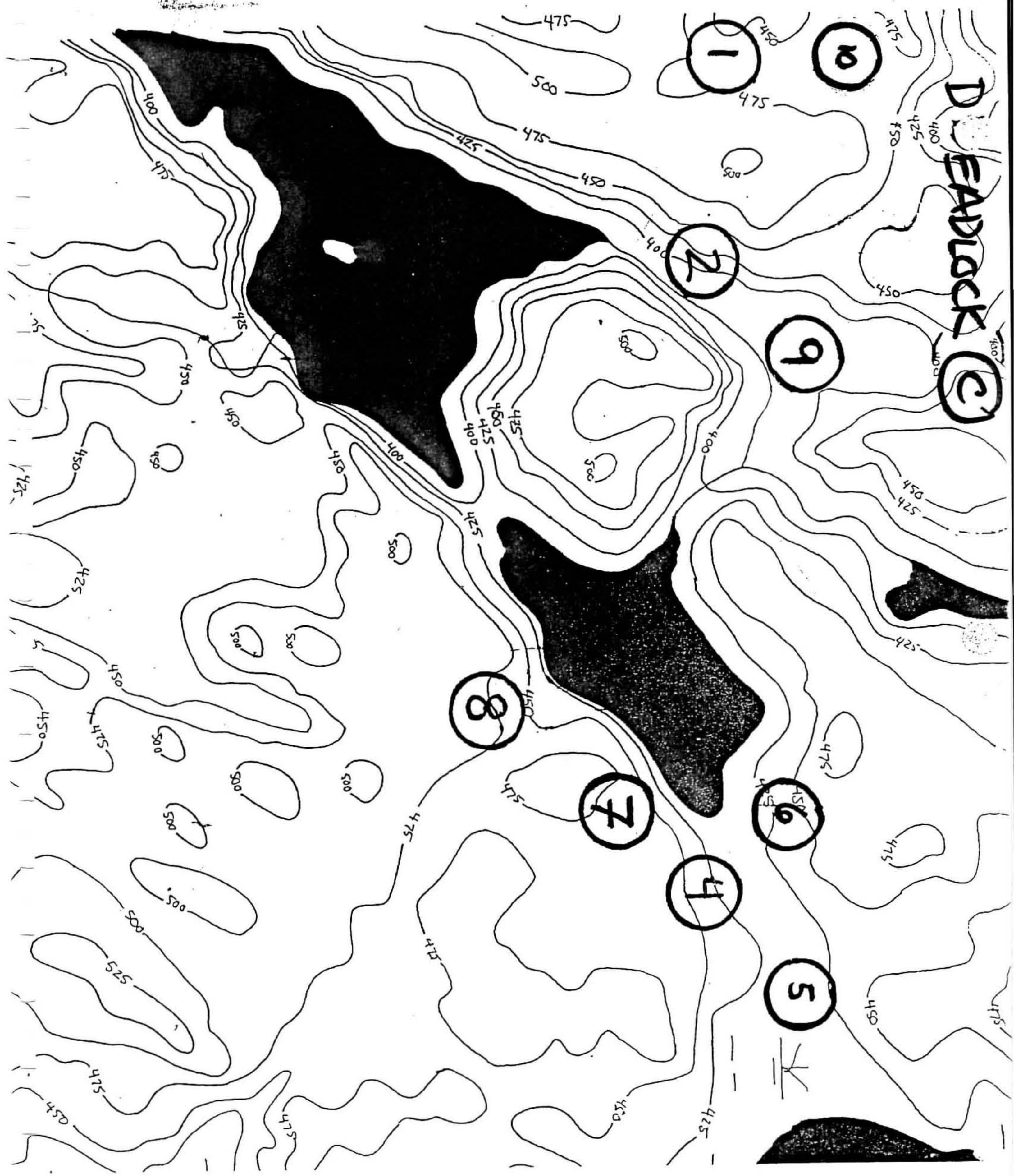
Appendix 3. Location of 10, 50m-radius, hardwood forest plots at the Sugarbush site (B) (one of three sites; see Figure 2). This location was subject to forest management for maple syrup harvesting, which resulted in more 'overmature' trees, relative to the other two sites.



Appendix 3. Location of 10, 50m-radius, hardwood forest plots at the Sugarbush site (B) (one of three sites; see Figure 2). Continued.



Appendix 4. Location of 10, 50m-radius, hardwood forest plots at the Deadlock Bay site (C) (one of three sites; see Figure 2).



Appendix 4. Location of 10, 50m-radius, hardwood forest plots at the Deadlock Bay site (C) (one of three sites; see Figure 2). Continued.

-x5m TREE SPECIES DIVERSITY

Site A4

Date 18 JL 93

DBH ≥2cm

TREE SPECIES	(5) 222° 23m	(6) 253° 37m	(7) 303° 10m	(8) 351° 22m
BASSWOOD	4; 2; 2; 3; (cm)	3; (cm)	2;	5;
SUGAR MAPLE	34;	3; 2;	33;	2; 3; 2; 2; 2;
WHITE ASH	5; 8;	25;	—	7; 3; 3; 4; 10;
IRONWOOD	5; 5; 2; 2; 2;	12;	4; 2;	—
LARGETOOTH ASPEN	—	—	—	5; 5; 30;
DEAD TREE	—	—	2;	3; 2; 3;
LOG	4; 5; 18; 10;	9; 5; 15; 10; 13; 12;	6;	7; 18; 13; 24; 8

Appendix 5. Example vegetation sampling data and figures illustrating methods of data collection.

VERTICAL HEIGHT STRUCTURE

Site A4

Date 18 JL 93

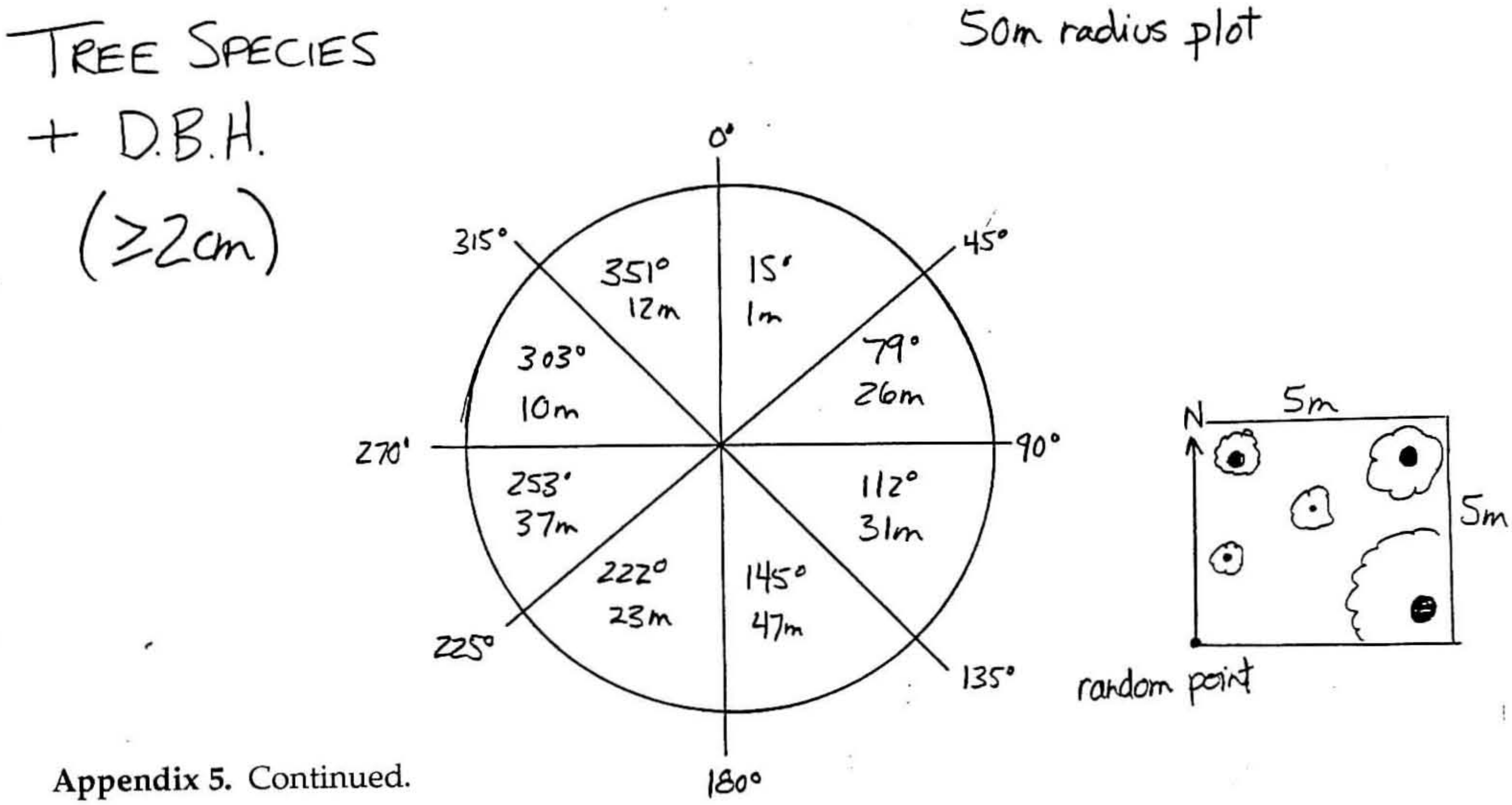
m. diam. circle.

1m	0-1.5	1.5-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30	max tree ht.
1 5° 17m	SM; SM	BA; WA	SM; BA IR	WA; WA IR	WA; IR	SM; WA	SM; WA; BE	SM; SM; BE	SM; BE	SM;	—	25m
2 20° 25m	SM; IR	IR; IR; BA	IR; IR; SM	IR; IR SM	IR; WA	SM;	SM; SM	SM	SM; SM SM	SM; SM	—	27m
3 27° 32m	SM; SM	SM; BA; WA	BA; IR	IR; WA	IR; SM WA	SA; BE SM	SA; BE	SA; SA; BE	SA; BE	BE; BE	BE	28m
4 50° 41m												
5 78° 21m												
6 79° 10m												
7 90° 10m												
8 94° 50m												

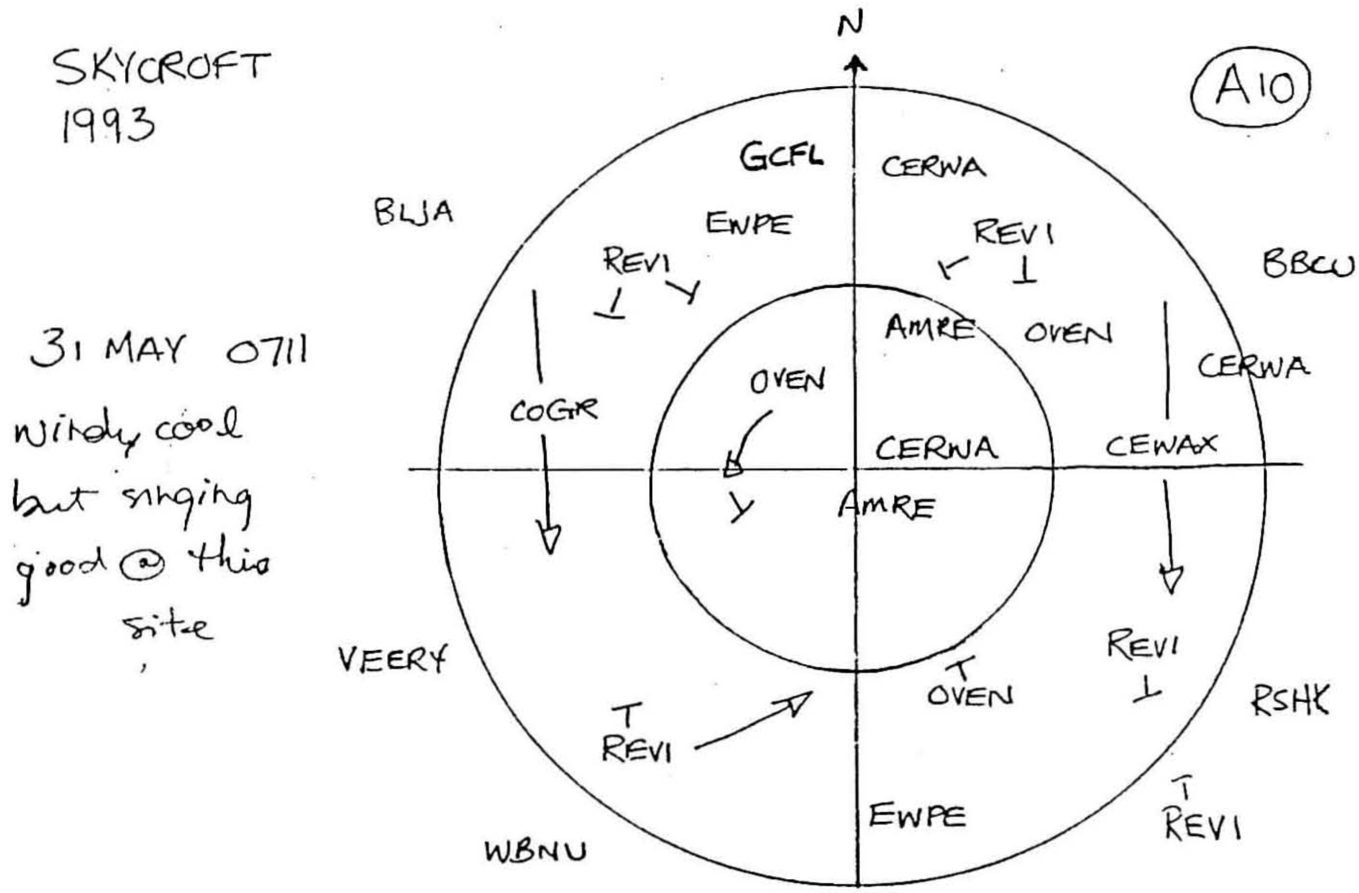
SHRUB DENSITY 1mx1m grid / GROUND COVER 1mx1m grid / CANOPY COVER cylinder

	ROCK incl. lichen	GRASS spp.	Leaf litter	herb. plants	fern spp	moss spp.	dead logs		[redacted]				
1	10%	Ø	80%	10%	Ø	Ø	Ø						
2	Ø	20%	60%	Ø	10%	Ø	10%						
3	Ø	Ø	50%	20%	5%	5%	20%						
4													
5													
6													
7													
8													
9													
10													

Appendix 5. Example vegetation sampling data and figures illustrating methods of data collection. Continued.



Appendix 5. Continued.



Appendix 6. Sample songbird survey data from one, ten-minute survey.

Appendix 7.
List of the tree species recorded on mature hardwood forest plots.

SPECIES	
Red Juniper	*Juniperus virginiana*
Eastern White Pine	*Pinus strobus*
Eastern White Cedar	*Thuja occidentalis*
Eastern Hemlock	*Tsuga canadensis*
Black Maple	*Acer nigrum*
Striped Maple	*Acer pensylvanicum*
Red Maple	*Acer rubrum*
Sugar Maple	*Acer saccharum*
Mountain Maple	*Acer spicatum*
Yellow Birch	*Betula alleghaniensis*
White Birch	*Betula papyrifera*
Blue-beech	*Carpinus caroliniana*
Bitternut Hickory	*Carya cordiformis*
Shagbark Hickory	*Carya ovata*
Alternate-leaf Dogwood	*Cornus alternifolia*
Beech	*Fagus grandifolia*
White Ash	*Fraxinus americana*
Black Ash	*Fraxinus nigra*
Red Ash	*Fraxinus pennsylvanica*
Witch-hazel	*Hamamelis virginiana*
Butternut	*Juglans cinerea*
Ironwood	*Ostrya virginiana*
Largetooth Aspen	*Populus grandidentata*
Trembling Aspen	*Populus tremuloides*
Pin Cherry	*Prunus pensylvanica*
Black Cherry	*Prunus serotina*
Choke Cherry	*Prunus virginiana*
White Oak	*Quercus alba*
Swamp White Oak	*Quercus bicolor*
Red Oak	*Quercus rubra*
Staghorn Sumac	*Rhus typhina*
Basswood	*Tilia americana*
American Elm	*Ulmus americana*
Slippery Elm	*Ulmus rubra*
Rock Elm	*Ulmus thomasii*

Appendix 8.

List of all bird species recorded during surveys of hardwood forest plots (both within and outside of the 50m-radius plots). Boldface indicates species recorded within a plot.

SPECIES	
Common Loon	*Gavia immer*
Great Blue Heron	*Ardea herodias*
Canada Goose	*Branta canadensis*
Wood Duck	*Aix sponsa*
American Black Duck	*Anas rubripes*
Red-shouldered Hawk	***Buteo lineatus***
Ruffed Grouse	*Bonasa umbellus*
Killdeer	*Charadrius vociferus*
Mourning Dove	*Zenaida macroura*
Black-billed Cuckoo	***Coccyzus erythropthalmus***
Yellow-billed Cuckoo	*Coccyzus americanus*
Great Horned Owl	***Bubo virginianus***
Barred Owl	*Strix varia*
Ruby-throated Hummingbird	***Archilochus colubris***
Red-bellied Woodpecker	***Melanerpes carolinus***
Yellow-bellied Sapsucker	***Sphyrapicus varius***
Downy Woodpecker	***Picoides pubescens***
Hairy Woodpecker	***Picoides villosus***
Northern Flicker	***Colaptes auratus***
Pileated Woodpecker	***Dryocopus pileatus***
Eastern Wood-Pewee	***Contopus virens***
Least Flycatcher	***Empidonax minimus***
Eastern Phoebe	***Sayornis phoebe***
Great Crested Flycatcher	***Myiarchus crinitus***
Eastern Kingbird	***Tyrannus tyrannus***
Purple Martin	*Progne subis*
Tree Swallow	*Tachycineta bicolor*
Blue Jay	***Cyanocitta cristata***
American Crow	***Corvus brachyrhynchos***
Common Raven	*Corvus corax*
Black-capped Chickadee	***Parus atricapillus***
White-breasted Nuthatch	***Sitta carolinensis***
Brown Creeper	***Certhia americana***
House Wren	*Troglodytes aedon*
Winter Wren	***Troglodytes troglodytes***
Blue-gray Gnatcatcher	***Polioptila caerulea***
Eastern Bluebird	*Sialia sialis*
Veery	***Catharus fuscescens***
Swainson's Thrush	***Catharus ustulatus***
Hermit Thrush	*Catharus guttatus*
Wood Thrush	***Hylocichla mustelina***
American Robin	***Turdus migratorius***

Appendix 8. continued.

SPECIES	
Gray Catbird	*Dumetella carolinensis*
Cedar Waxwing	*Bombycilla cedrorum*
Yellow-throated Vireo	***Vireo flavifrons***
Warbling Vireo	***Vireo gilvus***
Red-eyed Vireo	***Vireo olivaceus***
Golden-winged Warbler	*Vermivora chrysoptera*
Nashville Warbler	*Vermivora ruficapilla*
Yellow Warbler	***Dendroica petechia***
Yellow-rumped Warbler	***Dendroica coronata***
Black-throated Green Warbler	***Dendroica virens***
Blackburnian Warbler	***Dendroica fusca***
Pine Warbler	***Dendroica pinus***
Cerulean Warbler	***Dendroica cerulea***
Black-and-white Warbler	***Mniotilta varia***
American Redstart	***Setophaga ruticilla***
Ovenbird	***Seiurus aurocapillus***
Northern Waterthrush	*Seiurus noveboracensis*
Louisiana Waterthrush	*Seiurus motacilla*
Common Yellowthroat	*Geothlypis trichas*
Scarlet Tanager	***Piranga olivacea***
Northern Cardinal	*Cardinalis cardinalis*
Rose-breasted Grosbeak	***Pheucticus ludovicianus***
Indigo Bunting	***Passerina cyanea***
Rufous-sided Towhee	***Pipilo erythrophthalmus***
Chipping Sparrow	***Spizella passerina***
Field Sparrow	***Spizella pusilla***
Song Sparrow	*Melospiza melodia*
Swamp Sparrow	*Melospiza georgiana*
White-throated Sparrow	*Zonotrichia albicollis*
Red-winged Blackbird	***Agelaius phoeniceus***
Common Grackle	*Quiscalus quiscula*
Brown-headed Cowbird	***Molothrus ater***
Northern Oriole	***Icterus galbula***
Purple Finch	***Carpodacus purpureus***
American Goldfinch	***Carduelis tristis***

Appendix 9. Trends ($0.05 < p \leq 0.10$) between songbird species' abundance scores and environmental components derived from Principal Components Analyses.

Songbird Species	Environmental Component	Relationship
Eastern Wood Pewee	Ground Cover PC 1	negative
Least Flycatcher	Tree Species Diversity PC 1	negative
Yellow-throated Vireo	Tree Density PC1 Ground Cover PC 2	negative negative
Red-eyed Vireo	Ground Cover PC 1	positive
Black-thr. Green Warbler	Vertical Height PC 2 Tree Species Diversity PC 2	positive positive
Pine Warbler	Vertical Height PC 2 Vertical Height PC 3 Tree Density PC 2 Landscape PC 1	positive positive positive positive
Cerulean Warbler	Vertical Height PC 3 Vertical Height PC 4 Tree Species Diversity PC 2 Landscape PC 1 Landscape PC 2	negative negative negative negative negative
Black-and-white Warbler	Tree Species Diversity PC 1 Tree Species Diveristy PC 4 Landscape PC 1	negative negative negative
American Redstart	Tree Density PC 1	negative
Scarlet Tanager	Tree Species Diversity PC 1	negative
Rose-breasted Grosbeak	Vertical Height PC 2 Tree Species Diversity PC 1 Tree Species Diversity PC 2 Tree Species Diversity PC 4 Ground Cover PC 2	positive positive positive positive positive
Chipping Sparrow	Ground Cover PC 2	negative

Appendix 10.
List of all bird species recorded during surveys in pine plantations (both within and outside of 25m-radius plots). Boldface species were either recorded within the defined plots, or were observed within the plantation outside of defined plots.

SPECIES	
Common Loon	*Gavia immer*
American Bittern	*Botaurus lentiginosus*
Wood Duck	*Aix sponsa*
Mallard	*Anas platyrhynchos*
Northern Goshawk	*Accipiter gentilis*
Ruffed Grouse	*Bonasa umbellus*
Killdeer	*Charadrius vociferus*
Common Snipe	*Gallinago gallinago*
Mourning Dove	***Zenaida macroura***
Yellow-billed Cuckoo	*Coccyzus americanus*
Downy Woodpecker	***Picoides pubescens***
Hairy Woodpecker	*Picoides villosus*
Northern Flicker	***Colaptes auratus***
Pileated Woodpecker	*Dryocopus pileatus*
Eastern Wood-Pewee	***Contopus virens***
Alder Flycatcher	*Empidonax alnorum*
Eastern Phoebe	***Sayornis phoebe***
Great Crested Flycatcher	***Myiarchus crinitus***
Eastern Kingbird	***Tyrannus tyrannus***
Horned Lark	*Eremophila alpestris*
Tree Swallow	*Tachycineta bicolor*
Blue Jay	***Cyanocitta cristata***
American Crow	***Corvus brachyrhynchos***
Black-capped Chickadee	***Parus atricapillus***
Red-breasted Nuthatch	***Sitta canadensis***
White-breasted Nuthatch	*Sitta carolinensis*
Brown Creeper	*Certhia americana*
House Wren	*Troglodytes aedon*
Golden-crowned Kinglet	***Regulus satrapa***
Veery	*Catharus fuscescens*
Wood Thrush	*Hylocichla mustelina*
American Robin	***Turdus migratorius***
Gray Catbird	*Dumetella carolinensis*
Brown Thrasher	*Toxostoma rufum*
Cedar Waxwing	***Bombycilla cedrorum***
European Starling	*Sturnus vulgaris*
Solitary Vireo	***Vireo solitarius***
Red-eyed Vireo	***Vireo olivaceus***
Warbling Vireo	*Vireo gilvus*

Appendix 10. continued.

SPECIES	
Yellow Warbler	*Dendroica petechia*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Black-throated Green Warbler	***Dendroica virens***
Blackburnian Warbler	***Dendroica fusca***
Pine Warbler	***Dendroica pinus***
Black-and-white Warbler	***Mniotilta varia***
Ovenbird	***Seiurus aurocapillus***
Common Yellowthroat	*Geothlypis trichas*
Scarlet Tanager	*Piranga olivacea*
Northern Cardinal	***Cardinalis cardinalis***
Rose-breasted Grosbeak	***Pheucticus ludovicianus***
Indigo Bunting	*Passerina cyanea*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Chipping Sparrow	***Spizella passerina***
Field Sparrow	*Spizella pusilla*
Vesper Sparrow	*Pooecetes gramineus*
Savannah Sparrow	*Passerculus sandwichensis*
Song Sparrow	*Melospiza melodia*
Swamp Sparrow	*Melospiza georgiana*
Bobolink	*Dolichonyx oryzivorus*
Red-winged Blackbird	***Agelaius phoeniceus***
Eastern Meadowlark	*Sturnella magna*
Common Grackle	*Quiscalus quiscula*
Brown-headed Cowbird	***Molothrus ater***
Northern Oriole	***Icterus galbula***
Purple Finch	***Carpodacus purpureus***
American Goldfinch	*Carduelis tristis*
Evening Grosbeak	***Coccothraustes vespertinus***