AVIAN ASSEMBLAGES IN NATURAL AND SECOND-GROWTH BALSAM FIR FORESTS IN WESTERN NEWFOUNDLAND

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Avian Assemblages in Natural and Second-growth Balsam Fir Forests in Western Newfoundland

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ABSTRACT

Avian assemblages were investigated in natural (uncut) and mature second-growth balsam fir (*Abies balsamea*) forests in western Newfoundland. Within these forest classes, there were four forest types varying in site richness. Birds were studied to determine if assemblages differed between forest classes and among forest types, and to determine if differences in avian assemblages were associated with vegetation structure and composition. The IPA (Indice Ponctuel d'Abondance) version of the point-count method was used to census birds.

The result indicated avian species richness, diversity and total abundance (IPA) did not differ between natural growth and second growth forest. Three species were more abundant in natural growth. Black-backed Woodpeckers (*Picoides arcticus*) were found exclusively in natural growth. Five species and one guild (seed-eating) were more abundant in second growth forests.

A trend toward increased abundance with increased forest type richness was evident for Black-throated Green Warbler (*Dendroica virens*), Ovenbird (*Seiurus aurocapillus*) and Mourning Warblers (*Oporornis philadelphia*) and the seed-eating guild as well as for species richness and IPA. The foliage-gleaning guild was least abundant in moss forest types, where foliage height diversity and habitat diversity (Shannon-Wiener index) were lowest.

Twelve bird species and three guilds had significant multiple regression models in the analyses using principal components from analyses of vegetation variables from all stands. Of these, Black-backed Woodpecker, Yellow-bellied Flycatcher (*Empidonax minimus*) and Yellow-rumped Warbler (*Dendroica coronata*) and the fly-catching guild were indicated to avoid dense fir with canopy cover and snags (PC1), while Boreal Chickadees (*Parus hudsonicus*) and Black-throated Green Warbler, and the generalists guild preferred such areas. Seven species and two guilds (foliage-gleaning and generalists) strongly preferred rich forests with ferns and forbs (PC2). Seven species and one guild (flycatching) avoided older forests lacking deciduous litter (PC3). Deciduous litter was highly correlated with Ovenbird abundance. Principal Component 2 and PC3 explained most of the variance associated with species richness and IPA. Both second-growth and natural growth forests seemed to provide adequate breeding habitat for most species. It is important to maintain stand diversity in order to promote avian biodiversity and increased abundance. Important structural components to maintain are: snags, for bark foragers and cavity nesters, particularly Black-backed Woodpeckers; some deciduous trees, for some ground foraging species, especially Ovenbirds; and a portion of canopy trees, as a source for future snags.

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TABLE OF CONTENTS

Page

Page

LIST OF TABLES

Table		Page

LIST OF FIGURES

1. INTRODUCTION

The relationship between vegetation structure and avian assemblages was first recognized by MacArthur and MacArthur (1961), who proposed that bird species diversity was influenced by plant species composition, foliage height profiles and latitude. Subsequent research documented the relationships between avian assemblages and vegetation composition and structure (e.g. Willson 1974, James and Wamer 1982, Morgan and Wetmore 1986, Small and Hunter 1989, Morimoto and Wasserman 1991, Douglas *et al.* 1992, McGarigal and McComb 1992), as well as changes in avian communities in response to changes in vegetation (e.g. Franzreb and Ohmart 1978, Morrison and Meslow 1984, Morgan and Freedman 1986, Welsh 1987, Santillo *et al.* 1989, Lehmkhul *et al.* 1991).

Forest management can alter avian assemblages by changing vegetation structure and thus the availability of nest-sites, shelter and food (Morgan *et al.* 1989). Understanding the effects of these changes is critical in light of the accumulating literature that indicates a decline in neotropical migrant birds (Hall 1984, Wilcove and Terborgh 1984, Robbins *et al.* 1989, Askins 1990, Holmes *et al.* 1992, Johnston and Hagan 1992; Sauer and Droege 1992). In recent decades, indicator species have been used to monitor habitat quality and population trends (Landres *et al.* 1988, Noss 1990). For example, the ecological requirements Red-cockaded Woodpeckers (Conner and

Rudolpf 1991, Hooper *et al.* 1991, Rudolph and Conner 1991), Spotted Owls (Ripple *et al.* 1991) and Marbled Murrelet (Marshall 1988) have been used to support the importance of conserving mature and old growth forests in the USA. Although the single-species approach is often used for the conservation of vulnerable species, it has been criticised for lacking precise definition and procedures, and as having ambiguous criteria for species selection. These problems weaken the effectiveness and validity of the indicator species approach (Landres *et al.* 1988, Noss 1990).

A more holistic approach has evolved that emphasises habitat monitoring for the maintenance of biological diversity (biodiversity). Forest managers are currently attempting to develop sound harvesting practices that maintain biological diversity (O'Brien 1990, Morrison 1992, Adams and Morrison 1993). In order to pursue such strategies, it is necessary to determine the important variables of a given ecosystem that influence diversity. Biological diversity can be defined as the diversity and variability of all living things and the ecological complexes in which they occur (Office of Technology Assessment [OTA 1987]). Noss (1990) recommends monitoring biodiversity by considering the three main attributes of ecosystems (Franklin *et al.* 1981): composition (various measures of species composition); structure (physical structure of the ecosystem); and function (proximate and ultimate processes) at four levels of organisation: landscape, community, species and genes. Terrestrial birds provide a convenient measure of the biodiversity of an ecosystem, as they are sufficiently diverse, numerous and conspicuous during the breeding season.

It is often impractical to analyse all species in a community study. Species are frequently categorised into guilds that exploit similar resources in similar ways (Root 1967). The guild concept has been used in many avian studies (e.g., Franzreb and Ohmart 1978, Noon 1981a, Holmes and Recher 1986, Holmes *et al.* 1986, Landres *et al.* 1988, Sadoway 1988). Guilds can be constructed in various ways, depending on the resource used to define ecological similarities. The resource is generally food (Simberloff and Dyan 1991). In this study, feeding behaviour and food type was used to group species into guilds.

Breeding Bird Surveys conducted from 1980 to 1985 by Memorial University of Newfoundland, provided baseline data showing species trends in different ecoregions throughout the province (W.A. Montevecchi unpubl. data). Finer scale censusing efforts have been conducted at Gros Morne National Park (Lamberton 1976), the Long Range Mountains (Montevecchi *et al.* 1982) and at Godleich Pond (Goudie 1990). There have been no comparative analysis of avian assemblages in different forest types or classes in Newfoundland and Labrador.

My study focuses on avian assemblages in balsam fir (*Abies balsamea*) forests in western Newfoundland. Balsam fir forests are closed canopy softwood forests comprised of less than 50% hardwood trees, and with a crown cover of less than 75% black spruce (*Picea mariana*) (Meades and Moores 1989). The forest stands consisted of two forest classes: young mature second-growth, referring to stands 40-60 years post-harvesting; and mature/over-mature uncut forest, 80+ years old and of natural origin (referred to as "natural" forest stands). Within the second-growth and natural growth forests, there were the following four forest types, in order of decreasing richness: (i) fern/herb; (ii) fern; (iii) fern/moss; and (iv) moss. Stand richness was defined by the ground vegetation species that reflected soil fertility and moisture content (Meades and Moores 1989).

Balsam fir is a short-lived species maturing at about 70 years and surviving to a maximum of 120 years (Saunders 1970). It is the predominant tree species in western Newfoundland, due to limited fires in this region (Report of the Royal Commission on Forest Protection and Management 1981) and is the climax species on moderate to good sites (van Nostrand *et al.* 1982). In light of the relationship between avian assemblages and vegetation structure and the imminent harvesting of the few remaining natural stands in Newfoundland, it is important to determine if the avian assemblages are significantly different among these forest classes and types.

The avian assemblage variables used were: individual species; guilds; total number of species (species richness); species diversity (Shannon-Wiener diversity index); and abundance (IPA index of relative abundance). The latter three variables were referred to collectively as community indices (see 2.2).

The objectives of this study were:

(1) to determine if species richness, diversity and abundance differed between second-growth and natural forests;

(2) to determine if species richness, diversity and abundance differed among forest types; and

(3) to determine whether species and guild assemblages were reflected in vegetation structure and composition.

The null hypothesis tested was: individual species, guilds and community indices do not differ between forest classes or among forest stand types.

2. METHODS

2.1 Study Area

Thirty-five second-growth and natural-growth balsam fir forest stands in western Newfoundland were selected (Figure 1). Each stand included four or five observation points that were separated by ≥ 200 m and were at least 100 m from the nearest edge. Stands were separated by ≥ 300 m. Twenty two second-growth stands were selected near Birchy Lake, Hampden, South Brook, Pinchgut Lake, Adies Pond and Cooks Pond (Table 1) (e.g., Figure 2). Owing to the limited natural-growth forest remaining in Newfoundland (Figure 3), fewer of these stands could be included. Ten stands near Little Grand Lake and three stands in the Humber River/Birchy Lake area (Table 1) were selected (e.g., Figure 4)

2.2 Bird Censusing

The I.P.A. (Indice Ponctuel d'Abondance) method was modified for use in this study (D.A. Welsh, pers. comm., Pinowski *et al.* 1977). The results provided a list of total species (species richness) and an index of abundance: the total number of birds detected at an observation point, referred to as the IPA. Spot mapping and line transects are other common census methods for terrestrial bird surveys, but were not used in this study, since spot mapping is labour-intensive (International Bird Censusing Committee [I.B.C.C.] 1970),

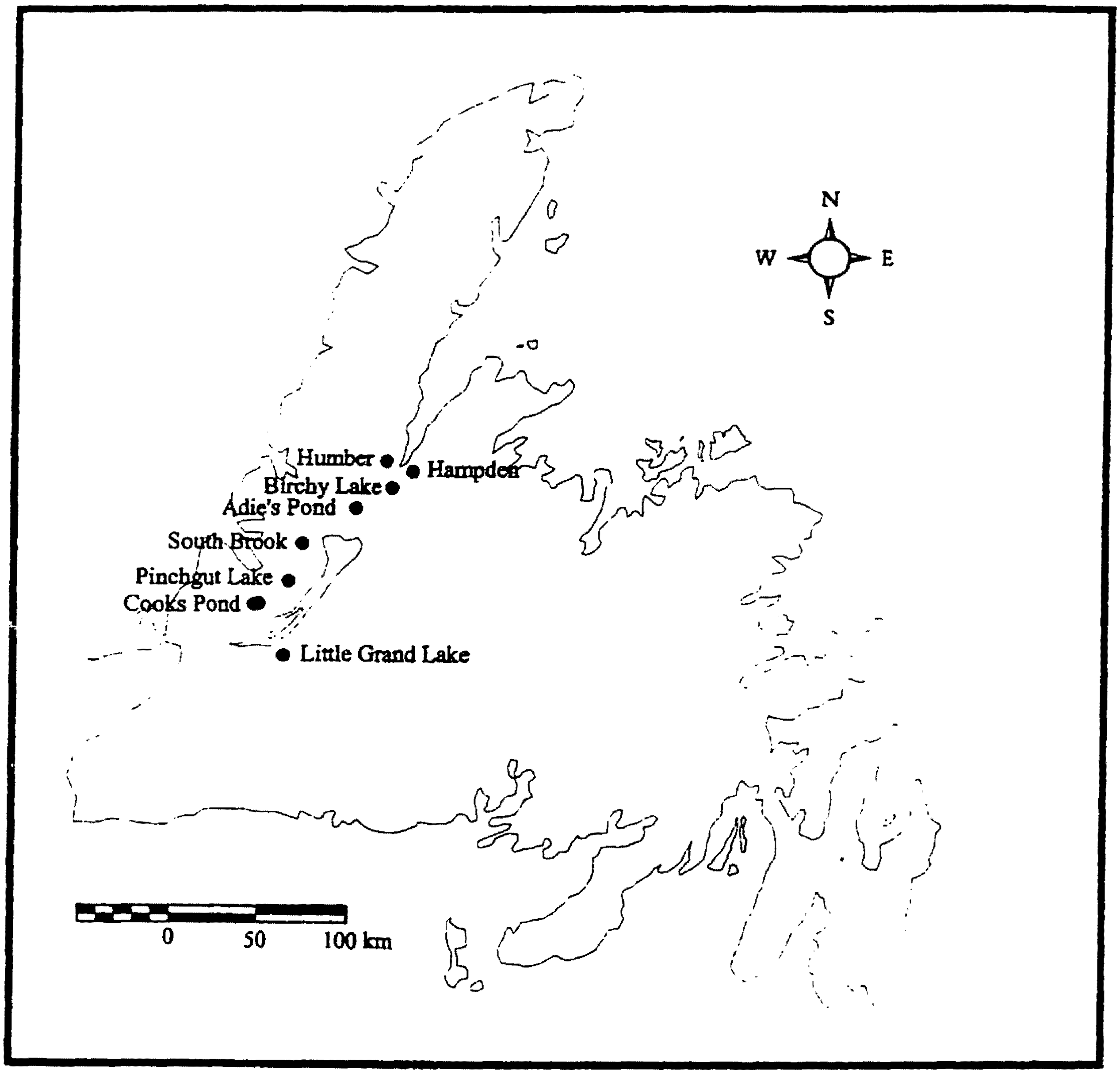

Figure 1. Location of study sites in western Newfoundland.

Table 1. The class, type and location of balsam fir stands in the study area (see Figure 1). The forest types are adapted from Meades and Moores (1989).

Stand Name	Class Type	Latitude (N)	Longitude (W)
Humber 30	natural moss	49^{0}38.00'	57^{0}12.75'
Humber 32	natural moss	49^{0}37.50'	57^{0}12.50'
Humber 33	natural moss	49^{0}37.50'	57^{0}13.00'
LGL 01	natural fern	49^{0}37.50'	57^{0}47.50'
LGL 02	natural fern	49^{0}35.25'	57^{0}55.50'
LGL 04	natural fern/moss	49^{0}38.00'	57^{0}50.25'
LGL 14	natural fern/moss	49^{0}38.25'	57^{0}46.00'
LGL 15	natural fern	49^{0}39.00'	57^{0}47.50'
LGL 16	natural fern	49^{0}39.25'	57^{0}47.00'
LGL 17	natural fern	49^{0}34.50'	57^{0}57.25'
LGL 18	natural fern	49^{0}39.50'	57^{0}47.25'
LGL 41	natural fern	49^{0}34.75'	57^{0}57.25'
LGL 42	natural fern	49^{0}35.00'	57^{0}56.50'
Hampden 26	second moss	49^{0}27.50'	57^{0}55.50'
Hampden 27	second moss	49^{0}28.00'	57^{0}55.00'
Hampden 28	second moss	49^{0}29.75'	57^{0}54.25'
Hampden 29	second moss	49^{0}29.25'	57^{0}54.50'
Taylor's Bk 36	second moss	49^{0}34.50'	57^{0}02.50'
Taylor's Bk 37	second moss	49^{0}34.75'	57^{0}02.00'
Adies 20	second moss	49^{0}24.50'	57^{0}19.75'
Adies 21	second moss	49^{0}25.00'	57^{0}19.25'
Adies 07	second fern/moss	49^{0}22.75'	57^{0}21.00'
Adies 19	second fern	49^{0}21.50'	57^{0}22.50'
South Bk 09	second fern/moss	48^{0}55.25'	57^{0}36.50'
South Bk 08	second fern	48^{0}54.50'	57^{0}36.50'
South Bk 10	second fern	48^{0}58.75'	57^{0}37.00'
South Bk 11	second fern	48^{0}57.00'	57^{0}37.25'
Cooks Pd 22	second fern	48^{0}52.00'	58^{0}05.25'
Cooks Pd 25	second fern	48^{0}51.50'	58^{0}06.75'
Cooks Pd 23	second fern/herb	48^{0}51.75'	58^{0}05.25'

Table 1 (Continued)

Stand Name	Class Type	Latitude (N)	Longitude (W)
Cooks Pd 24	second fern/herb	$48^0$51.50'	$58^0$05.50'
Pinchgut 06	second fern	$48^0$51.50'	$58^0$56.00'
Pinchgut 50	second fern	$48^0$48.00'	$58^0$04.00'
Pinchgut 05	second fern/herb	$48^0$51.50'	$58^0$56.50'
Pinchgut 51	second fern/herb	$48^0$48.50'	$58^0$04.00'

Figure 2. Representative forest of second growth stands.

Figure 3. Remaining natural growth forests in Newfoundland.

Figure 4. Representative forest of natural growth stands.

Millikin 1988) and hence would limit area of coverage, and line transects tend to underestimate species density (Franzreb 1981) and is not appropriate for density estimates (Manuwal and Carey 1991). Four or five observation points were selected in each stand, depending on area of suitable forest. Distances of 200 m between stations, and 100 m from edges were prescribed to avoid overlap of bird songs from one point to the next, and to avoid including birds from other habitats. At each observation point the following procedure was followed:

(i) upon arrival, a 1 min. rest was taken to allow any disturbance created by the observer to settle;

(ii) a north bearing was taken with a compass

(iii) a timer was activated for a 10 min interval [20 min in Pinowski *et al.* (1977)];

(iv) during this interval, all birds seen or heard were recorded on a card that was divided into four quadrants, defined by the four cardinal directions (north, south, east and west). Each bird detected was recorded in its approximate direction and distance from the point, to avoid recounting individuals. American Ornithologists Union (AOU) symbols were used for each species name. Different symbols were used to indicate singing males, single individuals, pairs, and behaviours indicating an active nest (carrying nest material or food). These were later translated into the number of individuals present: one singing male, one pair and one active nest each represented two (breeding) individuals; and a single bird seen or heard calling represented one individual.

Each observation point was censused twice during each of the two breeding seasons: between June 9 - July 9, 1991, and June 9 - June 30, 1992. Censuses were temporally spaced to ensure that both early and later breeders were detected. All counts were conducted while singing was most active, generally between 0500 and 0930. Counts were not made under rainy or windy (>25 km/hr) conditions. The common and scientific names, and AOU abbreviations (used in tables and figures) are provided in Appendix 1.

2.2.1 Assigning Species to Guilds

The species detected in the surveys were organised into six guilds, based on foraging behaviour and food resources exploited, adapted from those described by Morgan *et al.* (1991) (Table 2). Species that were not detected in both years were not assigned to guilds, to avoid including vagrants that were not directly utilising resources in the study forest stands.

2.3 Vegetation Analysis

Vegetation data were provided by Canadian Forest Service (I. Thompson, pers comm. and unpubl. data). To determine density and dominance of trees and shrubs in each stand, a modified version of the 'nearest-neighbour' point-distance method was used (Batchelor 1975). For each stand 50 or 100 points were randomly selected, depending on

Table 2. Assignment of species to guilds based on foraging behaviour and food resource exploitation, adapted from Morgan et a l. (1991).

Guild	Species	Abbreviation
Pecking/Probing	Downy Woodpecker	Pecking
(insects from	Hairy Woodpecker	
tree trunks)	Black-backed Woodpecker	
	Red-breasted Nuthatch	
Hawking/flycatching	Yellow-bellied Flycatcher	Flycatch
(insects from the air)	Tree Swallow	
Foliage Gleaner	Black-capped Chickadee	Foliage
(insects from	Boreal Chickadee	
foliage and	Golden-crowned Kinglet	
branches)	Ruby-crowned Kinglet	
	Magnolia Warbler	
	Yellow-rumped Warbler	
	Black-throated Green Warbler	
	Bay-breasted Warbler	
	Blackpoll Warbler	
	Black and White Warbler	
	Mourning Warbler	
Ground Gleaner	Swainson's Thrush	Ground
(insects on or	Hermit Thrush	
near the ground)	Gray-cheeked Thrush	
	American Robin	
	Ovenbird	
	Northern Waterthrush	
	Fox Sparrow	
	White-throated Sparrow	
	Dark-eyed Junco	
	Winter Wren	

Table 2 (Continued)

Guild	Species	Abbreviation
Seed Eater (seeds from cone-bearing trees)	Pine Grosbeak	Seed
	Evening Grosbeak	
	Purple Finch	
	Purple Finch	
	Common Redpoll	
	White-winged Crossbill	
	Pine Siskin	
Generalist (feed opportunistic-ally on a various foods)	Gray Jay	General
	Common Raven	

statistical variance. Data were collected on large trees (diameter at breast height (dbh) of ≥ 10 cm and a height > 3 m), small trees (dbh of < 10 cm and a height of ≥ 3 m), dead trees (≥ 3 m), and shrubs height between 0.5 and 3.0 m). From each random point, the nearest large tree was located and its distance from the point, dbh, and number of stems below breast height were recorded. This first tree was then used as the reference point for the next set of measurements. The distance from the first tree to the nearest large tree was measured and the same morphometric data collected. The second tree served as the reference for the final set of measurements for that location. For large trees, the maximum search radius was 10 m from the reference point. The same data were collected for small trees, dead trees, and shrubs, except that the search radius for these groups was 5 m. The number of stems for a shrub was defined as the number of stems arising from the ground that originated at a single plant.

For ground covers, 50 points were randomly selected in each stand. A 2 x 2 m quadrat was located in a predetermined direction from the marker stick. Within the quadrat, cover percentage values were recorded separately for the proportion of medium shrubs (0.5-1.0 m), low shrubs (<0.5 m), tall ferns (≥ 0.5 m), low ferns (< 0.5 m), graminoids, forbs, *Sphagnum* mosses, other mosses (by species), lichens, water, soil, rock, slash (sticks < 5 cm diameter), litter, logs (log diameter was also recorded) and stumps (> 5 cm diameter), and *Lycopodium* spp. Percent canopy cover and foliage height diversity (FHD) were also measured at the 50 points. Percent canopy cover was assessed using a densiometer (Lemon 1956), by taking the mean of four assessments taken at 90 degrees to each other. FHD was determined by indicating the presence or absence of vegetation along an imaginary vertical line with 9 height classifications: >0 to 0.5 m; >0.5 to 1.5 m; >1.5 to 3 m; >3.0 to 5 m; >5.0 to 8 m; >8 to 12; >12 to 16 m; 16 to 20 m; and >20 m. A 2 m pole marked at 0.5 m intervals was used for the first two FHD measures, and other height intervals were estimated visually. The vegetation data were used to identify important structural variables with which the bird species and guilds were associated. Forest Site Classification (FSC) was assigned to each point (Meades and Moores 1989). FSC was determined at four locations per point, oriented north, east, west and south, and approximately 50 m from the observation point. Since some stands comprised more than one FSC type (see Appendix 2), each stand type was averaged and assigned to one of one of four broader balsam fir forest type categories, in order of decreasing richness: fern/herb; fern; fern/moss; and moss. Richness was calculated by multiplying soil moisture by soil fertility from the edaphic grid provided for each FSC type. These values were then averaged for each forest stand. Richness refers to the vegetation supported by a site and reflects the soil nutrient levels and water flow through the soil. These data were collected between July and August, 1992. Some points were dominated by black spruce types and were eliminated from the analysis, reducing the number of observation points for five of the stands to four (see Appendix 2).

2.4 Statistical Analysis

Bird census data had heteroscedastic variance, so the data were log-transformed. Bird and vegetation data were averaged for each stand. Analysis of variance (ANOVA) was applied to stands with five versus four observation points, to ensure that there was no significant difference in species richness among them ($F_{1,33}$=2.78, $P > 0.05$). Point distance data were summarised for each stand as follows: for large trees, total tree species density and proportions of fir, birch and spruce (white and black pooled) were calculated. The data for small trees and dead trees was summarised in the same manner. For shrubs, total density and proportions of coniferous and deciduous were calculated.

Diversity indices are often used in ecological studies to characterise and compare communities (Hill 1973, Green 1979). The Shannon-Wiener index (S-W index), the most widely used of these (Magurran 1988), was used to calculate diversity indices for each stand (from Krebs 1989):

$$H' = \Sigma(p_i)(\log p_i)$$

where H' = index of species diversity

p_i = proportion of the total sample belonging to the i^{th} species

ANOVA was used on log-transformed bird data to compare species abundance between 1991 and 1992. After the 1991 field season, it was discovered that one observation point each at Adies 21 and Cooks Pond 24 violated the criteria for distance from the nearest edge and they were moved for the 1992 season. The corresponding data were eliminated from the 1991 data set. Species accumulation curves for Adies 21 and Cooks Pond 24 (Figure 5) indicated that the number of species was not affected by this change. Two-way factorial ANOVA was used to determine whether significant differences between the number of species, guilds, and community indices occurred between years, between forest classes, among forest types, and if there were any interactions between forest class and types. Forest types were grouped into two groups for this analysis: "richer" (fern/herb and fern) and "poorer" (fern/moss and moss) to allow sufficient sample size in each category for the analysis. Mean differences between stand classes and among stand types were also tested for FHD, the only categorical vegetation variable. Tukey's *a posteriori* multiple range test was used where significant differences among forest types occurred.

Principal components analysis (PCA) can be used to reduce the dimensions of a data set by producing a smaller number of variables that are linear, orthogonal combinations of the original variables (James and McCulloch 1990). The new variables are the eigenvectors, or principal component axes. Correlated variables cannot be used

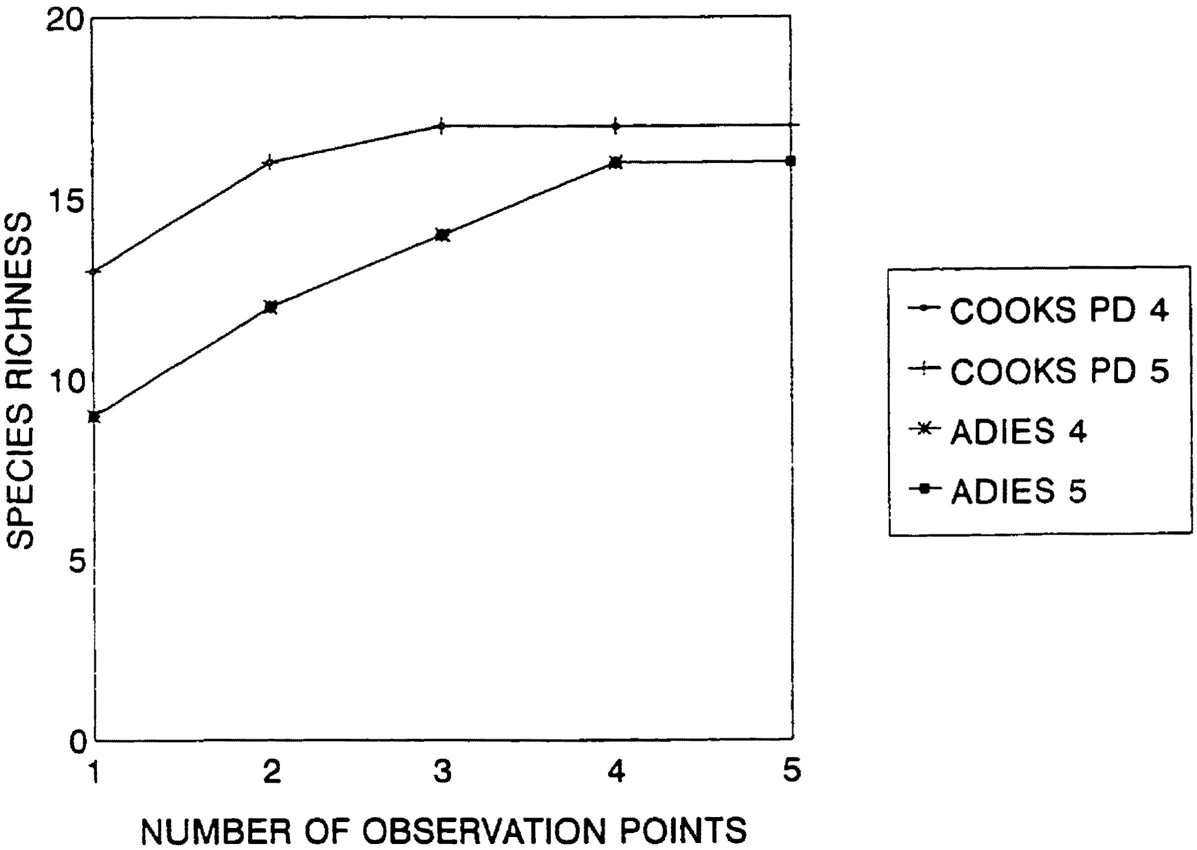

Figure 5. Species accumulation curves for Adies 21 and Cooks Pond 24 using four versus five observation points.

since the axes are not correlated (after Green 1971, quoted in James and McCulloch 1985). Correlation analysis (Pearson correlation co-efficient) was used to test all vegetation variables and those with $r \geq 0.60$ were eliminated prior to PCA (Appendix 3). Additional variables that were not correlated and thought to be of less importance (dead tree stems, small tree stems, graminoids, lycopodium, rock and soil) had to be eliminated, to reduce the number of vegetation variables to 15. Principal component axes were generated using the 15 vegetation variables x forest stand matrix for PCA (on the correlation matrix). The component loadings were matched with avian species abundance for each stand and then used in multiple regression analysis.

The object of multiple regression analysis is to use the minimum number of independent variables required to adequately describe the dependent variable (Zar 1974). Multiple regression analysis was applied using seven eigenvectors from the principal component analysis as the independent variables. The dependent variables selected for analysis were all guilds, the 10 most abundant species, additional species with significant differences between forest classes or among forest type, and the community indices. Separate regression analyses were done for natural-growth and second-growth stands, for species where significant differences were found between forest classes, and for all guilds.

3. RESULTS

3.1. General Species Trends Between Years

The 10 most commonly occurring species (Table 3) comprised 78% of the avian population. The mean abundance of most species was not significantly different between 1991 and 1992 (Table 4), although Northern Flicker, Olive-sided Flycatcher, Tree Swallow, Golden-crowned Kinglet and Common Redpoll were more abundant in 1991 than in 1992, and Yellow-bellied Flycatcher was more abundant in 1992 than in 1991. There was no significant difference in species richness, diversity, or IPA between years. Data for species abundance in each forest stand are in Appendix 2.

3.2. Avian Assemblages in Relation to Forest Class and Type

There were no significant interaction effects in the two-way factorial ANOVA between forest type and forest class ($F = 2.71$, $P > 0.05$). Results are presented separately for forest classes (Tables 5 and 6) and types (Tables 7 and 8). Significant differences in mean abundance per observation point occurred for eight of the 42 species between natural and second-growth stands (Table 5). Black-backed Woodpeckers were significantly more abundant in natural growth, while Boreal Chickadees were more abundant in second-growth. Gray-cheeked Thrush and Dark-eyed Junco, both ground foraging species, were more abundant in natural growth forests. However, greater

Table 3. The 10 most commonly occurring species in order of descending abundance. Numbers refer to the mean between 1991 and 1992, of the total number of birds in all forest stands for each species (n = 167 observation points).

Species	Mean ± s.d.
Yellow-rumped Warbler	530.00 ± 1.62
Black-throated Green Warbler	442.00 ± 2.19
Yellow-bellied Flycatcher	361.00 ± 1.42
Ruby-crowned Kinglet	332.00 ± 1.48
Swainson's Thrush	328.00 ± 1.73
White-throated Sparrow	250.00 ± 1.55
Ovenbird	220.00 ± 1.58
Golden-crowned Kinglet	184.00 ± 1.18
American Robin	153.00 ± 1.31
Northern Waterthrush	143.00 ± 1.21

Table 4. Analysis of variance of mean (± s.d.) species abundance per observation point between 1991 and 1992. Only significant F-values are presented. (*= P<0.05, ** = P<.01,*** = P<.001) (n = 68 stands).

Species	Mean abundance (± s.d.) 1991	1992	$F_{(1,66)}$
Downy Woodpecker	0.12 ± 0.21	0.08 ± 0.15	
Hairy Woodpecker	0.03 ± 0.10	0.02 ± 0.09	
Black-backed Woodpecker	0.05 ± 0.22	0.12 ± 0.26	
Northern Flicker	0.04 ± 0.10	0.00 ± 0.00	4.38*
Olive-sided Flycatcher	0.07 ± 0.20	0.00 ± 0.00	4.38*
Yellow-bellied Flycatcher	1.97 ± 0.84	2.65 ± 1.17	4.36*
Tree Swallow	0.04 ± 0.10	0.01 ± 0.03	4.20*
Gray Jay	0.26 ± 0.34	0.25 ± 0.25	
American Crow	0.01 ± 0.05	0.00 ± 0.00	
Common Raven	0.12 ± 0.23	0.06 ± 0.14	
Black-capped Chickadee	0.32 ± 0.34	0.41± 0.53	
Boreal Chickadee	0.46 ± 0.59	0.18 ± 0.27	
Red-breasted Nuthatch	0.00 ± 0.00	0.01 ± 0.03	
Brown Creeper	0.04 ± 0.12	0.00 ± 0.00	
Winter Wren	0.13 ± 0.34	0.04 ± 0.18	
Golden-crowned Kinglet	1.08 ± 0.61	0.51 ± 0.45	9.33***
Ruby-crowned Kinglet	1.74 ± 1.06	2.19 ± 0.83	
Swainson's Thrush	1.74 ± 1.09	1.37 ± 0.87	
Hermit Thrush	0.19 ± 0.48	0.25 ± 0.43	
Gray-cheeked Thrush	0.05 ± 0.14	0.01 ± 0.07	
American Robin	0.91 ± 0.95	0.70 ± 0.54	
Solitary Vireo	0.01 ± 0.07	0.00 ± 0.00	
Magnolia Warbler	0.34 ± 0.46	0.36 ± 0.58	
Tennessee Warbler	0.02 ± 0.10	0.00 ± 0.00	
Yellow-rumped Warbler	2.77 ± 1.10	2.57 ± 1.01	
Black-throated Green Warbler	2.59 ± 1.83	2.83 ± 1.66	
Bay-breasted Warbler	0.10 ± 0.10	0.11 ± 0.20	
Blackpoll Warbler	0.12 ± 0.29	0.09 ± 0.24	

Table 4 (continued)

Species	Mean abundance (± s.d.) 1991	1992	$F_{(1,66)}$
Black and White Warbler	0.10 ± 0.20	0.04 ± 0.15	
Ovenbird	1.24 ± 1.30	1.13 ± 1.34	
Northern Waterthrush	0.77 ± 0.80	0.35 ± 0.46	
Mourning Warbler	0.24 ± 0.46	0.25 ± 0.42	
Fox Sparrow	0.34 ± 0.55	0.24 ± 0.46	
Lincoln's Sparrow	0.01 ± 0.07	0.00 ± 0.00	
White-throated Sparrow	1.35 ± 1.04	1.29 ± 1.06	
Dark-eyed Junco	0.11 ± 0.28	0.05 ± 0.17	
Common Redpoll	0.06 ± 0.17	0.00 ± 0.00	4.37*
Pine Grosbeak	0.29 ± 0.39	0.29 ± 0.39	
Evening Grosbeak	0.02 ± 0.09	0.00 ± 0.00	
Purple Finch	0.35 ± 0.51	0.15 ± 0.30	
White-winged Crossbill	0.11 ± 0.34	0.08 ± 0.20	
Pine Siskin	0.55 + 0.54	0.64 + 0.63	

Table 5. Analysis of variance of mean abundance per observation point of each species in natural and second growth forests. Only significant F-values are presented. (* = P<0.05; ** = P<0.01; *** = P<0.001). (n = 35) (For species abbreviations, see Appendix 1).

Species	Natural mean ± s.d. (n = 13)	Second mean ± s.d. (n = 22)	$F_{(1,33)}$
DOWO	0.12 ± 0.23	0.13 ± 0.24	
HAWO	0.00 ± 0.00	0.03 ± 0.09	
BBWO	0.17 ± 0.34	0.00 ± 0.00	12.66***
NOFL	0.02 ± 0.06	0.05 ± 0.12	
OSFL	0.14 ± 0.30	0.02 ± 0.11	
YBFL	2.08 ± 0.97	1.94 ± 0.74	
TRSW	0.05 ± 0.10	0.04 ± 0.10	
GRJA	0.31 ± 0.41	0.30 ± 0.35	
AMCR	0.00 ± 0.00	0.02 ± 0.07	
CORA	0.00 ± 0.00	0.19 ± 0.26	8.41**
BCCH	0.24 ± 0.26	0.35 ± 0.38	
BOCH	0.11 ± 0.24	0.70 ± 0.70	17.47***
RBNU	0.00 ± 0.00	0.01 ± 0.04	
BRCR	0.06 ± 0.15	0.02 ± 0.09	
WIWR	0.21 ± 0.46	0.04 ± 0.12	
GCKI	1.05 ± 0.69	1.03 ± 0.59	
RCKI	2.37 ± 1.35	1.44 ± 0.66	
SWTH	2.06 ± 0.80	1.70 ± 1.26	
HETH	0.38 ± 0.71	0.07 ± 0.20	
GCTH	0.13 ± 0.21	0.00 ± 0.00	9.22**
AMRO	0.56 ± 0.64	1.07 ± 1.03	
MAWA	0.42 ± 0.62	0.37 ± 0.51	
TEWA	0.03 ± 0.11	0.02 ± 0.09	
YRWA	3.41 ± 1.33	2.53 ± 0.87	
BTGW	1.35 ± 0.83	3.22 ± 1.91	
BBWA	0.03 ± 0.11	0.14 ± 0.24	
BPWA	0.12 ± 0.24	0.13 ± 0.31	

Table 5 (continued)

Species	Natural mean ± s.d. (n = 13)	Second mean ± s.d. (n = 22)	$F_{(1,33)}$
BWWA	0.21 ± 0.46	0.02 ± 0.11	
OVEN	0.25 ± 0.35	1.76 ± 1.35	8.86^{**}
NOWA	1.00 ± 0.92	0.62 ± 0.73	
MOWA	0.29 ± 0.42	0.23 ± 0.51	
FOSP	0.16 ± 0.45	0.53 ± 0.60	5.68^{*}
LISP	0.07 ± 0.17	0.00 ± 0.00	
WTSP	1.94 ± 1.31	1.08 ± 0.88	
DEJU	0.19 ± 0.30	0.06 ± 0.26	4.45^{*}
CORE	0.00 ± 0.00	0.09 ± 0.21	
PIGR	0.15 ± 0.26	0.38 ± 0.41	
EVGR	0.04 ± 0.14	0.01 ± 0.04	
PUFI	0.02 ± 0.07	0.51 ± 0.56	14.98^{***}
WWCR	0.24 ± 0.61	0.04 ± 0.08	
PISI	0.31 ± 0.35	0.79 ± 0.66	6.39^{*}

Table 6. Analysis of variance of mean abundance per observation point of each guild and community index in natural and second-growth forests. Guilds are defined in Table 2. Only significant F-values are presented. (* = P<0.05; ** = P<0.01; *** = P<0.001).

Guild	Natural mean ± s.d. (n = 13)	Second-growth mean ± s.d. (n = 22)	$F_{(1,33)}$
PECK	0.62 ± 0.68	0.36 ± 0.43	
FLYCATCH	2.27 ± 1.12	2.00 ± 0.77	
FOLIAGE	9.41 ± 3.46	10.16 ± 2.7	
GROUND	6.94 ± 2.90	6.92 ± 3.66	
SEED	0.75 ± 0.62	1.82 ± 1.00	7.67**
GENERAL	0.31 ± 0.41	0.51 ± 0.46	
SPECIES RICHNESS	7.38 ± 1.27	8.36 ± 1.84	
S-W INDEX	2.41 ± 0.25	2.56 ± 0.20	
IPA	17.08 ± 3.13	19.97 ± 1.84	

Table 7. Analysis of variance of mean (± s.d.) abundance of each species and community index per observation point among forest types. Only significant F-values are presented. (* = P<0.05; ** = P<0.01; *** = P<0.001). (For species abbreviations, see Appendix 1).

Species	Fern/Herb mean ± s.d (n = 4)	Fern mean ± s.d. (n = 16)	Fern/Moss mean ± s.d. (n = 4)	Moss mean ± s.d (n = 11)	$F_{(3,31)}$
DOWO	0.20 ± 0.40	0.11 ± 0.22	0.00 ± 0.00	0.16 ± 0.22	
HAWO	0.00 ± 0.00	0.01 ± 0.05	0.00 ± 0.00	0.04 ± 0.12	
BBWO	0.05 ± 0.10	0.32 ± 0.56	0.13 ± 0.25	0.00 ± 0.00	
NOFL	0.20 ± 0.23^{A}	0.00 ± 0.00^{B}	0.00 ± 0.00^{B}	00.4 ± 0.08^{AB}	3.99^{*}
OSFL	0.13 ± 0.25	0.09 ± 0.26	0.00 ± 0.00	0.04 ± 0.12	
YBFL	2.18 ± 0.56	2.18 ± 0.97	1.93 ± 0.63	1.66 ± 0.69	
TRSW	0.00 ± 0.00	0.05 ± 0.10	0.06 ± 0.13	0.04 ± 0.12	
GRJA	0.10 ± 0.20	0.24 ± 0.34	0.50 ± 0.58	0.38 ± 0.34	
AMCR	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.09	
CORA	0.15 ± 0.30^{AB}	0.04 ± 0.11^{A}	0.00 ± 0.00^{AB}	0.27 ± 0.29^{B}	3.08^{*}
BCCH	0.53 ± 0.38^{AB}	$0.34\ 0.31^{A}$	0.56 ± 0.43^{A}	0.09 ± 0.24^{B}	4.38^{*}
BOCH	0.75 ± 0.70	0.41 ± 0.75	0.64 ± 0.72	0.42 ± 0.41	
RBNU	0.00 ± 0.00	0.01 ± 0.05	0.00 ± 0.00	0.00 ± 0.00	
BRCR	0.00 ± 0.00	0.05 ± 0.14	0.10 ± 0.20	0.00 ± 0.00	
WIWR	0.00 ± 0.00	0.19 ± 0.42	0.10 ± 0.20	0.00 ± 0.00	
GCKI	1.58 ± 0.05	1.07 ± 0.18	1.15 = 1.14	0.76 ± 0.30	
RCKI	0.55 ± 0.44^{A}	2.04 ± 0.88^{B}	2.55 ± 2.06^{B}	1.59 ± 0.57^{B}	5.92^{**}
SWTH	1.80 ± 1.48	1.80 ± 0.89	2.05 ± 1.38	1.83 ± 1.33	
HETH	0.10 ± 0.20	0.20 ± 0.33	0.73 ± 1.20	0.00 ± 0.00	
GCTH	0.00 ± 0.00	0.08 ± 0.18	0.10 ± 0.20	0.00 ± 0.00	

Table 7 (continued)

Species	Fern/Herb mean ± s.d. (n = 4)	Fern mean ± s.d. (n = 16)	Fern/Moss mean ± s.d. (n = 4)	Moss mean ± s.d. (n = 11)	$F_{(3,31)}$
AMRO	2.33 ± 0.91	0.71 ± 0.72	0.35 ± 0.47	0.80 ± 0.90	
SOVI	0.10 ± 0.20^{A}	0.00 ± 0.00^{B}	0.00 ± 0.00^{B}	0.00 ± 0.00	3.05^{*}
MAWA	0.33 ± 0.22	0.41 ± 0.61	0.60 ± 0.95	0.00 ± 0.00	
TEWA	0.00 ± 0.00	0.05 ± 0.14	0.00 ± 0.00	0.00 ± 0.00	
YRWA	2.38 ± 0.56	2.78 ± 1.35	3.63 ± 1.07	2.86 ± 0.71	
BTGW	4.93 ± 1.22^{A}	2.89 ± 1.47^{A}	2.55 ± 1.61^{AB}	1.13 ± 1.48^{B}	5.60^{**}
BBWA	0.20 ± 0.40	0.06 ± 0.16	0.00 ± 0.00	0.16 ± 0.22	
BPWA	0.10 ± 0.20	0.14 ± 0.28	0.00 ± 0.00	0.15 ± 0.37	
BWWA	0.13 ± 0.25	0.17 ± 0.42	0.00 ± 0.00	0.00 ± 0.00	
OVEN	2.60 ± 1.06^{A}	1.39 ± 1.40^{AB}	1.00 ± 1.33^{AB}	0.48 ± 0.76^{B}	1.95^{*}
NOWA	1.16 ± 1.02	0.94 ± 0.81	0.50 ± 1.00	0.44 ± 0.63	
MOWA	0.50 ± 0.76^{AB}	0.43 ± 0.52^{A}	0.00 ± 0.00	0.00 ± 0.00	4.38^{*}
FOSP	0.40 ± 0.80	0.35 ± 0.55	0.33 ± 0.40	0.47 ± 0.64	
LISP	0.00 ± 0.00	0.00 ± 0.00	0.13 ± 0.25	0.04 ± 0.12	
WTSP	0.93 ± 0.57	1.84 ± 1.26	1.95 ± 1.20	0.72 ± 0.57	
DEJU	0.00 ± 0.00	0.10 ± 0.27	0.00 ± 0.00	0.20 ± 0.36	
CORE	0.10 ± 0.20	0.08 ± 0.23	0.00 ± 0.00	0.02 ± 0.06	
PIGR	0.30 ± 0.38	0.28 ± 0.43	0.10 ± 0.20	0.40 ± 0.36	
WWCR	0.00 ± 0.00	0.06 ± 0.10	0.56 ± 1.13	0.06 ± 0.09	
PISI	1.18 ± 0.62	0.69 ± 0.69	0.20 ± 0.28	0.44 ± 0.39	

1 There is no significant difference between means with superscript letters in common in each row.

Table 8. Analysis of variance of mean (± s.d.) abundance of each guild and the three community indices per observation point among forest types. Only significant F-values are presented. (*=P<.5; ** = P<0.01; *** = P<0.001)

GUILD	Fern/Herb mean ± s.d. (n = 4)	Fern mean ± s.d (n = 16)	Fern/Moss mean ± s.d. (n = 4)	Moss mean ± s.d. (n = 11)	$F_{(3,31)}$
PECK	0.90 ± 0.48	0.57 ± 0.64	0.15 ± 0.19	0.26 ± 0.35	
FLYCATCH	2.30 ± 0.38	2.32 ± 1.10	1.99 ± 0.71	1.74 ± 0.72	
FOLIAGE[1]	11.93 ± 3.37^{A}	10.61 ± 2.61^{A}	11.68 ± 2.98^{A}	7.44 ± 2.03^{B}	5.50^{**}
GROUND	9.31 ± 5.00	7.60 ± 3.16	7.23 ± 3.76	4.97 ± 2.07	
SEED	2.58 ± 1.05^{A}	1.33 ± 0.99^{AB}	1.03 ± 1.16^{AB}	1.28 ± 0.79^{B}	3.05^{*}
GENERAL	0.25 ± 0.30	0.28 ± 0.36	0.50 ± 0.58	0.70 ± 0.47	
SP. RICHNESS	9.73 ± 1.32^{A}	8.51 ± 1.48^{A}	7.55 ± 0.79^{AB}	6.79 ± 1.61^{B}	5.72^{**}
S-W INDEX	2.69 ± 0.14	2.54 ± 0.15	2.35 ± 0.21	2.45 ± 0.30	
IPA	24.58 ± 4.00^{A}	20.59 ± 4.33^{AB}	16.45 ± 2.93^{BC}	15.26 ± 4.12^{C}	7.68^{**}

1 There is no significant difference between means with superscript letters in common in each row.

abundance in natural-growth was not typical of the entire ground-foraging guild. For example, Fox Sparrows were more abundant in second-growth (Table 5) and the ground-foraging guild abundance was almost identical in both forest classes (Table 6, Figure 6). The seed-eating guild was the only guild in which there was a significantly greater abundance in second-growth than in natural-growth (Table 6, Figure 6). Pine Siskin and Purple Finch, both seed-eaters, were also more abundant in second-growth forests than in natural-growth forests.

There were significant differences in the abundance of seven species among forest types (Table 7). Black-throated Green Warblers , Ovenbirds and Mourning Warblers demonstrated a trend of increased abundance with increased site richness. Common Ravens were significantly more abundant in the moss forest type than in the richer fern forest type, while Black-capped chickadees were significantly least abundant in moss forests (Table 7). Ruby-crowned Kinglets were significantly more abundant in the rich fern/herb type than the other three forest types (Table 7, Figure 7). Northern Flickers were more abundant in the fern/herb and moss forest types than in the other two types. height diversity (FHD) and habitat diversity were also lowest (Table 9) in the moss forest type.

Table 9. Analysis of variance of mean (± s.d.) foliage height diversity (FHD) and habitat diversity (Shannon-Wiener index) among forest types, using Tukey HSD for a posteriori multiple comparisons. ($n = 35$, $P \leq 0.05$).

Fern/herb mean ± s.e. n = 4	Fern mean ± s.e. n = 16 n = 4	Fern/moss mean ± s.e. n = 11	Moss mean ± s.e.
$3.04 \pm 0.28^{a*}$	2.99 ± 0.13^{a}	2.50 ± 0.28^{ab}	2.29 ± 0.10^{b}

* There is no significant difference among means with suprascript letters in common.

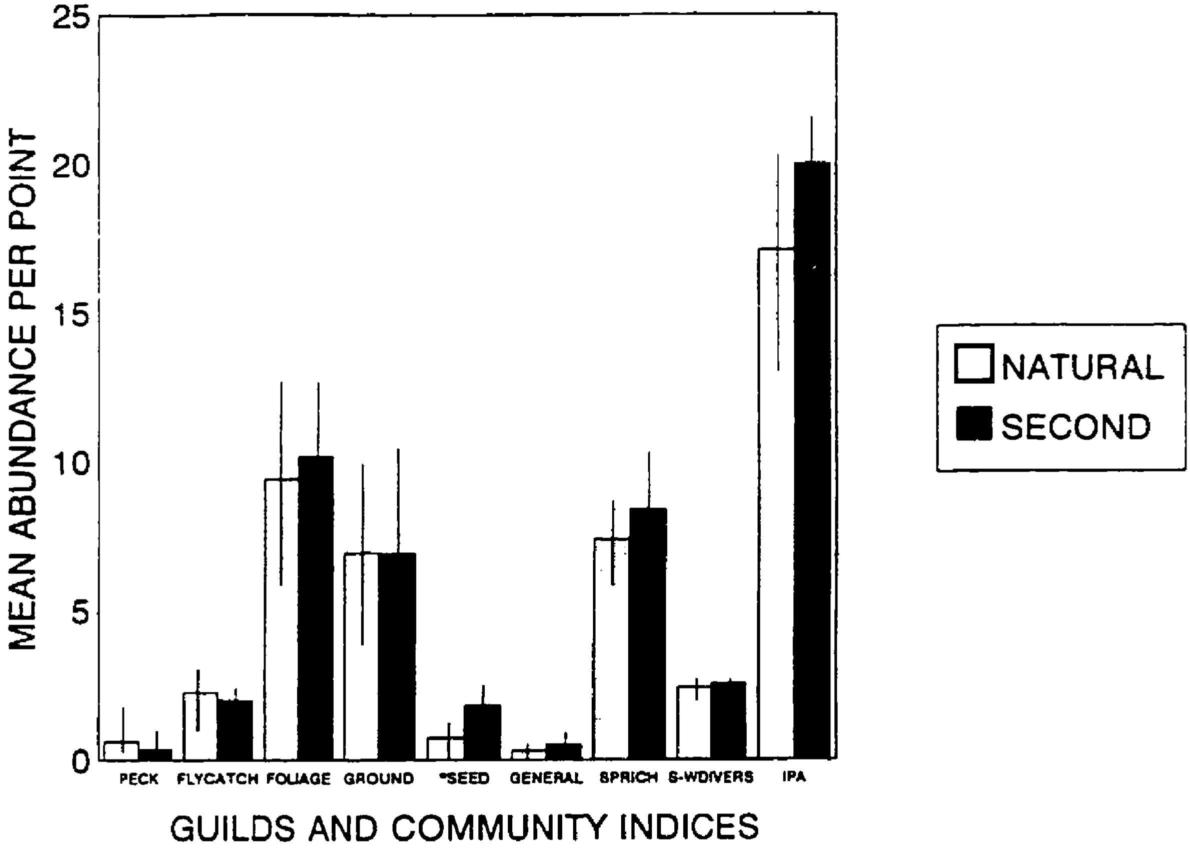

Figure 6. Mean abundance of each guild, and the three community indices per observation point, for each forest class.

The trend toward increased abundance with increased site richness was found for some species, but it was not pervasive. For example, none of the five most common species followed this trend (Figure 7). As well, the pattern of mean intra-species (Table 7) and intra-guild (Table 8) abundance differed among forest types. For instance, Ruby-crowned Kinglets were most abundant in the fern/moss forest type, while Black-throated Green Warblers were most abundant in the fern/herb forest type. For instance, Ruby-crowned Kinglets were most abundant in the fern/moss type, while Black-throated Green Warbler was most abundant in the fern/herb type.

3.3. Avian Assemblages and Habitat Structure

The 15 vegetation variables (Table 10) were used in regression analyses with species and guild abundance, and the community indices. The abundance of six species and one guild (foliage gleaning), and two community indices (Shannon-Wiener diversity index and IPA) were significantly related to vegetation (Table 11). The only vegetation variable associated with more than one species was fern litter, which was negative for Northern Waterthrush and positive for Mourning Warbler. Every other species was associated with a unique set of vegetation variables.

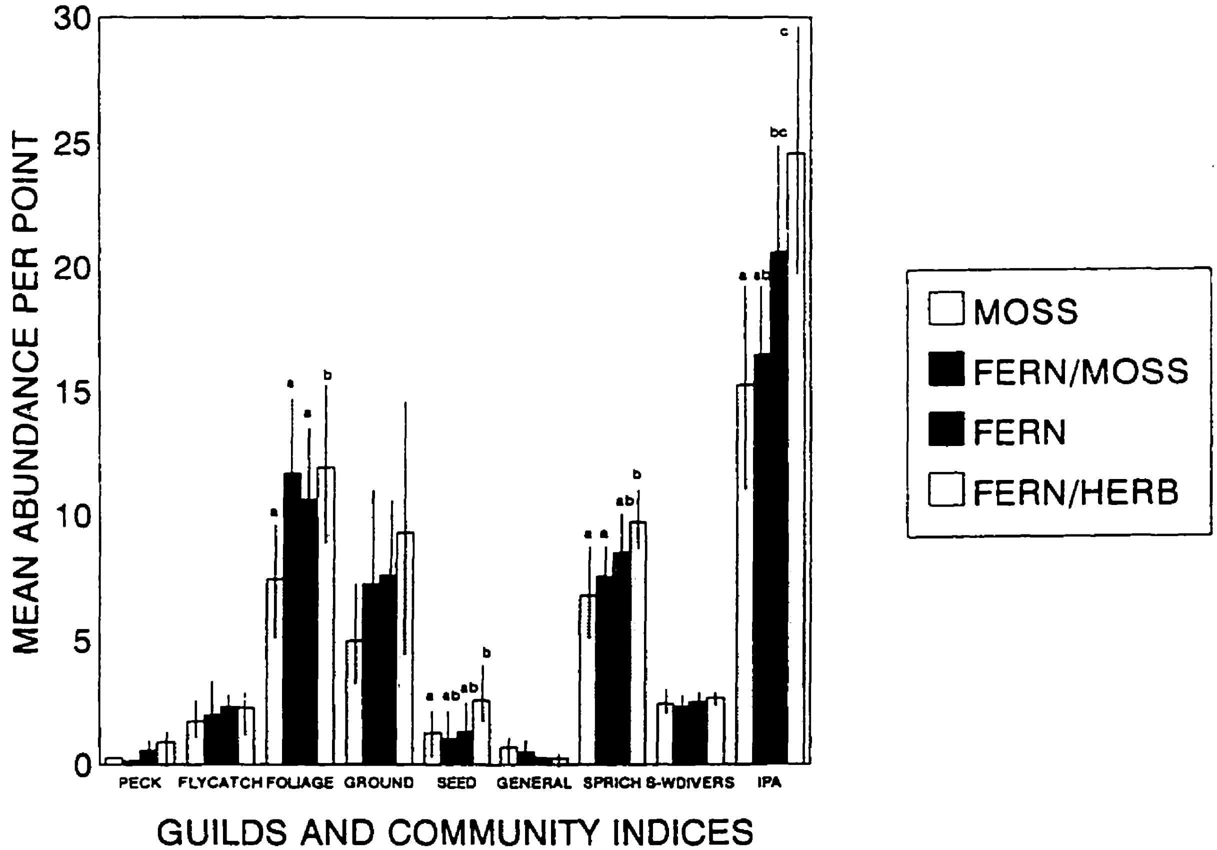

Figure 8. Mean abundance of each guild, and the community indices per observation point, for each forest type. There is no significant difference between means with superscript letters in common.

Table 10. Principal component loadings of 15 uncorrelated vegetation variables. Descriptions of each component are given below[1]. Variable abbreviations are given in Appendix 4.

Variable	Component Loadings PC1	PC2	PC3	PC4	PC5	PC6	PC7
DTDENS	0.749	0.337	0.335	-0.076	-0.055	0.007	-0.023
LOWSHRUB	-0.741	0.068	0.144	0.119	0.347	-0.065	0.358
TRDENS	0.682	0.338	-0.085	-0.130	0.143	-0.299	0.360
AGE	-0.648	0.227	0.551	0.252	-0.225	0.049	0.056
STHGT	0.612	0.134	0.406	-0.311	0.349	0.050	0.096
CANOPY	0.588	-0.190	-0.034	0.629	0.243	0.096	0.171
FORBS	-0.565	0.577	-0.248	-0.326	0.088	0.072	0.121
SITERICH	-0.162	0.758	-0.206	0.284	-0.179	0.058	0.267
FLITTER	-0.049	0.740	0.075	-0.241	-0.129	-0.454	-0.005
TRSPRPRO	-0.278	-0.736	0.096	0.109	0.012	-0.052	0.408
TRHGT	0.194	0.540	0.325	0.202	-0.258	0.563	0.072
SHHGT	0.122	-0.151	-0.795	0.047	-0.452	-0.101	0.074
DLITTER	0.232	0.332	-0.687	0.459	0.214	0.115	-0.009
TRBIRPRO	-0.308	0.342	0.071	0.614	0.383	-0.255	-0.344

Table 10 (Continued)

	Component Loadings						
Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7
LOGS	0.258	-0.128	0.444	0.528	-0.430	-0.360	0.050
% variance	22.7	19.3	14.3	11.7	7.2	5.7	4.6

[1]Component Interpretations

Component 1: dense fir, canopy cover; snags
2: rich forest; ferns and forbs
3: old forest lacking deciduous litter
4: birch canopy cover; logs
5: low shrubs; few logs
6: tall trees, lacking ferns
7: large spruce; low shrubs

Table 11. Regression models for abundance of 6 bird species and the three community indices (dependant variable) and vegetation variables (independent variables). Independent variables that were not significant and did not provide insight to the variance explained by themodel (R^2) were eliminated from the model. See Appendix 4 for descriptions of vegetation variables (* = P<0.05, ** = P<0.01, *** = P<0.001). (n=33).

Species	Regression Model	R^2	F
BCCH	Y = 4.92 - 29.89(lowshrub) - 16.48(canopy) + 6.93(siterich)	0.53	11.73***
AMRO	Y = -69.76+ 13.64(treehgt) - 1.39(dtdens)	0.31	6.62***
OVEN	Y = -31.53 + 8.19(dlitter) - 7.61(trsprpro) + 6.00(shrubhgt)	0.58	13.58***
NOWA	Y = -43.01 - 7.79(sthgt) + 7.42(flitter) + 15.04(trhgt)	0.48	8.87***
MOWA	Y = -7.42 + 16.30(flitter)	0.26	11.37**
PUFI	Y = 17.68 - 5.34(age)	0.27	12.41**
S-W INDEX	Y = -0.08 - 0.30(age)+ 0.80(trhgt)	0.32	6.97**
IPA	Y = 3.17 - 1.19(trsprpro)	0.39	21.47***

The principal component axis and associated component loadings used for multiple regression analysis are presented in Table 10. The abundance of twelve species (Table 12) and three guilds (Table 13) were significantly related to the PC variables in the overall multiple regression (i.e., the analyses using all stands). Of these, three species (Table 12) and one guild (Table 13) had strong negative loadings with PC1: dense fir, canopy cover; snags. Two species (Table 12) and one guild (Table 13) had strong negative loadings with PC1. Seven species and two guilds had strong positive loadings for PC2: rich forest; ferns and forbs. Six species (Table 12) and one guild (Table 13) had strong negative relationships with PC3: old forest lacking deciduous litter (Table 10). Note that "old" refers to increasing tree age; it is not synonymous with natural growth, as tree age is a continuum across second-growth and natural growth forests. Deciduous litter was significantly greater in second-growth (23.31 ± 15.9 % of ground cover) than in natural growth forests (11.04 ± 4.35 % of ground cover; $F_{(1,33)} = 7.26$, $P < 0.05$) and deciduous litter was highly correlated with Ovenbird abundance ($r = 0.64$, $P < 0.001$).

PC2 and PC3 explain most of the variance of species richness and IPA. Yellow-rumped Warblers, the only other warbler for which there was a significant regression model, were associated with older forests of poorer site richness (Table 12). Yellow-rumped Warblers (530 ± 1.6) and Black-throated Green Warblers (442 ± 2.2) are

Table 12. Overall multiple regression models for abundance of 19 bird species and the community indices (dependent variable) with seven multivariate vegetation variables (independent variables). Independent variables that were not significant and did not provide insight to the variance explained by the model (R^2) were eliminated from the model. (* = P<0.05; ** = P<0.01; *** = P<0.001). (n=33).

Species	Multiple Regression Model	R^2	F
BBWO	Y = 6.03 - 0.79(low shrubs; few logs) - 0.66(dense fir, canopy cover; snags) + 0.65(rich forest; ferns and forbs) - 0.60(large spruce; low shrubs)	0.405	4.77**
YBFL	Y = 0.56 - 0.18(dense fir, canopy cover; snags) - 0.18(old forest lacking deciduous litter) + 0.14(low shrubs; few logs)	0.360	5.45**
BCCH	Y = -3.72 +1.23(rich forest; ferns and forbs) - 0.99(old forest lacking deciduous litter) - 0.94(low shrubs; few logs)	0.267	4.95**
BOCH	Y = -3.02 + 1.53(dense fir, canopy cover; snags) + 0.87(low shrubs; few logs) - 0.60(old forest lacking deciduous litter)	0.329	4.74**
GCKI	-	0.065	NS[1]
RCKI	-	0.195	NS
SWTH	-	0.294	NS
GCTH	-	0.302	NS
AMRO	-	0.225	NS

Table 12 (continued)

Species	Multiple Regression Model	R^2	F
YRWA	Y = 0.95 - 0.20(dense fir, canopy cover; snags) - 0.12(large spruce; low shrubs) + 0.12(old forest lacking deciduous litter) - 0.11(rich forest; ferns and forbs)	0.324	3.36*
BTGW	Y = 0.01 + 1.12(rich forest; ferns and forbs) - 0.76(old forest lacking deciduous litter) + 0.48(dense fir, canopy cover; snags)	0.377	5.85**
OVEN	Y = -2.52 - 2.24(old forest lacking deciduous litter) + 1.22(rich forest; ferns and forbs) + 0.92 (dense fir, canopy cover; snags) - 0.68 (tall trees, lacking ferns)	0.558	12.19***
NOWA	Y = -2.44 - 1.60(low shrubs; few logs) + 1.13(rich forest; ferns and forbs)	0.363	0.001
MOWA	Y = -5.34 + 1.16(rich forest; ferns and forbs) - 0.95(dense fir, canopy cover; snags) - 0.53(tall trees, lacking ferns) - 0.46(large spruce; low shrubs)	0.341	0.017
FOSP	-	0.351	NS
WTSP	Y = -0.18 + 0.66 (rich forest; ferns and forbs) + 0.50(old forest lacking deciduous litter) + 0.33(tall trees, lacking ferns) - 0.32(low shrubs; few logs)	0.415	0.004

Table 12 (continued)

Species	Multiple Regression Model	R^2	F
DEJU	Y = -5.63 - 0.91(rich forest; ferns and forbs) - 0.77(young fir, canopy cover; snags)	0.221	0 .024
PUFI	-4.16 - 1.29(old forest lacking deciduous litter) - 1.04(birch canopy cover; logs) + 0.95(tall trees, lacking ferns) + 0.85(young fir, canopy cover; snags) + 0.66(low shrubs; few logs)	0.447	0.005
PISI	-	0.236	NS
SPECIES RICHNESS	Y = 2.03 - 0.12(old forest lacking deciduous litter) + 0.08(rich forest; ferns and forbs) - 0.03(large spruce; low shrubs)	0.610	0.000
S-W INDEX	-	0.212	NS
IPA	Y = 2.87 - 0.14(old forest lacking deciduous litter) + 0.12(rich forest; ferns and forbs) - 0.06(large spruce; low shrubs)	0.616	0.000

1. NS = model not significant

Table 13. Overall multiple regression models for guild abundance (dependent variable) with seven multivariate vegetation variables (independent variables). Independent variables that were not significant and did not provide insight to the variance explained by the model (R^2) were eliminated from the model. (* = P<0.05; ** = P<0.01; *** = P<0.001). (n=33)

GUILD	Multiple Regression Model	R^2	F
PECK	-	0.295	NS[1]
FLYCATCH	Y = 0.60 - 0.20(dense fir, canopy cover; snags) -0.19(old forest lacking deciduous litter) + 0.14(low shrubs; few logs) + 0.10(rich forest; ferns and forbs)	0.405	4.76**
FOLIAGE	Y = 2.21 + 0.13(rich forest; ferns and forbs) - 0.11(large spruce; low shrubs) - 0.10(old forest lacking deciduous litter)	0.402	6.50**
GROUND	-	0.267	NS
SEED	-	0.149	NS
GENERAL	Y = -2.91 - 1.55(rich forest; ferns and forbs) - 0.72(large spruce; low shrubs) + 0.51(dense fir, canopy cover; snags)	0.326	4.68**

1. NS = model not significant

insectivorous foliage gleaners and were the two most abundant species, yet they exhibited opposite trends in habitat associations (Table 13). Dark-eyed Juncos had a strong negative weighting for PC2 as well as PC4: young fir, canopy cover; logs. Black-backed Woodpecker has a negative relationship with young fir, large spruce, low shrubs, snags and few logs, and preferred rich forests (Table 12).

Regression analyses were performed separately for species (Table 14) and guilds (Table 15) in natural growth, and species (Table 16) and guilds (Table 17) in second-growth stands. There was a significant regression model in both forest classes for Ovenbird abundance (Tables 14 and 16) and abundance of ground foragers (Tables 15 and 17) demonstrated . For Ovenbirds, both models showed a negative relationship with PC6: tall trees lacking ferns. While PC3 had a strong negative loading in both the overall regression (Table 12) and the regression in second-growth (Table 15), Ovenbird abundance was not related to PC3 in the separate analysis for natural growth forests.

Table 14. Multiple regression models for abundance of seven bird species (dependent variable) with seven multivariate vegetation variables (independent variables) in natural growth forest stands. Independent variables that were not significant and did not provide insight to the variance explained by the model (R^2) were eliminated from the model. (* = P<0.05; ** = P<0.01; *** = P<0.001) (n=13)

Species	Multiple Regression Model	R^2	F
BBWO	-	0.61	NS[1]
CORA	Y = -7.37 - 1.41(low shrubs; few logs) - 0.65(tall trees, lacking ferns)	0.68	10.63**
GCTH	-	0.67	NS
BOCH	-	0.19	NS
OVEN	Y = -6.91 - 1.72(tall trees, lacking ferns) - 1.57(low shrubs; few logs) - 1.00(large spruce; low shrubs)	0.82	6.50*
DEJU	-	0.76	NS
PISI	-	0.81	NS

1. NS = model not significant

Table 15. Multiple regression models for guild abundance (dependent variable) with seven multivariate vegetation variables (independent variables) in natural growth forest stands. Independent variables that were not significant and did not provide insight to the variance explained by the model (R^2) were eliminated from the model. (* = P<0.05; ** = P<0.01; *** = P<0.001) (n=13).

GUILD	Multiple Regression Model	R^2	F
PECK	-	0.35	NS[1]
FLYCATCH	-	0.17	NS
FOLIAGE	-	0.16	NS
GROUND	Y = 1.36 + 0.37(rich forest; ferns and forbs) + 0.21(tall trees, lacking ferns) + 0.19(birch canopy cover; logs) + 0.18(low shrubs; few logs)	0.83	9.56**
SEED	-	0.72	NS
GENERAL	-	0.53	NS

1. NS = model not significant

Table 16. Multiple regression models for abundance of six bird species (dependent variable) with seven multivariate vegetation variables (independent variables) in second growth forest stands. Independent variables that were not significant and did not provide insight to the variance explained by the model (R^2) were eliminated from the model. (* = P<0.05; ** = P<0.01; *** = P<0.001) (n=20).

Species	Multiple Regression Model	R^2	F
CORA	-	0.27	NS[1]
BOCH	Y = -4.45 - 1.51(rich forest; ferns and forbs) + 1.47(dense fir, canopy cover; snags)	0.42	6.16**
OVEN	Y = -1.72 - 1.93 (old forest lacking deciduous litter) + 1.49(rich forest; ferns and forbs) - 0.76(tall trees, lacking ferns)	0.82	25.12***
DEJU	Y = -6.71 - 0.62(rich forest; ferns and forbs - 0.47(old forest lacking deciduous litter)	0.31	3.90*
PUFI	-	0.36	NS
PISI	-	0.36	NS

1. NS = model not significant

Table 17. Multiple regression models for guild abundance (dependant variable) with seven multivariate vegetation variables (independent variables) in second growth forest stands. Independent variables that were not significant and did not provide insight to the variance explained by the model (R^2) were eliminated from the model. (* = P<0.05; ** = P<0.01; *** = P<0.001) (n=20).

Guild	Multiple Regression Model	R^2	F
PECK	Y = -5.99 + 1.41(low shrubs; few logs) - 1.06(old forest lacking deciduous litter)	0.35	4.61*
FLYCATCH	Y = 0.62 - 0.36(old forest lacking deciduous litter) + 0.19(rich forest; ferns and forbs)	0.52	9.30**
FOLIAGE	Y = 2.04 + 0.22(low shrubs; few logs) - 0.21(old forest lacking deciduous litter) + 0.11(large spruce; low shrubs)	0.61	8.35***
GROUND	Y = 1.60 - 0.26(old forest lacking deciduous litter) + 0.13(rich forest; ferns and forbs)	0.49	8.26**
SEED	-	0.32	NS[1]
GENERAL	-	0.49	NS

1. NS = model not significant

4. DISCUSSION

4.1. Habitat Factors

Since most of the stands used in this study were mature or overmature, and were dominated by balsam fir, habitat differences among them may be relatively subtle; the exception being moss forest type stands, where habitat diversity was significantly lower than the other forest types. Thirty-three of the 42 species and five of the six guilds did not differ in abundance across forest class, and there was no significant difference in species richness, diversity, or IPA between natural and second-growth forests. The results of a study of silvicultural mosaics versus old-growth forests in boreal coniferous forests in Finland (Raivio and Haila 1990) were similar to this study: species abundance was similar (48 in Finland versus 42 in western Newfoundland), and there were few significant differences in species abundance between natural and second-growth forests.

In a study of bird communities in successional stages of a mixed coniferous-deciduous forest, Welsh (1987) noted that species can be associated with different successional stages because they are either able to find similar habitat associations in very different overall forest habitats, or they are very adaptable in their habitat requirements. This adaptability of some species may also partially explain the lack of difference in species and guild abundance, and the community indices between natural and second-growth forests found in my study.

Three species, one guild, species richness, and IPA increased in abundance with increased forest richness, and foliage-gleaners were least abundant in moss forests, where foliage height diversity (FHD) and habitat diversity were also lowest. These results suggest that forest type may have been more important in affecting species abundance and richness than forest class.

Vegetation provides foraging and nesting substrate and protection from predators and inclement weather for birds (Franzreb 1978, Maurer *et al.* 1981, Smith and Shugart 1987). Changes in vegetation structure affect bird foraging behaviour, and seed and insect prey availability (Robinson and Holmes 1984). MacArthur (1965) demonstrated vertical and horizontal vegetation foraging area preferences among species, as well as gender differences in foraging habitat selection within species. Many studies have demonstrated the positive relationship between vegetation diversity and avian species diversity and abundance (e.g. MacArthur and MacArthur 1961, MacArthur 1965, Raivio and Haila 1990, Morrison 1992, Probst *et al.* 1992). In addition to the trend toward increased species abundance and richness with site richness and habitat diversity, the overall multiple regression models show a positive relationship for seven species, species richness, IPA and two guilds with rich forests. Abundance of the pecking guild did not demonstrate a relationship with rich forests. This guild probably responds more to tree age and condition (and hence insect infestation and cavity-nesting opportunities), rather than site richness.

Although the guild concept is useful in community ecology, it should not preclude the analysis of trends in individual species, because important within-guild differences in habitat selection could be overlooked. Of the five most common species, three belonged to the foliage-gleaning guild, yet the pattern of abundance of each of these species differed across forest types. Of the six species for which there was a significant relationship in the regression model using vegetation variables, four belong to the foliage-gleaning guild. However, the unique set of vegetation variables in each model suggested the species responded differently to specific attributes of the vegetation structure. As well, the regression model for foliage-gleaners did not reflect the habitat requirements of the other guild members. It would appear that at this level of analysis, guilds do not always adequately represent their members, although using guilds does seem appropriate for the more general habitat associations derived from the regressions using principal component axes. The following discussion relates to individual species that had significant relationships in the analyses.

The importance of snags to cavity-nesting and bark-foraging species has been well documented (e.g., Franzreb 1978, Probst *et al.* 1992, Westworth and Telfer 1993). The removal of dead and dying trees during forest harvesting eliminates nesting and foraging sites for woodpeckers (Sadoway 1988). Goggans *et al.* (1987) found Black-backed Woodpeckers associated exclusively with dead and dying lodgepole pine (*Pinus contorta*) in mature/overmature forests in the Cascade Mountains, Oregon, and proposed that Black-backed Woodpecker and Three-toed Woodpecker, because of their unique anatomical feature of having three toes, rather than the usual four, are particularly reliant on old trees. The toe configuration of these woodpeckers allows them to deliver hard blows while pecking, but hinders their ability to climb and therefore pursue prey. Wood-boring insects, prey that these two woodpecker species are well adapted to extract, increase in density as trees become overmature and less vigorous (see Goggans *et al.* 1987). The results of my study were consistent with other observations that Black-backed Woodpeckers are associated with the mature/overmature natural-growth forests. More in-depth studies on the habitat associations of Black-backed Woodpeckers in western Newfoundland are currently under way (M. Setterington, unpubl. data). In boreal coniferous forests in Finland, Three-toed Woodpeckers, the Old-World congener, were found exclusively in old growth forests (Raivio and Haila 1990).

The multiple regression model for Black-backed Woodpeckers suggested the importance of logs and a preference for rich forest types, though there was no significant difference in Black-backed Woodpecker abundance among forest types. The sample size of Black-backed Woodpeckers was probably too small for adequate comparison among forest types. The regression model also indicated a negative relationship with snags, contrary to the findings of other studies of Black-backed Woodpeckers that identified the importance of dead and dying trees for foraging (Yunich 1985, Goggins *et al.* 1987, Villard and Beninger 1993). In Villard and Beninger's (1993) study of foraging behaviour in Black-backed and Hairy Woodpeckers, the former were never observed feeding on the ground. However, in a Newfoundland study of woodpecker feeding ecology, Black-backed Woodpeckers were most frequently observed on fallen trees during the 1993 summer field season in the natural growth stands at Little Grand Lake (M. Setterington, pers. comm.). It is possible that fallen trees provide an important foraging substrate for this species in this region. Because balsam fir is a short-lived species (Page *et al.* 1974), soils are shallow and winds are strong, dead trees may be left standing for only a short period of time. Black-backed Woodpeckers may therefore be unusually reliant on fallen trees in Newfoundland compared to forests elsewhere in North America. It is unlikely that standing dead trees are negatively related to the occurrence of Black-backed Woodpeckers.

Dark-eyed Juncos commonly nest at edges of openings in the forest canopy, created by streams, roads or clearing (Eaton 1968). In my study, Dark-eyed Juncos were significantly more abundant in natural-growth compared to second-growth forests (Table 6). Fallen dead trees in overmature forests create openings in the canopy (Lertzman

1992) and result in patches of early successional stages, and Dark-eyed Juncos may profit from these microhabitats. The overall regression model suggested a negative relationship with closed canopy and snags. The regression model for Dark-eyed Juncos in second-growth showed a similar relationship as the overall regression model. In a study of songbird response to commercial clear-cutting in a spruce/fir forest in Maine, Dark-eyed Juncos were most abundant in the early seral stages, characterised by low regeneration and slash (Titterington *et al.* 1979). Sabo's (1980) study of avian assemblages along an elevational gradient, showed juncos used low coniferous vegetation at high altitudes. The regression model for Dark-eyed Juncos in natural-growth was not significant, probably because of the small sample size.

Bent (1964) described Boreal Chickadees associating with dense forests of small spruce and fir. In my study, Boreal Chickadees were significantly more abundant in second-growth compared to natural growth stands. The overall regression model suggested a positive relationship between Boreal Chickadees and habitat with dense fir, low shrubs and deciduous litter. The regression model in second-growth also suggested an affinity for dense fir. Few studies describe specific habitat associations for boreal chickadees, however, Sabo (1980) found Boreal Chickadees associated with dense conifer foliage, with a mean dbh of 11 cm.

The Ovenbird is a species of particular interest, as there is evidence of declining numbers in eastern North America (Askins 1990). Ovenbirds were significantly more abundant in second-growth than in natural-growth forests and more abundant in rich forest types than in poorer sites. Other studies showed different results with respect to habitat relationships. For example, Probst *et al.* (1992) and Stenger (1958) identified a positive relationship between Ovenbird abundance and shrub density in deciduous forests in the USA Lake States and southern Ontario respectively. Titterington *et al.* (1979) also found Ovenbird in greatest abundance in the seral stage preceding mature spruce-fir, with the most woody herbaceous stems 0.3 and 2.0 m tall. In contrast, Smith and Shugart (1987) noted a decrease in Ovenbird abundance with increased shrub density in a Tennessee mixed forest, that they explained by a decrease in prey abundance. My regression analysis did not suggest an important relationship between Ovenbird abundance and shrub density and shrubs may be of low importance to Ovenbirds in Newfoundland balsam fir forests. Other Ovenbird studies have been conducted in deciduous-dominated forests, where the importance of ground vegetation structure varied greatly depending on forest ecotypes and management regimes (see Van Horn and Donovan 1994). However, it has been clearly established that Ovenbirds are an area sensitive forest-interior species (Robbins 1979, Shaw 1985, Morse 1989, Villard *et al.* 1994), associated with mature forests (Maurer *et al.* 1981, Welsh 1987). The presence of deciduous trees (Titterington et al. 1979) and deciduous litter (Stenger 1958, Smith and Shugart 1987) have been identified as important habitat components for Ovenbirds, for both foraging (Smith and Shugart 1987) and nesting (Stenger 1958). In a study of Ovenbird territory size in relation to habitat structure, Smith and Shugart (1987) noted that deciduous litter decreased soil acidity, thereby improving conditions for invertebrate prey. Ovenbirds have been observed both foraging (pers. obs. 1991) and nesting (M. Setterington, pers. comm. 1993) in second-growth stands in this study area, and Ovenbird abundance was had a positive correlation to deciduous litter; there was also a positive relationship between Ovenbird abundance and rich forests with ferns and forbs. The richer habitats likely supported a greater diversity and/or abundance of invertebrate prey. A study of beetle species diversity and abundance in the same forest types as this study is currently underway (D. Larson unpubl. data).

Gray-cheeked Thrushes were more abundant in natural growth than in second-growth stands, but no significant habitat relationships were found. This could be due either to the small sample size of Gray-cheeked Thrushes, or to the fact that strong species-habitat relationships did not occur. For all species, it is possible that important attributes of the habitat to which the species responds (i.e. "niche gestalt") were not measured. All Gray-cheeked Thrushes were found in forest stands in the Little Grand Lake area (see Appendix 2). It is possible that, rather than being related to forest class, the presence of Gray-cheeked Thrushes may be a regional phenomenon. In a montane forest study in Vermont, Noon (1981b) found Gray-cheeked Thrushes associated with stunted spruce forests with a dense understory. A preference for spruce-dominated forests has also been observed in Newfoundland boreal forests (B. Mactavish, pers. comm.), and it is possible that balsam fir forests provide marginal or sink habitats for Gray-cheeked Thrushes.

Yellow-rumped and Black-throated Green Warblers, the two most abundant species in my study, frequently co-occur in mature coniferous forests (Morse 1989). Yet, Yellow-rumped Warblers were associated with older forests on poorer sites, and Black-throated Green Warblers were found in younger forests on richer sites (Table 11). In a study of songbird response to commercial clearcutting in a spruce-fir forest in Maine, Titterington et al. (1979) also found Yellow-rumped Warblers in greater abundance in older forests than Black-throated Green Warblers . Franzreb (1978) also observed a greater abundance of Yellow-rumped Warblers in uncut old forest than in second-growth, in a mixed forest in the White Mountains, Arizona. MacArthur (1958) explained the ability of Yellow-rumped and Black-throated Green Warblers to co-exist through competition-driven differences in tree foraging zones within trees and modes of prey procurement. Morse (1976) maintains that the more aggressive Black-throated Green Warblers out-compete Yellow-rumped Warblers (and are therefore more abundant) in preferred habitats. This may help to explain why Black-throated Green Warblers were more abundant in richer forest types, if we assume that richer sites are "preferred". Though competition is likely an important factor, the two species are probably also responding to differences in ecological preferences (e.g. preferred nesting and foraging sites). Measuring nesting success for the two species across all stands would help determine if there are differences in optimal breeding site conditions between forest classes and among forest types.

4.2. Management Implications

For most species, adequate habitat was found in both second-growth and natural-growth forests. However, some important habitat structural components are required to maximize avian diversity and to maintain certain species. Fallen dead trees appear to be important for Black-backed Woodpeckers, and are found mostly in old/over-mature forest. Similarly, the presence of deciduous litter (and therefore deciduous trees) is important for the nesting and foraging requirements of Ovenbirds. Ovenbirds and other forest interior species can best be maintained through forest management that provides large tracts of forest connected to nearby large tracts of a similar age, joined by corridors of undisturbed forest habitat (Shaw 1985). In a study of bird abundance in mixed-conifer forests managed for timber and wildlife resources in California, Morrison (1992) concluded that diverse foliage profiles promotes species diversity. Santillo et al. (1989) found a positive correlation between songbird density and FHD in a study of the effect of glyco-phosphate induced changes on clearcuts. The results of my study support the growing body of literature that silvicultural methods must maintain habitat diversity, through consideration of site, age and stand size.

Today, clear-cut logging is the most economical and virtually exclusive method of forest harvesting in Newfoundland (Page *et al.* 1974, Freedman 1982, Baskerville 1992). The impact of clear-cut logging on the habitat structure of the future mature second-growth balsam fir forests in western Newfoundland is not known.

4.3. Conclusions

Both second-growth and natural-growth forests provide adequate habitat for most species. Species richness and abundance increase with increased site richness. It is important to maintain stand diversity in order to promote avian biodiversity and increased abundance. Important components to maintain are: snags, for bark foragers and cavity nesters, particularly Black-backed Woodpeckers; some deciduous trees, for some ground foraging species, especially Ovenbirds; and a portion of canopy trees, as a source for future snags. Future studies on breeding success would be beneficial for further assessing optimal breeding habitat.

Each of the forest classes and forest types supported slightly different avian assemblages. Therefore, both natural and second-growth forests on a variety of forest site types are needed to support the most diverse and abundant bird assemblages in balsam fir forests.

There is a recognized need to preserve rare and/or ecologically significant areas. Since very little natural-growth forest remains in Newfoundland and its ecological importance is poorly understood, it can well be argued that no further harvesting should proceed in natural stands, allowing natural regeneration to occur.

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Appendix 1. The common and scientific names and American Ornithological Union (AOU) abbreviations for the bird species detected in this study.

Species	**Scientific Name**	**AOU Code**
Downy Woodpecker	*Picoides pubescens*	DOWO
Hairy Woodpecker	*Picoides villosus*	HAWO
Black-backed Woodpecker	*Picoides arcticus*	BBWO
Northern Flicker	*Colaptes auratus*	NOFL
Olive-sided Flycatcher	*Nuttallornis borealis*	OSFL
Yellow-bellied Flycatcher	*Empidonax minimus*	YBFL
Tree Swallow	*Iridoprocne bicolor*	TRSW
Gray Jay	*Perisoreus canadensis*	GRJA
American Crow	*Corvus brachyrhyncos*	AMCR
Common Raven	*Corvus corax*	CORA
Black-capped Chickadee	*Parus atricapillus*	BCCH
Boreal Chickadee	*Parus hudsonicus*	BOCH
Red-breasted Nuthatch	*Sitta canadensis*	RBNU
Brown Creeper	*Certhia familiaris*	BRCR
Winter Wren	*Troglodytes troglodytes*	WIWR
Golden-crowned Kinglet	*Regulus satrapa*	GCKI
Ruby-crowned Kinglet	*Regulus calendula*	RCKI
Swainson's Thrush	*Catharus ustulatus*	SWTH
Hermit Thrush	*Catharus guttatus*	HETH
Gray-cheeked Thrush	*Catharus minimus*	GCTH
American Robin	*Turdus migratorius*	AMRO
Solitary Vireo	*Vireo solitarius*	SOVI
Magnolia Warbler	*Dendroica magnolia*	MAWA
Tennessee Warbler	*Vermivora peregrina*	TEWA
Yellow-rumped Warbler	*Dendroica coronata*	YRWA
Black-throated Green Warbler	*Dendroica virens*	BTGW
Bay-breasted Warbler	*Dendroica castanea*	BBWA
Blackpoll Warbler	*Dendroica striata*	BPWA
Black and White Warbler	*Mniotilta varia*	BWWA

Appendix 1. (continued)

Species	**Scientific Name**	**AOU Code**
Ovenbird	*Seiurus aurocapillus*	OVEN
Northern Waterthrush	*Seiurus noveboracensis*	NOWA
Mourning Warbler	*Oporornis philadelphia*	MOWA
Fox Sparrow	*Passerella iliaca*	FOSP
Lincoln's Sparrow	*Melospiza lincolnii*	LISP
White-throated Sparrow	*Zonotrichia albicollis*	WTSP
Dark-eyed Junco	*Junco hyemalis*	DEJU
Common Redpoll	*Carduelis flammea*	CORE
Pine Grosbeak	*Pinicola enucleator*	PIGR
Evening Grosbeak	*Coccothraustes vespertinus*	EVGR
Purple Finch	*Carpodacus purpureus*	PUFI
White-winged Crossbill	*Loxia leucoptera*	WWCR
Pine Siskin	*Carduelus pinus*	PISI

Appendix 2 (i). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Pleurozium/ Hylocomium forest: Humber 30.

Species		Total IPAs 1991	Total IPAs 1992
Northern Flicker		1	0
Yellow-bellied Flycatcher		14	10
Gray Jay		0	2
Swainson's Thrush		12	6
American Robin		5	3
Golden-crowned Kinglet		4	6
Ruby-crowned Kinglet		2	10
Yellow-rumped Warbler		12	14
Black-throated Green Warbler		0	12
Northern Waterthrush		2	0
Lincoln's Sparrow		2	0
White-throated Sparrow		1	0
Dark-eyed Junco		2	2
White-winged Crossbill		1	0
Pine Grosbeak		1	2
Pine Siskin		1	2
Species Richness	1991: 13 1992: 11	59	69

Appendix 2 (ii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Hylocomium forest: Humber 32.

Species		Total IPAs 1991	1992
Olive-sided flycatcher		2	0
Yellow-bellied Flycatcher		8	8
Boreal Chickadee		0	2
Swainson's Thrush		12	10
American Robin		4	4
Golden-crowned Kinglet		4	4
Ruby-crowned Kinglet		6	12
Yellow-rumped Warbler		14	17
Black-throated Green Warbler		0	4
White-throated Sparrow		4	2
Dark-eyed Junco		1	0
Pine Grosbeak		2	3
White-winged Crossbill		1	0
Pine Siskin		0	3
Species Richness	1991: 11 1992: 11	58	68

Appendix 2 (iii). Avian species richness, composition and total of five observation point IPAs for 1992 in a natural growth Pleurozium/Hylocomium forest: Humber 33. (survey not conducted in 1991)

Species		Total IPAs 1992
Downy Woodpecker		1
Yellow-bellied Flycatcher		10
Gray Jay		3
Golden-crowned Kinglet		4
Ruby-crowned Kinglet		8
Swainson's Thrush		6
Yellow-rumped Warbler		22
Black-throated Green Warbler		4
Northern Waterthrush		2
White-throated Sparrow		2
Dark-eyed Junco		1
Pine Grosbeak		2
Pine Siskin		2
Species Richness:	13	67

Appendix 2 (iv). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Dryopteris-Hylocomium forest: Little Grand Lake 01.

Species		Total IPAs 1991	Total IPAs 1992
Black-backed Woodpecker		0	1
Woodpecker sp.		1	0
Yellow-bellied Flycatcher		8	16
Tree Swallow		1	0
Gray Jay		0	3
Black-capped Chickadee		2	6
Swainson's Thrush		10	6
American Robin		2	0
Golden-crowned Kinglet		6	0
Ruby-crowned Kinglet		12	6
Yellow-rumped Warbler		26	22
Black-throated Green Warbler		8	12
Blackpoll Warbler		2	0
Ovenbird		0	2
Northern Waterthrush		8	2
Fox Sparrow		8	0
White-throated Sparrow		4	4
White-winged Crossbill		0	1
Pine Siskin		4	0
Species Richness	1991: 16 1992: 12	103	81

Appendix 2 (v). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Dryopteris-Hylocomium forest: Little Grand Lake 02.

Species		Total IPAs 1991	1992
Black-backed Woodpecker		2	2
Woodpecker sp.		2	0
Yellow-bellied Flycatcher		20	28
Swainson's Thrush		6	4
Hermit Thrush		4	4
American Robin		0	3
Golden-crowned Kinglet		0	2
Ruby-crowned Kinglet		8	10
Yellow-rumped Warbler		6	20
Black-throated Green Warbler		6	14
Bay-breasted Warbler		0	2
Northern Waterthrush		2	2
Mourning Warbler		6	4
White-throated Sparrow		6	8
Pine Siskin		3	0
Species Richness	1991: 11 1992: 13	71	71

Appendix 2 (vi). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Dryopteris-Hylocomium/Gaultheria forest: Little Grand Lake 04.

Species		Total IPAs 1991	1992
Black-backed Woodpecker		0	2
Yellow-bellied Flycatcher		4	10
Gray Jay		0	1
Black-capped Chickadee		0	2
Swainson's Thrush		0	2
Golden-crowned Kinglet		2	2
Ruby-crowned Kinglet		10	10
Yellow-rumped Warbler		10	16
Black-throated Green Warbler		2	6
Northern Waterthrush		2	2
Mourning Warbler		2	0
White-throated Sparrow		12	6
Dark-eyed Junco		6	2
Pine Grosbeak		1	1
Species Richness	1991: 10 1992: 13	51	62

Appendix 2 (vii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Dryopteris-Hylocomium/Hylocomium forest: Little Grand Lake 14.

Species		Total IPAs 1991	1992
Black-backed Woodpecker		1	0
Yellow-bellied Flycatcher		6	18
Black-capped Chickadee		2	8
Boreal Chickadee		0	2
Swainson's Thrush		13	6
Hermit Thrush		0	7
Gray-cheeked Thrush		2	0
American Robin		2	1
Golden-crowned Kinglet		8	0
Ruby-crowned Kinglet		26	16
Magnolia Warbler		2	0
Yellow-rumped Warbler		20	13
Black-throated Green Warbler		8	8
White-throated Sparrow		12	4
Pine Grosbeak		0	2
Pine Siskin		0	4
Species Richness	1991: 12 1992: 12	102	89

Appendix 2 (viii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Dryopteris-Hylocomium forest: Little Grand Lake 15.

Species		Total IPAs 1991	1992
Black-backed Woodpecker		1	0
Yellow-bellied Flycatcher		4	14
Gray Jay		4	0
Common Raven		0	1
Black-capped Chickadee		1	0
Boreal Chickadee		1	0
Swainson's Thrush		16	2
Hermit Thrush		2	1
American Robin		2	6
Golden-crowned Kinglet		8	6
Ruby-crowned Kinglet		14	10
Magnolia Warbler		2	2
Yellow-rumped Warbler		10	13
Black-throated Green Warbler		14	16
Bay-breasted Warbler		2	0
Ovenbird		4	6
Northern Waterthrush		2	0
Mourning Warbler		4	4
White-throated Sparrow		4	0
White-winged Crossbill		1	2
Pine Siskin		2	2
Species Richness	1991: 20 1992: 14	102	85

Appendix 2 (ix). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Dryopteris-Hylocomium forest: Little Grand Lake 16.

Species		Total IPAs 1991	1992
Downy Woodpecker		1	2
Black-backed Woodpecker		0	2
Yellow-bellied Flycatcher		6	16
Gray Jay		2	2
Black-capped Chickadee		2	0
Brown Creeper		2	0
Swainson's Thrush		2	4
Hermit Thrush		4	0
American Robin		12	7
Golden-crowned Kinglet		6	2
Ruby-crowned Kinglet		18	12
Tennessee Warbler		2	0
Magnolia Warbler		2	0
Yellow-rumped Warbler		16	18
Black-throated Green Warbler		8	14
Blackpoll Warbler		1	0
Ovenbird		2	0
Northern Waterthrush		12	6
White-throated Sparrow		10	12
Dark-eyed Junco		4	0
White-winged Crossbill		1	0
Pine Siskin		0	7
Species Richness	1991: 20 1992: 13	113	104

Appendix 2 (x). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Dryopteris-Hylocomium forest: Little Grand Lake 17.

Species		Total IPAs	
		1991	1992
Downy Woodpecker		0	1
Black-backed Woodpecker		2	3
Olive-sided Flycatcher		4	0
Yellow-bellied Flycatcher		18	18
Gray Jay		1	0
Black-capped Chickadee		2	1
Winter Wren		2	2
Swainson's Thrush		6	4
Hermit Thrush		2	2
Gray-cheeked Thrush		2	2
American Robin		1	0
Golden-crowned Kinglet		4	0
Ruby-crowned Kinglet		8	16
Yellow-rumped Warbler		14	13
Black-throated Green Warbler		8	4
Blackpoll Warbler		2	0
Black-and-white Warbler		2	0
Northern Waterthrush		4	0
Mourning Warbler		4	0
White-throated Sparrow		16	20
Dark-eyed Junco		2	0
Pine Grosbeak		4	0
Pine Siskin		1	1
Species Richness	1991: 22 1992: 13	107	87

Appendix 2 (xi). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Dryopteris-Hylocomium forest: Little Grand Lake 18.

Species		Total IPAs 1991	1992
Downy Woodpecker		2	0
Black-backed Woodpecker		1	1
Yellow-bellied Flycatcher		2	12
Gray Jay		2	1
Boreal Chickadee		0	1
Brown Creeper		2	0
Swainson's Thrush		14	6
Gray-cheeked Thrush		2	0
American Robin		2	2
Golden-crowned Kinglet		7	0
Ruby-crowned Kinglet		14	10
Yellow-rumped Warbler		15	18
Black-throated Green Warbler		4	10
Ovenbird		2	0
Northern Waterthrush		4	2
White-throated Sparrow		8	9
Pine Grosbeak		2	0
Pine Siskin		2	1
Species Richness	1991: 17 1992: 12	85	73

Appendix 2 (xii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Dryopteris-Hylocomium forest: Little Grand Lake 41.

Species		Total IPAs	
		1991	1992
Downy Woodpecker		3	2
Black-backed Woodpecker		0	6
Olive-sided Flycatcher		4	0
Yellow-bellied Flycatcher		8	18
Tree Swallow		1	0
Gray Jay		0	2
Black-capped Chickadee		2	0
Boreal Chickadee		1	0
Winter Wren		6	0
Swainson's Thrush		8	4
Gray-cheeked Thrush		2	0
Hermit Thrush		0	8
American Robin		2	1
Golden-crowned Kinglet		3	0
Ruby-crowned Kinglet		4	14
Magnolia Warbler		2	0
Yellow-rumped Warbler		8	16
Black-throated Green Warbler		2	8
Black-and-white Warbler		6	0
Blackpoll Warbler		0	4
Northern Waterthrush		4	0
Mourning Warbler		2	2
White-throated Sparrow		14	16
Pine Siskin		0	2
Evening Grosbeak		2	0
Species Richness	1991: 20 1992: 13	84	82

Appendix 2 (xiii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a natural growth Dryopteris-Hylocomium forest: Little Grand Lake 42.

Species		Total IPAs 1991	1992
Yellow-bellied Flycatcher		10	24
Winter Wren		2	0
Swainson's Thrush		10	9
Hermit Thrush		0	2
American Robin		0	3
Golden-crowned Kinglet		2	3
Ruby-crowned Kinglet		8	18
Magnolia Warbler		6	2
Yellow-rumped Warbler		6	18
Black-throated Green Warbler		8	11
Bay-breasted Warbler		0	2
Black-and-white Warbler		4	2
Blackpoll Warbler		0	2
Northern Waterthrush		14	4
Mourning Warbler		0	4
White-throated Sparrow		8	6
Pine Siskin		2	0
Species Richness	1991: 12 1992: 15	80	110

Appendix 2 (xiv). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Pleurozium forest: Hampden 26.

Species		Total IPAs	
		1991	1992
Downy Woodpecker		2	0
Yellow-bellied Flycatcher		6	2
Gray Jay		2	0
Common Raven		3	0
Black-capped Chickadee		2	0
Boreal Chickadee		2	2
Swainson's Thrush		3	4
American Robin		12	2
Golden-crowned Kinglet		4	6
Ruby-crowned Kinglet		4	2
Magnolia Warbler		4	0
Yellow-rumped Warbler		14	10
Northern Waterthrush		2	0
Fox Sparrow		6	6
White-throated Sparrow		10	8
Pine Grosbeak		0	2
Pine Siskin		1	0
Species Richness	1991: 15 1992: 11	84	46

Appendix 2 (xv). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Pleurozium forest: Hampden 27.

Species		Total IPAs 1991	1992
Yellow-bellied Flycatcher		4	2
Gray Jay		4	0
Common Raven		0	2
Black-capped Chickadee		0	2
Boreal Chickadee		4	0
Swainson's Thrush		3	0
American Robin		10	0
Golden-crowned Kinglet		2	0
Ruby-crowned Kinglet		10	4
Yellow-rumped Warbler		14	12
Black-throated Green Warbler		6	2
Northern Waterthrush		4	2
Mourning Warbler		4	0
Fox Sparrow		10	2
White-throated Sparrow		12	4
Purple Finch		2	0
White-winged Crossbill		0	2
Pine Siskin		5	9
Species Richness	1991: 16 1992: 12	97	47

Appendix 2 (xvi). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Pleurozium forest: Hampden 28.

Species		Total IPAs 1991	Total IPAs 1992
Yellow-bellied Flycatcher		6	6
Gray Jay		0	3
Common Raven		2	1
Black-capped Chickadee		0	2
Boreal Chickadee		1	2
Swainson's Thrush		8	4
American Robin		2	2
Hermit Thrush		0	4
Golden-crowned Kinglet		6	4
Ruby-crowned Kinglet		8	8
Yellow-rumped Warbler		14	11
Black-throated Green Warbler		6	8
White-throated Sparrow		4	6
Purple Finch		1	6
Dark-eyed Junco		6	0
White-winged Crossbill		1	0
Pine Grosbeak		2	0
Common Redpoll		2	0
Pine Siskin		3	3
Species Richness	1991: 16 1992: 15	71	70

Appendix 2 (xvii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Pleurozium forest: Hampden 29.

Species		Total IPAs 1991	1992
Yellow-bellied Flycatcher		2	2
Gray Jay		2	0
Common Raven		2	2
Boreal Chickadee		2	2
Swainson's Thrush		4	2
American Robin		2	4
Golden-crowned Kinglet		4	6
Ruby-crowned Kinglet		4	6
Magnolia Warbler		0	2
Yellow-rumped Warbler		11	6
Black-throated Green Warbler		2	6
Fox Sparrow		2	0
White-throated Sparrow		2	4
Purple Finch		0	3
Pine Grosbeak		4	2
Species Richness	1991: 16 1992: 15	71	70

Appendix 2 (xviii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Pleurozium forest: Taylor's Brook 36.

Species		Total IPAs 1991	1992
Downy Woodpecker		2	1
Hairy Woodpecker		2	0
Woodpecker sp.		1	0
Yellow-bellied Flycatcher		8	12
Gray Jay		2	3
Common Raven		3	2
Black-capped Chickadee		4	4
Boreal Chickadee		4	2
Swainson's Thrush		8	5
American Robin		3	4
Golden-crowned Kinglet		2	0
Ruby-crowned Kinglet		6	12
Magnolia Warbler		4	8
Yellow-rumped Warbler		8	10
Black-throated Green Warbler		2	2
Bay-breasted Warbler		2	0
Blackpoll Warbler		4	4
Ovenbird		6	4
Northern Waterthrush		0	2
Fox Sparrow		4	8
White-throated Sparrow		2	12
Purple Finch		4	0
Pine Grosbeak		8	8
Pine Siskin		3	0
Species Richness	1991: 22 1992: 17	91	101

Appendix 2 (xix). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Pleurozium forest: Taylor's Brook 37.

Species		Total IPAs	
		1991	1992
Downy Woodpecker		1	0
Yellow-bellied Flycatcher		12	14
Tree Swallow		0	1
Gray Jay		0	1
Common Raven		2	0
Boreal Chickadee		1	1
Swainson's Thrush		26	16
American Robin		0	12
Golden-crowned Kinglet		2	0
Ruby-crowned Kinglet		8	18
Magnolia Warbler		2	10
Yellow-rumped Warbler		16	18
Black-throated Green Warbler		4	14
Bay-breasted Warbler		2	4
Blackpoll Warbler		2	0
Ovenbird		10	10
Fox Sparrow		8	4
White-throated Sparrow		0	4
Dark-eyed Junco		1	4
Pine Grosbeak		4	2
Pine Siskin		3	4
Species Richness	1991: 17 1992: 18	104	141

Appendix 2 (xx). Avian species richness, composition and total of five observation point IPAs for 1991 and 1991 in a second growth Pleurozium forest: Adies Pond 20.

Species		Total IPAs 1991	1992
Hairy Woodpecker		0	1
Downy Woodpecker		1	0
Northern Flicker		1	0
Yellow-bellied Flycatcher		10	14
Tree Swallow		2	0
Gray Jay		1	0
Boreal Chickadee		1	0
Black-capped Chickadee		0	2
Red-breasted Nuthatch		0	1
Golden-crowned Kinglet		2	4
Ruby-crowned Kinglet		6	12
Swainson's Thrush		7	12
Hermit Thrush		0	4
American Robin		4	0
Magnolia Warbler		4	4
Yellow-rumped Warbler		8	10
Black-throated Green Warbler		20	14
Ovenbird		8	2
Northern Waterthrush		4	4
White-throated Sparrow		2	2
Pine Grosbeak		2	0
Purple Finch		0	2
Pine Siskin		1	4
Species Richness	1991: 19 1992: 16	89	92

Appendix 2 (xxi). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Pleurozium/ Hylocomium forest: Adies Pond 21.

Species		Total IPAs 1991	1992
Yellow-bellied Flycatcher		4	12
Gray Jay		4	1
American Crow		1	0
Boreal Chickadee		4	2
Swainson's Thrush		4	12
American Robin		0	4
Golden-crowned Kinglet		2	2
Ruby-crowned Kinglet		8	3
Magnolia Warbler		2	0
Yellow-rumped Warbler		6	2
Black-throated Green Warbler		16	20
Bay-breasted Warbler		0	2
Ovenbird		2	0
Northern Waterthrush		6	2
Mourning Warbler		0	2
White-throated Sparrow		2	2
Purple Finch		2	0
White-winged Crossbill		2	2
Pine Siskin		2	7
Species Richness	1991: 15 1992: 15	65	75

Appendix 2 (xxii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris/ Pleurozium forest: Adies Pond 07.

Species		Total IPAs 1991	1992
Yellow-bellied Flycatcher		8	16
Gray Jay		2	0
Black-capped Chickadee		6	4
Boreal Chickadee		6	6
Golden-crowned Kinglet		2	2
Ruby-crowned Kinglet		6	8
Swainson's Thrush		11	10
Hermit Thrush		1	2
Yellow-rumped Warbler		8	10
Black-throated Green Warbler		22	24
Bay-breasted Warbler		0	2
Ovenbird		4	6
Fox Sparrow		4	2
White-throated Sparrow		6	2
Pine Siskin		2	1
Species Richness	1991: 14 1992: 14	91	92

Appendix 2 (xxiii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris forest: Adies Pond 19.

Species		Total IPAs 1991	1992
Yellow-bellied Flycatcher		14	10
Tree Swallow		1	0
Gray Jay		0	4
Common Raven		2	2
Black-capped Chickadee		2	2
Boreal Chickadee		2	1
Golden-crowned Kinglet		1	2
Ruby-crowned Kinglet		8	12
Swainson's Thrush		10	9
Hermit Thrush		4	0
American Robin		4	5
Magnolia Warbler		6	6
Yellow-rumped Warbler		2	5
Black-throated Green Warbler		18	22
Bay-breasted Warbler		0	2
Ovenbird		16	18
Northern Waterthrush		1	0
Fox Sparrow		4	2
White-throated Sparrow		2	0
Pine Grosbeak		5	8
Pine Siskin		2	7
Species Richness	1991: 19 1992: 17	103	112

Appendix 2 (xxiv). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris-Hylocomium/Hylocomium forest: South Brook 09.

Species		Total IPAs 1991	1992
Yellow-bellied Flycatcher		8	8
Gray Jay		0	1
Black-capped Chickadee		2	2
Boreal Chickadee		1	0
Brown Creeper		2	0
Winter Wren		2	0
Swainson's Thrush		0	6
Hermit Thrush		0	6
American Robin		0	2
Golden-crowned Kinglet		6	0
Ruby-crowned Kinglet		2	7
Magnolia Warbler		0	2
Yellow-rumped Warbler		16	14
Black-throated Green Warbler		12	8
Ovenbird		14	6
Pine Grosbeak		2	1
Purple Finch		2	1
Pine Siskin		2	3
Species Richness	1991: 13 1992: 15	71	81

Appendix 2 (xxv). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris-Hylocomium forest: South Brook 08.

Species		Total IPAs	
		1991	1992
Downy Woodpecker		1	0
Yellow-bellied Flycatcher		6	6
Gray Jay		0	1
Winter Wren		4	0
Swainson's Thrush		3	14
American Robin		1	3
Golden-crowned Kinglet		4	1
Ruby-crowned Kinglet		6	10
Magnolia Warbler		2	8
Yellow-rumped Warbler		10	15
Black-throated Green Warbler		10	14
Ovenbird		10	10
Northern Waterthrush		2	0
Mourning Warbler		2	4
Fox Sparrow		0	6
White-throated Sparrow		6	16
Pine Grosbeak		1	1
Purple Finch		2	0
Pine Siskin		2	11
Species Richness	1991: 17 1992: 15	72	120

Appendix 2 (xxvi). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris-Hylocomium forest: South Brook 10.

Species		Total IPAs	
		1991	1992
Hairy Woodpecker		1	0
Yellow-bellied Flycatcher		9	22
Gray Jay		0	3
Black-capped Chickadee		0	4
Boreal Chickadee		2	4
Swainson's Thrush		2	4
Golden-crowned Kinglet		6	5
Ruby-crowned Kinglet		8	10
Yellow-rumped Warbler		8	10
Black-throated Green Warbler		12	6
Bay-breasted Warbler		0	2
Ovenbird		0	4
Fox Sparrow		0	2
White-throated Sparrow		2	2
Pine Grosbeak		0	4
Purple Finch		2	0
Common Redpoll		4	0
Pine Siskin		10	2
Species Richness	1991: 12 1992: 15	66	84

Appendix 2 (xxvii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris-Hylocomium forest: South Brook 11.

Species		Total IPAs 1991	1992
Hairy Woodpecker		0	2
Yellow-bellied Flycatcher		10	10
Gray Jay		1	0
Black-capped Chickadee		0	8
Boreal Chickadee		8	0
Swainson's Thrush		4	0
American Robin		2	2
Golden-crowned Kinglet		2	6
Ruby-crowned Kinglet		6	10
Yellow-rumped Warbler		10	10
Black-throated Green Warbler		12	23
Ovenbird		6	12
Mourning Warbler		2	2
Fox Sparrow		2	2
White-throated Sparrow		2	2
Common Redpoll		2	0
Pine Siskin		2	3
Species Richness	1991: 15 1992: 14	71	96

Appendix 2 (xxviii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris-Hylocomium/Dryopteris forest: Cooks Pond 22.

Species		Total IPAs 1991	1992
Downy Woodpecker		1	0
Yellow-bellied Flycatcher		8	16
Gray Jay		2	3
Black-capped Chickadee		2	0
Boreal Chickadee		0	1
Swainson's Thrush		7	6
American Robin		6	6
Golden-crowned Kinglet		10	4
Ruby-crowned Kinglet		4	7
Yellow-rumped Warbler		12	7
Black-throated Green Warbler		16	17
Ovenbird		12	14
Northern Waterthrush		6	8
White-throated Sparrow		8	6
Pine Grosbeak		0	2
Purple Finch		0	2
White-winged Crossbill		1	5
Pine Siskin		4	1
Species Richness	1991: 15 1992: 16	99	105

Appendix 2 (xxix). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris forest: Cooks Pond 25.

Species		Total IPAs 1991	1992
Yellow-bellied Flycatcher		4	14
Gray Jay		0	1
Black-capped Chickadee		2	0
Boreal Chickadee		2	2
Swainson's Thrush		7	6
Hermit Thrush		0	2
American Robin		1	7
Golden-crowned Kinglet		7	2
Ruby-crowned Kinglet		6	10
Yellow-rumped Warbler		13	12
Black-throated Green Warbler		16	22
Ovenbird		6	6
Northern Waterthrush		4	8
Fox Sparrow		2	0
White-throated Sparrow		8	0
Pine Grosbeak		6	1
Purple Finch		4	4
White-winged Crossbill		1	0
Pine Siskin		2	8
Species Richness	1991: 17 1992: 15	91	105

Appendix 2 (xxx). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris forest: Cooks Pond 23.

Species		Total IPAs	
		1991	1992
Downy Woodpecker		4	2
Northern Flicker		2	0
Yellow-bellied Flycatcher		8	24
Gray Jay		0	2
Black-capped Chickadee		4	2
Boreal Chickadee		6	0
Swainson's Thrush		6	9
American Robin		8	3
Golden-crowned Kinglet		6	2
Ruby-crowned Kinglet		1	14
Magnolia Warbler		2	2
Yellow-rumped Warbler		4	4
Black-throated Green Warbler		16	22
Ovenbird		12	14
Northern Waterthrush		2	2
Mourning Warbler		0	6
White-throated Sparrow		2	6
Pine Grosbeak		4	0
Purple Finch		6	0
Pine Siskin		6	5
Species Richness	1991: 18 1992: 16	100	119

Appendix 2 (xxxi). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Rubus/ Dryopteris forest: Cooks Pond 24.

Species		Total IPAs 1991	1992
Downy Woodpecker		0	1
Woodpecker sp.		2	0
Olive-sided Flycatcher		2	0
Yellow-bellied Flycatcher		6	16
Gray Jay		0	1
Common Raven		0	2
Black-capped Chickadee		2	4
Boreal Chickadee		4	0
Swainson's Thrush		0	8
American Robin		6	3
Golden-crowned Kinglet		6	6
Ruby-crowned Kinglet		4	16
Magnolia Warbler		2	2
Yellow-rumped Warbler		5	4
Black-throated Green Warbler		0	28
Ovenbird		8	22
Northern Waterthrush		1	0
Mourning Warbler		0	4
White-throated Sparrow		2	4
Purple Finch		2	4
Pine Siskin		2	2
Species Richness	1991: 16 1992: 17	93	128

Appendix 2 (xxxii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris forest: Pinchgut Lake 06.

Species		Total IPAs 1991	1992
Downy Woodpecker		0	1
Yellow-bellied Flycatcher		10	8
Gray Jay		0	1
Black-capped Chickadee		3	6
Boreal Chickadee		10	0
Swainson's Thrush		5	3
American Robin		2	3
Golden-crowned Kinglet		4	2
Ruby-crowned Kinglet		6	8
Magnolia Warbler		0	2
Yellow-rumped Warbler		7	10
Black-throated Green Warbler		16	16
Ovenbird		6	4
Northern Waterthrush		2	2
White-throated Sparrow		4	4
Pine Grosbeak		0	6
Purple Finch		4	0
Pine Siskin		4	2
Species Richness	1991: 14 1992: 16	83	78

Appendix 2 (xxxiii). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris forest: Pinchgut Lake 06.

Species		Total IPAs 1991	1992
Downy Woodpecker		0	2
Black-backed Woodpecker		0	1
Yellow-bellied Flycatcher		14	12
Gray Jay		4	0
Common Raven		1	0
Black-capped Chickadee		2	0
Swainson's Thrush		14	12
American Robin		9	8
Golden-crowned Kinglet		4	2
Ruby-crowned Kinglet		6	10
Tennessee Warbler		2	0
Magnolia Warbler		2	6
Yellow-rumped Warbler		10	17
Black-throated Green Warbler		23	26
Bay-breasted Warbler		0	2
Blackpoll Warbler		4	2
Ovenbird		20	16
Northern Waterthrush		6	4
Mourning Warbler		6	8
Fox Sparrow		2	4
White-throated Sparrow		10	12
Pine Grosbeak		4	4
Purple Finch		2	2
White-winged Crossbill		1	0
Pine Siskin		2	2
Species Richness	1991: 23 1992: 21	159	153

Appendix 2 (xxxiv). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris/ Rubus forest: Pinchgut Lake 05.

Species		Total IPAs 1991	Total IPAs 1992
Woodpecker sp.		1	0
Yellow-bellied Flycatcher		11	10
Gray Jay		0	1
Common Raven		3	0
Black-capped Chickadee		0	4
Swainson's Thrush		10	11
Hermit Thrush		0	2
American Robin		4	6
Golden-crowned Kinglet		6	1
Ruby-crowned Kinglet		0	18
Magnolia Warbler		0	2
Yellow-rumped Warbler		12	16
Black-throated Green Warbler		23	30
Ovenbird		6	14
Northern Waterthrush		6	4
Mourning Warbler		2	2
White-throated Sparrow		6	8
Pine Grosbeak		0	2
Purple Finch		4	0
Common Redpoll		2	0
Pine Siskin		5	9
Species Richness	1991: 16 1992: 17	101	140

Appendix 2 (xxxv). Avian species richness, composition and total of five observation point IPAs for 1991 and 1992 in a second growth Dryopteris/ Rubus forest: Pinchgut Lake 51.

Species	Total IPAs 1991	Total IPAs 1992
Black-backed Woodpecker	0	1
Northern Flicker	2	0
Woodpecker sp.	2	0
Yellow-bellied Flycatcher	12	10
Gray Jay	2	2
Black-capped Chickadee	2	0
Swainson's Thrush	18	14
Hermit Thrush	2	0
American Robin	17	6
Golden-crowned Kinglet	8	2
Ruby-crowned Kinglet	2	12
Solitary Vireo	2	0
Magnolia Warbler	2	0
Yellow-rumped Warbler	16	14
Black-throated Green Warbler	30	24
Bay-breasted Warbler	2	0
Blackpoll Warbler	2	0
Ovenbird	16	15
Northern Waterthrush	12	4
Mourning Warbler	6	0
Fox Sparrow	8	0
White-throated Sparrow	4	8
Pine Grosbeak	2	2

Appendix 2 (xxxv). (Continued)

Species		Total IPAs 1991	1992
Purple Finch		0	2
Pine Siskin		10	6
Evening Grosbeak		1	0
Species Richness	1991: 24 1992: 15	182	122

Appendix 3. Pearson correlation matrix for all of the habitat variables.
* designates variables selected for the PCA.

	AGE	CANOPY	DLITTER	DTBIRPRO	DTDENS
*AGE	1.000				
*CANOPY	-0.298	1.000			
*DLITTER	-0.424	0.396	1.000		
DTBIRPRO	-0.593	0.036	0.456	1.000	
*DTDENS	-0.263	0.274	0.043	-0.447	1.000
DTFIRPRO	0.427	-0.114	-0.327	-0.873	0.532
DTSPRPRO	0.433	0.106	-0.224	-0.159	-0.317
*FLITTER	0.076	-0.327	0.043	-0.176	0.268
*FORBS	0.242	-0.580	0.103	0.109	-0.292
GRAM	0.293	-0.593	-0.254	-0.024	-0.270
LICHEN	-0.628	-0.065	0.157	0.803	-0.435
LOGDIAM	-0.165	0.398	-0.221	-0.166	0.318
*LOGS	0.186	0.356	-0.136	-0.314	0.237
LOWFERN	0.366	-0.195	0.262	-0.245	0.008
*LOWSHRUB	0.477	-0.273	-0.091	-0.023	-0.477
LYCO	0.167	-0.138	0.028	-0.107	0.028
MEDSHRUB	0.107	-0.161	0.106	0.357	-0.622
MOSS	0.214	-0.212	-0.852	-0.249	-0.087
OLITTER	-0.417	0.125	0.044	0.025	0.418
ROCK	0.022	-0.122	0.243	0.168	-0.079
SHCONPRO	0.465	-0.157	-0.392	-0.207	-0.212
SHDECPRO	-0.465	0.155	0.388	0.210	0.209
SHDENS	-0.196	0.015	0.313	0.256	-0.318
*SITERICH	0.235	0.004	0.396	-0.226	0.126
SLASH	0.483	-0.308	-0.010	-0.294	-0.043
SOIL	0.038	-0.579	-0.133	-0.039	0.078
SPHAG	0.682	-0.415	-0.434	-0.257	-0.437
STBIRPRO	-0.534	0.463	0.684	0.543	0.092
STDENS	-0.852	0.300	0.266	0.442	0.217
STFIRPRO	0.208	-0.474	-0.452	-0.416	0.182
STSPRPRO	0.536	-0.070	-0.445	-0.245	-0.428
TALLFERN	0.287	-0.132	0.460	-0.079	-0.027
*TRBIRPRO	0.282	0.071	0.289	0.066	-0.075

Appendix 3 (continued)

	AGE	CANOPY	DLITTER	DTBIRPRO	DTDENS
*TRDENS	-0.436	0.330	0.220	0.007	0.567
TRFIRPRO	-0.170	-0.071	0.025	-0.230	0.475
*TRSPRPRO	0.143	0.026	-0.287	0.059	-0.419
WATER	0.267	-0.480	-0.252	-0.126	-0.054

	DTIFRPRO	TDTSPRPRO	FLITTER	FORBS	GRAM
DTFIRPRO	1.000				
DTSPRPRO	-0.319	1.000			
FLITTER	0.318	-0.356	1.000		
FORBS	0.044	-0.171	0.392	1.000	
GRAM	0.009	0.120	0.033	0.320	1.000
LICHEN	-0.713	-0.172	-0.257	-0.101	-0.011
LOGDIAM	-0.005	0.161	-0.159	-0.690	-0.281
LOGS	0.142	0.274	-0.007	-0.463	-0.261
LOWFERN	0.407	-0.219	0.432	0.444	0.025
LOWSHRUB	-0.040	0.255	0.078	0.418	0.330
LYCO	0.069	0.111	-0.207	0.035	-0.058
MEDSHRUB	-0.365	0.124	-0.129	0.324	0.160
MOSS	0.121	0.237	-0.411	-0.273	0.159
OLITTER	0.064	-0.309	0.451	-0.146	-0.196
ROCK	-0.025	-0.309	0.265	0.076	-0.016
SHCONPRO	0.080	0.281	-0.208	-0.080	0.179
SHDECPRO	-0.083	-0.282	0.209	0.077	-0.178
SHDENS	-0.241	-0.022	-0.000	0.183	0.010
SITERICH	0.306	-0.105	0.515	0.455	0.094
SLASH	0.362	-0.057	0.276	0.416	0.147
SOIL	0.075	-0.080	0.312	0.294	0.747
SPHAG	0.096	0.405	-0.077	0.225	0.361
STBIRPRO	-0.361	-0.327	0.044	-0.033	-0.268
STDENS	-0.402	0.227	-0.201	-0.407	-0.209
STFIRPRO	0.487	-0.212	0.146	0.115	0.009
STSPRPRO	-0.149	0.815	-0.252	-0.090	0.368
TALLFERN	0.227	-0.150	0.349	0.524	0.064
TRBIRPRO	-0.030	0.023	0.237	0.149	-0.033

Appendix 3 (continued)

	DTIFRPRO	TDTSPRPRO	FLITTER	FORBS	GRAM
TRDENS	0.072	-0.231	0.250	-0.043	-0.386
TRFIRPRO	0.488	-0.584	0.362	0.206	-0.195
TRSPRPRO	-0.390	0.665	-0.513	-0.324	0.299
WATER	0.096	0.118	0.121	0.296	0.816

	LICHEN	LOGDIAM	LOGS	LOWFERN	LOWSHRUB
LICHEN	1.000				
LOGDIAM	-0.055	1.000			
LOGS	-0.335	0.714	1.000		
LOWFERN	-0.413	-0.494	-0.147	1.000	
LOWSHRUB	-0.087	-0.429	-0.136	0.209	1.000
LYCO	-0.135	-0.122	-0.064	0.274	-0.005
MEDSHRUB	0.333	-0.433	-0.395	-0.035	0.699
MOSS	0.088	0.275	0.151	-0.450	0.018
OLITTER	0.032	0.248	-0.026	0.155	-0.267
ROCK	0.243	-0.056	-0.104	0.174	0.116
SHCONPRO	-0.188	0.085	0.229	-0.007	-0.128
SHDECPRO	0.192	-0.085	-0.235	0.004	0.125
SHDENS	0.312	-0.076	-0.230	-0.022	0.270
SITERICH	-0.503	-0.299	-0.074	0.661	0.090
SLASH	-0.380	-0.699	-0.269	0.639	0.344
SOIL	-0.008	-0.148	-0.131	0.036	0.203
SPHAG	-0.221	-0.125	-0.061	-0.092	0.277
STBIRPRO	0.276	-0.131	-0.194	0.077	0.042
STDENS	0.572	0.240	-0.173	-0.562	-0.488
STFIRPRO	-0.171	0.047	0.068	0.095	-0.359
STSPRPRO	-0.141	0.144	0.208	-0.306	0.403
TALLFERN	-0.378	-0.537	-0.100	0.757	0.177
TRBIRPRO	-0.250	-0.043	0.147	0.288	0.301
TRDENS	-0.146	-0.036	0.100	-0.024	-0.346
TRFIRPRO	-0.162	-0.129	-0.143	0.360	-0.425
TRSPRPRO	0.162	0.194	0.093	-0.557	0.270
WATER	0.102	-0.242	-0.116	0.128	0.248

Appendix 3 (continued)

	LYCO	MEDSHRUB	MOSS	OLITTER	ROCK
LYCO	1.000				
MEDSHRUB	-0.055	1.000			
MOSS	0.042	-0.091	1.000		
OLITTER	0.008	-0.257	-0.287	1.000	
ROCK	0.030	0.251	-0.235	0.052	1.000
SHCONPRO	0.134	-0.230	0.352	-0.298	-0.066
SHDECPRO	-0.134	0.227	-0.351	0.303	0.069
SHDENS	-0.085	0.424	-0.284	0.068	0.273
SITERICH	0.047	-0.095	-0.674	0.210	-0.009
SLASH	0.261	0.115	-0.183	-0.095	0.009
SOIL	0.033	-0.008	-0.021	0.171	0.103
SPHAG	-0.080	0.268	0.240	-0.527	-0.003
STBIRPRO	-0.128	0.298	-0.572	0.291	0.229
STDENS	-0.210	-0.154	-0.035	0.217	-0.095
STFIRPRO	0.160	-0.459	0.392	-0.140	-0.012
STSPRPRO	-0.031	0.213	0.353	-0.281	-0.297
TALLFERN	-0.006	0.096	-0.598	-0.181	0.141
TRBIRPRO	0.040	0.289	-0.449	0.039	0.405
TRDENS	-0.176	-0.333	-0.280	0.360	-0.318
TRFIRPRO	0.115	-0.510	-0.089	0.306	-0.058
TRSPRPRO	-0.150	0.293	0.420	-0.404	-0.265
WATER	0.111	-0.117	0.176	-0.067	-0.104

	SHCONPRO	SHDECPRO	SHDENS	SITERICH	SLASH
SHCONPR	1.000				
SHDECPRO	-1.000	1.000			
SHDENS	-0.488	0.491	1.000		
SITERICH	-0.243	0.240	0.245	1.000	
SLASH	0.181	-0.183	-0.156	0.40	1.000
SOIL	-0.063	0.067	0.068	0.123	0.103
SPHAG	0.496	-0.495	-0.032	-0.007	0.149
STBIRPRO	-0.535	0.536	0.371	0.155	-0.098
STDENS	-0.307	0.309	0.118	-0.357	-0.502

Appendix 3 (continued)

	SHCONPRO	SHDECPRO	SHDENS	SITERICH	SLASH
STFIRPRO	0.373	-0.375	-0.407	-0.109	0.161
STSPRPRO	0.338	-0.336	-0.031	-0.139	-0.089
TALLFERN	-0.102	0.096	0.002	0.633	0.473
TRBIRPRO	-0.019	0.019	0.032	0.297	0.106
TRDENS	-0.161	0.158	-0.202	0.158	0.123
TRFIRPRO	-0.135	0.136	-0.103	0.276	0.207
TRSPRPRO	0.266	-0.267	-0.010	-0.421	-0.250
WATER	0.208	-0.208	-0.151	0.108	0.211

	SOIL	SPHAG	STBIRPRO	STDENS	STFIRPRO
SOIL	1.000				
SPHAG	-0.010	1.000			
STBIRPRO	-0.067	-0.578	1.000		
STDENS	-0.084	-0.434	0.263	1.000	
STFIRPRO	0.007	0.240	-0.771	-0.063	1.000
STSPRPRO	0.119	0.557	-0.460	-0.319	-0.182
TALLFERN	0.036	0.096	0.168	-0.434	0.005
TRBIRPRO	0.073	0.087	0.351	-0.503	-0.369
TRDENS	-0.077	-0.460	0.267	0.386	-0.002
TRFIRPRO	0.000	-0.328	-0.028	0.122	0.441
TRSPRPRO	-0.044	0.401	-0.306	0.110	-0.181
WATER	0.761	0.104	-0.256	-0.217	0.051

	STSPRPRO	TALLFERN	TRBIRPRO	TRDENS	TRFIRPRO
STSPRPRO	1.000				
TALLFERN	-0.311	1.000			
TRBIRPRO	-0.010	0.375	1.000		
TRDENS	-0.396	0.098	-0.129	1.000	
TRFIRPRO	-0.559	0.201	-0.454	0.390	1.000
TRSPRPRO	0.692	-0.455	-0.13		

Appendix 4. Description of the 12 variables used in principle component analysis.

Dtdens:	dead tree (snag) density
Lowshrub:	shrubs $\leq$ 0.5 m height
Trdens:	tree density
Age:	tree age
Sthgt:	small tree height
Canopy:	percent canopy cover
Forbs:	forbs
Siterich:	site richness, derived by multiplying soil moisture x soil richness from the edaphic grid for that forest type (Meades and Moores 1989)
Flitter:	fern litter
Trsprpro:	proportion of large spruce trees
Trhgt:	large tree height
Shhgt:	shrub height
dlitter:	deciduous litter
trbirpro:	proportion of large birch trees
Logs:	logs on ground