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EXECUTIVE SUMMARY

Recent concern for the status of North American bird populations has resulted in an escalation of monitoring and management efforts. Much of this effort has been focused on declining forest-dwelling species that migrate between breeding areas in North America and wintering areas in Latin America and the Caribbean. Fragmentation of temperate forests has been shown to negatively affect many of these species by exposing them to higher rates of predation and brood parasitism, resulting in lower productivity and survivorship. Weyerhaeuser Company is the largest private landowner in North Carolina. Because of the extent and geographic location of current landholdings, Weyerhaeuser's forest tracts offer the opportunity to manage populations of declining bird species at a landscape scale. This project was initiated to examine the underlying relationship between the vegetative structure and the breeding bird community within managed pine plantations.

Breeding bird communities were sampled within a network of forest stands located in the coastal plain of North Carolina. All stands were located on Weyerhaeuser land and were chosen to represent points along the forest management cycle and to reflect natural variation in understory vegetation. A total of 24,490 bird observations were made of 70 species during the two year study period. Both species richness and bird abundance were positively related to stand age. Early successional stands (ages 1 through 11) and forest stands (all stands after first thin) had distinctly different vegetation structures and bird communities. Early successional bird communities were dominated by species generally associated with grasslands and shrublands. Species turnover rates were higher in early successional stands compared to forest stands, reflecting differences in the rates of vegetation change. Forest bird communities were dominated by habitat generalists and species typically associated with closed canopy forests. In general, forest birds showed little discrimination between stand categories after the first commercial thinning.

The large canopy openings created during commercial thinning allowed for understory regeneration and had a positive influence on both species richness and overall bird density. These openings appear to have extended the habitat use of some early successional species and provided habitat elements required by some forest bird species. Thinning events had a particularly positive influence on the use of stands by Brown-headed Nuthatches, a southeastern pinewoods endemic.

A few species detected during surveys are of special interest because of their relative rarity or are of high conservation priority within the region. Worm-eating Warblers were detected in densities that regionally have only been reported from the Great Dismal Swamp. Black-throated Green and Swainson's Warblers showed similar patterns. Black-and-white Warblers were detected in low densities and may also only occur at a few sites within the immediate region.

INTRODUCTION

In recent years, concern for the status of many North American bird populations has greatly increased within both the general populous and the scientific community. Much of this concern has been focused on the many species of neotropical migrants (those species that migrate between breeding grounds in the temperate latitudes of North America and wintering grounds in Central and South America and the Caribbean) that have exhibited dramatic population declines in recent decades (sensu Hagan and Johnston 1992). In particular, a great deal of attention has been given to forest-dwelling neotropical migrants. This bird assemblage is very diverse, accounting for 65-85% of birds within the forest ecosystems of North America. Many of these species require interior forest areas and so are especially vulnerable to habitat fragmentation (e.g. Forman et al. 1976, Lynch and Whigham 1984, Blake and Karr 1987, Robbins et al. 1989). Growing evidence of declines in other species has extended these concerns to temperate migrants (those species that migrate between breeding and wintering grounds within North American latitudes) and non-migratory species (Askins 1993).

In some cases, suites of species that share ecological requirements have declined suggesting that habitat loss may be a contributing factor. In fact, the overall loss of breeding habitat has accompanied population declines in several communities. For example, results from the U.S. Fish and Wildlife Service Breeding Bird Survey indicate that nearly 75% of the species that specialize on early successional habitats such as grassland and shrubland have declined significantly over the last three decades. Widespread changes in farming have reverted vast land areas back to forest and resulted in the loss of open lands. In the New England area a loss of 60% of the early successional lands over the past 100 years has left many species threatened or endangered within the region (Vickery et al. 1994). Similarly, surveys of the bottomland hardwood forest in the Tensas watershed basin show that the number of breeding forest species and the population densities of forest interior species decreased with cumulative losses of forest area (Burdick et al. 1989).

The coastal plain of North Carolina is recognized for its rich diversity of bottomland and upland forest communities. This physiographic region serves as an important drainage area for several southeastern rivers. Due to its geology, a large proportion of this region is composed of poorly drained areas that form alluvial and non-alluvial swamps, pocosins, and carolina bays. Currently, Weyerhaeuser Company is the largest private landowner in North Carolina. Because of the extent of their landholdings, Weyerhaeuser's forest tracts offer the opportunity to manage populations of declining bird species at a landscape scale. However, before species may be incorporated into existing forest management programs it is first necessary to identify habitat requirements so that management objectives may be developed.

This project was initiated to examine the underlying relationship between the vegetative structure and the breeding bird community within managed pine plantations.

Specifically, our objectives were:

1) to examine patterns of variation in vegetative structure within pine plantations.

2) to examine bird community patterns associated with variation in vegetative structure within pine plantations.

3) for common bird species, to examine patterns of habitat use within pine plantations.

METHODS

Study Site

This study was conducted entirely on Weyerhaeuser Company land holdings in eastern North Carolina (approximately lat. 35° 50', long. 76° 60') (Figure 1). Surveys were conducted on the J&W, Orchard, Parker, and Rodman Meyer management tracts. Management tracts are embedded within a matrix of agricultural fields, residential areas, and forested areas. Locally, Weyerhaeuser's managed tracts represent a major proportion of all upland forest habitats. Although most of the acreage is currently managed in pine plantation, the tracts also contain natural areas such as the last remnants of the nonriverine swamp forest, collectively known as the East Dismal Swamp.

Pine plantation management activities occur within a 30 to 35 year crop rotation schedule. Pine plantations are planted as seedlings in parallel rows. After a period of tree maturation, the stand is commercially thinned from one to three times. Commercial thinning activities create alternating strips of sheared (treeless) and non-sheared lanes. The harvesting of a fully mature stand is completed by clear-cutting all pine and hardwood stems. The staggered regime of harvesting and thinning creates a spatial

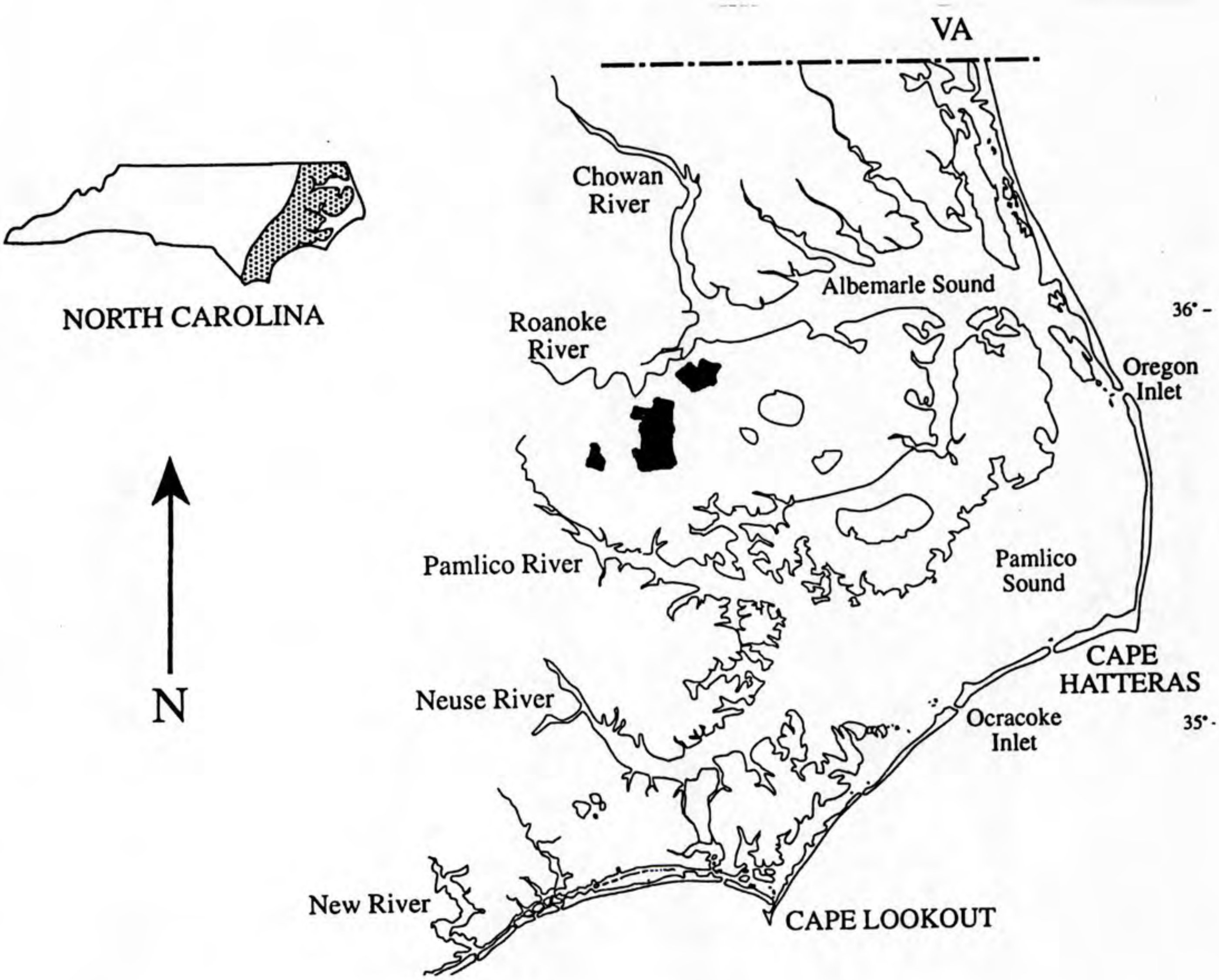


Figure 1. Northeastern Coastal Plain of North Carolina. Study areas are highlighted in black.

mosaic of uneven stand ages. A network of logging roads and drainage ditches permeates the plantation landscape and creates regular edges and hard boundaries between many stands.

Study Design

The main study utilized a simple two-way design with stand age (10 levels) and understory vegetation type (2 levels) as main factors. Stand ages were selected and surveyed for a period of two years to provide even coverage across the 35-year growing cycle and to examine the influence of specific sylvicultural events within the cycle (see Table 1 for description of age categories). For functional comparisons, the growing cycle was subdivided into two periods according to the formation of a closed canopy. Periods include 1) early successional (growing seasons 1-11 before the formation of a closed canopy) and 2) forest (growing seasons 11-35 after the formation of a closed canopy). The characteristics and composition of understory vegetation varied considerably within and between forest stands. In order to examine the influence of understory vegetation on the bird community, understory type was visually categorized and considered in stand selection. Understory types considered in the main study were "cane-dominated" and "hardwood-dominated". These categories are not exclusive but represent opposite ends along a continuum of understory types. Understory categories were used in this context to ensure that understory variation was represented across the full range of stand ages.

A total of 3 spatial replicates was selected for each cell within the main study design (study design included 10 levels of stand age and 2 of understory type or 20 cells). Other criteria used during stand selection include 1) stand size and shape, 2) prior

Table 1. List of stands and their statistics used for surveys in this study. Age class represents the season in which the stands were selected.

Stand age class	U*	Stand #	Year planted or origin	Gross stand acreage	Total pine stems/acre	Pine basal area
1st growing season	c	44806	1997	151.7	0	0
	c	44630	1997	141.6	0	0
	c	44005	1997	148.8	0	0
	h	45400	1997	144.9	0	0
	h	44347	1997	163.5	0	0
	h	41449	1997	155.5	0	0
3rd growing season	c	44219	1995	172.6	352.0	0
	c	42091	1994	59.6	400.0	0
	c	42430	1994	97.1	400.0	0
	h	42633	1995	82.0	232.0	0
	h	42432	1995	62.7	346.0	0
	h	42218	1995	139.6	400.0	0
5th growing season	c	42194	1993	83.3	412.0	0
	c	46123	1992	214.4	421.0	20.7
	c	51207	1992	178.8	413.0	13.5
	h	46143	1992	197.0	413.0	12.5
	h	56205	1992	152.2	403.0	13.2
	h	56208	1992	192.8	416.0	13.0
10th growing season	c	44988	1987	221.4	627.3	65.5
	c	56062	1989	81.3	573.9	58.3
	c	45212	1987	260.8	720.2	70.1
	h	56076	1989	240.1	401.3	41.4
	h	44990	1987	86.8	640.2	73.9
	h	44931	1987	181.8	662.5	71.1
1st year after 1st thin	c	42040	1981	83.8	195.1	79.1
	c	40863	1983	157.5	189.2	83.8
	c	54262	1982	270.7	153.2	83.3
	h	44298	1981	96.2	196.1	97.0
	h	44397	1982	83.1	169.5	67.9
	h	44304	1981	281.4	174.3	74.6
3rd year after 1st thin	c	44328	1981	182.3	192.1	93.5
	c	51289	1979	147.8	194.6	84.0
	c	44090	1980	335.2	187.6	77.2
	h	44023	1979	205.7	178.0	95.7
	h	53050	1979	63.6	152.9	104.3
	h	53060	1979	75.1	160.7	105.1

Table 1 contd.

Stand age class	U*	Stand #	Year planted	Gross stand acreage	Total pine stems/acre	Pine basal area
5th year after 1st thin	c	42482	1976	181.0	198.3	91.6
	c	42757	1976	277.8	152.7	78.3
	c	53055	1979	103.8	119.9	82.6
	h	42154	1976	134.3	184.7	93.3
	h	53052	1978	206.6	129.1	88.6
	h	51181	1977	82.2	135.6	86.9
6th year after 1st thin	c	42153	1976	147.7	192.3	95.1
1st year after 2nd thin	c	42406	1971	112.3	77.5	92.6
	c	42462	1973	246.1	89.5	66.5
	c	42269	1972	91.6	73.6	63.3
	h	42560	1974	153.0	90.5	82.0
	h	40719	1973	141.2	85.3	61.3
	h	42727	1975	127.0	83.8	61.2
3rd year after 2nd thin	c	42198	1969	370.3	84.0	89.1
	c	42050	1970	345.0	84.9	88.1
	c	42272	1970	135.0	120.9	76.2
	h	42219	1969	505.0	99.7	100.7
	h	44916	1970	407.0	74.1	84.1
	h	42603	1970	183.9	116.3	104.1
5th year after 2nd thin	c	42785	1966	214.2	74.0	91.7
	c	44694	1962	87.5	67.5	81.5
	c	42765	1964	176.5	75.0	83.8
	h	42685	1966	159.0	92.1	92.5
	h	45019	1966	185.0	93.4	88.5
	h	42357	1961	79.4	105.9	106.1
Hardwood stands	-	51270	1920	-	-	-
	-	51449	1928	-	-	-
	-	51241	1924	-	-	-
Mineral soil	-	53052	1978	-	-	-
	-	54601	1983	-	-	-
Organic soil	-	53124	1984	-	-	-
	-	56203	1992	-	-	-

U* denotes understory type; c = cane, h = hardwood sylvicultural treatment, 3) ease of access, and 4) plans for future sylvicultural activities. Only stands of 60 acres or greater were considered for inclusion in the study. Stands that were long and thin or irregular in shape were avoided as much as possible. Within each age category, stands were chosen to minimize variation in stocking level and basal area of pine. Because stocking and harvesting procedures have varied over the years, it was not possible to control for management histories across stand ages. Wherever possible, forest stands were chosen that were easily accessible by good roads. Stands that appeared on thinning or harvesting schedules within the next 2 years were not selected for inclusion in the study.

In addition to the main study, surveys were conducted in three hardwood stands and four pine stands. Hardwood stands were surveyed to allow comparisons of the bird community to those observed in the main study. One hardwood stand was subdivided into five sections each of which were surveyed to provide baseline data prior to anticipated habitat alterations. Additional pine stands were used to assess possible influences of soil type on the bird community. Two pine stands were located on organic soils and two on mineral soils.

Bird Survey Technique

A fixed-radius point count technique was used to measure bird density and frequency of occurrence. Survey plots (point counts) consisted of a 50 m radius circle with a wire flag located at its center. An observer stood at the center of the plot and recorded all birds seen or heard within the stand for a period of 7 min. Birds detected within stands were recorded as either within or outside the 50 m radius.

To examine the effects of stand edge on the bird community, survey plots were established in both "edge" and "interior" locations (Figure 2). Four point counts were established within each forest stand and were split evenly between edge and interior locations. The center of "edge" plots was positioned 50 m from the stand edge such that the plot perimeter was tangent to the actual stand edge. For all stands, edge plots were positioned on stand edges that were adjacent to logging roads. This protocol allowed for easier access to survey plots and, as much as possible, controlled for edge type effects. The center of "interior" plots was positioned $\geq$ 150 m from the stand edge. All survey plots were positioned $\geq$ 100 m from adjacent forest stands.

Bird surveys were conducted between 1 June and 4 July 1997, and 20 May and June 30 1998. Each stand was surveyed three times during these periods. All surveys were conducted by three observers. A maximum of four stands were surveyed per observer per day and the order in which patches were surveyed was rotated between days so no stand was surveyed in the same time position twice. Surveys were initiated 0.5 hr after sunrise and concluded by 10:00 EST.

Vegetation Survey Techniques

Vegetation was sampled within all bird survey plots to examine the response of the bird community to variation in habitat structure. A linear, band transect configuration was used to allow for comparisons of sheared and non-sheared areas within commercially thinned stands. The length of vegetation transects was standardized to 25 m. The width of transects varied between 4 and 7 m to accommodate variation in sheared and non-sheared lanes.

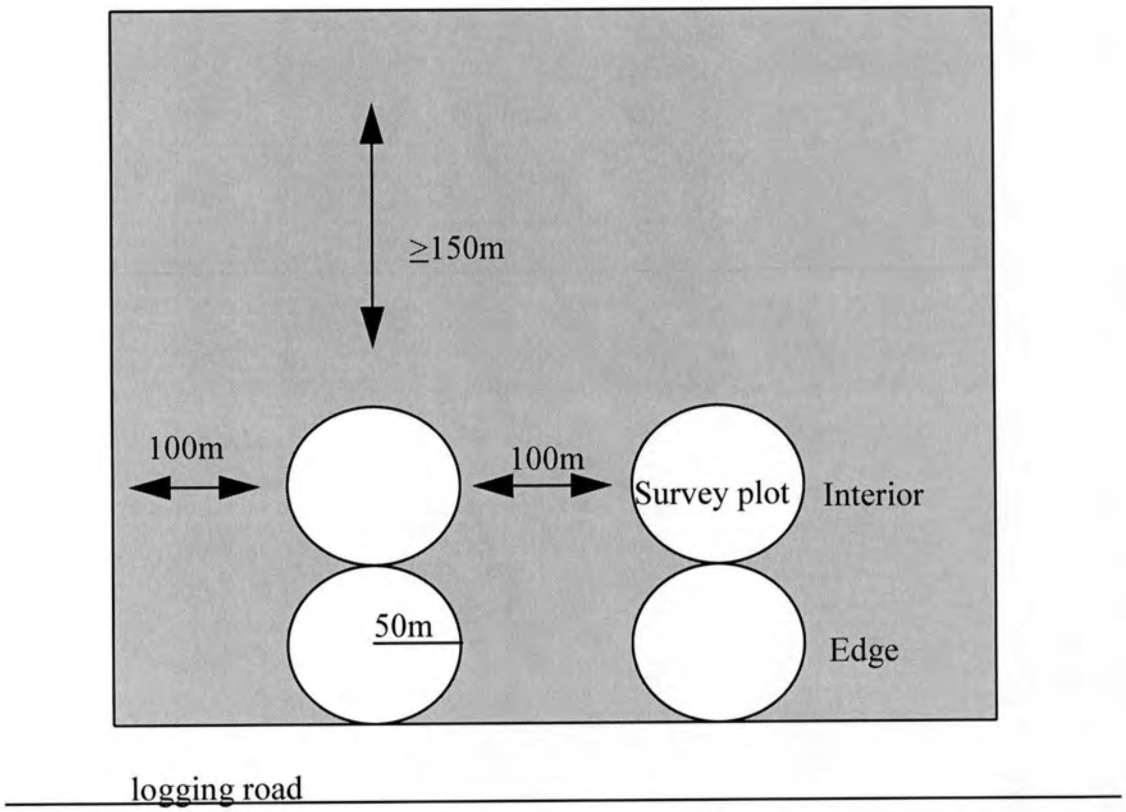


Figure 2. General layout of sample plots used for bird surveys.

Four vegetation transects were established within each 50 m radius survey plot. Within commercially thinned stands, vegetation transects were equally distributed between sheared and non-sheared lanes. The first transect was positioned within the sheared lane nearest to the center of the bird survey plot. A non-sheared transect was then positioned adjacent to the first transect. Remaining transects were positioned in a similar fashion forming a diagonal pattern (Figure 3). Vegetation transects within stands that had not been commercially thinned were positioned in a similar configuration.

Vegetation data was collected on two different levels within transects. All information on trees was collected over the entire 25 m transect. Information included counts of all large woody plants (> 8 cm dbh) and dead standing stems (snags) by species and stem diameter class (diameter classes used included 8-23, 24-38, and > 38 cm dbh) canopy cover and canopy height. Remaining habitat information on understory and surface condition was collected within two 2 x 2 m quadrats established at opposite ends of transects. Information quantified within quadrats included counts of all stems, shrubs, and saplings > 0.5 m in height and < 8 cm dbh by species, litter depth, understory vegetation height, percent bare ground, litter, grass, and forb cover (see Table 2 for list and description of habitat variables).

Data summary and Analysis

Habitat data was summarized to represent independent levels of organization. Comparisons were made between stand ages, understory type and survey years. Across all stands, survey plots were used as statistical units. To further refine changes in habitat structure over different levels of organization, stand ages were separated into early

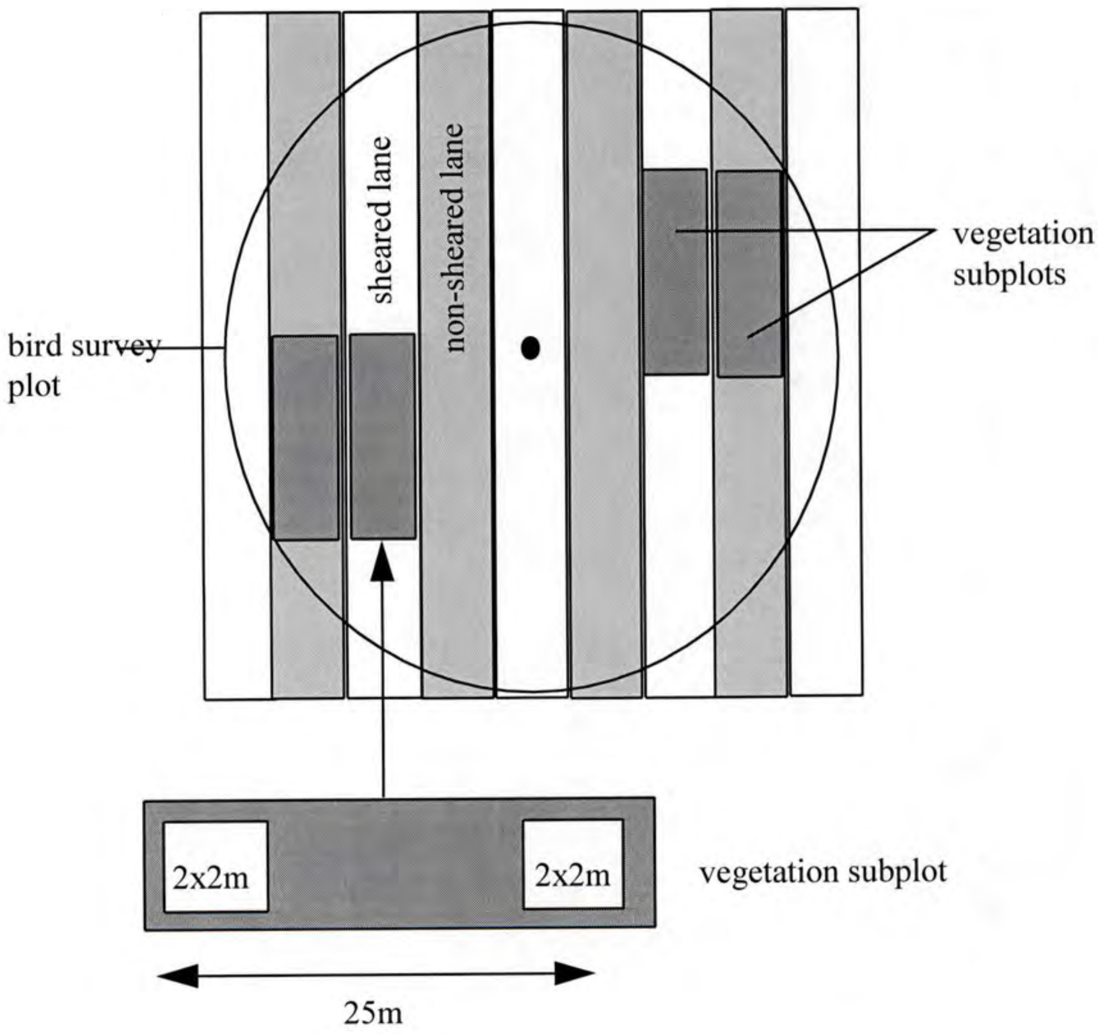


Figure 3. Layout of vegetation transects within bird survey plots.

Table 2. List of vegetation variables used for analyses.

Variable	method of measurement	units for presentation	stand age class sampled
1. Canopy height	height of tallest canopy tree within 25m subplot	meters	10th growing season and all thinned stands
2. Canopy cover	estimate of canopy vegetation cover using convex densiometer; sampled at each end of 25m subplots	percent	10th growing season and all thinned stands
3. % of total Pine stems 8-23 cm dbh **4.** % of total Pine stems 24-38 cm dbh **5.** % of total Pine stems > 38 cm dbh	stem counts within respective size class/total pine stems counted within 25m subplots	percent of total pine stems in respective size class	all thinned stands
6. Hardwood tree density Pine tree density	stem counts (≥ 8cm dbh) within 25m subplots	stems/hectare(ha)	all thinned stands
7. Snag density	stem counts of all standing dead stems (≥ 8cm dbh) within 25m subplots	stems/ha	all thinned stands
8. Snag frequency	# of points with standing dead stems	# of points	all thinned stands
9. Bare ground cover **10.** Litter cover **11.** Grass cover **12.** Forb cover	visual estimate of percent cover within 2x2m subplots	percent cover	all stand ages
13. Litter depth	depth of leaf litter layer; one sample within each 2x2m subplot using mm ruler	millimeters	all stand ages
14. Cane density **15.** Pepperbush density **16.** Total stem density	stem counts (> 0.5m height) within 2x2m subplots	stems/m^2	all stand ages
17. Hardwood sapling density	stem counts (> 0.5m height, < 8cm dbh) within 2x2m subplots	stems/m^2	all stand ages

successional (1 through 11 growing seasons) and commerically-thinned (all forest stands after first commercial thin) subgroups. Stepwise Discriminant Function Analysis was used to determine which habitat variables discriminate between stand ages within each subgroup. For habitat data, non-normal variable distributions and unequal variances among different levels of organization did not allow all variables to be entered during multivariate comparisons (even after standard transformations). Therefore, all habitat variables are also compared and presented with non-parametric univariate tests. Kruskal-Wallis was used for multi-level comparisons and Mann-Whitney U was used for pairwise level comparisons. Additionally, among commercially thinned stands, data were summarized for both sheared and non-sheared lanes for further comparison.

Bird survey data was summarized to produce community and species-level variables. Bird community variables included species richness, overall bird abundance, and community similarity. Species richness (total number of species) was used to estimate community breadth. Richness values for each stand were based on the accumulated number of species detected (either inside or beyond 50 m radius) over three survey visits. Overall bird density was calculated for each survey plot from the number of birds detected within the 50 m survey radius. For each bird species detected, the survey visit with the highest recorded density was used for analysis. A community similarity index was calculated for pairwise comparisons between stand ages, based on the number of shared species (weighted by their density) (see Appendix I for computation).

The effects of stand age, understory type and year on bird species richness and bird density were examined by using three-way Analysis of Variance (ANOVA). The effect of distance from the edge (i.e. edge versus interior plots) on bird density was examined using t-tests. One-way ANOVA in combination with Tukey's Honestly Significant Difference (HSD) test was used for post-hoc comparisons to differentiate which factor levels (i.e. stand ages or understory types) were responsible for statistically significant results. Community similarity was examined by single linkage cluster analysis. Cluster analysis identifies the most similar stand ages by the repeated grouping of a sample matrix of stand age community similarities. Euclidean distances between stand ages reflect the degree of similarity among bird communities surveyed in each category.

Frequency statistics were used to compare habitat patterns for individual species. For common species, comparisons were made based on the frequency of occupied points relative to an expected even distribution among age categories (included birds detected within the 50m point count radius). Other species were compared using the frequency of occupied stands relative to an expected even distribution. Common species that showed significant non-random distributions among stand ages were examined to evaluate if any vegetation characteristics influenced the probability of occupation within points. To accomplish this, the results from the Discriminant Function Analysis of vegetation data were compared to the distribution of occupied and non-occupied points for selected species. A univariate t-test was used to compare the discriminant analysis scores for each occupied and non-occupied point. The results of this comparison would indicate if bird species are associated with specific habitat characteristics distinguished between stand age categories. In addition, parametric and non-parmetric tests were used to examine the variation of each habitat variable between occupied and non-occupied points.

RESULTS

Vegetation Surveys

A total of 59 stands selected for the main study design were sampled for habitat analysis in 1997 (one 5 year after first thin was clear-cut before surveys could be conducted) and 60 stands were sampled in 1998 (includes one 5 year after first thin stand selected as a replacement). During surveys, a diverse assemblage of plant species were encountered. Across all stand ages, dominant plant types included: cane, blackberry (*Rubus sp.*), sweet pepperbush (*Clethra anifolia*), fetterbush (*Lyonia lucida*), high bush blueberry (*Vaccinium corymbosum*), gallberry (*Ilex glabra*), and greenbrier (*Smilax sp.*) Dominant canopy and midstory hardwood trees included: red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), red bay (*Persea borbonia*), sweet bay (*Magnolia virginiana*), and tulip poplar (*Liriodendron tulipifera*).

Within stand age classes, median values of habitat variables were quite similar between survey years. Percent grass cover significantly increased between one and two year old stands (Mann-Whitney $U = 212.5$, $p < 0.05$), and hardwood sapling density significantly increased between one year and two years after first thin (Mann-Whitney $U = 158.5$, $p < 0.05$). Aside from this, all other variables were statistically similar between survey years (Mann-Whitney U tests, all $p > 0.10$). Because of the general similarity of variables between years, vegetation data were pooled for all further comparisons.

Stand age had a significant effect on all habitat variables that were commonly measured (Table 3). Understory type had a significant effect on percent forb cover (Mann-Whitney $U = 24045$, $p < 0.05$) (forb cover was greater in hardwood understory), cane density (Mann-Whitney $U = 12603$, $p < 0.001$), and total stem density (Mann-Whitney $U = 19852.5$, $p < 0.001$). Variation in total stem density between understory types was entire due to cane density which accounted for 30 % of the total stems. Aside from cane density, there was no statistical difference in the density of other understory plants examined (Mann-Whitney $U = 6940$, $p > 0.10$).

Within the early successional subgroup (1 through 11 growing seasons) (Table 4), Discriminant function analysis yielded two significant axes ($\chi^2 > 60.0$, $p < 0.001$ for each axis) that significantly discriminated between the floristics and density of vegetation all early successional stand ages (Mahalanobis distances - $p < 0.01$ for all pairwise comparisons of stand ages). The two axes accounted for 97.6 % of the variation among stand ages (76.3 and 21.3 % for Axis I and Axis II respectively). A stepwise procedure included four ground-level vegetation variables (Table 5). Litter depth was eliminated from this analysis because it's strong positive association with stand age (Figure 4) overwhelms the response of other vegetation variables during multivariate analysis. Percent bare ground cover was excluded due to zero variance and 100 % cover in older ages classes (Figure 4). The proportion of cane stems and proportion of pepperbush stems (a co-dominant understory plant) was used instead of density values to lessen

Table 3. Kruskal-Wallis ANOVA and Spearman rank correlation results for the effect of stand age on vegetation variables. Data were examined for both survey years among all stand age classes. Only variables measured in all age classes were included in these analyses. For description of variables see Table 2.

Variable	Statistic KW ANOVA H	p-value	Statistic Spearman r	p-value
% Bare ground	121.65	< 0.0001	- .60	< 0.0001
% Litter cover	114.99	< 0.0001	.60	< 0.0001
% Grass cover	118.28	< 0.0001	- .52	< 0.0001
% Forb cover	47.45	< 0.05	- .30	< 0.0001
Litter depth	157.83	< 0.0001	.91	< 0.0001
Cane density	15.82	< 0.01	- .08	> 0.21
Pepperbush density	74.73	< 0.0001	.50	< 0.0001
Hardwood sapling	35.74	< 0.0001	.13	< 0.05
Stem density	40.22	< 0.0001	.06	> 0.30
Other stem density	41.65	< 0.0001	- .19	> 0.05

Table 4. Kruskal Wallis ANOVA and Spearman rank correlation results for the effect of stand age on vegetation variables among early successional stands (growing season 1-10). Data were examined for both survey years. For description of variables see Table 2.

Variable	Statistic KW ANOVA H	p-value	Statistic Spearman r	p-value
% Bare ground	121.65	< 0.0001	- .68	< 0.0001
% Litter cover	114.99	< 0.0001	.68	< 0.0001
% Grass cover	118.28	< 0.0001	- .81	< 0.0001
% Forb cover	1.92	> 0.50	.08	> 0.81
Litter depth	157.83	< 0.0001	.94	< 0.0001
Cane density	9.84	> 0.10	.05	> 0.50
% Cane stems	10.05	< 0.05	.07	> 0.50
Pepperbush density	35.93	< 0.005	.22	< 0.01
% Pepperbush stems	31.21	< 0.01	- .03	> 0.50
Hardwood sapling	32.45	< 0.001	- .10	> 0.60
Stem density	44.49	< 0.001	- .05	> 0.80
Other stem density	37.55	< 0.001	- .11	> 0.30

Table 5. Summary of vegetation variables included in a stepwise Discriminant Function Analysis of early successional stands (stand ages 1 through 11). The percentage of grass cover contributes most to the overall separation between stand ages, total stem density second most and so on (the smaller the partial *lambda*, the greater the contribution to the overall discrimination).

Variable	Wilk's Lambda	Partial Lambda	F	P
% Grass cover	0.603	.479	66.88	< 0.001
% Cane stems	0.335	.861	9.94	< 0.001
% Pepperbush stems	0.307	.941	3.81	< 0.01
Total stem density	0.401	.722	23.74	< 0.001

Table 6. Standardized structure coefficients of canonical variables based on Discriminant Function Analysis of early successional stand ages. Axis I is heavily weighted on percent grass cover and percentage of cane stems. Axis II is heavily weighted on total stem density and the percentage of cane stems.

Variable	Axis I	Axis II
% Grass Cover	.96	-.03
% Cane stems	- .33	-.59
% Pepperbush stems	- .19	-.15
Total stem density	.21	1.07
Eigenvalue	1.38	.38
Cumulative proportion of variance explanined	.76	.98

Table 7. Means of canonical scores for stand age groups on each Discriminant Axis. Mean values are calculated for each stand age from the individual score of each vegetation survey plot. Mean values indicate the nature of the discrimination for each Axis.

Stand age	Axis I	Axis II
1-2nd growing season	1.83	- .06
3-4th growing season	.14	.24
5-6th growing season	-.77	- .30
10-11 growing season	-1.20	.12

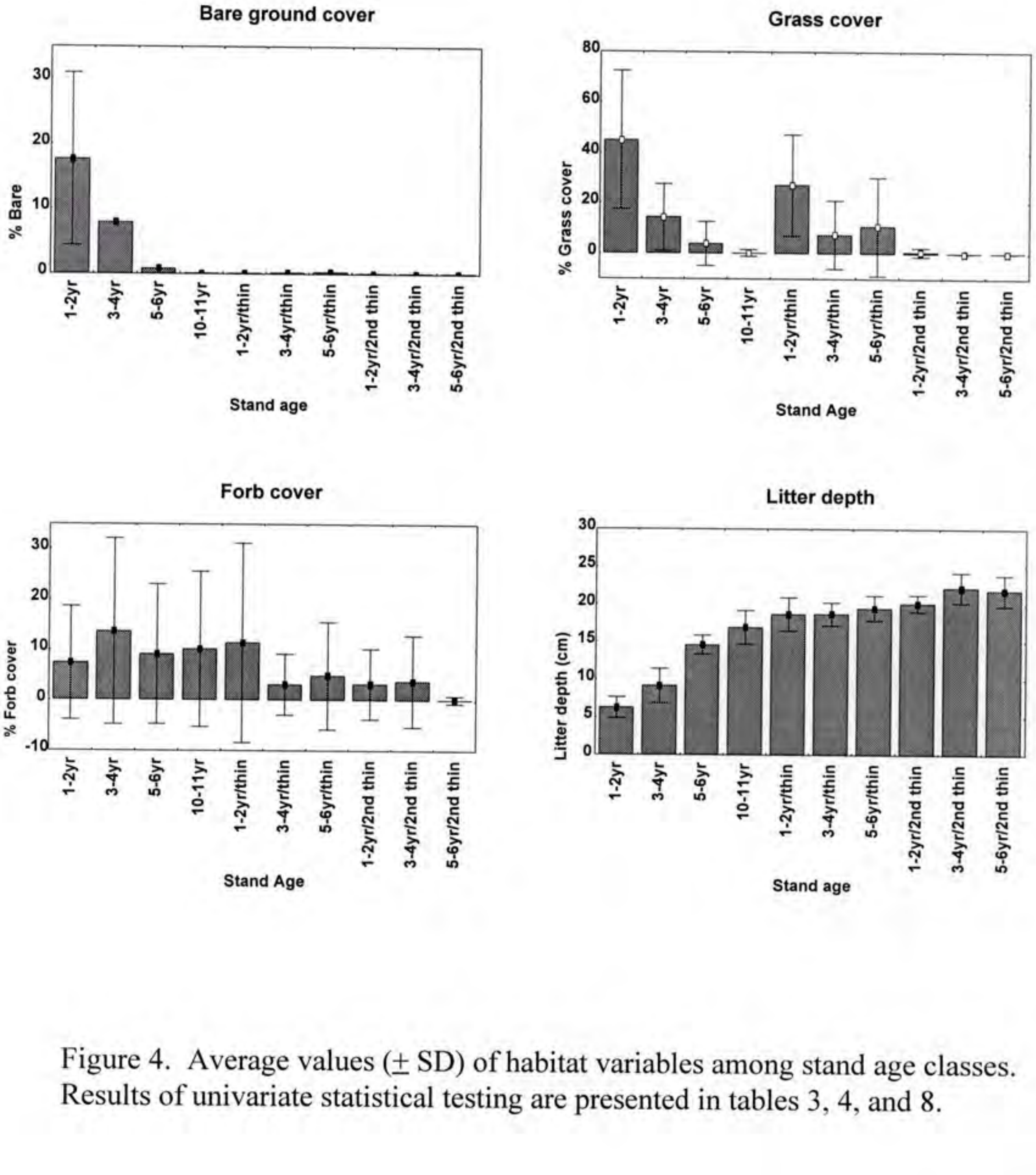
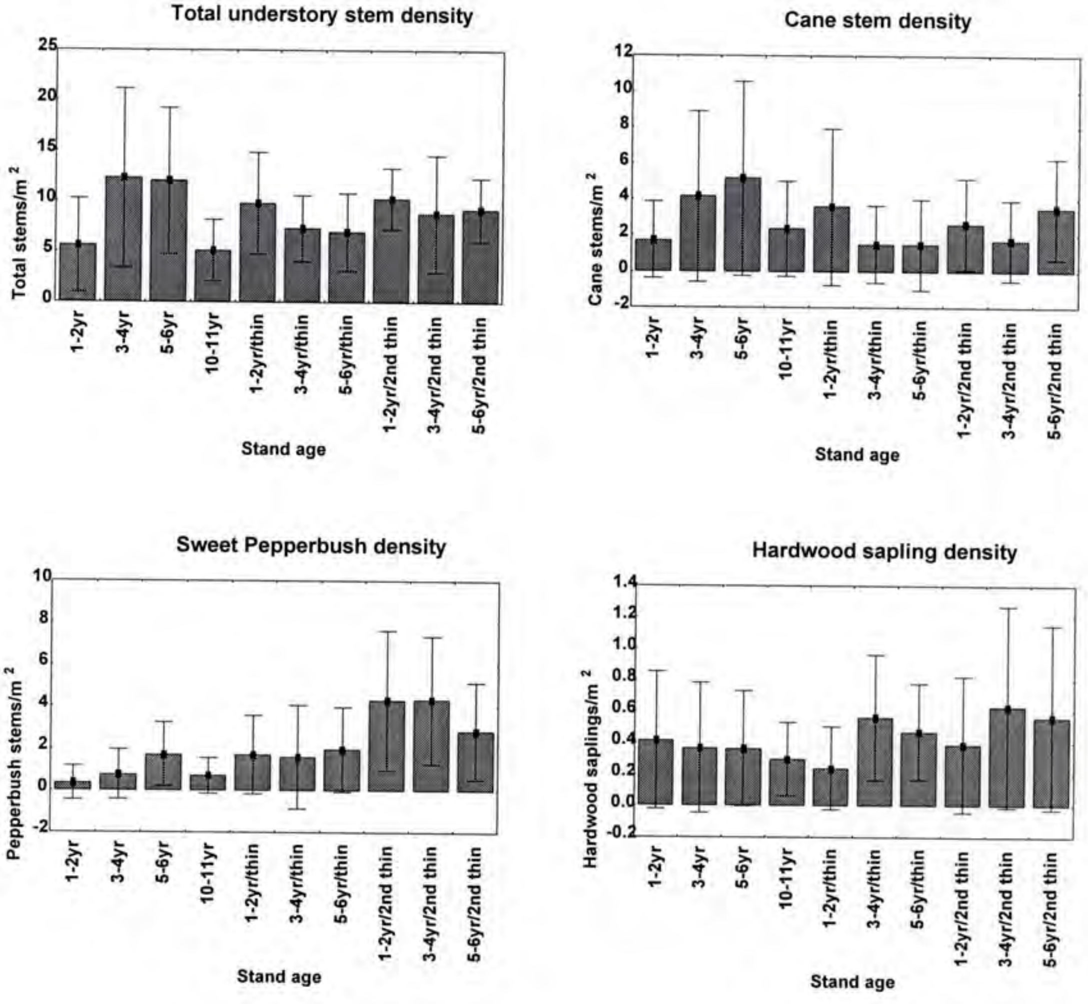


Figure 4. Average values (± SD) of habitat variables among stand age classes. Results of univariate statistical testing are presented in tables 3, 4, and 8.



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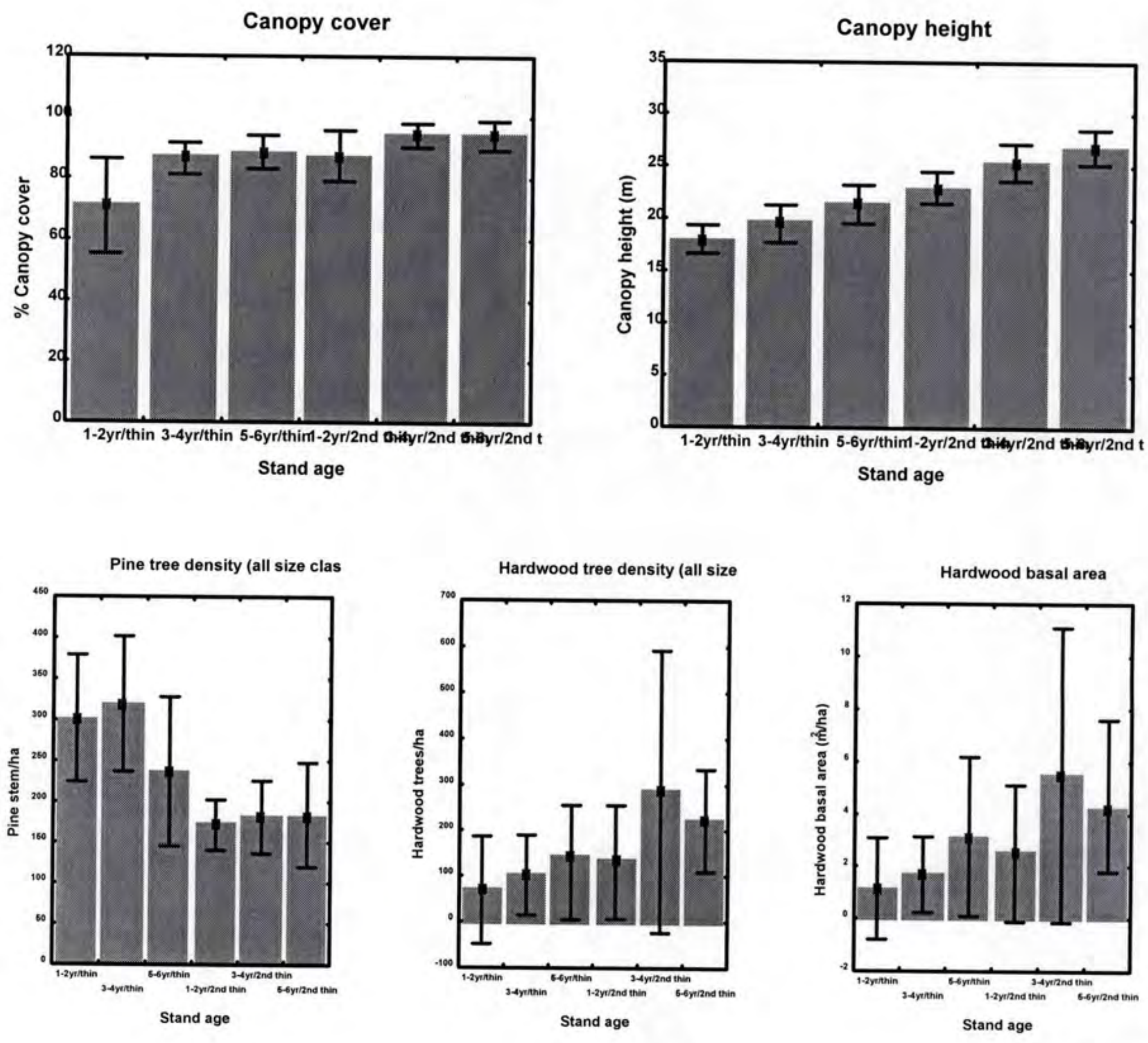

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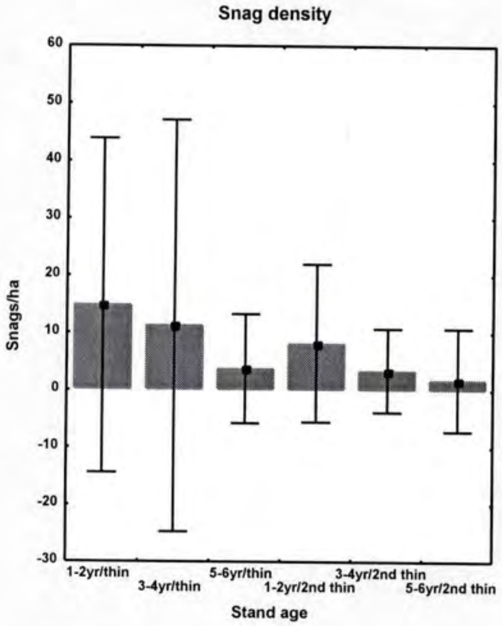

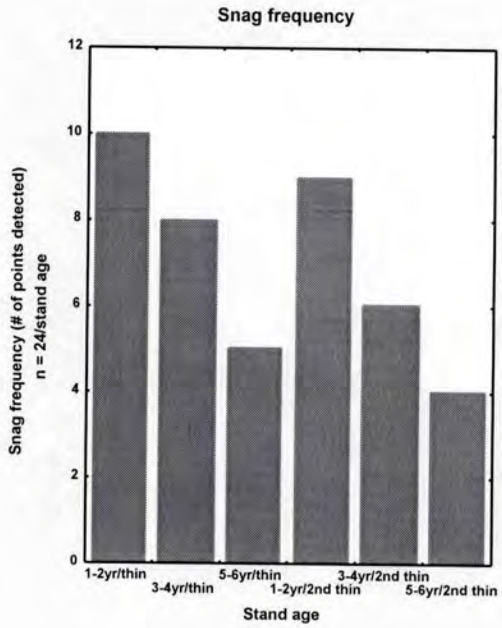

Figure 4. (A) Average value (± SD) for snag density among stand age classes. (B) Snag frequency among stand age classes. Results of univariate statistical testing are presented in Tables 3, 4, and 8.

collinearity effects with total stem density. The standardized structure coefficients of Axis I (Table 6) showed a high positive relationship for percent grass cover and a negative relationship for proportion of cane stems. Apparently, Axis I discriminates 1-2 year old stands and 3-4 year old stands from other early successional stand age classes (see canonical means- Table 7). Percent grass cover is highest in 1-2 and 3-4 year old stands and decreases sharply in later early successional age classes (Figure 4). The standardized structure coefficients of Axis II showed a high positve relationship for total stem density and a high negative relationship for proportion of cane stems. Axis II mostly discriminates 1-2 year old stands and 10-11 year old stand from other early successional age classes (Table 7). This result is based on the trend in total stem density as it increases from 1-2 year old stands through 5-6 year old stands and then sharply decreases in 10-11 year old stands. Axis II also describes the variation in floristics between cane dominated 3-4 and 5-6 year old stands and domination of 1-2 year old stands by grass cover and plant species other than cane. Overall, the two discriminant axes classified nearly 62 % of all points in their correct age class.

Among the group of commercially thinned stands, all variables except for percent bare ground cover, litter cover and snag density were significantly different among stand ages (Table 8); (Figure 4). Variables most associated with pine tree growth (e.g. canopy height, canopy cover, percent of total pine tree accounted for by the larger diameter classes) were positively correlated with stand age (Figure 4). All other significant variables increased with stand age but were also influenced by commercial thinning. Discriminant function analysis yielded two significant axes ($\chi^2 > 65.0$, $p < 0.001$ for each

Table 8. Kruskal-Wallis ANOVA and Spearman rank correlation results for the effects of stand age on vegetation variables among commercially thinned stands. Data were examined for both survey years. For description of variables see Table 2.

Variable	Statistic KW ANOVA H	p-value	Statistic Spearman r	p-value
Canopy height	224.94	< 0.0001	.91	< 0.0001
Canopy cover	114.68	< 0.0001	.73	< 0.0001
% Pine (8-23cm dbh)	69.80	< 0.001	- .76	< 0.0001
% Pine (23-38 cm dbh)	32.65	< 0.0005	.21	> 0.05
% Pine (> 38 cm dbh)	101.43	< 0.0001	.81	< 0.0001
Pine basal area	116.09	< 0.0001	.93	< 0.0001
Hardwood tree density	44.52	< 0.001	.43	< 0.0001
Hardwood basal area	53.94	< 0.001	.57	< 0.0001
Snag density	11.32	> 0.10	- .16	> 0.05
% Bare ground	9.24	> 0.50	- .03	> 0.10
% Litter cover	9.24	> 0.50	.02	> 0.70
% Grass cover	123.82	< 0.0001	- .59	< 0.0001
% Forb cover	31.79	< 0.001	- .23	< 0.01
Litter depth	115.92	< 0.001	.78	< 0.0001
Cane density	31.75	< 0.001	.07	> 0.70
% Cane stems	29.05	< 0.001	-.18	> 0.10
Pepperbush density	29.59	< 0.001	.38	< 0.0001
% Pepperbush stems	55.33	< 0.001	.41	< 0.001
Hardwood sapling	29.34	< 0.001	.23	< 0.01
Stem density	27.94	< 0.001	.05	> 0.30
Other stem density	13.34	< 0.01	- .29	< 0.05

axis) that discriminated vegetation characteristics of all stand age classes from each other (Mahalanobis distances - $p < 0.01$ for all pairwise comparisons of stand ages). These axes accounted for 93 % of the variation (84 % and 9 % for Axis I and II respectively) in habitat variables among stand age classes. A stepwise procedure included six vegetation variables (Table 9). Percent grass cover was excluded because of zero variance (no cover) in older age classes. Percent grass cover was highest in stands 1-2 years after first thin and declined in years since thin (Figure 4). Canopy height, canopy cover, and litter depth were excluded prior to analysis because of strong positive relationships with stand age that overpower relationships among other variables. The standardized structure coefficients of Axis I show a high positive relationship for total pine stems and strong negative relationships for hardwood basal area and proportion of pepperbush stems (Table 10). Apparently Axis I discriminates mostly between stands that have been thinned once from those that have been second thinned (see canonical means, Table 11). For instance, total pine stems are reduced after second thin (Figure 4). Additionally hardwood basal area generally increases with stand age and is greatest for stands after second thin. Finally, the negative relationship of the proportion of pepperbush stems describes the turnover in understory dominance with stand age. The standardized structure coefficients of Axis II show a high positive relationship for total stem density and proportion of cane stems and a negative relationship for basal area of hardwoods (Table 10). Axis II mostly discriminates stands 1-2 years after first and second thin from stands with increasing time since thin (Table 11). The basal area of hardwoods generally increases with stand age (as indicated by Axis I) but was reduced by thinning events and

Table 9. Summary of vegetation variables included in a stepwise Discriminant Function Analysis of commercially thinned stands. Total pine stems contributes the most to the overall separation between stand ages, percent of pepperbush stems the second most and so on (the smaller the partial *lambda*, the greater the contribution to the overall discrimination).

Variable	Wilk's Lambda	Partial Lambda	F	P
Forb cover	0.33	0.97	2.41	< 0.05
% Cane stems	0.38	0.92	4.45	< 0.0001
% Pepperbush stems	0.43	0.81	12.77	< 0.001
Total stem density	0.36	0.95	2.49	< 0.03
logTotal pine stems (>8cm dbh)	0.53	0.67	26.88	<0.0001
logHardwood basal area	0.43	0.83	11.25	< 0.0001

Table 10. Standardized structure coefficients for vegetation variables based on Discriminant Function Analysis of commercially thinned stands. Axis I weights most heavily on Total pine stems, percentage of pepperbush stems, and the basal area of hardwood trees. Axis II weights most heavily on the percentage of cane stems, total stem density, and the basal area of hardwood trees.

Variable	Axis I	Axis II
Forb cover	- .15	.13
% Cane stems	- .23	.68
% Pepperbush stems	- .65	- .05
Total stem density	- .05	.54
*log*Total pine stems (>8cm dbh)	- .75	- .08
*log*Hardwood basal area	- .50	- .21
Eigenvalue	1.25	.14
Cumulative proportion of variance explained	.84	.93

Table 11. Means of canonical scores for stand age groups on each Discriminant Axis. Mean values are calculated for each stand age from the individual score of each vegetation survey plot. Mean values indicate the nature of the discrimination for each Axis.

Stand age	Axis I	Axis II
1-2 years after 1st thin	1.42	0.47
3-4 years after 1st thin	1.39	- 0.34
5-6 years after 1st thin	0.24	- 0.47
1-2 years after 2nd thin	- 0.84	0.27
3-4 years after 2nd thin	- 1.29	- 0.31
5-6 years after 2nd thin	- 0.87	- 0.30

subsequently increases with time since thin. Total stem density showed the opposite pattern and had the highest density in stands immediately after thin and declined with time since thin.

In addition to the above comparisons, a number of habitat variables showed patterns of variation that differed between the two age subgroups or that were associated with commercial thinning. For example, total stem density increased from the first growing season to the sixth and then significantly decreased in the tenth growing season. Subsequently, stem density increased significantly only after the first and second commercial thin. Grass cover was significantly lower in 10-11 year old stands compared to younger stands but was significantly higher one year after the first commercial thin. Canopy cover showed the opposite pattern.

Within commercially thinned stands, several commonly measured habitat variables were significantly influenced by transect type (sheared vs. non-sheared) (Table 12). In addition to the obvious differences in tree density, percent canopy cover and grass cover exhibited the greatest differences between transect types. This result was primarily due to habitat changes one year after first thin. Differences between transect types became less pronounced with increasing stand age. Finally , for both transect types, all commonly measured variables were significantly influenced by stand age.

Bird Surveys

Community Patterns

A total of 12,362 bird observations were made during the 1997 study period and 12,128 bird observations were made during 1998. Species composition and relative

Table 12. Mann-Whitney U test results for the effect of lane type (sheared versus non-sheared) on vegetation variables measured within commercially thinned stands. Data analysis was restricted to variables measured in both lane types and includes information from both survey years.

		Stand Age Class						
Variable		All classes	1 year after thin	3rd year after thin	5th year after thin	1 year after 2nd thin	3rd year after 2nd thin	5th year after 2nd thin
Canopy cover	U =	5990.0	232.5	156.3	75.1	106.0	99.3	212.0
	p-value	<0.001	= 0.007	< 0.001	< 0.003	<0.01	< 0.01	< 0.01
% Bare cover	U =	7576.0	275.0	288.0	200.0	288.0	288.0	288.0
		> 0.50	> 0.70	1.00	1.00	1.00	1.00	1.00
% Litter cover	U =	8993.0	288.0	288.0	190.0	288.0	288.0	288.0
	p-value	> 0.90	1.00	1.00	> 0.70	1.00	1.00	1.00
% Grass cover	U =	7905.0	47.5	162.0	121.5	188.0	288.0	275.0
	p-value	>0.001	<0.001	< 0.008	> 0.10	> 0.10	1.00	> 0.80
% Forb cover	U =	9658.5	205.5	255.0	262.5	277.0	220.5	288.0
	p-value	> 0.40	> 0.20	> 0.40	> 0.60	> 0.50	> 0.30	1.00
Litter depth	U =	8970.0	231.5	177.5	215.5	262.0	280.0	232.0
	p-value	> 0.50	> 0.40	> 0.20	> 0.70	> 0.50	> 0.90	> 0.40
Cane density	U =	8427.5	205.0	192.0	210.0	245.5	261.0	210.5
	p-value	> 0.10	> 0.30	> 0.20	> 0.80	> 0.30	> 0.80	> 0.20
Pepperbush	U =	9222.0	169.0	225.0	213.5	269.0	245.0	199.5
density	p-value	> 0.60	< 0.05	> 0.60	> 0.70	> 0.80	> 0.30	> 0.40
Hardwood	U =	8275.0	125.0	210.5	232.5	241.0	189.0	163.5
sapling	p-value	< 0.05	< 0.01	> 0.20	> 0.60	> 0.30	> 0.05	< 0.01
Stem density	U =	7345.0	205.0	139.0	195.0	155.5	171.5	165.5
	p-value	< 0.01	> 0.10	< 0.005	> 0.40	< 0.005	< 0.05	< 0.03
Other stems	U =	6222.5	156.5	132.0	219.0	127.5	245.0	240.5
	p-value	< 0.001	< 0.03	< 0.005	> 0.80	< 0.005	> 0.40	> 0.30

abundance were very similar between years. Although the same composition of 70 species were detected in each year, 11 species accounted for nearly 70 % of all observations (Figure 5). Species such as the Common Yellowthroat, Eastern Towhee, and Gray Catbird, that are associated with early successional habitats or dense understory vegetation were the most commonly observed.

Species richness was significantly and positively (Pearson $r = 0.73$ and $r = 0.71$, $p < 0.001$ for 1997 and 1998 respectively) influenced by stand age (Table 13, Figure 6). However, significant differences in species richness between specific stand age categories were variable (results of post-hoc tests, Table 14). There were no significant differences in species richness attributed to understory type or survey year. In addition, there was no significant interaction detected between factors indicating a consistent statistical tend across all factor level combinations (Table 13).

Stand age was also found to have a significant influence on overall bird density (Table 15, Figure 7). This effect was generally due to the statistically significant difference between the early successional and commercially thinned subgroups (Table 16). There were no significant differences between any pairwise combination of stand ages after first commercial thin. Overall, bird density was positively correlated with stand age (Pearson $r = 0.58$, and $r = 0.61$, $p < 0.01$ for 1997 and 1998 respectively). Understory type had no significant influence on overall bird density (Table 15). However, a significant interaction term between stand age and understory type was detected suggesting that the effect of these two factors was not additive. To investigate this interaction further, a single univariate test was performed on each understory type

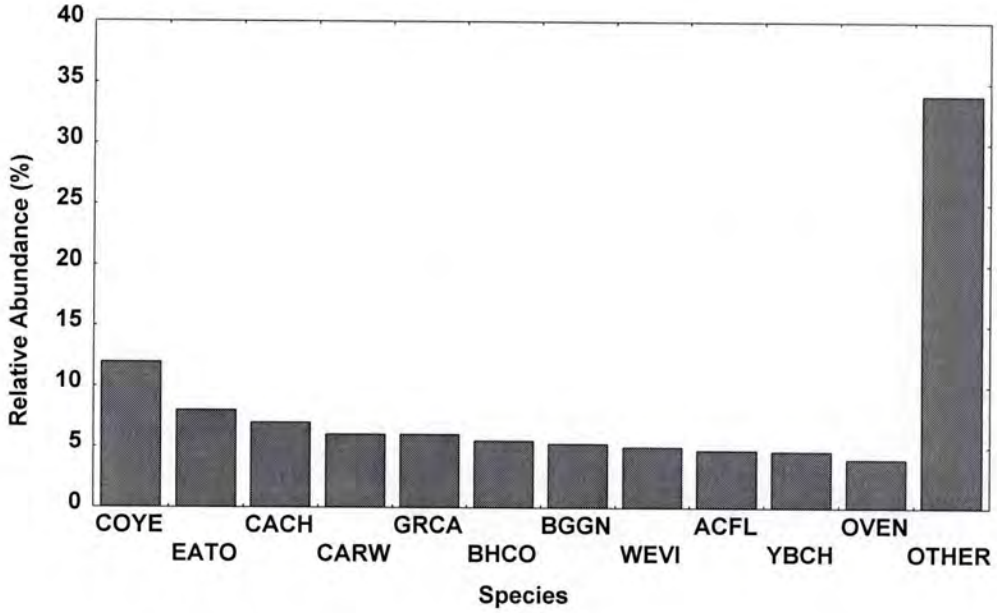

Figure 5. Relative abundance of species among all pine plantation stand ages. Data presented are based on bird detections from both survey years and within 50m radius point counts.

Table 13. Results of a three-way ANOVA for species richness. Factors included stand age (10 levels), understory type (2 levels; cane and hardwood), and year (2 levels).

Factor	d.f.	SS	MS	F	P
Stand age	9	1950.66	216.74	23.09	< 0.001
Understory type	1	19.17	19.17	2.04	0.15
Stand age x Understory type	9	153.72	17.08	1.84	0.07
Year x Stand age	9	110.97	12.33	1.31	0.24
Year x Understory type	1	0.79	0.79	0.08	0.77
Year x Stand age x Understory type	9	59.67	6.63	0.70	0.70
Error	80	750.40	9.38		

Table 14. Post-hoc ANOVA results from Tukey's HSD test for species richness and stand age. P-values ≤ 0.05 (highlighted in bold) indicate significant variation for species richness between pairwise stand age comparisons.

	Growing season				Year(s) after 1st thin			Year(s) after 2nd thin		
Age	1	3	5	10	1	3	5	1	3	5
1-2		0.134	0.872	0.357	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
3-4	0.134		0.932	0.999	0.788	0.310	0.517	**0.025**	**0.024**	**0.134**
5-6	0.872	0.932		0.997	0.091	0.012	**0.031**	**0.001**	**0.001**	**0.003**
10-11	0.357	0.999	0.997		0.462	0.111	0.227	**0.005**	**0.005**	**0.039**
year after 1st thin										
1-2	**0.001**	0.788	0.091	0.462		0.998	0.999	0.686	0.686	0.970
3-4	**0.001**	0.310	**0.012**	0.111	0.998		0.999	0.981	0.981	0.999
5-6	**0.001**	0.517	**0.031**	0.227	0.999	0.999		0.905	0.905	0.998
year after 2nd thin										
1-2	**0.001**	**0.025**	**0.001**	**0.005**	0.686	0.981	0.905		1.000	0.999
3-4	**0.001**	**0.025**	**0.001**	**0.005**	0.686	0.981	0.905	1.000		0.999
5-6	**0.001**	0.134	**0.001**	**0.039**	0.970	0.999	0.998	0.999	0.999	

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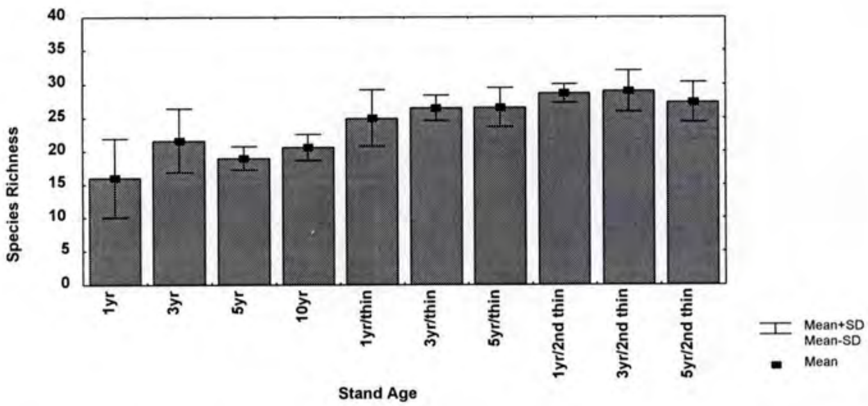

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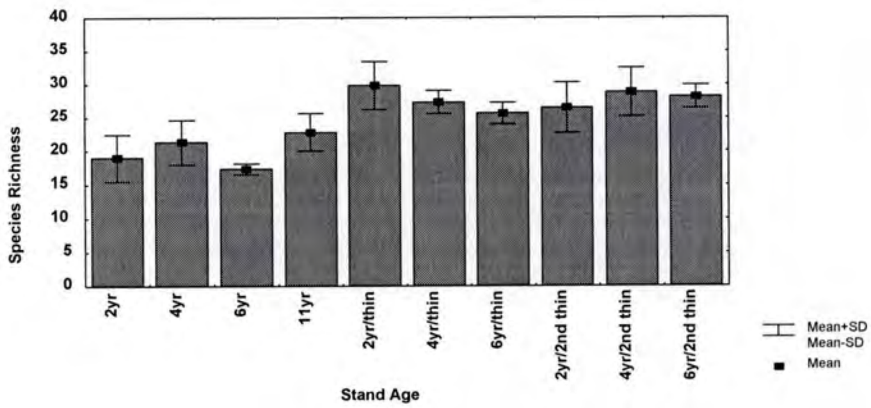

Figure 6. Average species richness (± SD) among stand age classes. Data presented represents species detections in (A) 1997 and (B) 1998 from unlimited radius point counts.

Table 15. Results of a three-way ANOVA for bird density. Factors included stand age (10 levels), understory type (2 levels; cane and hardwood), and year (2 levels).

Factor	d.f.	SS	MS	F	P
Stand age	9	6041.25	671.25	38.59	< 0.001
Understory type	1	7.92	7.92	0.45	0.50
Stand age x Understory type	9	390.69	43.41	2.49	0.008
Year x Stand age	9	39.69	4.41	1.61	0.11
Year x Understory type	1	27.97	27.97	0.25	0.61
Year x Stand age x Understory type	9	151.83	16.87	0.97	0.46
Error	9	156.51	17.39		

Table 16. Post-hoc ANOVA results from Tukey's HSD test for bird density and stand age. P-values ≤ 0.05 (highlighted in bold) indicate significant variation for bird density between pairwise stand age comparisons.

	Growing season				Year(s) after 1st thin			Year(s) after 2nd thin		
Age	1	3	5	10	1	3	5	1	3	5
1-2		0.184	**0.002**	0.999	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
3-4	0.183		0.941	0.645	**0.003**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
5-6	**0.002**	0.941		**0.034**	0.243	**0.001**	0.124	**0.001**	**0.001**	**0.014**
10-11	0.999	0.645	0.034		**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
year after 1st thin										
1-2	**0.001**	**0.003**	0.243	**0.001**		0.992	1.000	0.315	0.842	0.992
3-4	**0.001**	**0.001**	**0.001**	**0.001**	0.992		0.999	0.922	0.999	1.000
5-6	**0.001**	**0.001**	0.124	**0.001**	1.000	0.999		0.507	0.948	0.999
year after 2nd thin										
1-2	**0.001**	**0.001**	**0.001**	**0.001**	0.315	0.921	0.507		0.998	0.921
3-4	**0.001**	**0.001**	**0.001**	**0.001**	0.843	0.999	0.949	0.998		0.999
5-6	**0.001**	**0.001**	**0.001**	**0.001**	0.992	1.000	0.999	0.921	0.999	

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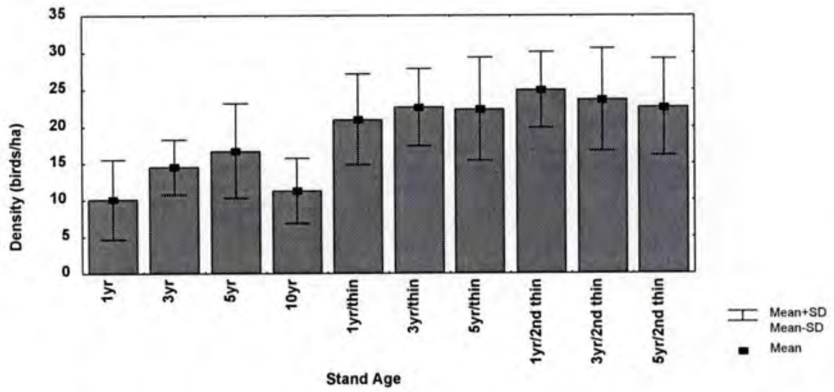

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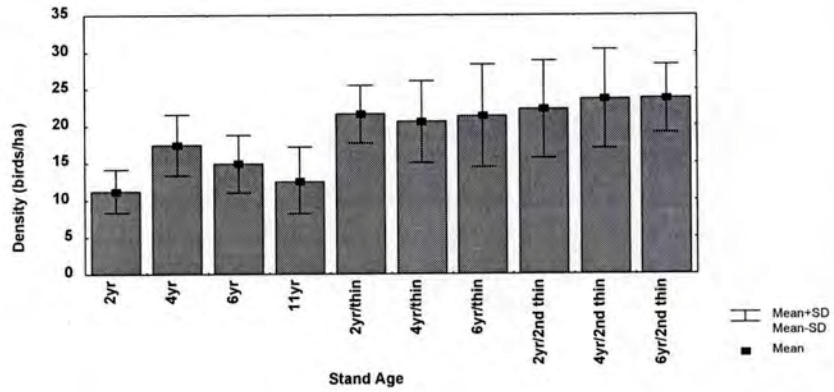

Figure 7. Average bird density (± SD) among stand age classes. Data presented represent bird detection in (A) 1997 and (B) 1998 within 50m radius point counts.

and stand age combination for both survey years. The result of this comparison was variable between years and stand ages. During 1997, stands that were one year after thin had greatest bird density in cane dominated stands. In contrast, stands that were three years after second thin had greater bird density in hardwood-dominated stands. There was no significant influence of understory type observed for any stand age during 1998 surveys. Additionally, there was no significant interaction between year and stand age, and year and understory type, and no significant three-way interaction among all factors indicating a consistent statistical trend between the two survey years. Distance from edge of certain thinned stands also had a significant influence on overall bird density . This pattern was due to a higher average bird density within edge plots compared to interior plots.

Cluster analysis further highlighted the influence of stand age on community organization (Figure 8). The greatest Euclidean distance (the greatest difference in community indices) was between stands in their first-second growing season and all other stands. A second grouping separated early successional stands (ages 3-4 through 10-11) from forested (thinned) stands. All post thin stands were grouped with greater similarity that any other group of stands. Community similarity indices for stand ages were statistically similar between years ($\chi^2 < 3.8$, $p > 0.05$ for all pairwise comparisons). However the most notable change was a 27 % increase in community overlap during the progression from the first to second growing seasons when compared to stands in their fourth growing season.

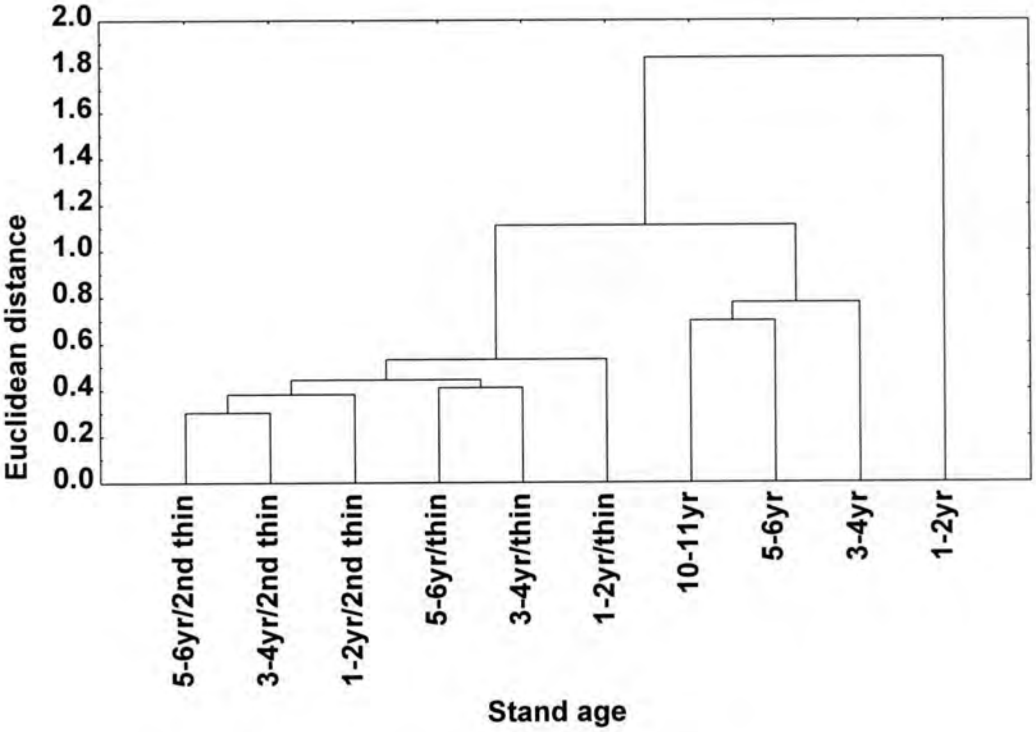

Figure 8. Cluster dendrogram of community similarity among stand age classes. Data are based on Euclidean distanes between pairwise stand age comparisons. Greater Euclidean distances represent greater differences in community similarity.

Species-level patterns

Of the total species observed during the study, 55 (79 %) species were detected in early successional stands, and 60 (86 %) were detected in forest stands. Seven species (10 %) were detected exclusively in early successional stands and 11 (16 %) species in forest stands. The remaining 42 (59 %) were detected within both age subgroups. Although the majority of species observed during the study were detected in both age subgroups, many were not evenly distributed. Based on the overall habitat use patterns for the various species (Figures 10, 12, and 13), three functional species groups were formed including: 1) early successional species - those species exhibiting a significant association with early successional stands, 2) Forest species - those species exhibiting a significant association with forest stands, and 3) habitat generalists - those species that exhibited no significant association.

Early Successional Species - All species in this group exhibited a significant association with early successional stands (all $\chi^2 > 5.0$, $p < 0.05$). The most commonly observed species within the early successional subgroup were species that are typically associated with shrublands (Figure 9). Some of these species exhibited a significant association with specific stand ages within the early successional subgroup (Figure 10). For example the Eastern Bluebird, Eastern Kingbird, Blue Grosbeak, and Indigo Bunting were all significantly associated with stands in their first four growing seasons. Both the American Goldfinch and Field Sparrow were associated with stands that were in their first six growing seasons. The Prairie Warbler showed a different pattern and was detected with significantly greater frequency in early successional stands that were 3

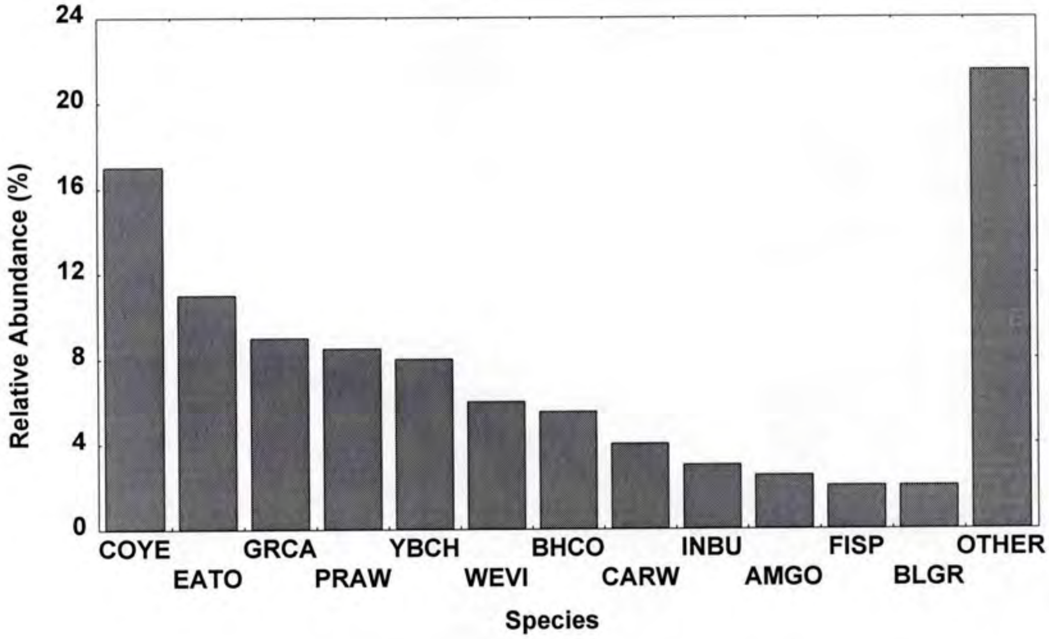

Figure 9. Relative abundance of species among early succesional stand ages (1-11 growing seasons). Data presented ar based on bird detections from both survey years and within 50m radius point counts.

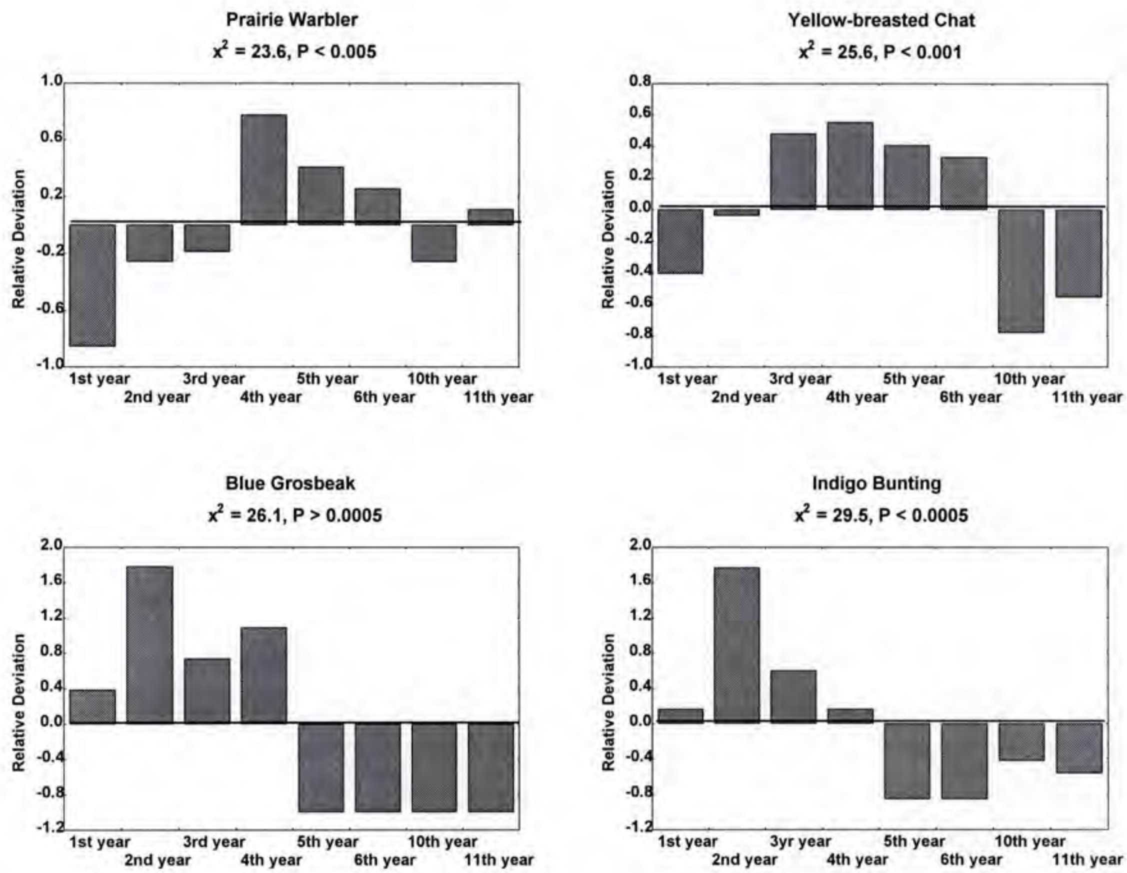

Figure 10. Stand age associations of selected early successional species. Columns indicate the relative distribution of individuals from an expected even across all early successional ages based on bird detections within 50m radius point counts. Positive deviationsindicate ages that are overutilized relative to the total number of points surveyed. Negative deviaitons indicate ages that are underutilized relative to the number of points surveyed. Chi-square statistics and significance values (df = 7) indicate results of frequency tests of the above observed and expected distributions.

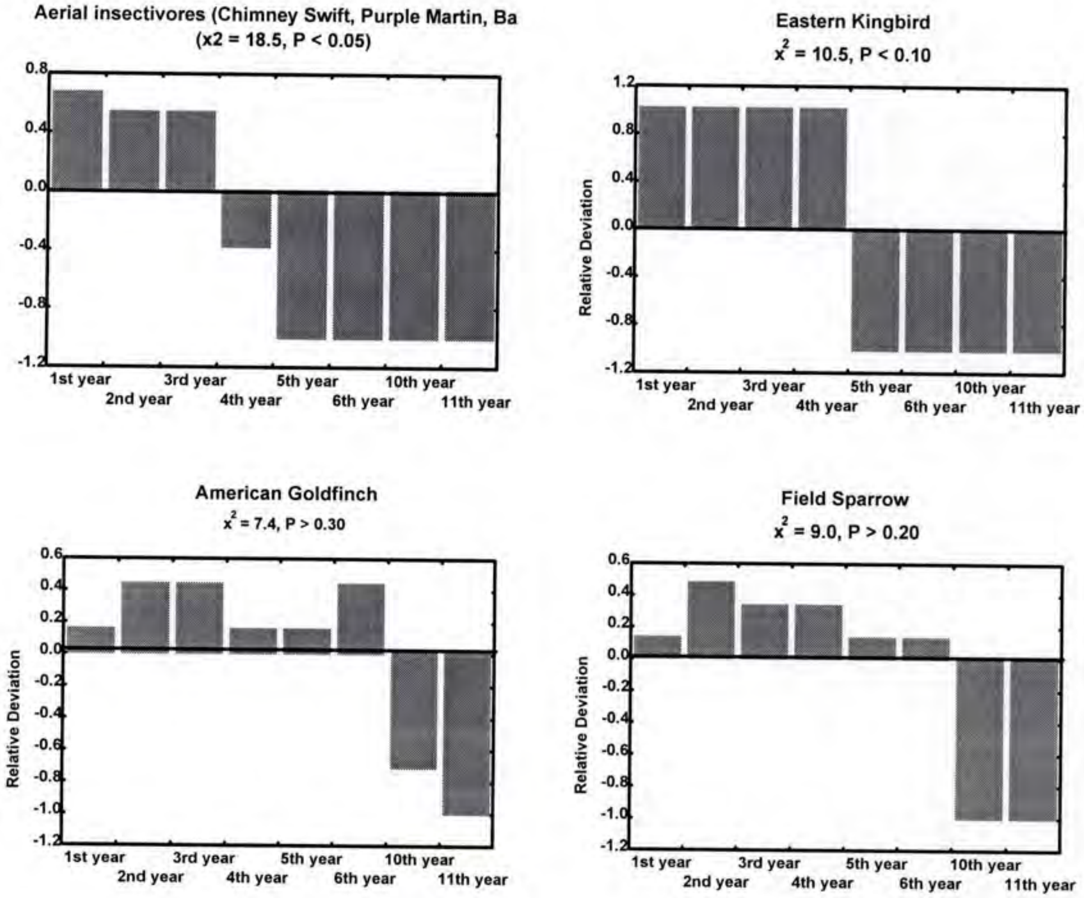

Figure 10. Stand age associations of selected early successional species. Columns indicate the relative distribution of individuals from an expected even across all early successional ages based on bird detections within stands. Positive deviations i ndicate ages that are overutilized relative to the total number of stands surveyed. Negative deviaitons indicate ages that are underutilized relative to the number of standss surveyed. Chi-square statistics and significance values (df = 7) indicate results of frequency tests of the above observed and expected distributions.

through 11 years old. Aerial insectivores (e.g. Barn Swallow, Chimney Swift, and Purple Martin) that use these habitats for foraging purposes only, were significantly associated with stands in their first growing season. The Indigo Bunting and Yellow-Breasted Chat exhibited relatively unique distribution patterns. At the broader level, these species were detected with a higher frequency in early successional stands compared to forest stands. However, the Indigo Bunting also showed a high association with stands that were one and two years after first thin. The Yellow-breasted Chat had a similar pattern, but was associated with stands 1-2 years after both first and second thin.

Forest Species - All species in this group exhibited a significant association with forest (commercially thinned) stands (all $\chi^2 > 5.9$, p , 0.05). As with the early successional stands, the most common species observed included the shrub-dependent species such as the Common Yellowthroat, Eastern Towhee, and Gray Catbird. However, many species that are associated with true forests were also common (Figure 11 composition). Across all forest stands, there was relatively little variation in detection frequencies (Figures 12). This result is consistent with the community patterns described above. Only two of the forest species examined exhibited significant variation in stand use across the range of age categories within the subgroup. The Hooded Warbler showed a significant association with stands after second thin compared to stand that had only been thinned once. The Brown-headed Nuthatch was detected with greater frequency in stands one and two years after first and second thin.

Comparisons of space use and vegetation structure for these three species follow the same general patterns as described above. For the Hooded Warbler, canonical values

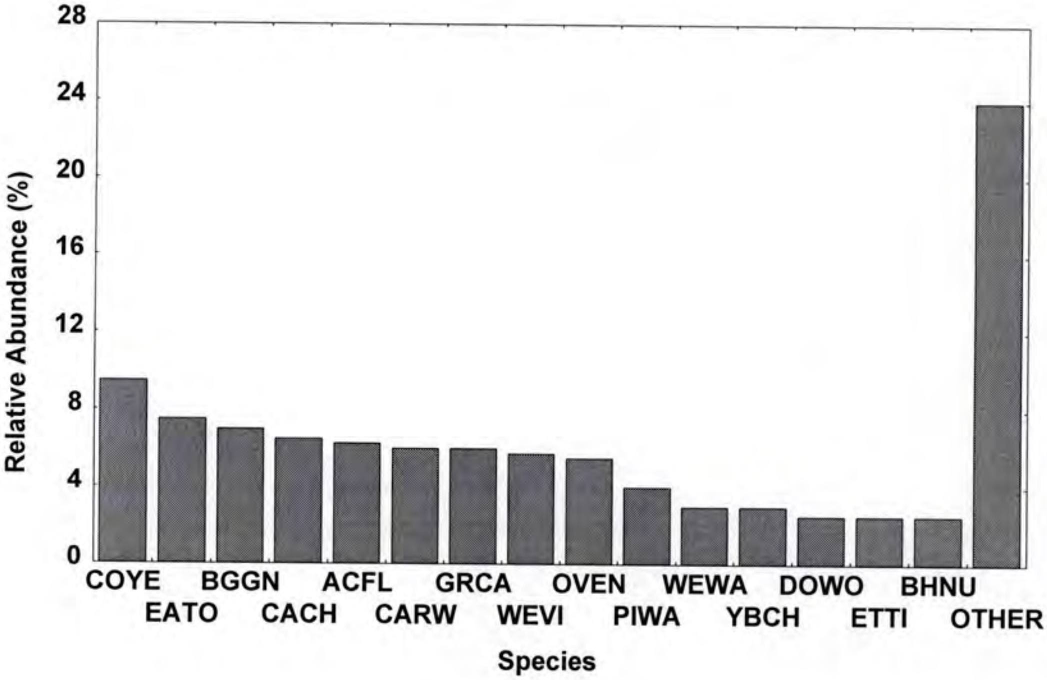

Figure 11. Relative abundance of species among commercially thinned stands. Data presented are based on bird detections from both survey years and within 50m radius point counts.

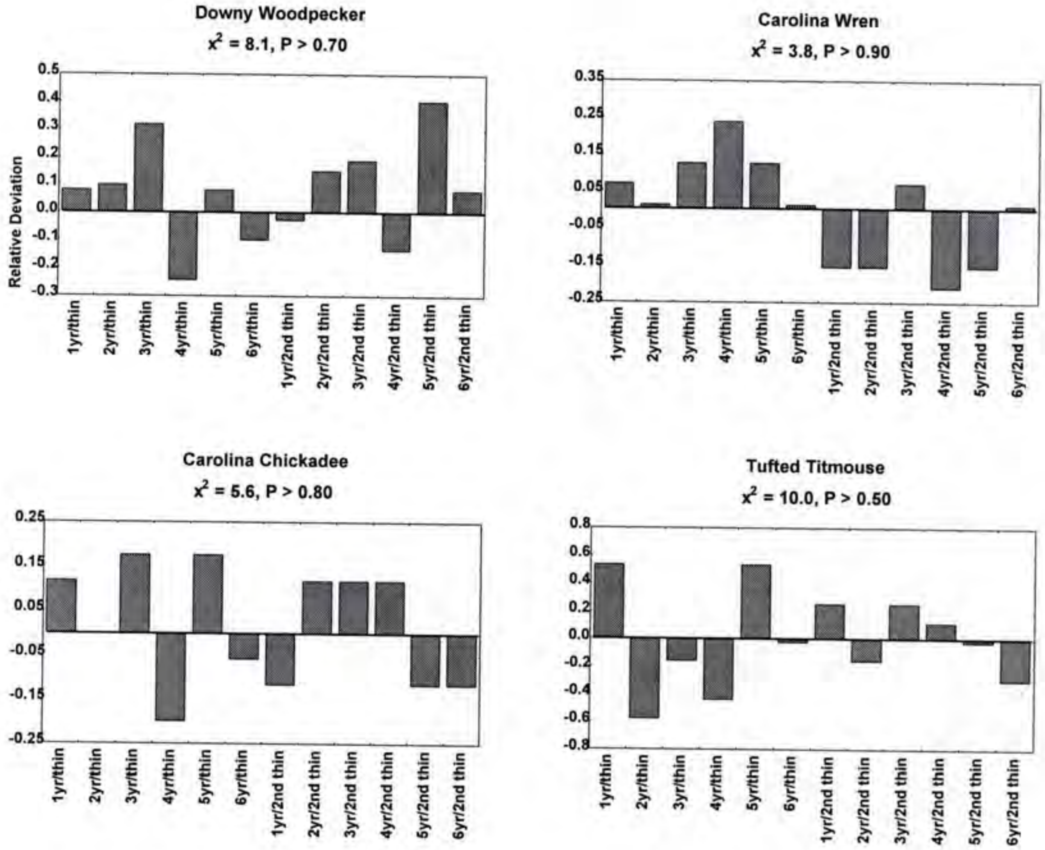

Figure 12. Stand age associations of selected forest species. Columns indicate the relative distribution of individuals from an expected even across all forest stand ages based on bird detections within 50m radius point counts. Positive deviationsindicate ages that are overutilized relative to the total number of points surveyed. Negative deviaitons indicate ages that are underutilized relative to the number of points surveyed. Chi-square statistics and significance values (df = 11) indicate results of frequency tests of the above observed and expected distributions.

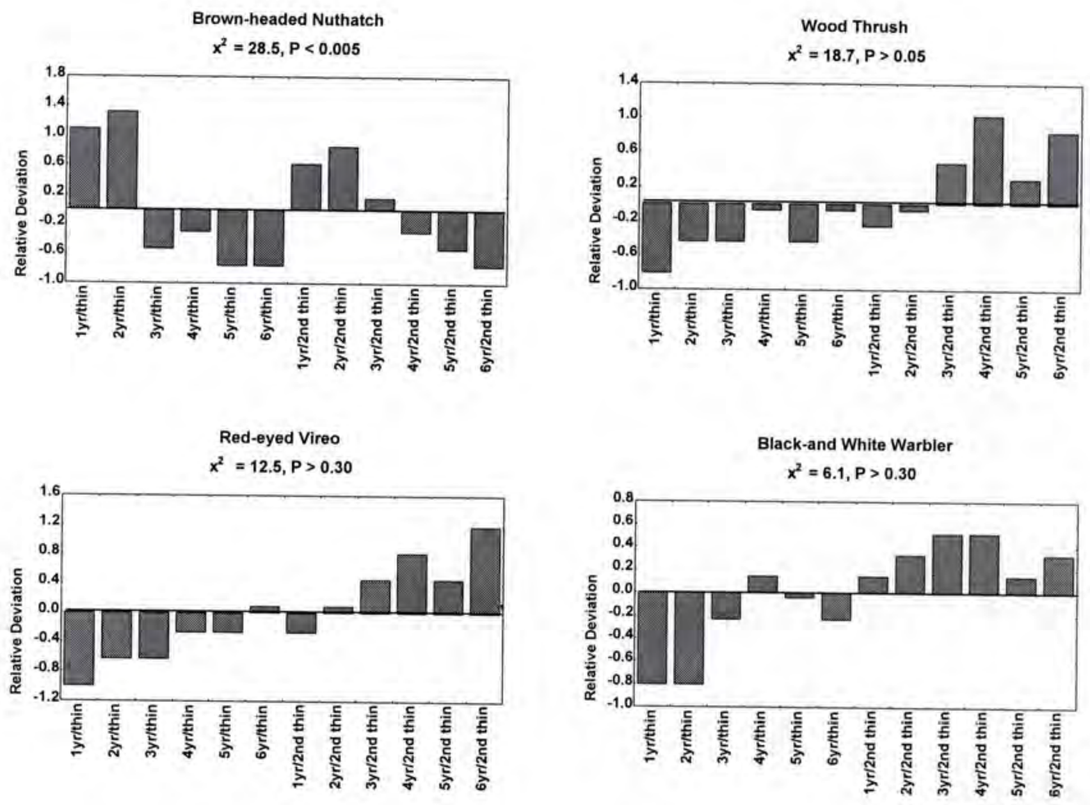

Figure 12. Stand age associations of selected forest species. Columns indicate the relative distribution of individuals from an expected even across all forest stand ages based on bird detections within 50m radius point counts. Positive deviationsindicate ages that are overutilized relative to the total number of points surveyed. Negative deviaitons indicate ages that are underutilized relative to the number of points surveyed. Chi-square statistics and significance values (df = 11) indicate results of frequency tests of the above observed and expected distributions.

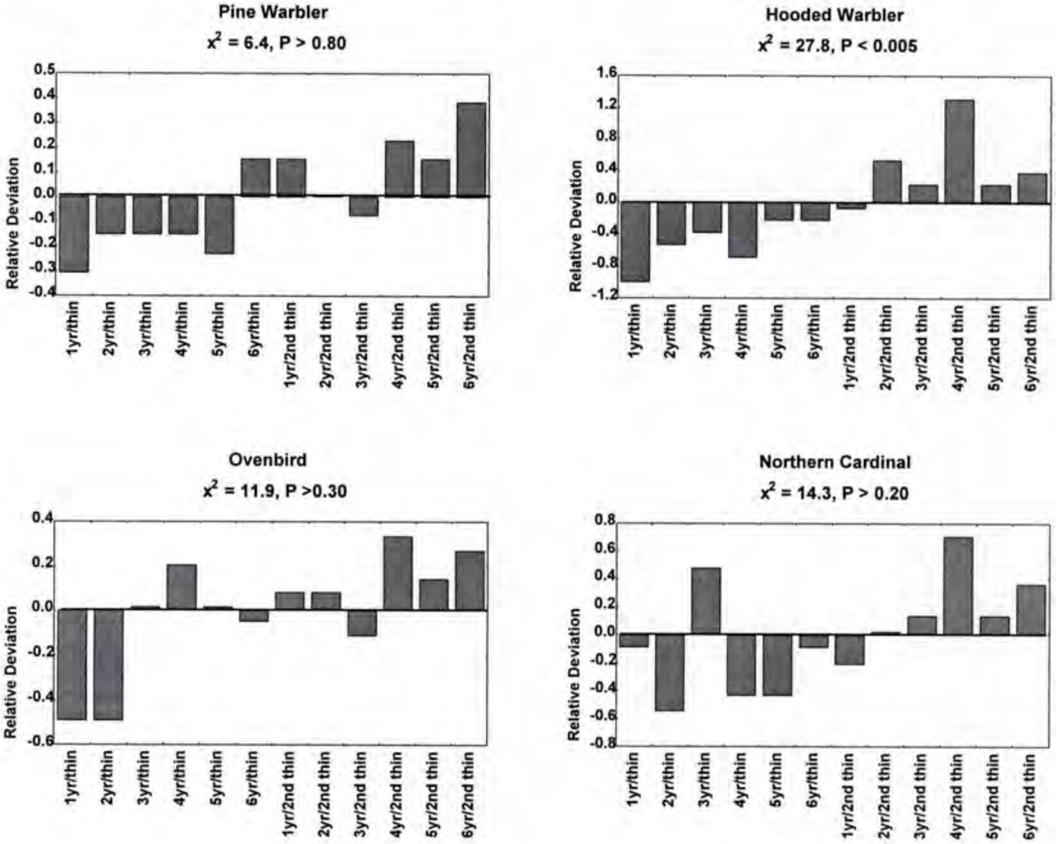

Figure 12. Stand age associations of selected forest species. Columns indicate the relative distribution of individuals from an expected even across all forest stand ages based on bird detections within 50m radius point counts. Positive deviationsindicate ages that are overutilized relative to the total number of points surveyed. Negative deviaitons indicate ages that are underutilized relative to the number of points surveyed. Chi-square statistics and significance values (df = 11) indicate results of frequency tests of the above observed and expected distributions.

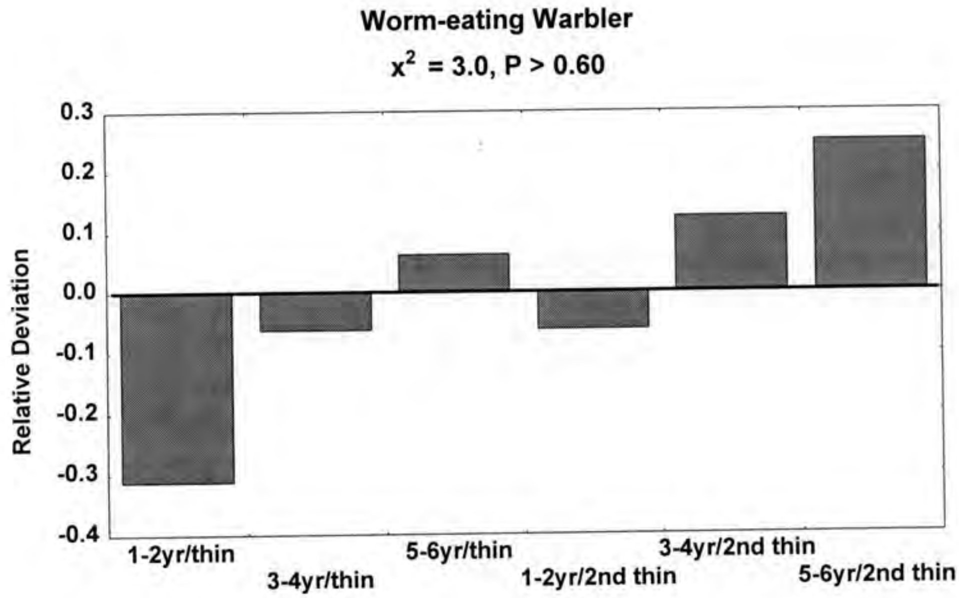

Figure 12. Stand age associations of the Worm-eating Warbler. Columns indicate the relative distribution of individuals from an expected even across all forest stand ages based on bird detections within 50m radius point counts. Positive deviations indicate ages that are overutilized relative to the total number of points surveyed. Negative deviaitons indicate ages that are underutilized relative to the number of points surveyed. Frequencies are based on two-year totals for each point because of significantly different detection rates between years. Chi-square statistics and significance values (df = 5) indicate results of frequency tests of the above observed and expected distributions.

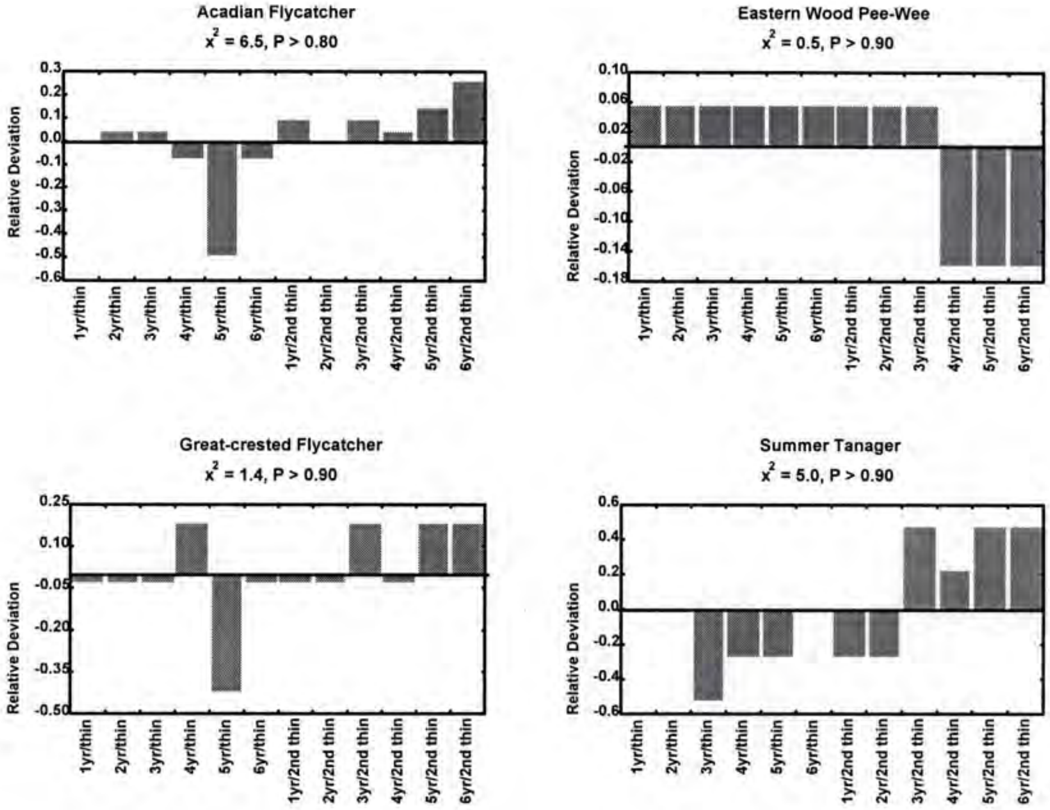

Figure 12. Stand age associations of selected forest species. Columns indicate the relative distribution of individuals from an expected even across all forest stand ages based on 1) bird detections within 50m radius point counts (Acadian Flycatcher) and 2) within stand ages (all other species). Positive deviationsindicate ages that are overutilized relative to the total number of points or stands surveyed. Negative deviaitons indicate ages that are underutilized relative to the number of points surveyed. Chi-square statistics and significance values (df = 11) indicate results of frequency tests of the above observed and expected distributions.

of occupied points were significantly different from non-occupied points when superimposed on Discriminant Axis I ($t = 3.32$, $p < 0.005$) but not on Axis II ($t = 0.23$, $p > 0.80$) (Table 17). This result was due to a greater canonical mean for non-occupied points compared to occupied points (Table 17) and suggests that structural habitat characteristics associated with older stand ages may influence patch use (in particular after second thin, see Axis I results, Table 10). Points that were occupied by Hooded Warblers had higher values for canopy cover, canopy height, litter depth, and hardwood basal area compared to non-occupied points. In contrast, percent grass cover, and pine stem density were lower in occupied points compared to non-occupied points. Although the Worm-eating Warbler did not show significant differences in occupation patterns among stand ages, further analysis was performed. For this species there were no differences between canonical values of occupied and non-occupied points for Axis I ($t = 0.04$, $p > 0.97$) or Axis II ($t = 0.89$, $p > 0.30$) (Table 18). However, points occupied by Worm-eating Warbler did show higher values for canopy cover and litter depth compared to non-occupied points. Finally, the Brown-headed Nuthatch showed no significant difference in canonical values between occupied and non-occupied points on Axis I ($t = 0.65$, $p > 0.50$) but did show a significant difference on Axis II ($t = 2.12$, $p < 0.04$). This result was due to a lower mean for occupied points compared to non-occupied points when superimposed on Axis II (Table 19). The presence of Brown-headed Nuthatches was significantly associated with habitat characteristics that were directly influenced by thinning events (see Axis II results, Table 10). Points occupied by nuthatches had significantly greater values for percent grass and forb cover and lower values for canopy

Table 17. Results of habitat use patterns for the Hooded Warbler based on the distribution of occupied and non-occupied survey points. Analyses examined canonical values (based on DFA of vegetation variables within commercially thinned stands), and observed values of vegetation variables, between occupied and non-occupied survey points.

Variable	occupied point (N=52) mean ± SD	non-occupied point (N= 88) mean ± SD	t	*P*
Canonical values for DFA Axis I	- .18 ± 1.52	.69 ± 1.27	3.3	< 0.001
Canonical values for DFA Axis II	- .01 ± 1.04	- .06 ± 1.06	0.2	> 0.80
% Canopy cover	91.6 ± 8.2	85.3 ± 10.9	3.4	< 0.001
Canopy height (m)	24.3 ± 3.3	21.7 ± 3.4	4.2	**< 0.001**
% Bare ground	0.0 ± 0.0	0.0 ± 0.0	0.0	> 9.0
% Litter cover	0.0 ± 0.0	0.0 ± 0.0	0.0	> 9.0
% Grass cover	2.7 ± 8.8	8.8 ± 17.7	2.2	**< 0.05**
% Forb cover	3.4 ± 7.7	4.8 ± 10.5	0.8	> 0.40
Litter depth (cm)	21.6 ± 2.4	19.8 ± 2.4	4.2	**< 0.001**
Cane density (stems/m^2)	10.7 ± 11.5	9.2 ± 11.7	0.7	> 0.50
% Cane stems	28.1 ± 26.0	22.5 ± 24.9	1.2	> 0.20
Pepperbush density (stems/m^2)	12.9 ± 11.5	12.0 ± 12.7	0.4	> 0.60
% Pepperbush stems	36.0 ± 27.7	30.3 ± 27.9	1.2	> 0.20
Hardwood sapling density	1.8 ± 2.2	2.3 ± 2.2	1.0	> 0.30
Total stem density (stems/m^2)	35.6 ± 13.4	36.0 ± 17.6	0.1	> 0.80
Pine tree density (stems/ha)	208.0 ± 66.8	245.5 ± 88.6	2.6	**< 0.05**
Hardwood tree density	238.6 ± 248.7	162.8 ± 205.9	2.1	**< 0.05**
Hardwood basal area (m^2/ha)	4.7 ± 4.6	3.1 ± 3.9	2.0	**< 0.05**
Snag frequency (# of points)	8	13	$\chi^2 = 0.7$	> 0.50

Table 18. Results of habitat use patterns for the Worm-eating Warbler based on the distribution of occupied and non-occupied survey points. Analyses examined canonical values (based on DFA of vegetation variables within commercially thinned stands), and observed values of vegetation variables, between occupied and non-occupied survey points.

Variable	occupied point (N= 84) mean ± SD	non-occupied point (N= 56) mean ± SD	t	*P*
Canonical values for DFA Axis I	.11 ± 1.4	.09 ± 1.6	0.04	> 0.90
Canonical values for DFA Axis II	.05 ± 1.0	- .11 ± 1.1	0.9	> 0.30
% Canopy cover	89.6 ± 8.0	84.6 ± 12.5	2.9	**< 0.005**
Canopy height (m)	22.6 ± 3.5	22.3 ± 3.7	0.4	> 0.50
% Bare ground	0.0 ± 0.0	0.3 ± 1.53	1.9	< 0.05
% Litter cover	100 ± 0.0	99.7 ± 1.53	1.9	< 0.05
% Grass cover	6.9 ± 15.9	6.9 ± 15.3	0.03	> 0.90
% Forb cover	3.2 ± 6.7	5.8 ± 12.4	1.5	> 0.10
Litter depth (cm)	20.8 ± 2.6	19.8 ± 2.4	2.5	**< 0.02**
Cane density (stems/m^2)	9.3 ± 11.4	10.2 ± 11.8	0.4	> 0.60
% Cane stems	23.7 ± 24.9	25.0 ± 27.2	0.3	> 0.70
Pepperbush density (stems/m^2)	11.5 ± 11.3	13.3 ± 13.5	0.8	> 0.40
% Pepperbush stems	31.4 ± 25.9	33.3 ± 30.3	0.4	> 0.60
Hardwood sapling density	2.1 ± 2.0	2.1 ± 2.3	0.3	> 0.70
Total stem density (stems/m^2)	34.4 ± 16.7	37.8 ± 15.7	1.2	> 0.20
Pine tree density (stems/ha)	232.4 ± 80.7	234.8 ± 85.0	0.2	> 0.80
Hardwood basal area (m^2/ha)	3.7 ± 4.1	3.6 ± 4.1	0.1	> 0.90
Snag frequency (# of points)	4	11	$\chi^2 = 1.7$	> 0.10

Table19. Results of habitat use patterns for the Brown-headed Nuthatch based on the distribution of occupied and non-occupied survey points. Analyses examined canonical values (based on DFA of vegetation variables within commercially thinned stands), and observed values of vegetation variables, between occupied and non-occupied survey points.

Variable	occupied point (N=29) mean ± SD	non-occupied point (N= 101) mean ± SD	t	*P*
Canonical values for DFA Axis I	.08 ± 1.56	- .14 ± 1.59	0.7	> 0.50
Canonical values for DFA Axis II	- .38 ± 1.23	.12 ± 0.99	2.1	< 0.05
% Canopy cover	79.4 ± 11.6	88.9 ± 9.6	4.1	< 0.001
Canopy height (m)	21.6 ± 3.9	22.7 ± 3.5	1.3	> 0.10
% Bare ground	0.0 ± 0.0	0.2 ± 1.1	0.7	> 0.40
% Litter cover	99.9 ± 1.1	0.0 ± 0.0	0.7	> 0.40
% Grass cover	8.2 ± 16.7	6.68 ± 15.5	0.4	> 0.60
% Forb cover	12.2 ± 17.6	2.8 ± 6.4	4.5	< 0.001
Litter depth (cm)	19.3 ± 2.4	20.5 ± 2.5	1.1	> 0.50
Cane density (stems/m^2)	14.9 ± 17.9	8.6 ± 9.7	2.4	< 0.05
% Cane stems	27.4 ± 27.7	23.4 ± 25.0	0.6	> 0.50
Pepperbush density (stems/m^2)	13.5 ± 13.3	12.1 ± 12.2	0.5	> 0.60
% Pepperbush stems	29.6 ± 23.8	32.7 ± 28.7	0.5	> 0.60
Hardwood sapling density	1.6 ± 1.3	2.2 ± 2.3	1.4	> 0.10
Total stem density (stems/m^2)	42.9 + 20.0	34.5 ± 15.2	2.3	< 0.05
Pine tree density (stems/ha)	232.2 ± 93.9	233.7 ± 80.4	0.1	> 0.90
Hardwood tree density	147.1 ± 211.0	195.0 ± 224.7	2.29	**< 0.05**
Hardwood basal area (m^2/ha)	2.6 ± 3.6	3.8 ± 4.3	1.87	**< 0.05**
Snag frequency (# of points)	14	14	7.7	**< 0.05**

cover and hardwood basal area compared to non-occupied points (Table 19). Aside from the habitat characteristics influenced by thinning, nuthatches were also associated with standing snags. Nuthatches were over three times as likely to be detected within points that contained snags (14 of 34 points, 41 %) compared to points that did not (14 of 124 plots, 11.3 %) ($\chi^2 = 7.65$, df = 1, $p < 0.007$).

Distance from stand edge had a significant influence on the detection frequency for several forest species. Both the Carolina Chickadee and the Downy Woodpecker were detected in higher densities within edge plots compared to interior plots in both survey years. The Hooded Warbler and Worm-eating Warbler were detected with equal densities between interior and edge locations in 1997, however both were detected with higher densities within interior points compared to edge points in 1998.

Habitat Generalist Species - All species within this group showed no association with either early successional or forest subgroups (All $\chi^2 < 3.0$, all p values > 0.10). Most habitat generalists only underutilized stands that were in the first and 10-11 growing seasons (i.e. stands with the lowest stem densities) (Figure 13). There was a substantial increase in the use of two year old stands compared to first year stands for many habitat generalists which is indicative of increases in vegetative cover between years. Some of these species were the most abundant and widespread of all species detected. For example, the Common Yellowthroat was ranked the most abundant species in every stand age examined. Similarly, the Brown-headed Cowbird, Gray Catbird, and White-eyed Vireo were among the species with the highest detection frequencies. These three species were the only generalists examined that were significantly influenced by distance to the

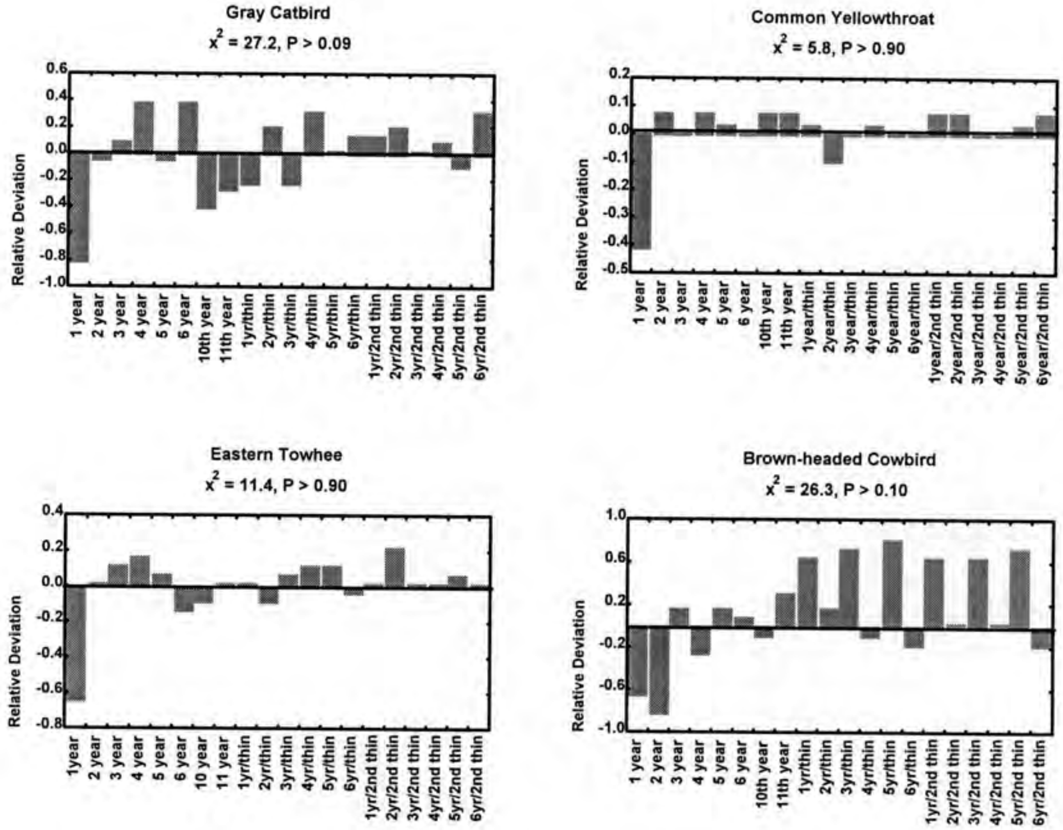

Figure 13. Stand age associations of selected habitat generalist species. Columns indicate the relative distribution of individuals from an expected even across all forest stand ages based on bird detections within 50m radius point counts. Positive deviationsindicate ages that are overutilized relative to the total number of points surveyed. Negative deviaitons indicate ages that are underutilized relative to the number of points surveyed. Chi-square statistics and significance values (df = 19) indicate results of frequency tests of the above observed and expected distributions.

stand edge. All three species had greater densities at edge points compared to interior points.

<u>Hardwood Stands</u>

The structure and floristics of hardwood stands were clearly different from pine plantations sampled. In the areas where samples were taken, the canopy was dominated by red maple, yellow poplar, and to a lesser degree by red bay. Common midstory trees included sweet bay and paw-paw (*Asimina triloba*). The understory of hardwood stands was not as dense as pine plantations but was dominated by cane and sweet pepperbush. Structurally, there was more heterogeneity among stem size classes (Figure 14) compared to mature pine plantations. Also the vegetation in hardwood stands was more vertically stratified with a more developed midstory when compared to plantations.

A total of 40 bird species were detected in hardwood stands. Unlike both the early successional and forest pine stands, the most common species detected were not shrub-associated species (Figure 15). Thirty-nine of the species detected in hardwood stands were also detected in mature pine plantations. However, the relative abundance of shared species was somewhat different (Figures 11 and 15, Appendix III). Aside from Brown-headed Nuthatches, cavity nesting species (e.g. woodpeckers, Great-crested Flycatcher, Prothonotary Warbler, and White-breasted Nuthatch) were detected with higher frequency in hardwood stands.

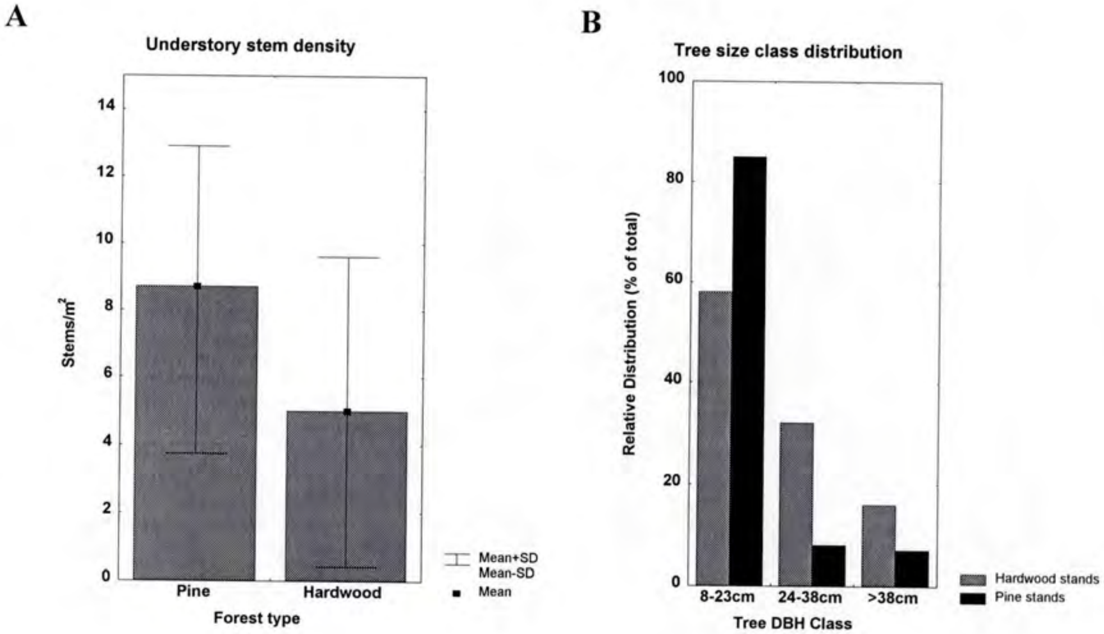

Figure 14. Comparison of mature pine stand (commmercially thinned) and hardwood stand forest structure. (A) Average understory density (± SD). (B) Relative distribution of trees in three size classes.

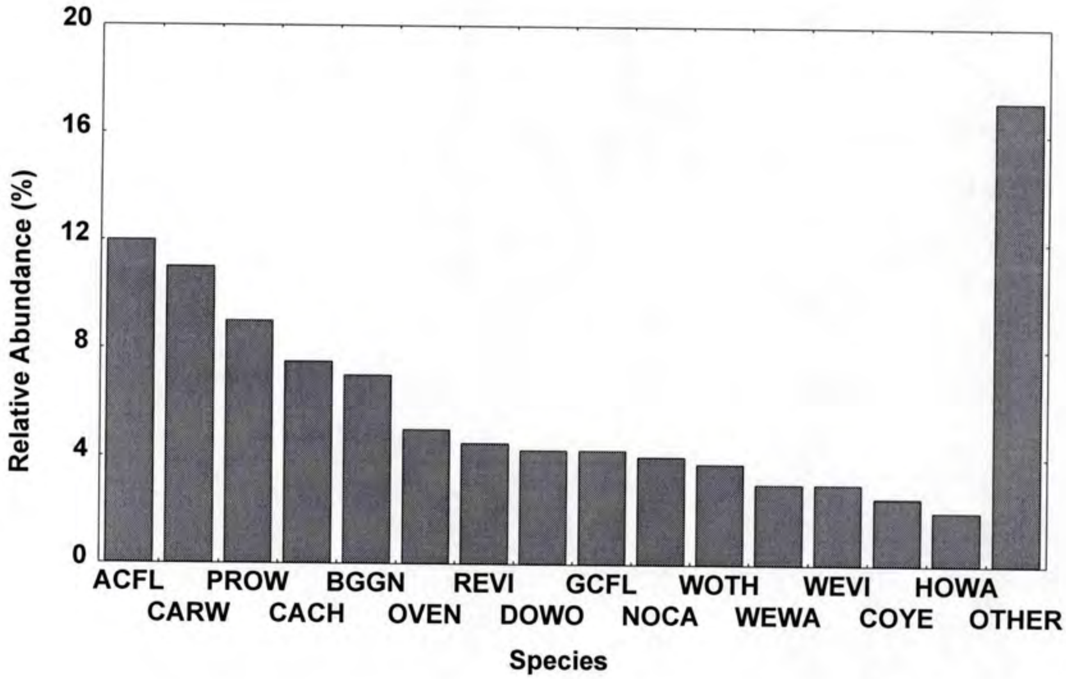

Figure 15. Relative abundance of species among hardwood stands. Data presented are based on bird detections from both survey years and within 50m radius point counts.

Mineral and Organic Stands

The abundance of species detected in pine stands grown on each of the soil types is presented in Appendix V. Because selected stands were not balanced within age classes, data are only presented for descriptive purposes.

DISCUSSION

The results of this study indicate that the structure of the avian community is influenced by the age of forest stands. In general, species richness was positively related to stand age. Systematic shifts in organization of avian communities are common along successional gradients (Johnston and Odum 1956, Karr 1971, May 1982). In general, the increase in structural complexity that often accompanies succession is thought to lead to an increase in resource availability and diversity. This change in resources is presumed to afford species more ecological space for colonization. Among the stands examined in this study, vertical complexity increased with the growth of pine trees, understory vegetation, and midstory tree species with stand age.

Early successional and forest stands had recognizable differences in vegetative structure. Early successional pine stands were characterized by low plant height and higher coverage of grasses and forbs. In contrast, forest stands were characterized by a relatively tall canopy height dominated by pine, and a variable density of midstory and understory vegetation. The gradient between early successional and forest stands (as defined here) is punctuated by stands that have a very dense, closed canopy and an associated sparse understory (represented by 10-11 year old stands in this study).

In addition to their overall gross structure, early successional and forest stands exhibited different rates of vegetation change. Early successional stands change from patches of bare ground to patches with dense, woody vegetation in a relatively short period of time. In contrast, the change in forest vegetation takes place over much longer time periods.

The influence of differences in both the vegetation structure and rate of change between early successional and forest categories is clearly evident in the avian community. Species observed exclusively in early successional patches such as Field Sparrows and Blue Grosbeaks are those typically associated with grasslands and shrublands. Some of these species were observed within a relatively narrow window of stand ages reflecting the rapid change of conditions across this period. Species associated with forest stands were either habitat generalists or species typically found in closed-canopy forests. Unlike many of the early successional species, most species associated with forest patches did not generally discriminate between forest age categories, reflecting a much slower rate of vegetation change across this period. None of the bird species detected were most associated with stands that were between early successional and forest stands (10-11 year old stands). These patches had some of the lowest overall bird densities and did not appear to provide the requirements for either early successional or forest birds.

The large canopy openings created during commercial thinning allowed for understory regeneration and had a positive influence on species richness and overall bird density. These openings appeared to have extended the habitat use of early successional species such as the Indigo Bunting and Yellow-breasted Chat. Only three forest bird species showed a significant response to commercial thinning. The Hooded Warbler underutilized stands before the second thin. The Worm-eating Warbler underutilized stands one and two years after the first commercial thin compared to older aged stands. Both of these species are known to nest on or near the ground and require dense vegetation for breeding (Gale et al. 1997). The openness of the understory just after thinning may have deterred these species from using recently thinned stands. However, the thinning process allowed for the release of the understory that was used in subsequent years. Additionally, hardwood tree densities reached their highest values in stands at least three years after second thin. The availability of a sufficient basal area of hardwoods appears to be an important habitat requirement for the Hooded Warbler and most for other species such as the Wood Thrush and Red-eyed Vireo. The Brown-headed Nuthatch was primarily associated with stands one year after the first and second commercial thins. Occurrence of this species was negatively influenced by hardwood tree density which is lower in stands one year after thinning. Brown-headeds are pine forest specialists that excavate cavities relatively low to the ground (McNair 1984). Obstruction of cavity sites by a dense hardwood understory may deter this species. In Florida slash pine plantations, the abundance of this species was related to variation in snag availability and dispersion (Land et al. 1989). In this study, Brown-headed Nuthatches were more likely to be detected within points that contained snags compared to those that did not.. However, nuthatch occurrence was influenced by both thinning and snag density, implies that snag density alone does not fully explain distribution among pine stands.

Species of Special Interest

A few species detected during surveys are of special interest because of their relative rarity or are of high conservation priority within the region. Worm-ating Warblers were detected in a greater than 55 % of survey points within mature pine and hardwood stands. Within plantations, this species appears to benefit from the appearance of mid-story hardwoods and dense ground level vegetation. Results from the U.S. Fish and Wildlife Breeding Bird Survey indicate that the Worm-eating Warbler is only found in low densities within the region (Sauer et al., 1997). The relatively high abundance of Worm-eating Warblers within Weyerhaeuser tracts is comparable only to those reported from the Great Dismal Swamp (Terwilliger 1987). Also, Black-throated Green Warblers were detected in hardwood stands in late June. This species has been detected previously in hardwood stands on the Parker tract during other surveys (Weyerhaeuser-EDF Management Plan 1996). Elsewhere within the Mid-Atlantic coastal plain, Black-throated Green Warblers are only known to occur within a few sites including the Great Dismal Swamp (Terwilliger 1987, Hamel 1992). Black-and-white Warblers were detected in low densities within plantations and hardwood stands and may also only occur at a few sites within the immediate region. The Swainson's Warbler is considered as a top species for conservation concern within the southeast. This species was detected in hardwood stands and several mature pine plantations (a total of six pine stands over the two survey years) within the Parker and J&W tracts. This species is typically associated with canebrakes and moist areas of bottomland hardwood forests throughout the southeastern Coastal Plain. In this study, the Swainson's Warbler was detected in pine stands that were relatively isolated from any nearby hardwood stands. Moreover, the species was found in plantations with an understory dominated by ericaceous species as well as other stands dominated by cane. Finally, an adult Broad-winged Hawk was observed in June and July aside from formal survey efforts during both years. Nesting for this species has only been recorded in a few locations on the Southeastern Coastal Plain.

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Appendix I. Community similarity index ($\mathbf{C_n}$)

$$\mathbf{C_n} = 2_{jN} / (aN + bN)$$

where; aN = the total number of individuals in stand A
bN = the total number of individuals in stand B
jN = the sum of the lower of the two abundances recorded for species found in both stands

Appendix II. Bird species abundance in early successional stand ages. Numbers indicate the cumulative detections within and beyond the 50m survey plot radius for three survey visits.

	1st growing season		2nd growing season		3rd growing season		4th growing season	
Species	< 50m	>50m	< 50m	> 50m	< 50m	> 50m	< 50m	> 50m
Green-backed Heron (Butroides striatus)	0	0	0	0	0	0	0	0
Common Bobwhite (Colinus Virginianus)	0	15	3	21	4	17	5	12
Turkey Vulture (Cathartes aura)	5	1	0	0	0	0	0	0
Red-shouldered Hawk (Buteo lineatus)	0	0	0	0	0	0	0	0
Killdeer (Charadrius vociferus)	0	8	1	5	0	0	0	0
Mourning Dove (Zenaida macroura)	0	9	6	4	3	20	4	17
Yellow-billed Cuckoo (Coccyzus americanus)	0	0	0	0	1	0	0	2
Whip-poor-Will (Caprigmulus vociferus)	0	0	0	0	0	0	0	0
Ruby-throated Hummingbird (Archilochus colubris)	0	0	0	0	1	0	0	0
Red-headed Woodpecker (Melanerpes erythrocephalus)	0	0	0	0	0	0	0	0
Red-bellied Woodpecker (Melanerpes carolinus)	0	0	0	0	0	0	0	0
Downy Woodpecker (Picoides pubescens)	0	3	0	0	7	4	2	3
Hairy Woodpecker (Picoides villosus)	0	0	0	0	0	1	0	0
Pileated Woodpecker (Dryocopus pileatus)	0	0	0	0	0	0	0	0
Northern Flicker (Colaptes auratus)	0	0	0	1	2	1	0	3
Eastern Wood-Peewee (Contopus virens)	1	1	0	2	0	3	0	0
Acadian Flycatcher (Empidonax virescens)	0	0	0	0	0	2	0	0
Great-crested Flycatcher (Myiarchus crinitus)	0	0	0	0	0	0	0	0
Eastern Kingbird (Tyrannus tyrannus)	3	3	2	4	7	3	6	7
Purple Martin (Progne subis)	4	0	3	0	1	0	0	0
Barn Swallow (Hirundo rustica)	34	17	12	8	0	4	0	0
Chimney Swift (Chaetura pelagica)	66	59	11	12	1	0	0	0
Blue Jay (Cyanocitta cristata)	0	0	0	0	1	0	2	2
American Crow (Corvus brachyrhynchos)	0	0	2	1	3	0	0	0

Fish Crow (Corvus ossifraus)	0	3	0	0	0	2	1	0
Carolina Chickadee (Parus carolinensis)	0	2	2	6	5	12	2	6
Tufted Titmouse (Parus bicolor)	0	5	0	3	0	4	0	2
White-breasted Nuthatch (Sitta carolinensis)	0	0	0	0	0	1	0	0
Brown-headed Nuthatch (Sitta pusilla)	0	0	0	0	0	0	0	0
Carolina Wren (Thryothrus ludovicianus)	6	14	4	17	9	25	13	17
Blue-gray Gnatcatcher (Poliptila caerulea)	0	2	1	3	5	0	4	7
Eastern Bluebird (Sialia sialis)	5	14	3	6	2	9	0	1
Wood Thrush (Hylocichla mustelina)	0	0	0	0	0	0	0	0
American Robin (Turdus migratorius)	0	0	0	0	0	0	0	0
Gray Catbird (Dumetella carolinensis)	12	4	27	29	33	26	24	17
Northern Mockingbird (Mimus polyglottus)	0	3	0	0	0	0	0	0
Brown Thrasher (Toxostoma rufum)	6	1	4	2	4	0	1	1
European Starling (Sturnus vulgaris)	0	0	0	0	0	0	0	0
White-eyed Vireo (Vireo griseus)	1	2	0	0	22	18	31	24
Yellow-throated Vireo (Vireo flavifrons)	0	0	0	0	0	0	0	0
Red-eyed Vireo (Vireo olivaceus)	0	0	0	0	0	0	0	0
Black-and-White Warbler (Mniotilta varia)	0	0	0	0	0	0	0	0
Black-throated Green Warbler (Dendroica virens)	0	0	0	0	0	0	0	0
Yellow-throated Warbler (Dendroica dominica)	0	0	0	0	0	0	0	0
Prairie Warbler (Dendroica discolor)	2	1	18	31	27	47	22	20
Pine Warbler (Dendroica pinus)	0	0	0	0	0	2	0	0
Hooded Warbler (Wilsonia citrina)	0	0	0	0	0	1	0	0
Worm-eating Warbler (Helmitheros vermivorus)	0	0	0	0	0	0	0	0
Swainson's Warbler (Limnothlypis swainsonii)	0	0	0	0	0	0	0	0
Ovenbird (Seirus aurocapillus)	0	0	0	0	0	1	0	1
Common Yellowthroat (Geothylpis trichas)	20	58	58	77	86	109	80	74
Yellow-breasted Chat (Icteria virens)	10	23	22	18	56	121	42	66
American Redstart (Setophaga ruticilla)	0	0	0	0	0	0	0	0
Prothonotary Warbler (Protonotaria citrea)	0	0	0	0	0	0	0	0

Blue Grosbeak (Guiraca caerulea)	6	17	12	19	11	15	12	10
Northern Cardinal (Cardinalis cardinalis)	0	5	1	3	3	13	7	6
Indigo Bunting (Passerina cyanea)	11	70	33	45	18	31	15	27
Eastern Towhee (Piplio erythrophthalmus)	14	66	36	88	47	106	35	110
Field Sparrow (Spizella pusilla)	4	19	7	23	9	22	12	15
Chipping Sparrow (Spizella passerina)	0	1	0	0	0	0	0	0
Eastern Meadowlark (Sturnella magna)	0	3	1	4	0	2	0	0
Common Grackle (Quiscalus quiscula)	0	0	0	0	0	2	0	0
Brown-headed Cowbird (Molothrus ater)	9	13	3	8	28	25	16	13
Orchard Oriole (Icterus spurius)	1	0	0	0	0	0	0	0
Scarlet Tanager (Piranga olivacea)	0	0	0	0	0	0	0	0
Summer Tanager (Piranga rubra)	0	1	2	0	2	0	1	2
American Goldfinch (Carduelis tristis)	1	6	7	10	26	17	12	31

Tufted Titmouse (Parus bicolor)	3	13	1	5	4	15	10	8
White-breasted Nuthatch (Sitta carolinensis)	0	0	0	0	0	0	0	0
Brown-headed Nuthatch (Sitta pusilla)	0	0	0	0	0	0	0	0
Carolina Wren (Thryothrus ludovicianus)	25	22	32	19	13	54	24	31
Blue-gray Gnatcatcher (Poliptila caerulea)	2	0	4	1	2	0	5	5
Eastern Bluebird (Sialia sialis)	1	1	0	0	0	0	0	0
Wood Thrush (Hylocichla mustelina)	0	0	0	0	8	19	6	25
American Robin (Turdus migratorius)	0	0	0	0	0	1	0	0
Gray Catbird (Dumetella carolinensis)	41	25	32	21	22	11	35	10
Northern Mockingbird (Mimus polyglottus)	0	0	0	0	0	0	0	0
Brown Thrasher (Toxostoma rufum)	0	0	0	0	0	1	1	0
European Starling (Sturnus vulgaris)	0	0	0	0	0	0	0	0
White-eyed Vireo (Vireo griseus)	34	21	27	15	21	22	17	12
Yellow-throated Vireo (Vireo flavifrons)	0	0	0	0	0	0	0	0
Red-eyed Vireo (Vireo olivaceus)	1	1	0	0	0	3	0	0
Black-and-White Warbler (Mniotilta varia)	0	0	0	0	1	0	3	2
Black-throated Green Warbler (Dendroica virens)	0	0	0	0	0	0	0	0
Yellow-throated Warbler (Dendroica dominica)	0	0	0	0	0	0	0	0
Prairie Warbler (Dendroica discolor)	51	60	42	53	19	27	9	13
Pine Warbler (Dendroica pinus)	6	5	1	2	2	2	0	3
Hooded Warbler (Wilsonia citrina)	0	1	0	0	2	6	1	2
Worm-eating Warbler (Helmitheros vermivorus)	0	0	0	1	2	1	4	5
Swainson's Warbler (Limnothlypis swainsonii)	0	0	0	0	0	0	0	0
Ovenbird (Seirus aurocapillus)	2	2	0	3	1	6	1	6
Common Yellowthroat (Geothylpis trichas)	112	113	106	111	81	87	72	71
Yellow-breasted Chat (Icteria virens)	44	72	32	54	3	11	1	7
American Redstart (Setophaga ruticilla)	0	0	0	0	0	0	0	0
Prothonotary Warbler (Protonotaria citrea)	0	0	0	0	0	0	0	0
Blue Grosbeak (Guiraca caerulea)	0	0	1	0	0	0	0	0
Northern Cardinal (Cardinalis cardinalis)	6	16	11	4	9	21	2	12

Appendix II continued.

	5th growing season		6th growing season		10th growing season		11th growing season	
Species	< 50m	>50m	< 50m	> 50m	< 50m	> 50m	< 50m	> 50m
Green-backed Heron (Butroides striatus)	0	0	0	0	0	0	0	0
Common Bobwhite (Colinus Virginianus)	2	20	5	22	0	5	2	7
Turkey Vulture (Cathartes aura)	0	0	0	0	0	0	0	0
Red-shouldered Hawk (Buteo lineatus)	0	0	0	0	0	0	0	0
Killdeer (Charadrius vociferus)	0	0	0	0	0	0	0	0
Mourning Dove (Zenaida macroura)	1	24	4	22	0	8	2	4
Yellow-billed Cuckoo (Coccyzus americanus)	3	4	5	7	2	7	7	11
Whip-poor-Will (Caprigmulus vociferus)	0	0	0	0	0	1	0	0
Ruby-throated Hummingbird (Archilochus colubris)	0	0	0	0	1	0	0	0
Red-headed Woodpecker (Melanerpes erythrocephalus)	0	0	0	0	0	0	0	0
Red-bellied Woodpecker (Melanerpes carolinus)	0	5	0	0	0	0	0	0
Downy Woodpecker (Picoides pubescens)	8	7	3	2	4	3	7	4
Hairy Woodpecker (Picoides villosus)	0	0	0	1	1	0	0	0
Pileated Woodpecker (Dryocopus pileatus)	0	3	0	0	0	0	0	0
Northern Flicker (Colaptes auratus)	2	2	0	3	2	7	3	2
Eastern Wood-Peewee (Contopus virens)	2	3	0	0	0	0	0	0
Acadian Flycatcher (Empidonax virescens)	4	4	0	0	4	2	5	2
Great-crested Flycatcher (Myiarchus crinitus)	2	1	0	0	0	2	0	3
Eastern Kingbird (Tyrannus tyrannus)	0	0	0	0	0	0	0	0
Purple Martin (Progne subis)	0	0	0	0	0	0	0	0
Barn Swallow (Hirundo rustica)	0	0	0	0	0	0	0	0
Chimney Swift (Chaetura pelagica)	0	0	0	0	2	0	0	0
Blue Jay (Cyanocitta cristata)	1	1	1	4	5	12	6	4
American Crow (Corvus brachyrhynchos)	0	1	7	2	0	0	0	6
Fish Crow (Corvus ossifraus)	0	0	0	0	0	0	0	0
Carolina Chickadee (Parus carolinensis)	29	6	12	16	12	12	17	15

Tufted Titmouse (Parus bicolor)	3	13	1	5	4	15	10	8
White-breasted Nuthatch (Sitta carolinensis)	0	0	0	0	0	0	0	0
Brown-headed Nuthatch (Sitta pusilla)	0	0	0	0	0	0	0	0
Carolina Wren (Thryothrus ludovicianus)	25	22	32	19	13	54	24	31
Blue-gray Gnatcatcher (Poliptila caerulea)	2	0	4	1	2	0	5	5
Eastern Bluebird (Sialia sialis)	1	1	0	0	0	0	0	0
Wood Thrush (Hylocichla mustelina)	0	0	0	0	8	19	6	25
American Robin (Turdus migratorius)	0	0	0	0	0	1	0	0
Gray Catbird (Dumetella carolinensis)	41	25	32	21	22	11	35	10
Northern Mockingbird (Mimus polyglottus)	0	0	0	0	0	0	0	0
Brown Thrasher (Toxostoma rufum)	0	0	0	0	0	1	1	0
European Starling (Sturnus vulgaris)	0	0	0	0	0	0	0	0
White-eyed Vireo (Vireo griseus)	34	21	27	15	21	22	17	12
Yellow-throated Vireo (Vireo flavifrons)	0	0	0	0	0	0	0	0
Red-eyed Vireo (Vireo olivaceus)	1	1	0	0	0	3	0	0
Black-and-White Warbler (Mniotilta varia)	0	0	0	0	1	0	3	2
Black-throated Green Warbler (Dendroica virens)	0	0	0	0	0	0	0	0
Yellow-throated Warbler (Dendroica dominica)	0	0	0	0	0	0	0	0
Prairie Warbler (Dendroica discolor)	51	60	42	53	19	27	9	13
Pine Warbler (Dendroica pinus)	6	5	1	2	2	2	0	3
Hooded Warbler (Wilsonia citrina)	0	1	0	0	2	6	1	2
Worm-eating Warbler (Helmitheros vermivorus)	0	0	0	1	2	1	4	5
Swainson's Warbler (Limnothlypis swainsonii)	0	0	0	0	0	0	0	0
Ovenbird (Seirus aurocapillus)	2	2	0	3	1	6	1	6
Common Yellowthroat (Geothylpis trichas)	112	113	106	111	81	87	72	71
Yellow-breasted Chat (Icteria virens)	44	72	32	54	3	11	1	7
American Redstart (Setophaga ruticilla)	0	0	0	0	0	0	0	0
Prothonotary Warbler (Protonotaria citrea)	0	0	0	0	0	0	0	0
Blue Grosbeak (Guiraca caerulea)	0	0	1	0	0	0	0	0
Northern Cardinal (Cardinalis cardinalis)	6	16	11	4	9	21	2	12

Indigo Bunting (Passerina cyanea)	1	3	0	4	4	2	2	2
Eastern Towhee (Piplio erythrophthalmus)	73	93	81	73	27	78	39	69
Field Sparrow (Spizella pusilla)	5	11	2	7	0	1	0	0
Chipping Sparrow (Spizella passerina)	0	0	0	0	1	0	1	0
Eastern Meadowlark (Sturnella magna)	0	0	0	0	0	0	0	0
Common Grackle (Quiscalus quiscula)	0	0	0	0	1	0	0	3
Brown-headed Cowbird (Molothrus ater)	29	20	14	13	19	14	11	5
Orchard Oriole (Icterus spurius)	0	0	0	0	0	0	0	0
Scarlet Tanager (Piranga olivacea)	0	0	0	0	0	0	0	0
Summer Tanager (Piranga rubra)	0	0	1	1	1	1	1	4
American Goldfinch (Carduelis tristis)	6	4	3	4	1	0	0	0

Appendix III. Bird species abundance in commercially thinned stands. Numbers indicate the cumulative detections within and beyond the 50m survey plot radius for three survey visits.

	1 year/2nd thin		2 year/2nd thin		3 year/2nd thin		4 year/2nd thin		5 year/2nd thin		6 year/2nd thin	
Species	<50m	>50m	<50m	>50m	<50m	>50m	<50m	>50m	<50m	>50m	<50m	>50m
Green-backed Heron (Butroides striatus)	0	0	0	0	0	0	0	0	0	0	0	0
Common Bobwhite (Colinus Virginianus)	0	4	3	5	0	1	2	4	0	2	1	2
Turkey Vulture (Cathartes aura)	0	0	0	0	0	0	0	0	0	0	0	0
Red-shouldered Hawk (Buteo lineatus)	0	0	0	0	2	2	0	0	0	0	0	0
Killdeer (Charadrius vociferus)	0	0	0	0	0	0	0	0	0	0	0	0
Mourning Dove (Zenaida macroura)	3	11	2	9	1	20	5	9	0	16	4	11
Yellow-billed Cuckoo (Coccyzus americanus)	6	13	10	5	4	13	10	15	3	10	6	14
Whip-poor-Will (Caprigmulus vociferus)	0	0	0	0	0	0	0	0	0	0	0	0
Ruby-throated Hummingbird (Archilochus colubris)	1	0	0	0	1	0	3	0	0	0	0	0
Red-headed Woodpecker (Melanerpes erythrocephalus)	0	0	0	0	0	0	0	0	0	0	0	0
Red-bellied Woodpecker (Melanerpes carolinus)	2	0	2	1	3	4	1	2	2	4	1	5
Downy Woodpecker (Picoides pubescens)	12	10	13	5	13	5	15	11	17	11	11	13
Hairy Woodpecker (Picoides villosus)	1	3	0	1	4	2	2	4	4	1	2	3
Pileated Woodpecker (Dryocopus pileatus)	1	3	2	1	4	3	2	1	0	2	2	4
Northern Flicker (Colaptes auratus)	2	3	2	0	6	4	8	1	4	6	2	9
Eastern Wood-Peewee (Contopus virens)	6	18	3	9	5	10	8	12	7	23	11	13
Acadian Flycatcher (Empidonax virescens)	50	28	53	35	44	38	61	32	49	33	57	41
Great-crested Flycatcher (Myiarchus crinitus)	17	30	18	12	8	13	15	19	14	13	19	12
Eastern Kingbird (Tyrannus tyrannus)	0	0	0	0	0	0	0	0	0	0	0	0
Purple Martin (Progne subis)	0	0	0	0	0	0	0	0	0	0	0	0
Barn Swallow (Hirundo rustica)	0	0	0	0	0	0	0	0	0	0	0	0
Chimney Swift (Chaetura pelagica)	0	0	0	0	0	0	0	0	0	0	0	0
Blue Jay (Cyanocitta cristata)	1	0	5	1	1	4	2	4	0	3	1	0
American Crow (Corvus brachyrhynchos)	0	2	3	2	0	1	3	2	0	0	2	0
Fish Crow (Corvus ossifraus)	2	0	0	0	0	0	0	2	1	1	0	0

Carolina Chickadee (Parus carolinensis)	53	9	41	17	54	12	41	24	43	18	32	29
Tufted Titmouse (Parus bicolor)	13	32	22	12	15	29	14	18	15	29	12	37
White-breasted Nuthatch (Sitta carolinensis)	0	0	0	0	0	0	0	0	0	0	0	0
Brown-headed Nuthatch (Sitta pusilla)	13	7	12	2	12	1	5	2	9	2	3	0
Carolina Wren (Thryothrus ludovicianus)	34	67	44	51	28	62	24	49	31	64	42	70
Blue-gray Gnatcatcher (Poliptila caerulea)	51	5	56	2	40	6	55	2	62	8	59	3
Eastern Bluebird (Sialia sialis)	3	0	0	0	0	0	0	0	0	0	0	0
Wood Thrush (Hylocichla mustelina)	8	48	7	21	7	40	10	55	4	41	17	52
American Robin (Turdus migratorius)	0	0	0	0	0	0	0	0	0	0	0	0
Gray Catbird (Dumetella carolinensis)	49	30	33	22	32	23	40	48	26	19	39	21
Northern Mockingbird (Mimus polyglottus)	0	0	0	0	0	0	0	0	0	0	0	0
Brown Thrasher (Toxostoma rufum)	0	0	0	0	0	0	0	0	0	0	0	0
European Starling (Sturnus vulgaris)	0	0	0	0	0	0	0	0	0	0	0	0
White-eyed Vireo (Vireo griseus)	30	41	39	23	40	35	31	43	34	39	24	32
Yellow-throated Vireo (Vireo flavifrons)	0	6	1	0	1	5	0	2	1	1	0	3
Red-eyed Vireo (Vireo olivaceus)	6	4	5	12	7	12	8	15	6	8	10	13
Black-and-White Warbler (Mniotilta varia)	2	2	4	7	7	0	6	7	3	1	5	5
Black-throated Green Warbler (Dendroica virens)	0	0	0	0	0	0	0	0	0	0	0	0
Yellow-throated Warbler (Dendroica dominica)	2	4	5	9	2	5	5	9	1	7	2	6
Prairie Warbler (Dendroica discolor)	1	4	4	7	0	1	3	1	0	3	1	0
Pine Warbler (Dendroica pinus)	25	32	37	22	19	37	25	45	34	42	43	52
Hooded Warbler (Wilsonia citrina)	8	16	11	7	11	23	21	32	10	23	15	31
Worm-eating Warbler (Helmitheros vermivorus)	18	11	31	22	16	4	39	23	9	9	32	22
Swainson's Warbler (Limnothlypis swainsonii)	0	0	0	0	2	2	0	2	1	0	4	1
Ovenbird (Seirus aurocapillus)	38	54	44	47	24	38	41	50	36	55	48	39
Common Yellowthroat (Geothylpis trichas)	94	70	77	81	60	61	107	91	62	70	67	61
Yellow-breasted Chat (Icteria virens)	25	36	17	24	8	17	11	15	8	21	16	29
American Redstart (Setophaga ruticilla)	1	0	0	0	0	0	0	1	0	0	2	2
Prothonotary Warbler (Protonotaria citrea)	0	0	0	2	0	0	1	1	0	0	0	0
Blue Grosbeak (Guiraca caerulea)	0	3	0	0	0	0	0	0	0	0	0	0

Northern Cardinal (Cardinalis cardinalis)	12	15	16	27	14	25	9	18	18	17	27	29
Indigo Bunting (Passerina cyanea)	3	3	2	6	0	0	2	7	0	0	0	0
Eastern Towhee (Piplio erythrophthalmus)	52	81	55	67	56	77	48	75	47	79	52	71
Field Sparrow (Spizella pusilla)	0	0	0	0	0	0	0	0	0	0	0	0
Chipping Sparrow (Spizella passerina)	0	0	0	0	0	0	0	0	0	0	0	0
Eastern Meadowlark (Sturnella magna)	0	0	0	0	0	0	0	0	0	0	0	0
Common Grackle (Quiscalus quiscula)	0	0	0	0	0	0	0	0	0	0	0	0
Brown-headed Cowbird (Molothrus ater)	25	17	17	10	32	15	14	21	32	24	45	37
Orchard Oriole (Icterus spurius)	0	0	0	0	0	0	0	0	0	0	0	0
Scarlet Tanager (Piranga olivacea)	0	0	0	0	0	0	0	0	1	1	3	3
Summer Tanager (Piranga rubra)	3	14	5	11	4	16	9	11	3	11	5	18
American Goldfinch (Carduelis tristis)	0	0	2	2	2	0	0	0	2	0	0	1

Appendix III. Bird species abundance in commercially thinned stands. Numbers indicate the cumulative detections within and beyond the 50m survey plot radius for three survey visits.

	1 year after thin		2 years after thin		3 year after thin		4 years after thin		5 years after thin		6 year after thin	
Species	<50m	>50m	<50m	>50m	<50m	>50m	<50m	>50m	<50m	>50m	<50m	>50m
Green-backed Heron (Butroides striatus)	0	0	1	0	0	0	0	0	0	0	0	0
Common Bobwhite (Colinus Virginianus)	1	18	5	12	2	10	3	7	0	0	5	1
Turkey Vulture (Cathartes aura)	0	0	0	0	0	0	0	0	0	0	0	0
Red-shouldered Hawk (Buteo lineatus)	1	0	0	0	0	0	0	0	0	0	0	0
Killdeer (Charadrius vociferus)	0	0	0	0	0	0	0	0	0	0	0	0
Mourning Dove (Zenaida macroura)	0	6	3	12	0	8	3	6	1	17	5	11
Yellow-billed Cuckoo (Coccyzus americanus)	1	5	2	7	10	13	5	10	11	11	7	5
Whip-poor-Will (Caprigmulus vociferus)	0	0	0	0	0	0	0	0	0	0	0	0
Ruby-throated Hummingbird (Archilochus colubris)	2	0	0	0	0	0	2	0	1	0	0	0
Red-headed Woodpecker (Melanerpes erythrocephalus)	0	0	0	0	0	0	0	0	1	3	0	0
Red-bellied Woodpecker (Melanerpes carolinus)	0	3	1	2	6	4	3	3	0	4	1	2
Downy Woodpecker (Picoides pubescens)	9	7	11	4	22	8	12	5	9	5	11	5
Hairy Woodpecker (Picoides villosus)	2	2	1	1	0	0	1	1	2	0	2	1
Pileated Woodpecker (Dryocopus pileatus)	0	2	1	2	1	3	1	1	4	2	2	3
Northern Flicker (Colaptes auratus)	0	8	3	3	1	1	2	2	1	6	2	3
Eastern Wood-Peewee (Contopus virens)	4	13	6	10	10	18	6	13	9	15	5	17
Acadian Flycatcher (Empidonax virescens)	34	36	32	21	55	33	50	24	27	42	54	213
Great-crested Flycatcher (Myiarchus crinitus)	4	20	9	14	11	18	17	12	5	6	12	14
Eastern Kingbird (Tyrannus tyrannus)	0	0	0	0	0	0	0	0	0	0	0	0
Purple Martin (Progne subis)	0	0	0	0	0	0	0	0	0	0	0	0
Barn Swallow (Hirundo rustica)	0	0	0	0	0	0	0	0	0	0	0	0
Chimney Swift (Chaetura pelagica)	0	0	0	0	0	0	0	0	0	0	0	0
Blue Jay (Cyanocitta cristata)	1	3	1	2	3	2	5	3	1	5	2	1
American Crow (Corvus brachyrhynchos)	2	6	7	2	0	4	4	5	0	0	3	0
Fish Crow (Corvus ossifraus)	0	4	0	0	0	0	0	0	0	1	0	2

Carolina Chickadee (Parus carolinensis)	41	21	29	31	37	27	41	5	52	4	37	22
Tufted Titmouse (Parus bicolor)	22	25	12	17	13	25	17	24	29	23	19	21
White-breasted Nuthatch (Sitta carolinensis)	0	0	0	0	1	0	0	0	0	1	0	0
Brown-headed Nuthatch (Sitta pusilla)	14	4	11	2	4	0	5	2	2	0	1	0
Carolina Wren (Thryothrus ludovicianus)	31	58	21	33	61	66	22	46	42	66	33	57
Blue-gray Gnatcatcher (Poliptila caerulea)	50	0	61	1	51	3	58	2	49	3	54	7
Eastern Bluebird (Sialia sialis)	0	3	0	0	0	0	0	0	3	0	0	0
Wood Thrush (Hylocichla mustelina)	0	3	4	7	2	14	10	12	7	42	10	33
American Robin (Turdus migratorius)	0	1	0	0	0	0	0	0	0	0	0	0
Gray Catbird (Dumetella carolinensis)	26	19	31	12	23	12	33	35	40	22	39	379
Northern Mockingbird (Mimus polyglottus)	0	0	0	0	0	0	0	0	0	0	0	0
Brown Thrasher (Toxostoma rufum)	0	0	0	0	0	0	0	0	0	0	0	0
European Starling (Sturnus vulgaris)	0	4	0	0	0	1	0	0	0	0	0	0
White-eyed Vireo (Vireo griseus)	26	12	17	19	31	41	36	44	33	31	41	36
Yellow-throated Vireo (Vireo flavifrons)	0	0	0	1	1	1	0	2	0	0	0	0
Red-eyed Vireo (Vireo olivaceus)	0	1	2	5	3	0	4	7	3	4	5	11
Black-and-White Warbler (Mniotilta varia)	2	0	1	3	0	0	5	9	3	1	6	4
Black-throated Green Warbler (Dendroica virens)	0	0	0	0	0	0	0	0	0	0	0	0
Yellow-throated Warbler (Dendroica dominica)	2	1	5	6	2	4	2	5	0	0	2	3
Prairie Warbler (Dendroica discolor)	4	1	3	7	4	4	3	2	7	2	1	0
Pine Warbler (Dendroica pinus)	13	25	11	17	24	20	21	17	13	14	21	23
Hooded Warbler (Wilsonia citrina)	0	0	4	5	5	2	11	12	12	8	15	15
Worm-eating Warbler (Helmitheros vermivorus)	2	2	12	16	11	5	29	24	6	3	24	16
Swainson's Warbler (Limnothlypis swainsonii)	0	0	0	0	0	0	0	0	2	0	0	0
Ovenbird (Seirus aurocapillus)	8	19	17	12	31	42	35	41	29	51	41	39
Common Yellowthroat (Geothylpis trichas)	77	70	70	63	65	73	79	83	80	63	71	81
Yellow-breasted Chat (Icteria virens)	17	29	15	33	1	29	4	21	5	13	13	9
American Redstart (Setophaga ruticilla)	4	1	0	0	0	0	0	0	0	0	0	1
Prothonotary Warbler (Protonotaria citrea)	0	0	1	0	1	2	0	0	0	1	0	0
Blue Grosbeak (Guiraca caerulea)	0	1	0	2	0	1	0	0	0	0	0	0

Northern Cardinal (Cardinalis cardinalis)	10	11	12	17	23	22	20	31	14	19	12	24
Indigo Bunting (Passerina cyanea)	10	21	11	15	6	4	2	7	1	0	2	0
Eastern Towhee (Piplio erythrophthalmus)	57	59	63	52	53	68	56	63	73	63	52	61
Field Sparrow (Spizella pusilla)	0	0	0	0	0	0	0	0	0	0	0	0
Chipping Sparrow (Spizella passerina)	0	0	0	0	0	0	0	0	0	0	0	0
Eastern Meadowlark (Sturnella magna)	0	0	0	0	0	0	0	0	0	0	0	0
Common Grackle (Quiscalus quiscula)	0	0	0	0	0	0	0	0	0	0	0	0
Brown-headed Cowbird (Molothrus ater)	35	15	12	23	22	13	19	6	33	18	17	22
Orchard Oriole (Icterus spurius)	0	0	0	0	1	0	0	0	0	0	0	0
Scarlet Tanager (Piranga olivacea)	0	0	0	0	0	0	0	0	0	0	0	0
Summer Tanager (Piranga rubra)	6	12	5	8	3	9	10	14	1	3	5	9
American Goldfinch (Carduelis tristis)	0	2	2	2	1	0	0	0	2	0	0	4

Appendix IV. Abundance of bird species detected in hardwood stands. Numbers indicate cumulative totals within and beyond the 50m survey plot radius for three survey visits.

Species	< 50m	> 50m
Common Bobwhite (*Colinus Virginianus*)	1	2
Mourning Dove (*Zenaida macroura*)	2	38
Yellow-billed Cuckoo (*Cocczyus americanus*)	5	20
Ruby-throated Hummingbird (*Archilochus colubirs*)	2	0
Red-bellied Woodpecker (*Melanerpes carolinus*)	5	4
Downy Woodpecker (*Picoides pubescens*)	23	10
Hairy Woodpecker (*P. villosus*)	0	1
Pileated Woodpecker (*Dryocopus pileatus*)	1	4
Northern Flicker (*Colaptes auratus*)	1	10
Eastern Wood-Peewee (*Contopus virens*)	8	25
Acadian Flycatcher (*Empidonax virescens*)	67	37
Great-crested Flycatcher (*Myiarchus crinitus*)	17	22
Blue Jay (*Cyanocitta cristata*)	0	4
Carolina Chickadee (*Parus carolinensis*)	30	10
Tufted Titmouse (*P. bicolor*)	16	19
White-breasted Nuthatch (*Sitta carolinensis*)	3	2
Carolina Wren (*Thryothorus ludovicianus*)	55	73
Blue-gray Gnatcatcher (*Polioptila caerulea*)	22	0
Wood Thrush (*Hylocichla mustelina*)	12	48
Gray Catbird (*Dumetella carolinensis*)	1	0
White-eyed Vireo (*Vireo griseus*)	14	12
Yellow-throated Vireo (*V. flavifrons*)	4	0
Red-eyed Vireo (*V. olivaceus*)	21	21
Prothonotary Warbler (*Protonotaria citrea*)	40	43
Black-and-White Warbler (*Mniotilta varia*)	2	1
Black-throated Green Warbler (*Dendroica virens*)	1	0
Prairie Warbler (*D. discolor*)	0	1
Hooded Warbler (*Wilsonia pusilla*)	10	6
Worm-Eating Warbler (*Helmitheros vermivorus*)	2	0
Swainson's Warbler (*Limnothylpis swainsonii*)	12	4
Ovenbird (*Seirus aurocapillus*)	20	19
Common Yellowthroat (*Geothylpis trichas*)	7	10
Yellow-Breasted Chat (*Icteria virens*)	0	1
American Redstart (*Setophaga ruticilla*)	5	1
Indigo Bunting (*Passerina cyanea*)	1	1
Northern Cardinal (*Cardinalis cardinalis*)	15	20
Eastern Towhee (*Piplio erythrophthalmus*)	2	9
Brown-headed Cowbird (*Molothrus ater*)	11	4
Orchard Oriole (*Icterus spurius*)	1	0
Scarlet Tanager (*Piranga olivacea*)	1	1

Appendix V. Abundance of bird species detected within stand #51241 during 1997 surveys. The stand area is partitioned into five units. Units are numbered 1 through 5 in a west to east orientation and each unit contains two bird survey plots (one edge and one interior plot). Numbers for each species are based on the survey with the highest total detections within the 50m survey plot radius. Scientific names for species are given in Appendix IV.

	Unit 1		Unit 2		Unit 3		Unit 4		Unit 5	
Species	edge	int.	edge	int.	edge	int.	edge	int.	edge	int.
Mourning Dove	0	0	0	1	0	0	0	0	0	0
Yellow-billed Cuckoo	0	0	1	0	0	0	0	0	0	0
Ruby-th. Hummingbird	0	0	1	0	0	0	0	0	0	0
Red-bellied Woodpecker	1	0	0	1	0	0	0	0	0	0
Downy Woodpecker	0	1	0	2	1	1	0	0	0	0
Pileated Woodpecker	0	0	0	0	0	1	0	0	0	0
Northern Flicker	1	0	0	0	0	0	0	0	0	0
Eastern Wood-Pewee	1	1	1	1	0	1	1	0	0	0
Acadian Flycatcher	3	2	2	2	2	2	1	2	2	2
Great-crested Flycatcher	1	0	0	1	2	2	1	0	0	1
Carolina Chickadee	1	0	1	2	1	3	0	2	1	4
Tufted Titmouse	1	0	0	0	0	2	0	0	3	1
White-breasted Nuthatch	0	0	0	0	0	1	0	0	0	0
Carolina Wren	2	1	2	2	2	3	3	2	1	2
Blue-gray Gnatcatcher	0	1	1	1	0	2	0	1	1	0
Wood Thrush	0	1	1	1	0	1	0	2	0	0
Gray Catbird	0	0	0	0	0	0	0	0	1	0
White-eyed Vireo	2	1	0	0	0	0	1	0	1	0
Yellow-throated Vireo	0	0	1	0	1	0	0	0	0	0
Red-eyed Vireo	0	0	1	1	2	1	1	2	0	1
Prothonotary Warbler	1	0	1	2	1	1	2	1	2	2
Black-and White Warbler	0	1	0	1	0	0	0	0	0	0
Hooded Warbler	0	0	1	1	0	0	0	0	0	2
Worm-eating Warbler	0	0	1	0	0	0	0	0	0	0
Swainson's Warbler	0	1	1	0	1	0	0	1	1	1
Ovenbird	2	0	2	0	1	2	1	1	1	1
Common Yellowthroat	1	0	2	0	1	0	1	1	1	1
Indigo Bunting	0	0	0	0	0	0	0	0	1	0
Scarlet Tanager	0	0	0	0	1	0	0	0	0	0

Appendix V continued. Abundance of bird species detected within stand #51241 during 1998 surveys. The stand area is partitioned into five units. Units are numbered 1 through 5 in a west to east orientation and each unit contains two bird survey plots (one edge and one interior plot). Numbers for each species are based on the survey with the highest total detections within the 50m survey plot radius. Scientific names for species are given in Appendix IV.

	Unit 1		Unit 2		Unit 3		Unit 4		Unit 5	
Species	edge	int.	edge	int.	edge	int.	edge	int.	edge	int.
Mourning Dove	0	0	3	0	0	0	0	0	0	0
Yellow-billed Cuckoo	0	1	0	0	0	0	0	0	1	1
Ruby-th. Hummingbird	0	0	0	0	0	0	0	0	0	0
Red-bellied Woodpecker	0	0	0	1	0	1	0	1	1	1
Downy Woodpecker	2	0	0	0	1	0	2	0	1	0
Pileated Woodpecker	0	1	0	0	0	1	0	1	1	1
Northern Flicker	0	0	0	1	0	1	0	0	0	0
Eastern Wood-Pewee	0	0	1	0	1	0	0	0	1	0
Acadian Flycatcher	1	1	1	1	2	2	1	1	2	1
Great-crested Flycatcher	1	0	0	0	1	0	2	0	0	0
Carolina Chickadee	0	0	1	1	3	2	1	0	1	2
Tufted Titmouse	0	2	0	0	0	0	0	1	0	1
White-breasted Nuthatch	2	0	0	0	0	0	0	0	0	0
Carolina Wren	1	2	2	1	1	2	2	1	0	1
Blue-gray Gnatcatcher	1	1	4	2	2	1	0	1	2	1
Wood Thrush	0	0	2	1	0	2	2	1	2	1
Gray Catbird	0	0	0	0	0	0	0	0	0	0
White-eyed Vireo	0	1	2	0	1	1	2	1	0	0
Yellow-throated Vireo	1	1	0	1	0	0	0	0	0	0
Red-eyed Vireo	1	1	2	1	1	1	0	1	1	0
Prothonotary Warbler	2	2	3	1	1	2	2	2	2	2
Black-and White Warbler	0	0	1	0	0	0	0	0	0	0
Hooded Warbler	0	1	0	1	0	1	0	0	0	1
Worm-eating Warbler	0	0	1	0	0	0	1	0	0	0
Swainson's Warbler	0	1	1	0	1	0	0	1	1	1
Ovenbird	1	2	2	0	1	2	2	2	0	1
Common Yellowthroat	0	0	1	0	0	0	1	1	0	0
Indigo Bunting	0	0	0	0	0	0	0	0	0	0
Scarlet Tanager	0	0	0	0	0	1	0	1	0	0
Summer Tanager	1	0	1	0	0	0	0	0	0	1

Appendix VI. Abundance of bird species detected in "mineral" and "organic" soil stands. Numbers for each species are cumulative totals for two survey years (six survey visits). Scientific names are given in Appendix II and III.

	Mineral		Organic	
Species	< 50m	> 50m	< 50m	> 50m
Green-backed Heron	0	0	3	2
Common Bobwhite	2	2	3	5
Mourning Dove	1	7	2	11
Yellow-billed Cuckoo	6	7	9	3
Red-bellied Woodpecker	0	0	0	1
Downy Woodpecker	7	5	9	13
Hairy Woodpecker	2	1	0	0
Acadian Flycatcher	57	15	35	24
Great-crested Flycatcher	5	8	7	9
Blue Jay	4	5	0	0
American Crow	1	2	2	1
Fish Crow	0	3	0	3
Carolina Wren	19	45	35	30
Blue-gray Gnatcatcher	2	10	20	0
Wood Thrush	17	70	0	1
American Robin	0	0	1	0
Gray Catbird	12	9	18	5
White-eyed Vireo	9	9	3	12
Prairie Warbler	7	4	13	15
Pine Warbler	21	9	13	12
Hooded Warbler	3	1	0	0
Worm-eating Warbler	1	1	0	2
Ovenbird	33	51	5	16
Common Yellowthroat	24	27	24	20
Yellow-breasted Chat	0	1	9	20
Northern Cardinal	7	21	7	21
Indigo Bunting	0	0	7	23
Eastern Towhee	21	19	23	19
Field Sparrow	0	0	1	2
Brown-headed Cowbird	17	6	22	10
American Goldfinch	4	6	0	3