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Diversity and abundance of migratory landbirds on Little Creek Naval Amphibious Base

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Final Report
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EXECUTIVE SUMMARY

Reported declines of neotropical migratory songbird populations have drawn the attention of the scientific community and the general public. Much of this concern has been focused on the loss of breeding and winter habitat. However, each year during the spring and fall, these species migrate thousands of kilometers along major movement corridors known as flyways. In order to successfully complete migration, birds must make periodic stops in flyway habitats to replenish energy reserves. Changes in the availability of these stop-over habitats may contribute to population declines.

One of the most important migration corridors for bird species that breed throughout northeastern North America is the Atlantic Flyway. Each year millions of birds migrate along the coastal fringe and utilize habitats for refueling. Coastal habitats such as those used by migrants are experiencing some of the highest development pressures of any within North America. Because of the high concentration of military installations within the Atlantic Flyway, U.S. Department of Defense (DOD) lands represent one of the most promising opportunities to manage lands for the benefit of migrant songbirds. Through its partnership with the Partners in Flight initiative, DOD has committed to integrate neotropical migratory bird management efforts into existing natural resource management programs that are consistent with the military mission. This project was initiated to 1) investigate the diversity and abundance of migrants using forested habitats within the Little Creek Naval Amphibious Base in Norfolk, Virginia, and 2) to investigate habitat use patterns for the purpose of making management recommendations.

Birds were sampled throughout the peak of fall migration in 1995 and 1996. A banding station was operated for over 8,700 net-hours resulting in the capture of 1,600 individuals of 66

species. A total of 480 point counts were conducted during the fall of 1996, resulting in the detection of 2,800 individuals of 71 species. Finally, a total of 14,907 seconds of foraging data was collected on 3 representative species of neotropical migrants (including Black-throated-blue Warbler, Black-and-white Warbler, and Ovenbird).

Habitat type was shown to have a significant influence on the use of forest patches by neotropical migrants. Capture rates were several times higher in live oak and deciduous patches compared to pine. Similarly, survey data show that both species richness and migrant abundance were significantly higher in deciduous patches when compared to pine. In addition, both species richness and overall abundance were positively and significantly influenced by the presence of understory vegetation. For all 3 species observed, foraging success was 2-3 times higher in deciduous when compared to pine stands.

The results of this study provide insights into the habitat requirements of land bird migrants that are important to the development of appropriate land management strategies. The most significant finding in this regard is that forested habitats are not equal with respect to migration habitat.

Specific Management Recommendations include:

1. Maintain existing forested habitat.

2. Protect existing deciduous and live oak forest.

3. Promote and maintain understory vegetation.

INTRODUCTION

Over the past several years, concern for the status of many North American bird populations has been greatly heightened within both the general populous and scientific community. This concern has been fueled by the growing realization that the decline in many breeding populations is likely linked to the acceleration in land-use changes within both temperate and tropical zones (Askins et al. 1990, Hagan and Johnston 1992). This pattern is particularly evident in those species that breed in North America and migrate south to Latin America and the Caribbean. These birds are known as neotropical migrants. Fragmentation of temperate forests has been shown to negatively affect many migrant species by exposing them to higher rates of predation and brood parasitism, resulting in lower productivity and survivorship (Wilcove 1985, Small and Hunter 1988, Robinson 1992). Additionally, the restricted winter ranges of many neotropical migrants, mainly confined to eastern Central America and the Caribbean, translate into higher concentrations of birds per unit area. Thus, loss of specific tropical habitats may affect relatively large proportions of whole populations (Sherry and Holmes 1995).

The vast majority of nearctic-neotropical migratory birds are incapable of carrying enough energy to complete non-stop flights between their breeding and wintering areas (Nisbet et al. 1963, Bertold 1975, Dawson et al. 1983, Pettersson and Hasselquist 1985). To overcome this problem, migrants make periodic stops en route to replenish energy reserves. During these stop-overs, migrants encounter unfamiliar landscapes where they must maintain a positive energy balance often under severe time constraints and uncertain conditions. Migrants depend on stop-over habitats positioned along migration routes in order to successfully complete migration. As with the winter habitats, changes in the availability of habitats needed during migration may contribute to population declines (Moore and Woodrey 1995).

During the spring and fall, avian migrants may be seen throughout North America. There are however, sites that experience predictably heavy visitation. These areas often follow distinctive landforms and are referred to as flyways. One such landform is the Atlantic Coast. Birds from throughout northeastern North America migrate along a narrow coastal corridor known as the Atlantic Flyway. Stop-over concentration sites are both ecologically interesting and critical to the health of migrant populations. High densities of migrants increase the potential for direct and indirect competition and increase the relative importance of all available resources (Winker et a. 1992, Moore and Young 1991). It follows that the loss of resources through human manipulation of the environment could affect a large proportion of entire populations.

Coastal habitats such as those in the Atlantic Flyway are experiencing some of the fastest development rates of any habitats within North America. Greater than 52% of the United States human population now lives within 80 km of U.S. coastlines (Southworth 1989). Between 1950 and 1986, the number of people living along the shores of the Chesapeake Bay increased by 50%. This population is projected to increase by at least 2.6 million or an additional 20% by the year 2020. Growth within the coastal zone will likely continue for the foreseeable future, placing increasing pressures on stop-over habitats.

The U.S. Department of Defense (DOD) controls over 10 million hectares of land within the United States making it the third largest land holder in the federal government (Goodman 1996). Because of the high concentration of military installations within the mid-Atlantic region, DOD lands may represent the most promising opportunity to manage lands for populations of declining species. In 1991, DOD through each of the military services joined the Partners in Flight initiative. Through this partnership, DOD has committed to integrate neotropical migratory bird management efforts into existing natural resource and land management programs that are consistent with the military mission. However, before species may be incorporated into existing management programs it is first necessary to identify habitat requirements so that management objectives may be developed.

This project was initiated to determine the relative importance of the Little Creek Naval Amphibious Base to landbirds during fall migration. Specifically, our objectives are:

1. to investigate the diversity and abundance of migrants using forested habitats within the installation.

2. to investigate habitat use patterns for the purpose of making management recommendations.

LITTLE CREEK NAVAL AMPHIBIOUS BASE

Field work was conducted on the Little Creek Naval Amphibious Base in Norfolk, Virginia. The installation is located along the south shoreline of the Chesapeake Bay near its mouth and the Atlantic Ocean (Figure 1). Base landholdings are surrounded by dense residential development and positioned directly within the Atlantic Flyway.

The landscape within the installation is highly dissected and dominated by open lands. Open lands are maintained for training areas, parks, recreational fields, and golfing. Forest patches are scattered throughout the base. Forest types include live oak/maritime (Quercus virginiana), deciduous, pine, and deciduous/pine mix. The live oak stands are near monicultures with scattered tangles of greenbriar (Smilax spp.) and various shrubs. Pine stands are dominated by loblolly pines (Pinus taeda) with a sparse understory of blueberry, sweet bay (Magnolia virginia), black cherry (Prunus serotina), red maple (Acer rubrum), and other hardwoods. Deciduous stands are dominated by White Oak (Q. alba), Black Oak (Q. velutina), Yellow Poplar (Leriodendron tulipifera), and various hickories (Carya spp.). Deciduous undestories are dominate by dogwood (Cornus florida), black cherry, red maple, and devils walkingstick (Aralia spinosa).

FIELD METHODOLOGY

BANDING

Mist nets were used to survey birds in 3 forest patches in 1995 and 5 forest patches in 1996 (See Figure 2, Table 1). Habitat patches selected for study in 1995 included 1 patch each of deciduous, pine, and live oak/maritime forest. In 1996, habitat patches included 2 deciduous, 2 pine, and 1 deciduous-pine-maritime mix (work within the live oak/maritime forest patch was

Figure 1. Map of Chespeake Bay region showing the general geographic context of Little Creek Naval Amphibious Base.

Geographic Position Study Area

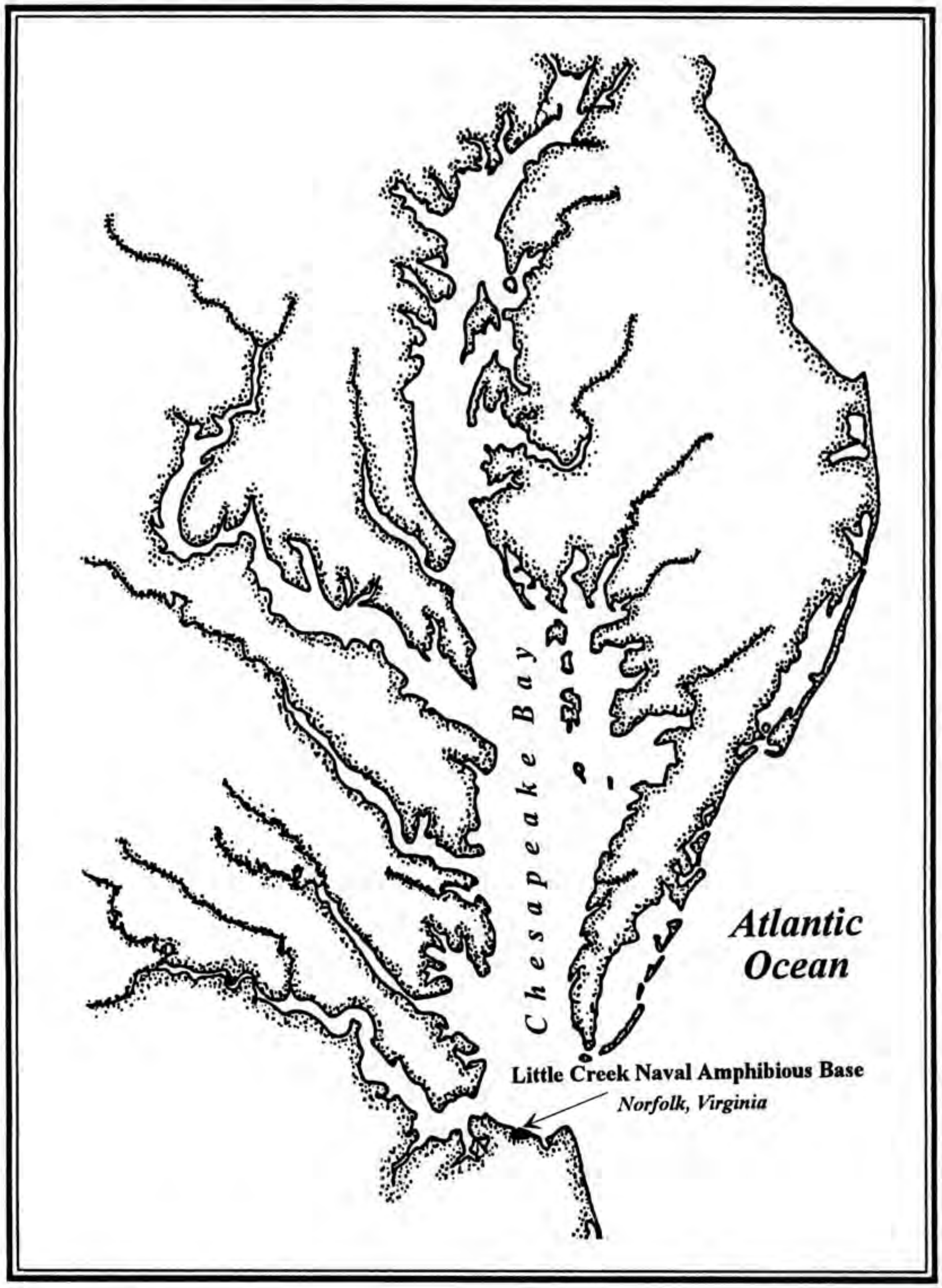


Figure 1

Figure 2. Map of Little Creek Naval Amphibious Base. Stippled areas indicate water. Numbered polygons refer to forest patches used in the migration study. See Table 1 for description of study patches.

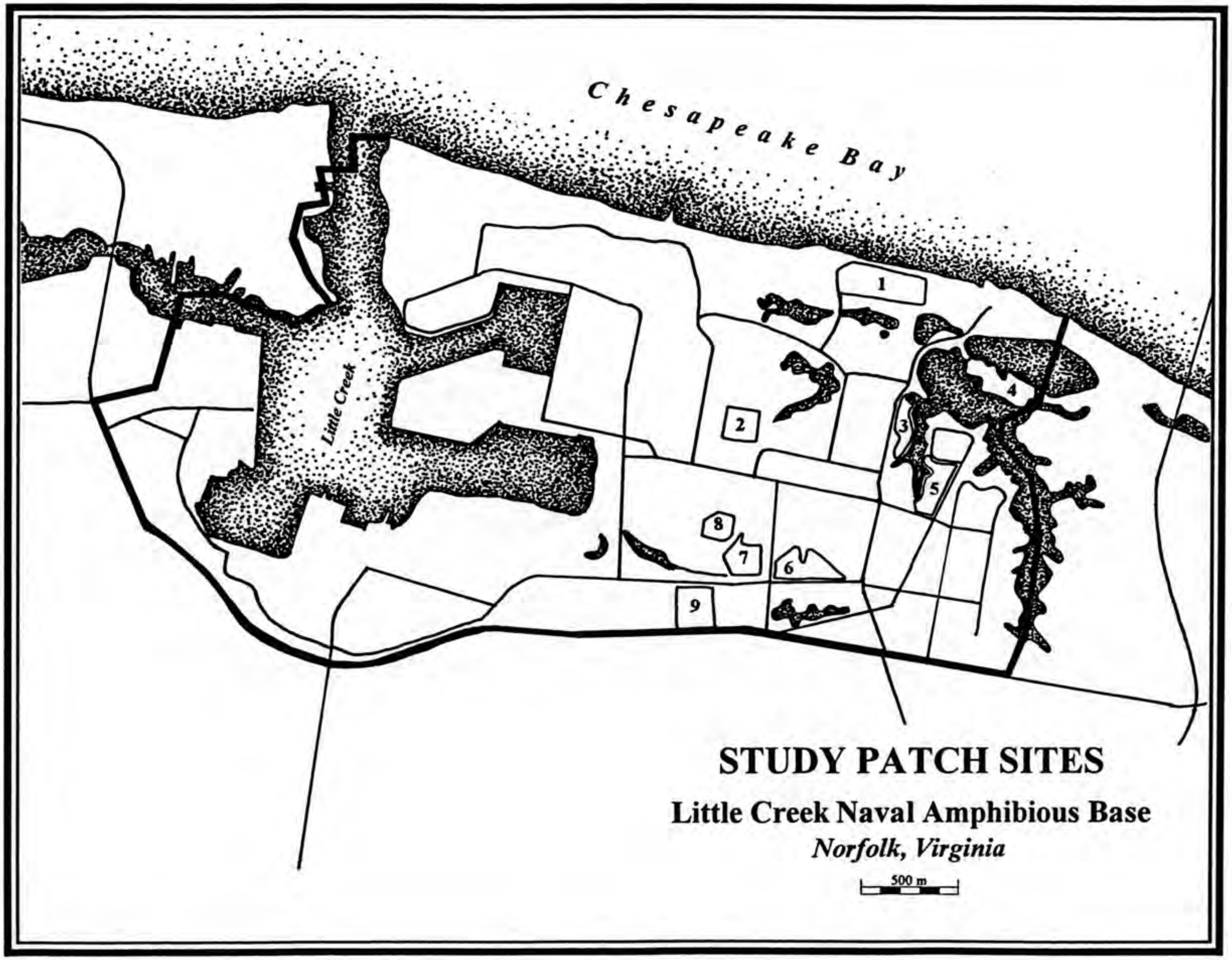

Chesapeake Bay
Little Creek
1
2
3
4
5
6
7
8
9
STUDY PATCH SITES
Little Creek Naval Amphibious Base
Norfolk, Virginia
500 m

Figure 2

Table 1. Forested patches selected within the study designs.

Patch Number	Description	Banding Study 1995	Banding Study 1996	Point Count Study	Foraging Study
1	Live Oak	x			
2	Deciduous/no understory			x	
3	Deciduous/no understory			x	
4	Deciduous/Pine mix w/ understory		x		
5	Deciduous/understory	x	x	x	x
6	Deciduous/understory		x	x	x
7	Pine/understory		x	x	x
8	Pine/no understory			x	
9	Pine/understory	x	x	x	x

not feasible in 1996 due to access difficulties). With the exception of the mixed forest patch used in 1996, 6 mist nets were used in each patch. Ten nets were used in the mixed forest patch. Mist nets were established in 2-net stations. Black, 30 mm-mesh, nylon nets were used that measured 12 m long by 2 m high.

Banding operations generally covered the primary movement period for neotropical migrants within the mid-Atlantic region. Net stations were chosen and established during the first week of September in 1995 and during the third week of August in 1996. Mist nets were operated from 12 September through 10 November 1995 and from 25 August through 16 November 1996. Banding operations were conducted 4 d/wk in 1995 and 2 d/wk in 1996. All nets were opened at dawn and were generally closed between 1200 and 1400 hrs. The only exception to the banding schedule was during heavy movement days when nets were not closed until, as late as, 1700 hrs. Mist nets were not operated on days with moderate to heavy rains.

Upon capture, birds were removed from mist nets, placed in holding boxes and transported to a temporary banding station for processing. Forest stand and net number were recorded for each individual. All individuals were identified to species and placed in age and sex classes according to recognized criteria (Pyle et al. 1987). Morphometric data including unflattened wing chord and weight were also collected. Wing chord was measured to the closest mm using a steel wing ruler. Weight was measured to 0.5 gm using a Pesola spring scale. Fat class was determined by visual inspection using the following criteria: 0 fat score - no visible subcutaneous fat within interclavicular fossa, 1 fat score - trace of subcutaneous fat in the interior corners of the interclavicular fossa, 2 fat score - continuous sheet of subcutaneous fat across the floor of the interclavicular fossa, 3 fat score - continuous layer of subcutaneous fat filling at least

1/3 of the interclavicular fossa, 4 fat score - interclavicular fossa filled with subcutaneous fat and level with surface of pectoralis muscles, 5 fat score - subcutaneous fat filling interclavicular fossa to bulging beyond pectoralis muscles, subcutaneous fat deposited on flanks and abdomen. After processing, birds were returned to the stand of capture.

POINT COUNTS

Point counts were used to survey birds in 8 forest patches during the fall of 1996 (See Figure 2, Table 1). A simple two-way design was used with forest type (2 levels) and understory condition (2 levels) as factors. Forest types included pine and deciduous. Patches were considered pine if a minimum of 85% of canopy-forming stems were loblolly pine. Patches were considered deciduous if greater than 85% of canopy-forming stems were deciduous, hardwoods species. Understory conditions used represented the extremes available and included natural and cleared. Forest patches considered to have natural understories were those with well formed shrub, sapling, and midstory vegetation layers that were relatively undisturbed. Forest patches considered to have cleared understories were open parklands where all understory vegetation had been removed leaving only the canopy. An attempt was made to locate 2 spatial replicates for each of the 4 cells within the field design. A complete search for appropriate field sites on the installation was conducted in August of 1996. Appropriate replicates were located on the installation except one. Only a single appropriate replicate could be located for the cleared pine category. For this reason, one field site was chosen outside the installation within a nearby city park (Bayville Park). Within each forest patch a network of three 30-m fixed-radius survey plots (N=24) were established. Each plot consisted of a wire flag or other marker at the center with the perimeter indicated with flagging tape. Plots were arranged along a survey route within each forest patch and separated by a minimum of 75 m.

Birds were surveyed within established plots during the main peak of migration in the fall of 1996 (10 September - 18 November). Upon entering a forest patch, the observer walked along the survey route until reaching a numbered plot. The observer then quietly searched the plot for a period of 5 min, recording all birds detected, their identification, and vertical location. Aural identification was not allowed and no playbacks or enticement calls were used. All plots were surveyed on the same field day twice/wk. Surveys commenced 0.5 hr after sunrise and were concluded within 4 hr. A single observer conducted all surveys. Within field days, survey order was randomly determined to reduce any time-of-day bias. Surveys were not conducted during heavy winds or rain.

FORAGING

In order to compare patch quality between deciduous and pine habitats, foraging data were collected on 3 neotropical migrant species (including Black-and-white Warbler, Black-throated-blue Warbler, and Ovenbird). These species were chosen for study because they are common fall migrants along the mid-Atlantic coast, they forage low to the ground (making them easy to observe), and they represent different foraging guilds. Birds were observed while resident on 1 ha grids established within 2 deciduous stands and 2 pine stands (See Figure 2, Table 1). Grids were established between 15 and 25 August, 1996 and behavioral observations were made between 2 September and 28 October, 1996. Data were collected between 0.5 h after sunrise and 1400 h, 4 days/wk. Observations were not made during heavy winds or rain.

Foraging observations were made on both "captured" birds and "free-ranging" birds. Captured birds included individuals of the 3 focal species that were captured during the course of banding operations. Such birds were fitted with unique combinations of color bands for individual identification. Captured birds were released onto study grids and observed for extended periods of time. Free-ranging birds included individuals (both unbanded birds and birds that had been banded on previous days) that were encountered while conducting surveys on study grids.

All individuals encountered were followed on grids and observed with 10X40 binoculars for periods ranging from 34 to 420 s. An attempt was made to maintain contact with birds for, as long as, possible but care was taken to minimize disturbance. Information collected included foraging data, movement data, and substrate data. Foraging data included prey type, type of attack maneuvers, attack success, and handling time. Movement data included perch changes, number of hops, and the number of flights. Flights were categorized as short, medium, and long. Short flights were < 2 m in length, medium flights were 2-5 m, and long flights > 5 m in length. Substrate data included perch type, foraging substrate type, and strata use. Vegetational strata was categorized as ground and heights above ground in 1 m increments up to 10 m. All observations were recorded using a microcassette recorder and were later transcribed using a stopwatch.

DATA ANALYSIS

For purposes of comparison, we categorized all birds observed as either residents, temperate migrants, or neotropical migrants. Resident species are those species that are considered to have stable, year-round populations in our study area. Here, we consider temperate migrants to be those species that breed in the northern United States and Canada and fly relatively short distances to winter in the mid to lower latitudes of North America. Within the study area, this group includes those species that breed far to the north and only appear in the winter months, as well as, species that breed but move further south for the winter only to be replaced by birds moving in from further north. Neotropical migrants are those species that breed in North America and winter in Mexico, Central America, the Caribbean, and South America. These two groups of birds migrate during distinctly different times within the fall season, move different distances to reach wintering areas, and generally depend on different food resources during migration. For this reason, we analyzed the two migration groups separately. Several species do not fit cleanly into a single migration class. In these cases, species were classified according to the majority of individuals likely to be encountered in the mid-Atlantic A complete list of species encountered and their migration status within the study area is presented in APPENDIX 1.

Banding data were summarized for both 1995 and 1996 to generate species richness (total number of species) and bird abundance values for overall species. Species richness and abundance values were also calculated for the three migration classes independently. Bird abundance was standardized as the number of birds captured/100 net hours (net-h) (i.e. index of trapping effort). To examine temporal patterns, the relative proportion of standardized capture from 1995 banding results was compared for three time periods including early (25 August - 22 September), middle (23 September - 21 October), and late (22 October - 16 November). Separate comparisons were made for each migration class and for selected species. To examine relative habitat use, the standardized capture rates were compared between deciduous, pine and live oak patches using paired t-tests. Tests were performed using capture days as independent observations. Separate comparisons were made for 1995 and 1996.

Point count data were summarized to generate species richness and bird abundance data for all birds and individual migration classes. Species richness and abundance was calculated at the stand level by combining data from point counts over the entire season. The effect of habitat type and understory condition was compared with two-way Analysis of Variance (ANOVA) using forest patches as statistical units. Separate comparisons were made for overall species and each migration class.

Foraging observations were analyzed for all 3 species using habitat type as the independent variable. The total amount of time that an individual was observed was recorded as a single bout. Because individuals were observed for varying lengths of time, all dependent variables were converted to rates. Foraging success and movement rates were compared between habitats using standard t-tests and Mann-Whitney U tests. Chi-square statistics were used to compare the types of prey attacks used and the proportion of time spent on different substrates and vegetational strata.

RESULTS

BANDING STUDY

Over the fall seasons of 1995 and 1996, a banding station was operated for a total of 8,753 net hours. Banding operations resulted in the capture of 1,600 birds representing 66 species (See APPENDICES 1, 2, and 3 for species list and capture frequencies respectively). Of the three migration classes used, neotropical migrants were the most diverse, followed by temperate migrants, and permanent residents. However, in terms of overall abundance, a different pattern was observed (Table 2). Temperate migrants accounted for over half of all birds captured (823, 51.4%), followed by nearly even numbers of residents and neotropical migrants.

Within individual migration categories, as well as, for the entire species list as a whole, species were not equally abundant (Figure 3) (See APPENDICES 2 and 3 for abundance of remaining species). All three bird categories were numerically dominated by relatively few species. For example, over 75% of all temperate migrants were accounted for by only 4 species (including Yellow-rumped Warbler, Hermit Thrush, Ruby-crowned Kinglet and Golden-crowned Kinglet). Over 75% of all resident species were accounted for by only 3 species (including Common Grackle, Carolina Chickadee, and Northern Cardinal). For neotropical migrants, the Black-throated-blue Warbler and the American Redstart were the most abundant, accounting for 35% combined.

TEMPORAL PATTERNS

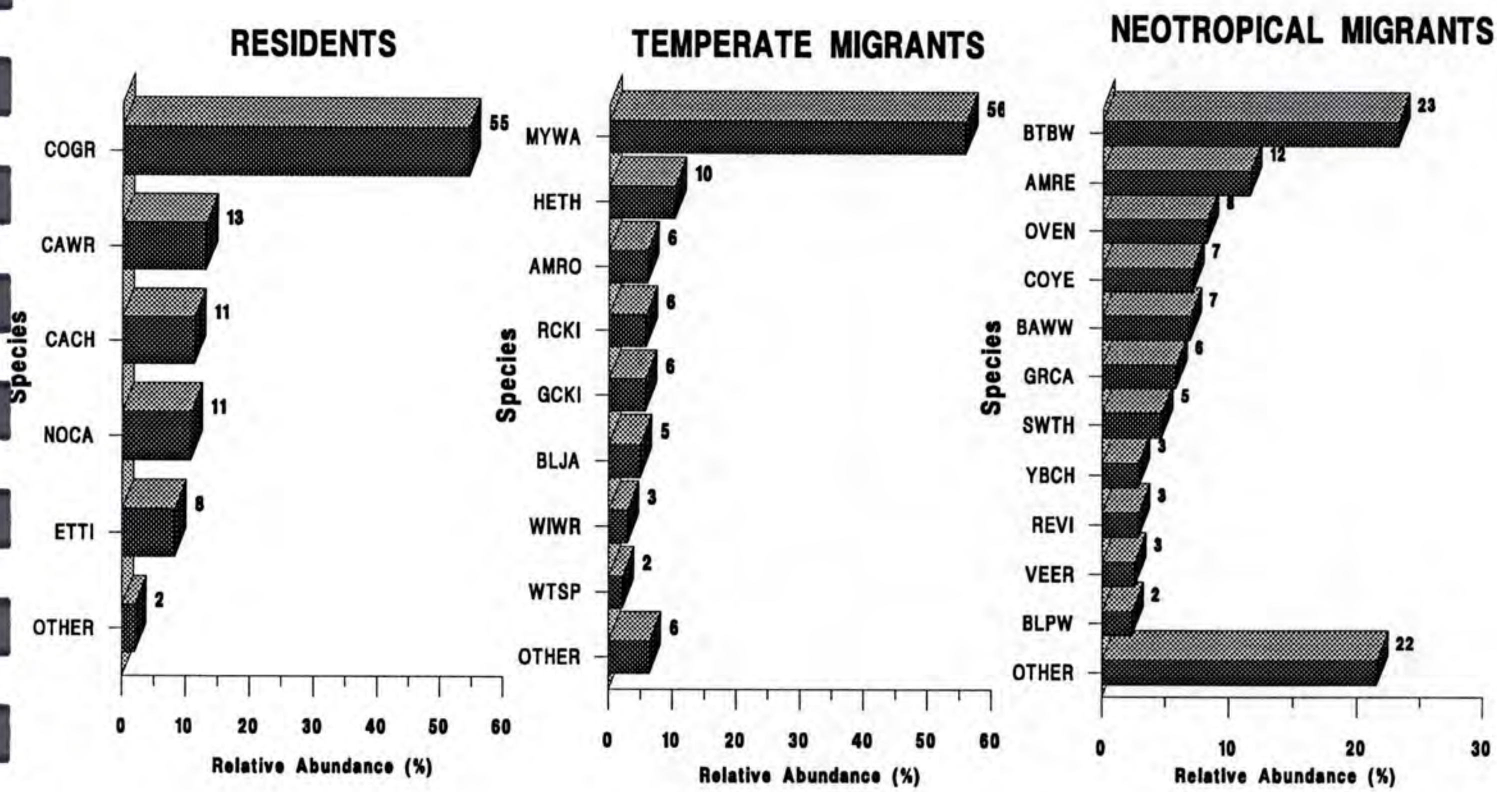
Between Year

Overall, capture rates were similar between the 1995 and the 1996 fall seasons (Table 2). However, the capture rate for neotropical migrants, as a group, was over twice as high in 1995 as it was in 1996. Numerous individual species, across all migration classes, also showed substantial variation in capture rates between years (See APPENDICES 2 and 3). For some of these species, differences may be due to natural between-year variation in migration volume. For example, the capture rate for the Black-throated-blue Warbler was over twice as high in 1995 as it was in 1996. For this species, the difference between years may partially be due to the fact that 1995 was an extraordinary migration year for the Black-throated-blue Warbler (best migration

Table 2. Summary of banding results for three migration classes at Little Creek Amphibious Base. Value indicate the sum for captures within all habitat types.

	1995			**1996**			**Total**		
Species Group	Species Richness	Number Captured	Captures/ 100 net-h	Species Richness	Number Captured	Captures/ 100 net-h	Species Richness	Number Captured	Captures/ 100 net-h
Resident	11	138	3.54	8	260	5.36	11	398	4.55
Temperate Migrants	17	347	8.89	13	476	9.81	18	823	9.40
Neotropical Migrants	34	235	6.02	26	144	2.97	37	379	4.33
Total Birds	62	720	18.45	47	880	18.14	66	1600	18.28

Figure 3. Relative abundance for species in the three migration classes. Values are based on captures from 1995 and 1996 combined.


RESIDENTS
Species
COGR
CAWR
CACH
NOCA
ETTI
OTHER
55
13
11
11
8
2
0
10
20
30
40
50
60
Relative Abundance (%)
TEMPERATE MIGRANTS
Species
MYWA
HETH
AMRO
RCKI
GCKI
BLJA
WIWR
WTSP
OTHER
56
10
6
6
6
5
3
2
6
Relative Abundance (%)
NEOTROPICAL MIGRANTS
Species
BTBW
AMRE
OVEN
COYE
BAWW
GRCA
SWTH
YBCH
REVI
VEER
BLPW
OTHER
23
12
7
7
6
5
3
3
3
2
22
Relative Abundance (%)

year for this species over a 30 year period, Kiptopeke Banding Station unpub. data). Variation in capture rates for other species were undoubtedly influenced in a similar way.

Variation in capture rates for other species may also have been influenced by the shift in habitats sampled between years. For example, in 1995 there were 94 kinglets captured compared to only 1 in 1996. During fall migration, kinglets are canopy-associated species (Watts and Mabey 1993). Because of this, capture rates from ground-deployed mist nets underestimate their numbers in most forest situations. However, in vertically compressed forests such as the maritime live oak stands, capture rates may more closely represent real densities. A large portion of the birds in 1995 were captured in the maritime forest patch. The fact that mist nets were not operated in this habitat during the 1996 season likely contributed to the low capture rates.

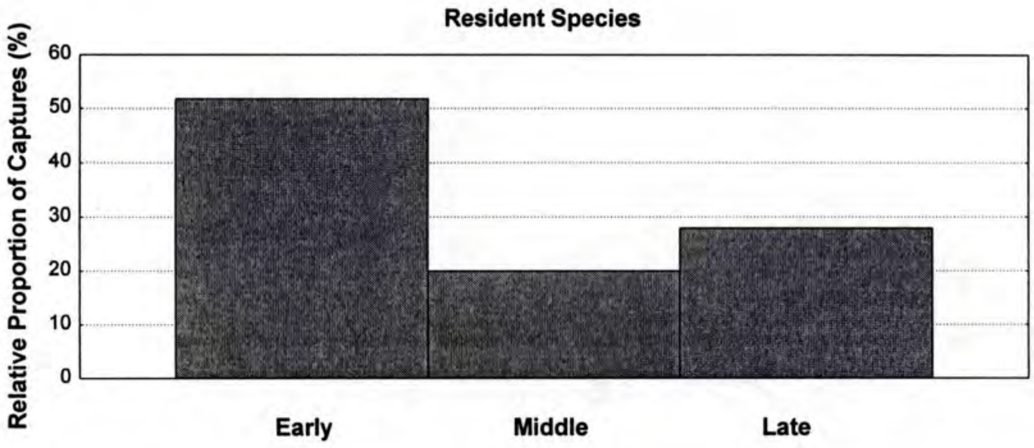
Variation in capture rates for still other species may have been influenced by chance events. Capture rates for the Yellow-rumped Warbler were 3 times higher in 1996 compared to 1995. This difference was almost entirely due to large fall outs of this species on only 2 days. Similar patterns were seen for the Winter Wren, and the American Robin.

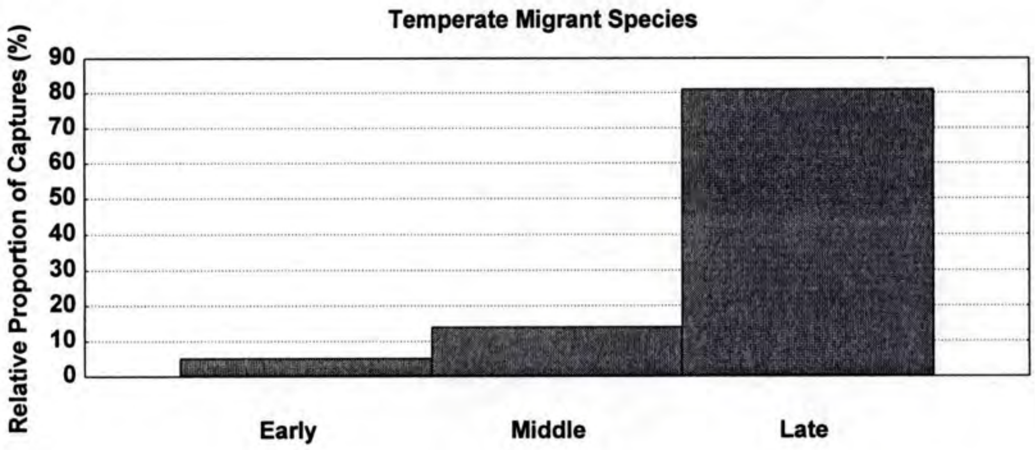
Within Season

The frequency of capture for both migrant groups varied with season during both field seasons (Figures 4 and 5). If the field season is subdivided into an early (25 August - 22 September), middle (23 September - 21 October), and late (22 October - 16 November) period, then both migration classes exhibit a significant seasonal pattern in capture frequency during both years (all G-statistics > 40, $P < 0.01$). Observed patterns suggest that neotropical migrants tend to move through the study area early in the season. By comparison, temperate migrants tend to move through later in the fall. Over 95% of all neotropical migrants were captured before 22

Figure 4. Temporal patterns of passage for three migration classes. Time periods include: early (25 August - 22 September), middle (23 September - 21 October), late (22 Octdober - 16 November). Values are based on relative percent of total captures from 1995 banding results.

Figure 4 **1995 Banding Year**





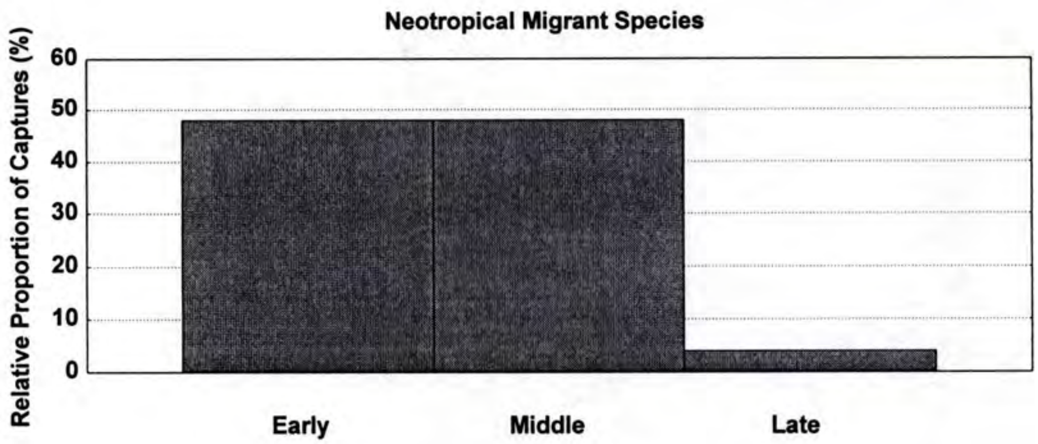
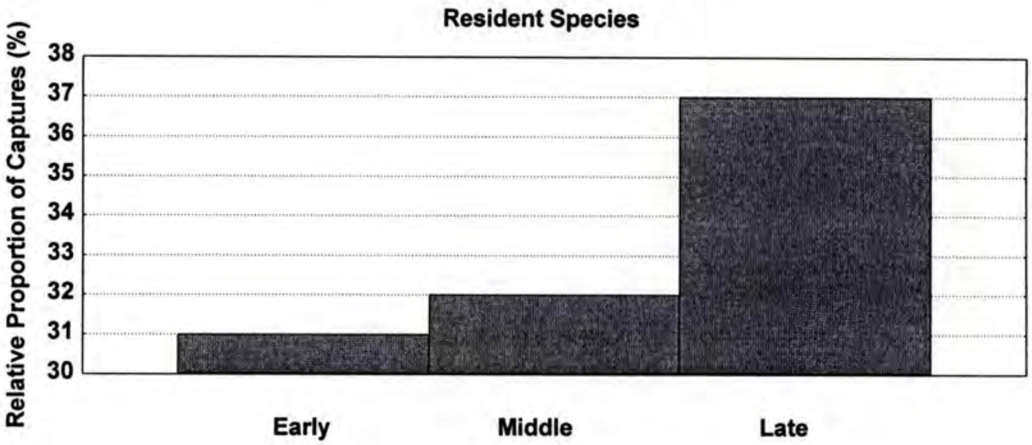
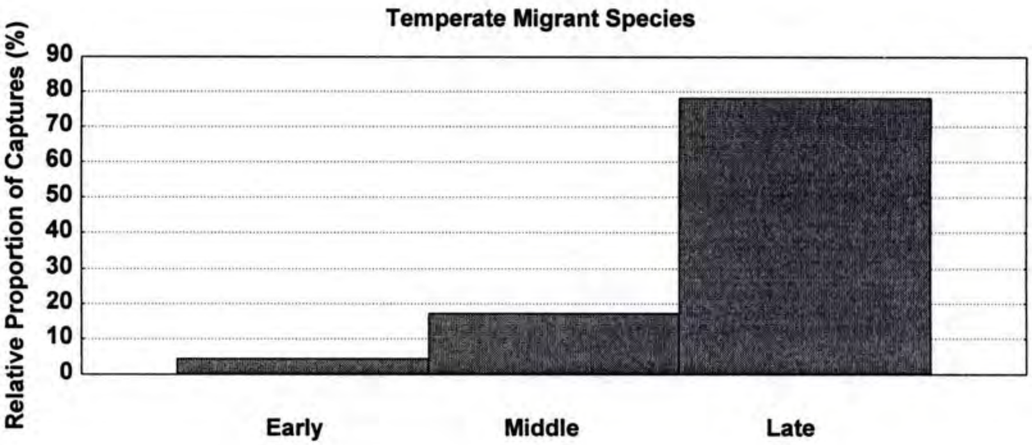


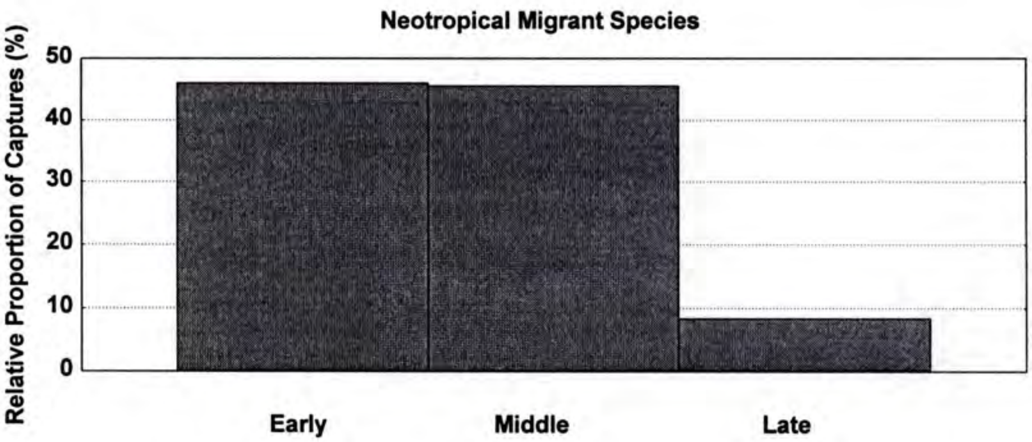
Figure 5. Temporal patterns of passage for three migration classes. Time periods include: early (25 August - 22 September), middle (23 September - 21 October), late (22 Octdober - 16 November). Values are based on relative percent of total captures from 1996 banding results.

Figure 5

1996 Banding Year







October compared to less than 20% for temperate migrants. Resident species showed a significant early-season bias in 1995 (G-statistic > 40, P , 0.01) but a late-season bias in 1996.

Most of the individual species showed seasonal patterns similar to those of their respective migration classes (Figures 6 and 7). Five of 6 common temperate migrants were not captured in the early period. At least 90% of the individuals captured of these species were captured during the late period. The remaining 2 species were captured most frequently during the middle period. By comparison, the 6 common species of neotropical migrants showed the opposite pattern. Half of these species were not captured in the late period. Four of 6 species were captured predominantly in the early period. The remaining 2 species were captured most frequently in the middle period.

HABITAT USE

1995 Season

In 1995, overall capture frequency varied significantly with habitat type (Table 3, Figure 8). Capture rate was highest in the live oak habitat (25.54 birds/100 net-h) followed by deciduous (22.77) and pine (7.08) habitats. Patterns in overall species richness were very similar to capture frequency with live oak having the most species (53) followed by deciduous (42) and pine (25). Differences between habitat types in both overall species richness and abundance were due to patterns in the migration classes.

The different migration classes varied with respect to habitat associations (Figure 8). For residents, species richness was relatively even between habitat types. Although capture rate for residents was higher in deciduous habitat, there was no statistically significant pattern (Table 3). Capture rates for both temperate and neotropical migrants were significantly different between

Figure 6. Temporal patterns of passage for selected temperate migrant species. Time periods include: early (25 August - 22 September), middle (23 September - 21 October), late (22 Octdober - 16 November). Values are based on relative percent of total captures from 1995 banding results.

Figure 6 **Temperate Migrant Species**

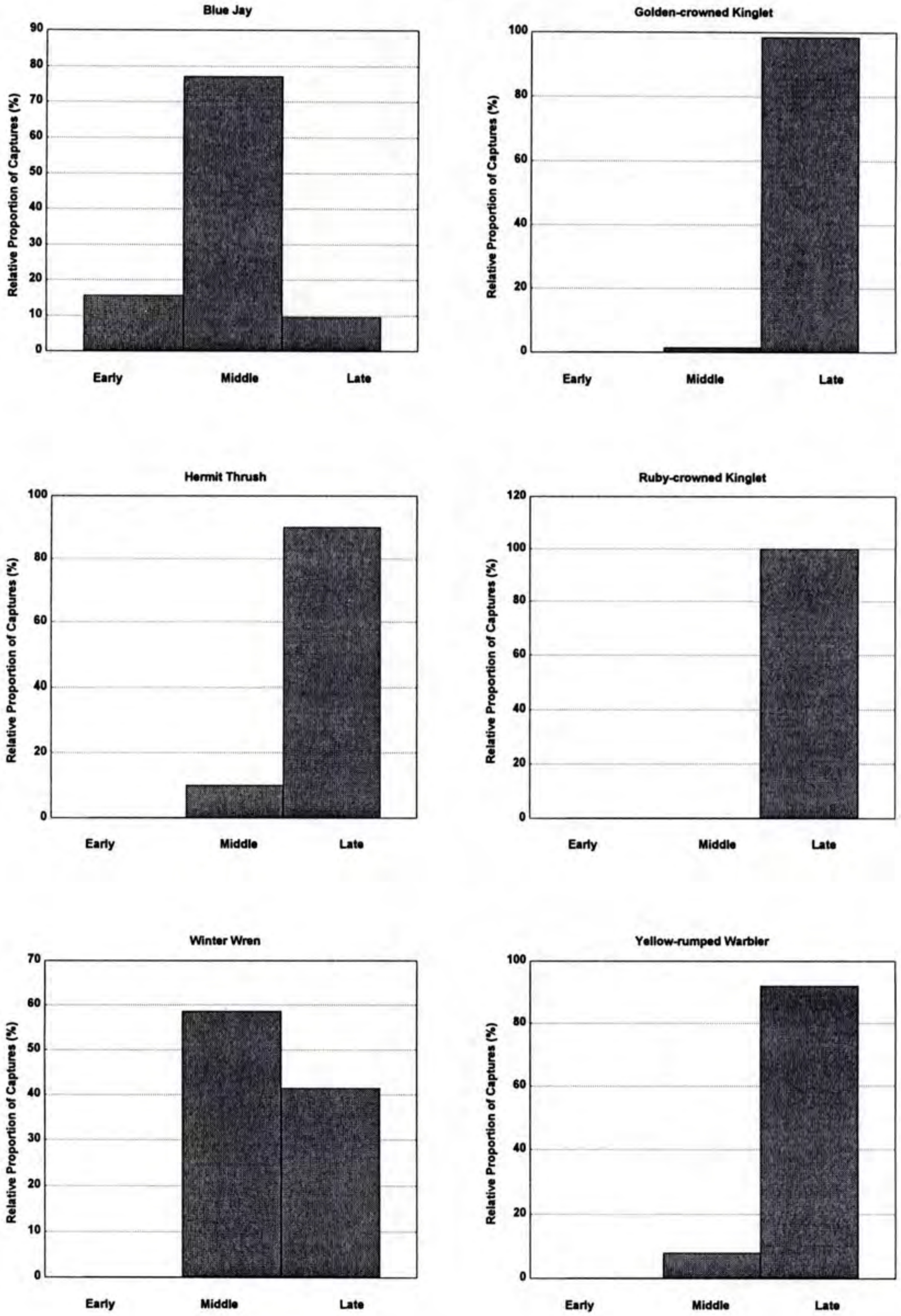


Figure 7. Temporal patterns of passage for selected neotropical migrant species. Time periods include: early (25 August - 22 September), middle (23 September - 21 October), late (22 Octdober - 16 November). Values are based on relative percent of total captures from 1995 banding results.

Figure 7 **Neotropical Migrant Species**

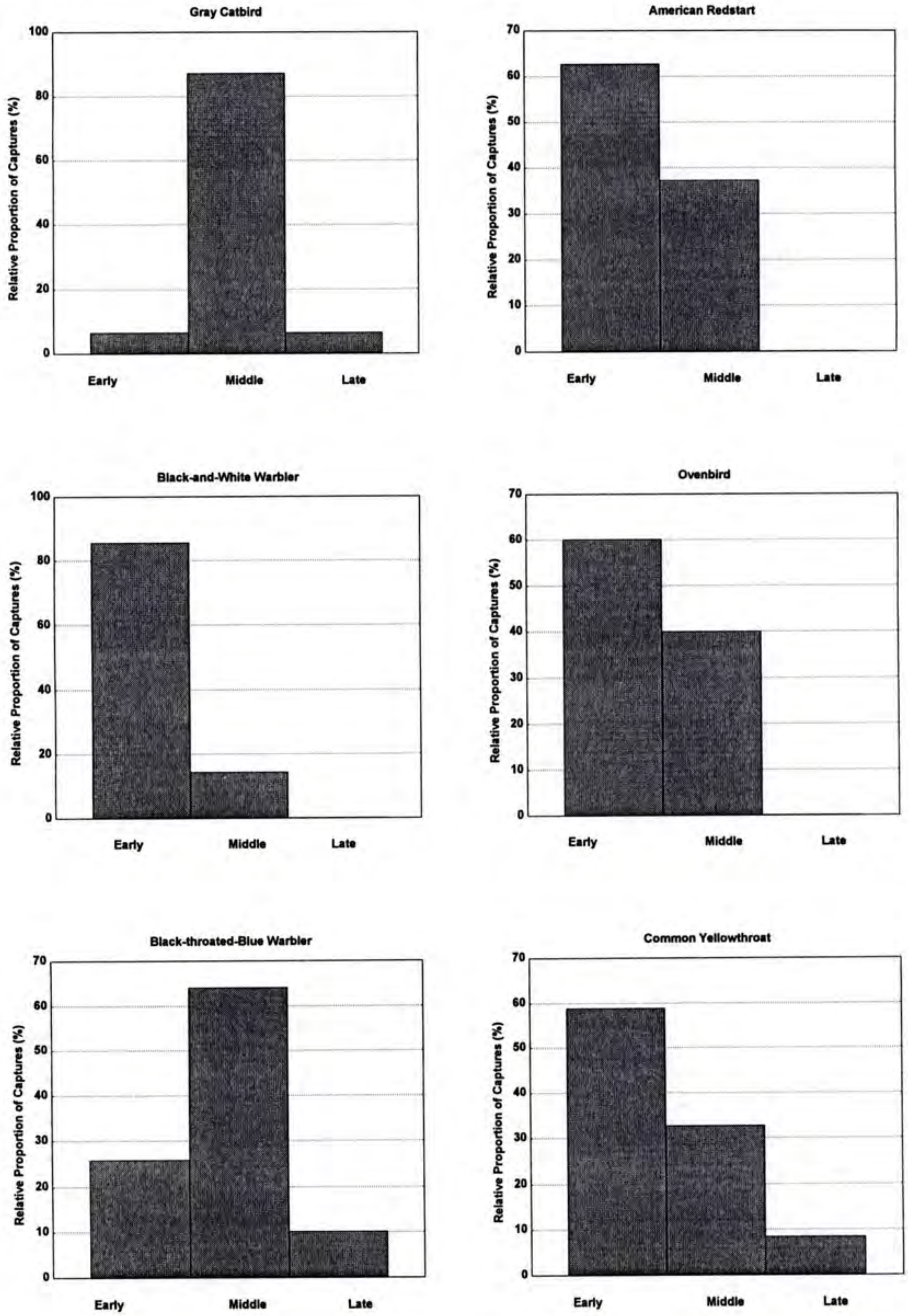


Table 3. Comparisons of capture rates from three habitat types based on 1995 banding results. Statistics given below are results from paired t-tests using capture days as independent observations.

Habitat Comparison	Total Species	Resident Species	Temperate Migrant Species	Neotropical Migrant Species
Deciduous/Pine	$t = -2.2$ $p < 0.04$	$t = 0.9$ $p > 0.30$	$t = 2.7$ $p < 0.02$	$t = 2.9$ $p < 0.02$
Deciduous/Live Oak	$t = -3.0$ $p < 0.005$	$t = 0.6$ $p > 0.50$	$t = -2.1$ $p = 0.05$	$t = 0.2$ $p > 0.80$
Pine/Live Oak	$t = -3.1$ $p < 0.005$	$t = 0.1$ $p > 0.80$	$t = -2.6$ $p < 0.03$	$t = -2.5$ $p < 0.02$

Table 4. Comparison of capture rates from deciduous and pine habitats based on 1996 banding results. Statistics given below are results from paired t-tests using capture days as independent observations

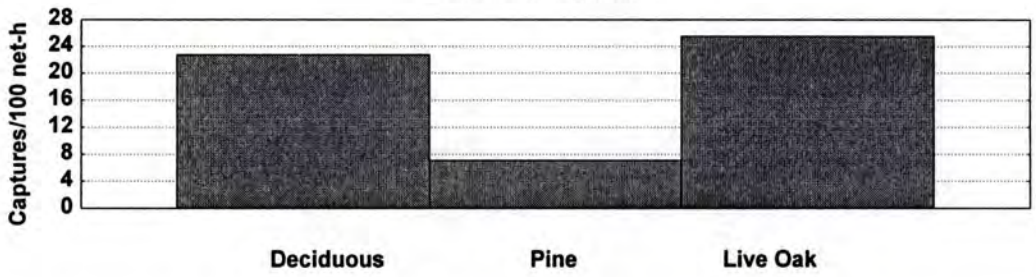
Habitat Comparison	Total Species	Resident Species	Temperate Migrant Species	Neotropical Migrant Species
Deciduous/Pine	$t = 1.5$ $p > 0.15$	$t = -0.9$ $p > 0.40$	$t = -1.1$ $p > 0.30$	$t = -2.4$ $p < 0.04$

Figure 8. Patterns of habitat use for total bird species and three migration classes. Numbers are based on capture rates from 1995 banding results.

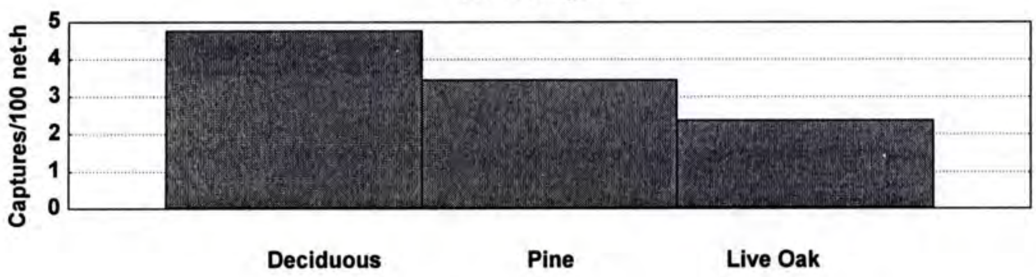
Figure 8

1995 Banding Year

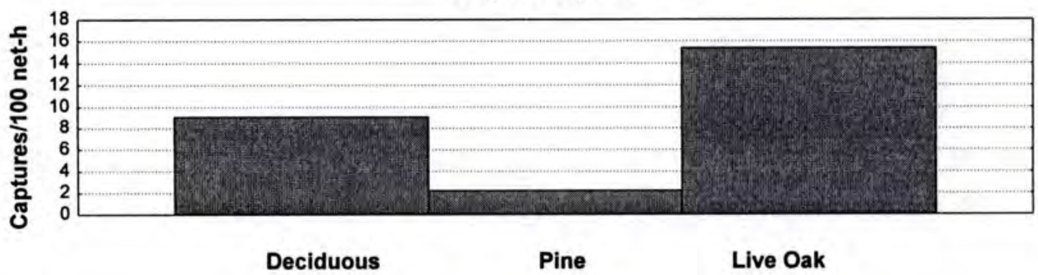
Total Bird Species



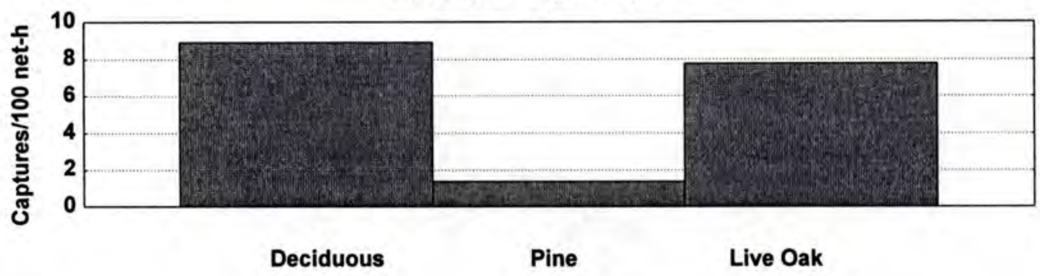
Resident Species



Temperate Species



Neotropical Migrant Species



habitat types (Table 3). Capture rates for both migration groups were several times higher in deciduous and live oak patches compared to pine (Figure 8). Less than 10% of all captures for these migration classes were located in pine habitat.

1996 Season

The 1996 migration year was not as heavy as in 1995 but habitat patterns were similar (Figure 9). Overall capture rates were higher in deciduous patches (20.45 birds/100 net-h) compared to pine patches (14.73 birds/100 net-h). However, this difference was not statistically significant (Table 4). Patterns in overall species richness were lower in 1996 compared to 1995 but similar habitat patterns were observed. A total of 38 species were captured in deciduous patches compared to 23 species in pine patches. As in 1995, capture rates for resident species were not statistically distinguishable between habitats (Table 4). Also as in 1995, neotropical migrants were captured with significantly greater frequency in deciduous patches compared to pine patches. Capture frequency for temperate migrants was not different between habitats.

POINT COUNT STUDY

During the fall of 1996, 480 point counts were conducted. Counts resulted in the detection of 2,800 birds representing 71 species (See APPENDIX 4 for species list and abundance). As with the banding data, neotropical migrants were the most diverse migration class (36 species, 49.3% of total) followed by permanent residents (18 species, 26.1% of total) and temperate migrants (17 species, 24.6% of total). Also consistent with the banding data, residents and temperate migrants were the most abundant migration classes (1,418 and 1,005 individuals respectively) followed by neotropical migrants (216 individuals). Similar to the banding data above, species were not equally abundant (Figure 10, See APPENDIX 4 for

Figure 9. Patterns of habitat use for total bird species and three migration classes. Numbers are based on capture rates from 1996 banding results.

Figure 9

1996 Banding Year

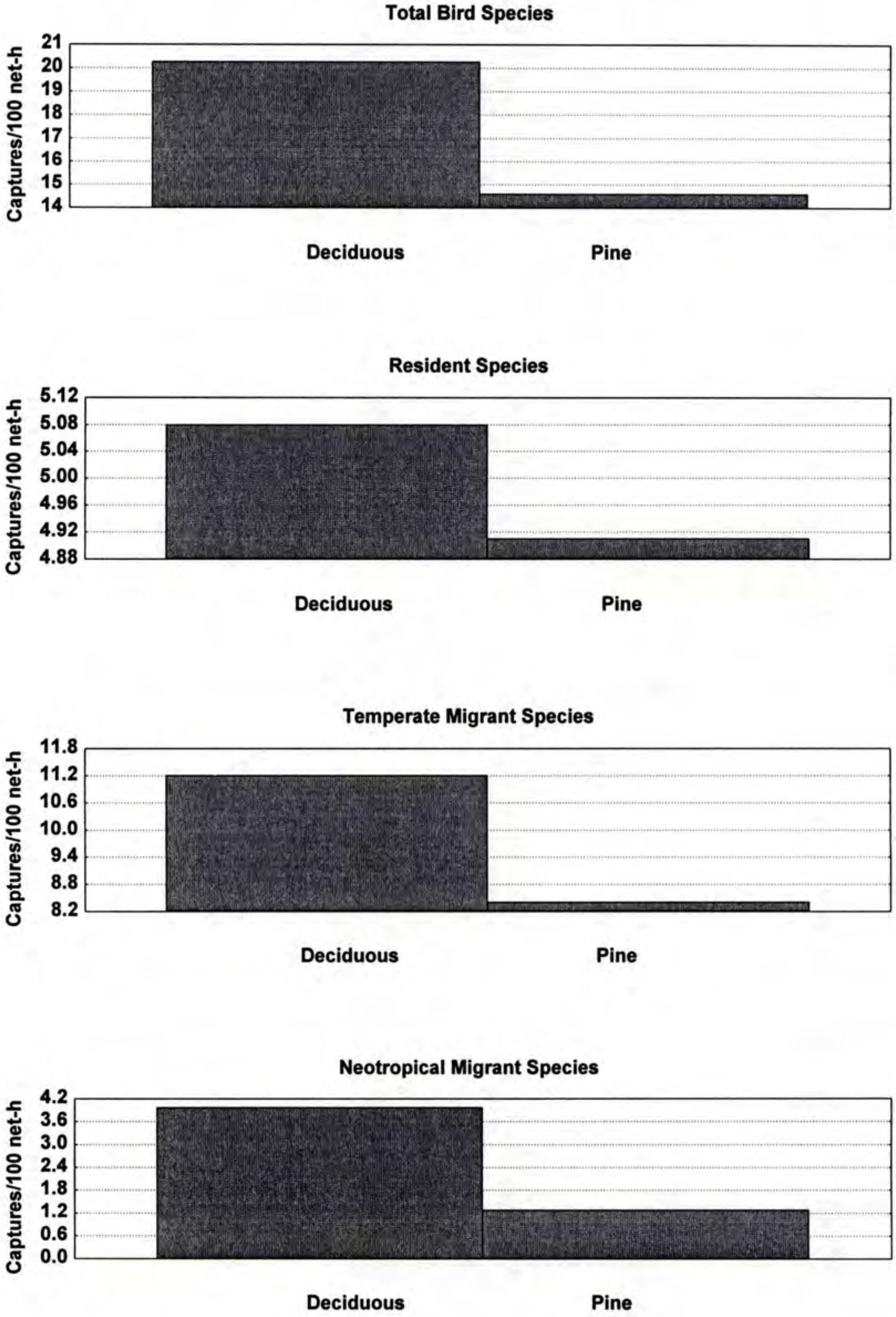
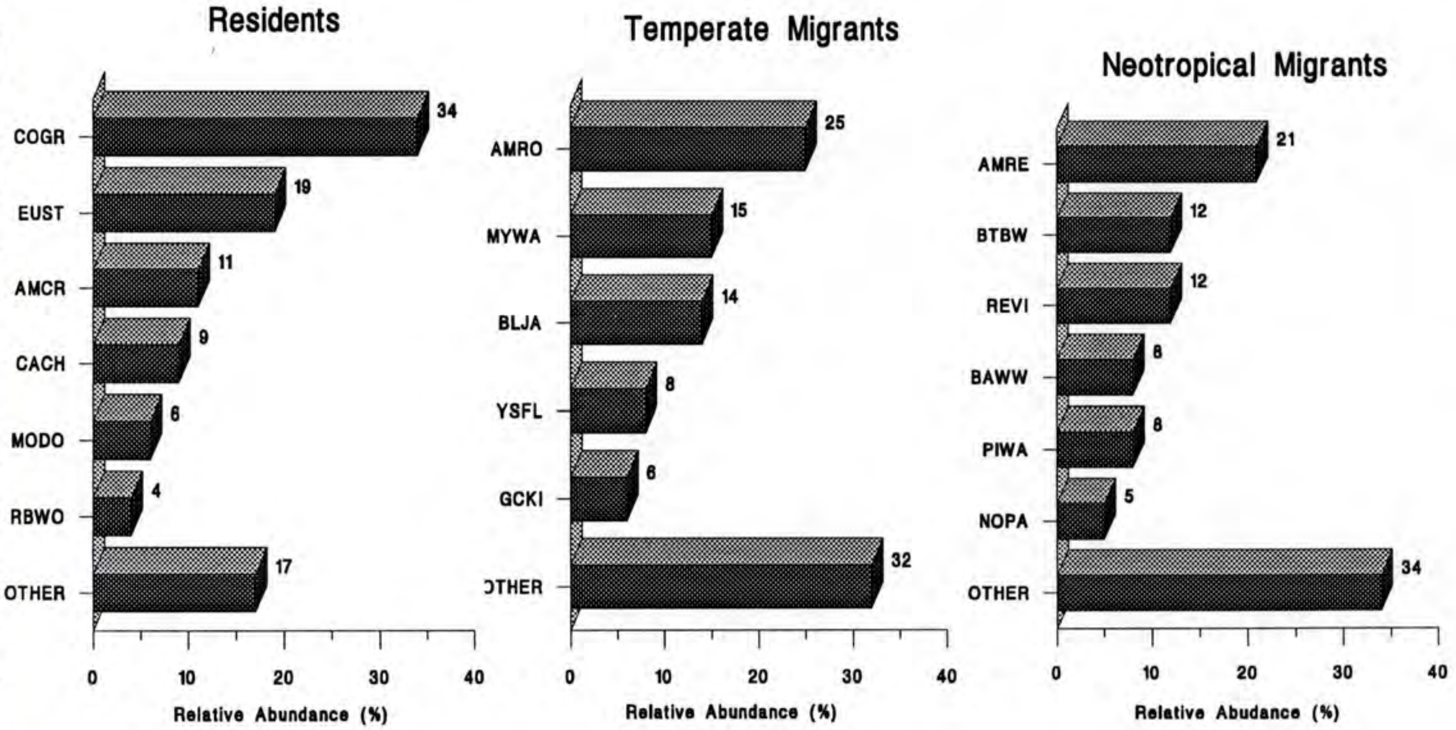


Figure 10. Relative abundance for species in the three migration classes. Values are based on point counts conducted during 1996



Residents
COGR
EUST
AMCR
CACH
MODO
RBWO
OTHER
34
19
11
9
6
4
17
0
10
20
30
40
Relative Abundance (%)
Temperate Migrants
AMRO
MYWA
BLJA
YSFL
GCKI
OTHER
25
15
14
8
6
32
0
10
20
30
40
Relative Abundance (%)
Neotropical Migrants
AMRE
BTBW
REVI
BAWW
PIWA
NOPA
OTHER
21
12
12
8
8
5
34
0
10
20
30
40
Relative Abudance (%)

remaining species). Nearly 85% of temperate migrants were accounted for by only 4 species (including American Robin, Blue Jay, Yellow-rumped Warbler, and Common Flicker). With the exception of the Yellow-rumped Warbler, these species are not the same species that dominated the temperate migrants in the banding data. Over 70% of residents were accounted for by 4 species (including Common Grackle, European Starling, American Crow, and Carolina Chickadee). Finally, over 40% of neotropical migrants were accounted for by 3 species (including American Redstart, Red-eyed Vireo, and Black-throated-blue Warbler).

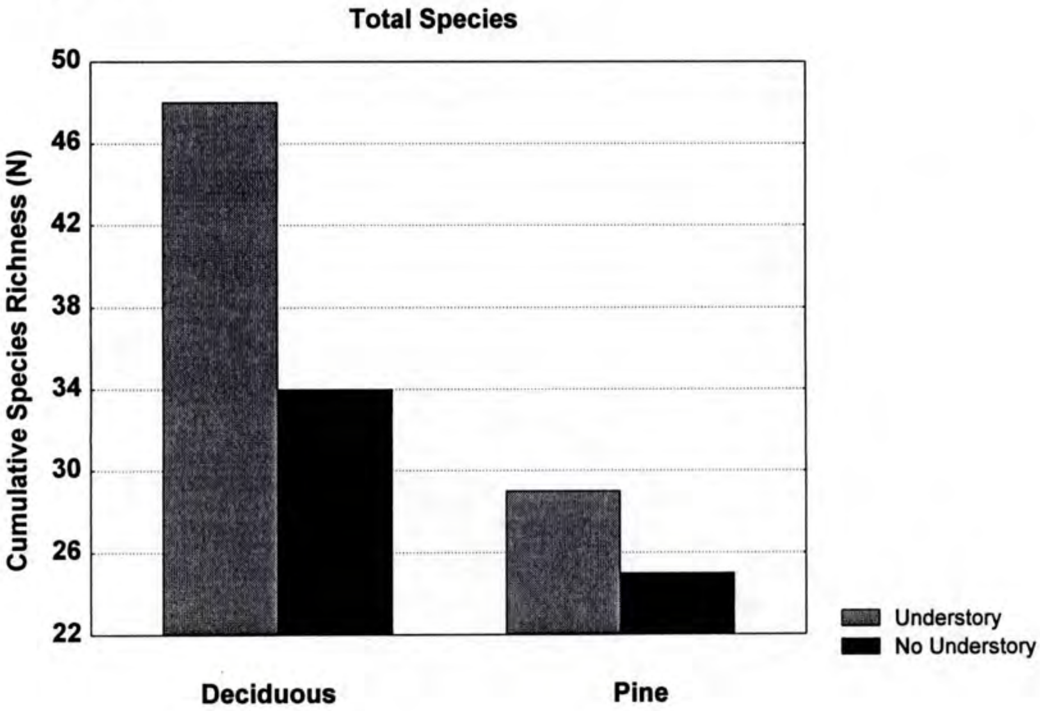
HABITAT USE

Overall, species richness varied significantly with habitat type (Figure 11, Table 5). Consistent with the banding data, more species were detected within deciduous stands compared to pine. Species richness also varied with understory condition. More species were detected in stands where understory was present compared to stands where understory vegetation had been removed. This trend was notable but only marginally significant (Table 5). Bird abundance was generally higher in deciduous stands and in stands of both types without understories. Neither of these patterns were statistically significant (Table 6). The overall bias toward stands without understories was caused by a relatively few resident and temperate migrant species that move in large flocks and forage on the ground in open stands.

As with the banding data, response to habitat type and understory presence varied between migration classes (Figure 12). For residents, species richness was significantly higher without understory present (Table 7). Resident abundance was also higher in open stands (Table 8). This pattern was driven by the large number of European Starlings, Rock Doves, and Common Grackles that utilize the lawn areas within the park-like stands. However, this pattern

Figure 11. Habitat use patterns for overall species richness and bird abundance. Shown are bird distributions between all 4 forest type and understory combinations. Values are based on cumulative detections from point counts conducted during 1996.

Figure 11


Total Species
Cumulative Species Richness (N)
50
46
42
38
34
30
26
22
Understory
No Understory
Deciduous
Pine

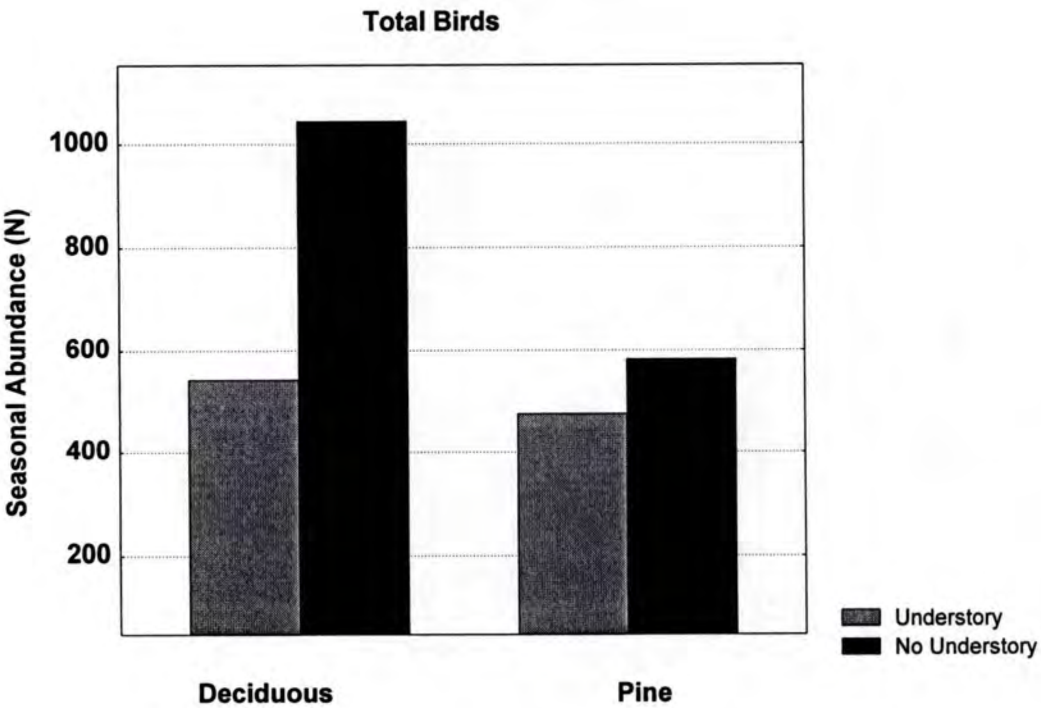

Total Birds
Seasonal Abundance (N)
1000
800
600
400
200
Understory
No Understory
Deciduous
Pine

Table 5. Results of a two-way ANOVA for total species richness. Factors include habitat type (deciduous and pine) and understory type (understory and no understory).

Source of Variation	df	SS	MS	F	p
Habitat Type	1	264.5	264.5	13.74	0.02
Understory Type	1	98.0	98.0	5.09	0.08
Interaction	1	32.0	32.0	1.66	0.26
Error	3	394.5	19.25		

Table 6. Results of a two-way ANOVA for total bird abundance. Factors include habitat type (deciduous and pine) and understory type (understory and no understory).

Source of Variation	df	SS	MS	F	p
Habitat Type	1	38920.5	38920.5	0.74	0.43
Understory Type	1	50880.5	50880.5	0.97	0.37
Interaction	1	20200.5	20200.5	0.38	0.57
Error	3	110001.5	52262.5		

Figure 12. Habitat use patterns for the three migration classes. Shown are bird distributions between all 4 forest type and understory combinations. Values are based on cumulative detections from point counts conducted during 1996.

Figure 12

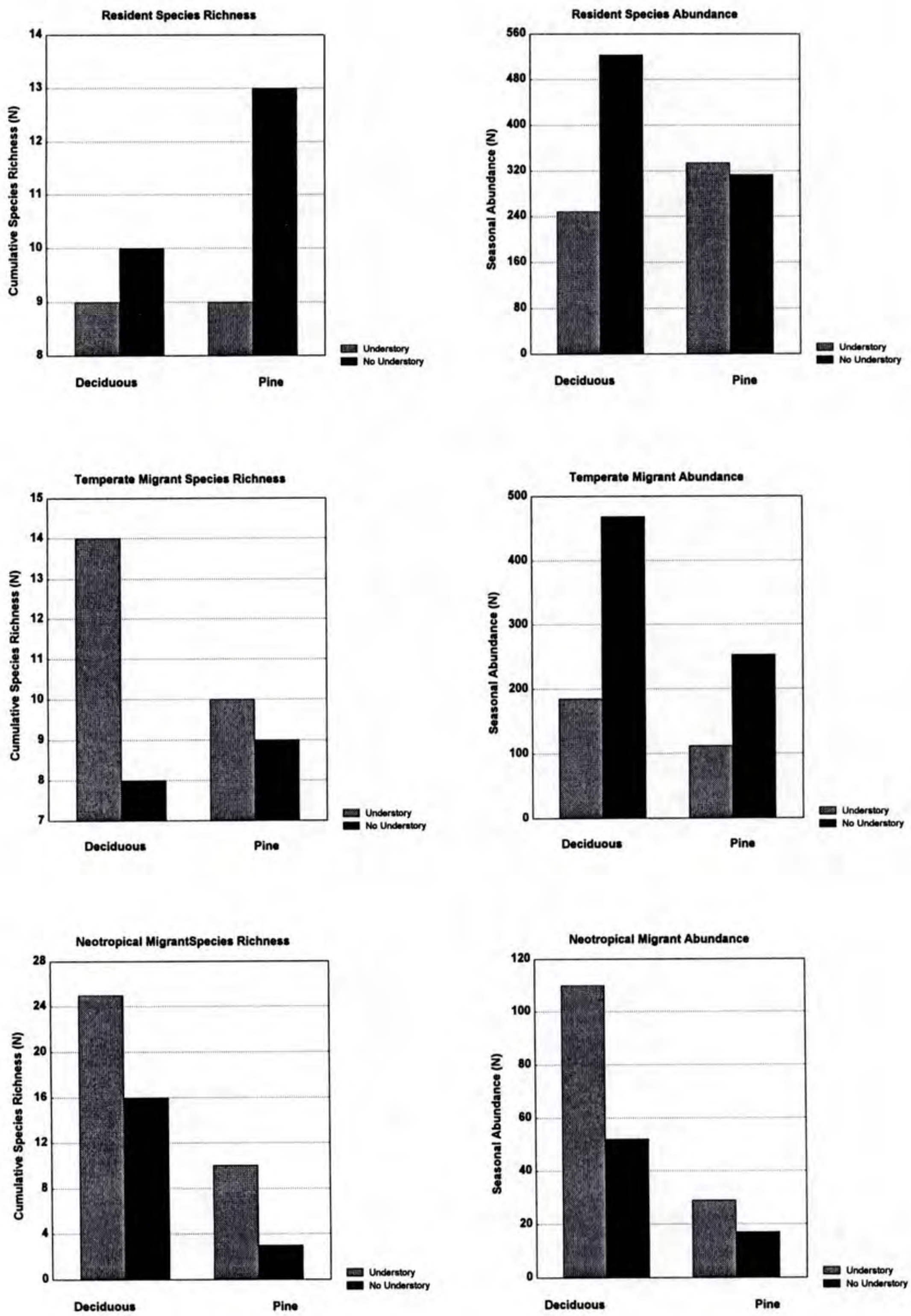

Resident Species Richness
Cumulative Species Richness (N)
14
13
12
11
10
9
8
Deciduous
Pine
Understory
No Understory
Resident Species Abundance
Seasonal Abundance (N)
560
480
400
320
240
160
80
0
Deciduous
Pine
Understory
No Understory
Temperate Migrant Species Richness
Cumulative Species Richness (N)
15
14
13
12
11
10
9
8
7
Deciduous
Pine
Understory
No Understory
Temperate Migrant Abundance
Seasonal Abundance (N)
500
400
300
200
100
0
Deciduous
Pine
Understory
No Understory
Neotropical MigrantSpecies Richness
Cumulative Species Richness (N)
28
24
20
16
12
8
4
0
Deciduous
Pine
Understory
No Understory
Neotropical Migrant Abundance
Seasonal Abundance (N)
120
100
80
60
40
20
0
Deciduous
Pine
Understory
No Understory

Table 7. Results of a two-way ANOVA for resident species richness. Factors include habitat type (deciduous and pine) and understory type (understory and no understory).

Source of Variation	df	SS	MS	F	p
Habitat Type	1	0.12	0.12	0.09	0.77
Understory Type	1	10.12	10.12	7.36	0.05
Interaction	1	1.12	1.12	0.81	0.41
Error	3	11.36	1.37		

Table 8. Results of a two-way ANOVA for resident bird abundance. Factors include habitat type (deciduous and pine) and understory type (understory and no understory).

Source of Variation	df	SS	MS	F	p
Habitat Type	1	1922.0	1922.0	0.12	0.74
Understory Type	1	8064.5	8064.5	0.52	0.50
Interaction	1	10952.0	10952.0	0.71	0.44
Error	3	20938.5	15363.8		

was not statistically significant (Table 9). Patterns for temperate migrants were similar to those detected in the banding data (Figure 12, Tables 9 and 10). Both species richness and abundance were higher in deciduous compared to pine stands. However, a reversal was detected in the response to understory. Although there were relatively more species in stands with understory vegetation present, there were more individuals detected in stands with the understory removed. As was the case with resident species, the bias in abundance toward open stands is due to a small number of species that use these stands in large numbers. Large flocks of American Robins, Common Flickers, and occasionally Blue Jays forage on the ground in these park-like stands. The habitat response by neotropical migrants was also consistent with that detected in the banding data. Both species richness and abundance were significantly higher in deciduous compared to pine stands (Figure 12, Tables 11 and 12). In addition, both species richness and abundance were significantly influenced by understory presence. The presence of understory vegetation increased the number of both species and individuals from 2-4 fold.

The responses of migrant species to habitat conditions were more variable than the migration classes as a whole. Even within the common temperate migrants, there were species that responded to the entire spectrum of habitat combinations (Figure 13a and 13b). For example, both the Hermit Thrush and Winter Wren appear to require understory vegetation but in addition prefer deciduous patches. In contrast, the Common Flicker appears to prefer open stands. Common neotropical migrants were generally more consistent in habitat use. Most of these species were detected in higher numbers in deciduous stands and many appear to require understory vegetation (Figure 14).

Table 9. Results of a two-way ANOVA for temperate migrant species richness. Factors include habitat type (deciduous and pine) and understory type (understory and no understory).

Source of Variation	df	SS	MS	F	p
Habitat Type	1	1.12	1.12	0.22	0.66
Understory Type	1	15.12	15.12	2.95	0.16
Interaction	1	10.12	10.12	1.97	0.23
Error	3	26.36	5.12		

Table 10. Results of a two-way ANOVA for temperate migrant abundance. Factors include habitat type (deciduous and pine) and understory type (understory and no understory type).

Source of Variation	df	SS	MS	F	p
Habitat Type	1	11100.5	11100.5	0.98	0.37
Understory Type	1	23544.5	23544.5	2.09	0.22
Interaction	1	2178.0	2178.0	0.19	0.68
Error	3	36823.0	11237.25		

Table 11. Results of a two-way ANOVA for neotropical migrant species richness. Factors include habitat type (deciduous and pine) and understory type (understory and no understory).

Source of Variation	df	SS	MS	F	p
Habitat Type	1	231.12	231.12	43.00	0.002
Understory Type	1	78.12	78.12	14.53	0.018
Interaction	1	3.12	3.12	0.58	0.48
Error	3	312.36	5.37		

Table 12. Results of a two-way ANOVA for neotropical migrant abundance. Factors include habitat type (deciduous and pine) and understory type (understory and no understory).

Source of Variation	df	SS	MS	F	p
Habitat Type	1	1682.0	1682.5	137.30	0.0003
Understory Type	1	612.5	612.5	50.00	0.002
Interaction	1	264.5	264.5	21.60	0.009
Error	3	2559.5	12.25		

Figure 13a and b. Habitat use patterns for selected species of temperate migrants. Values are based on cumulative detections from point counts conducted during 1996.

Figure 13a **Habitat Associations**

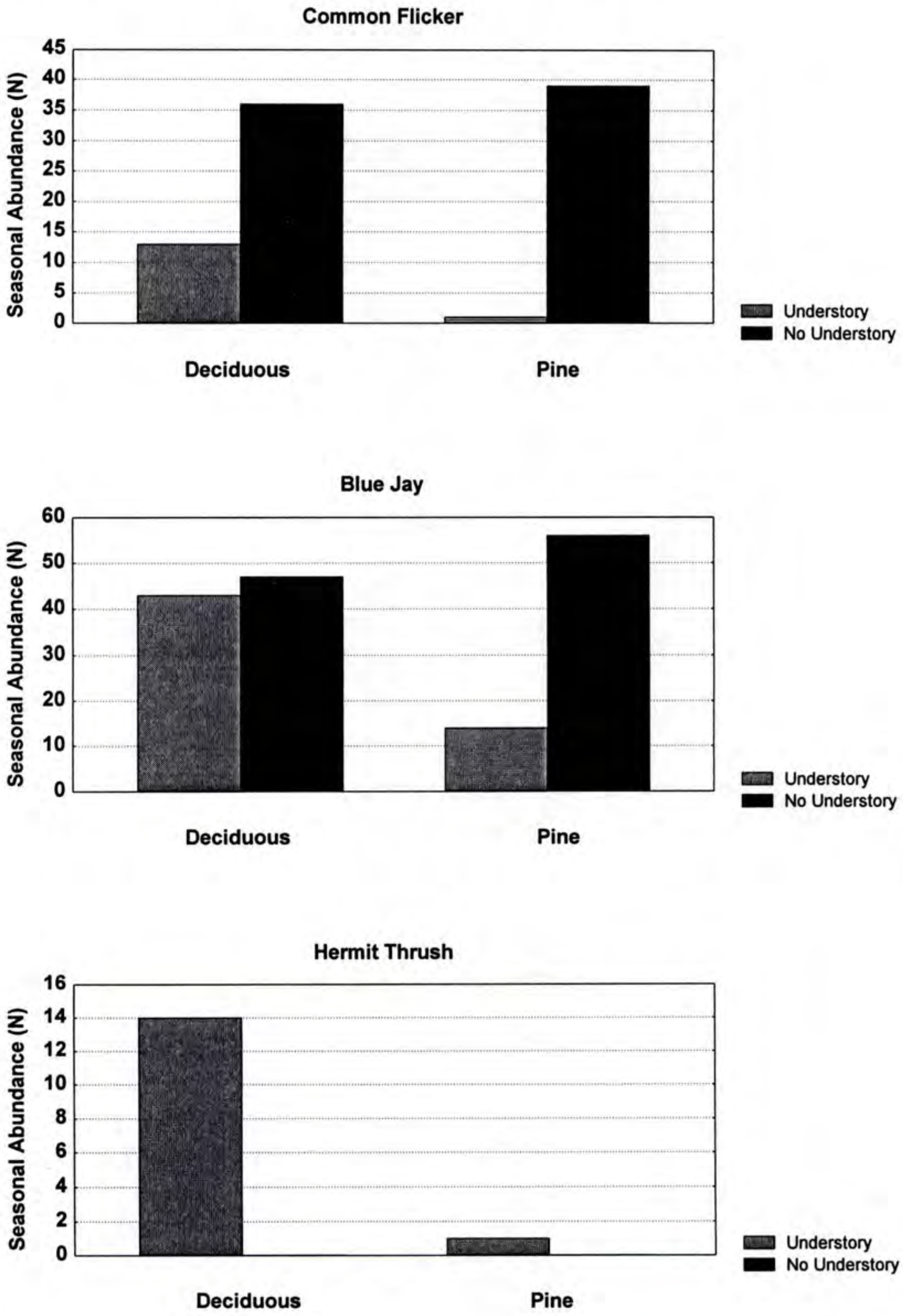


Figure 13b **Habitat Associations**

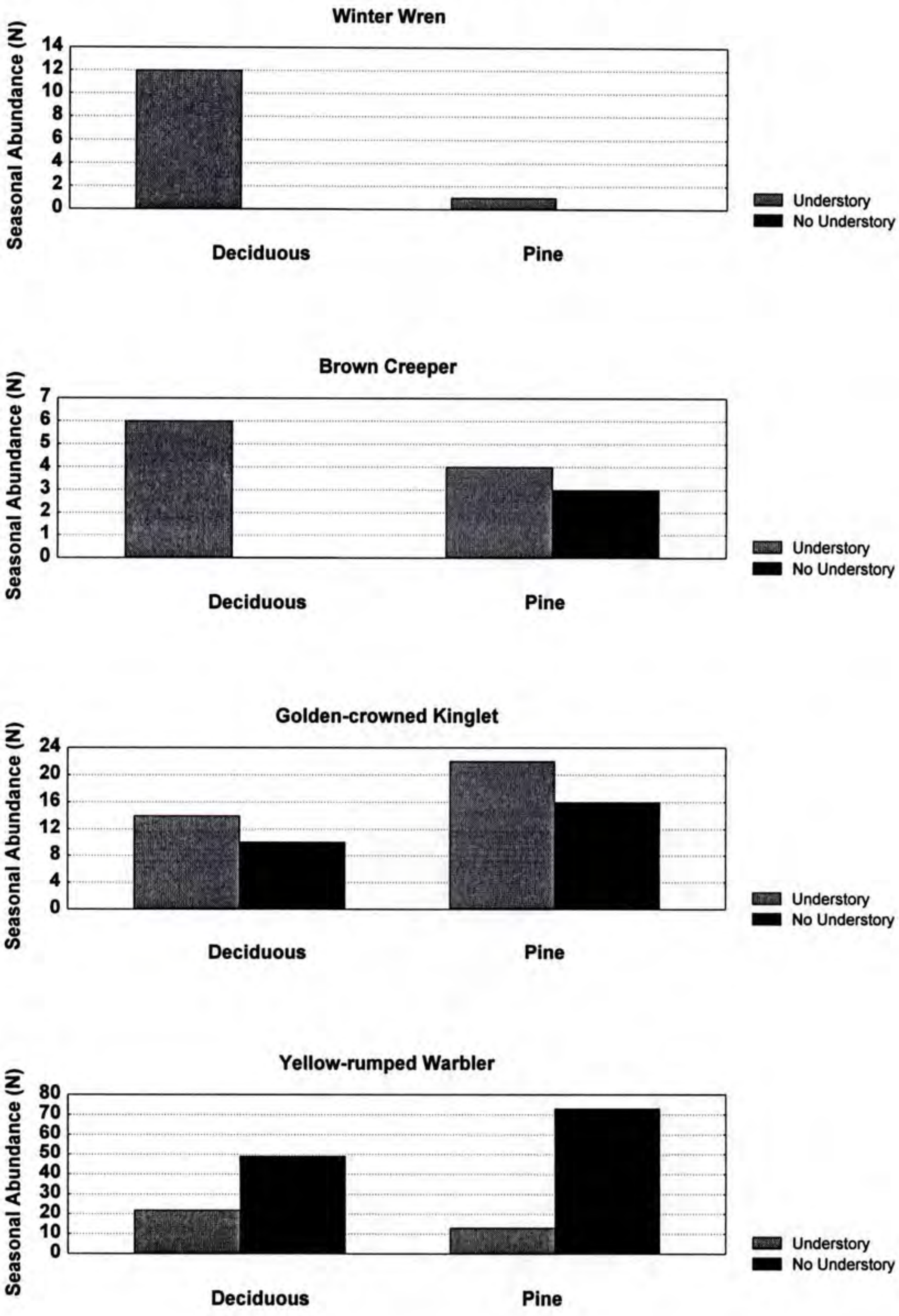
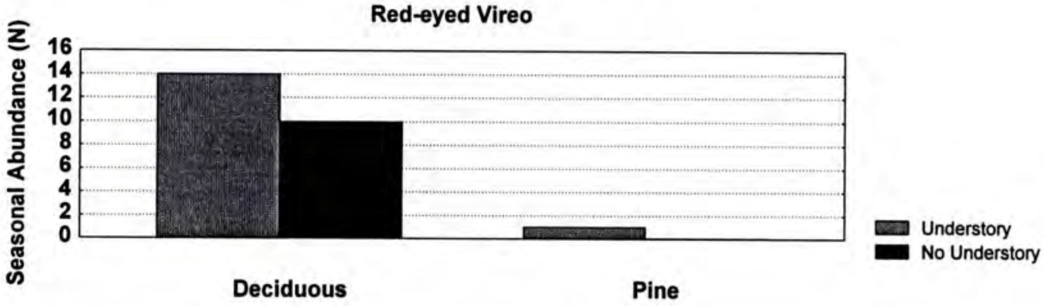
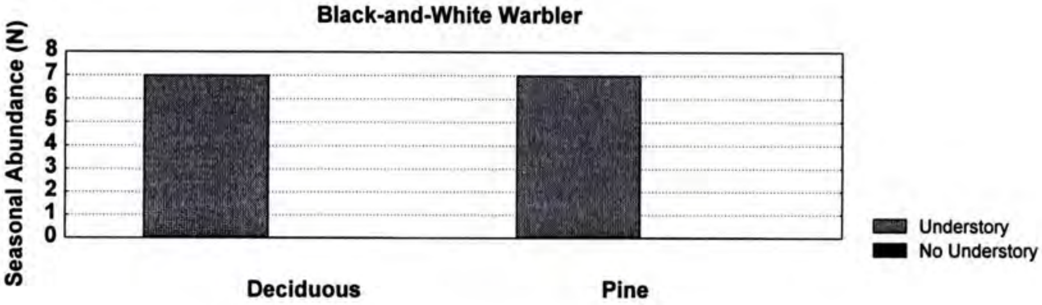
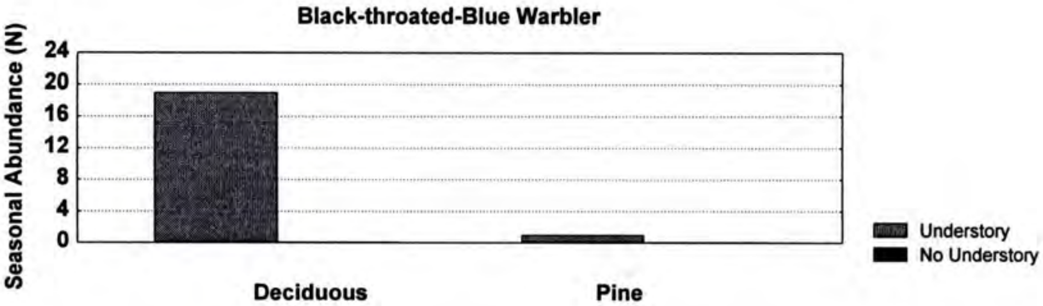


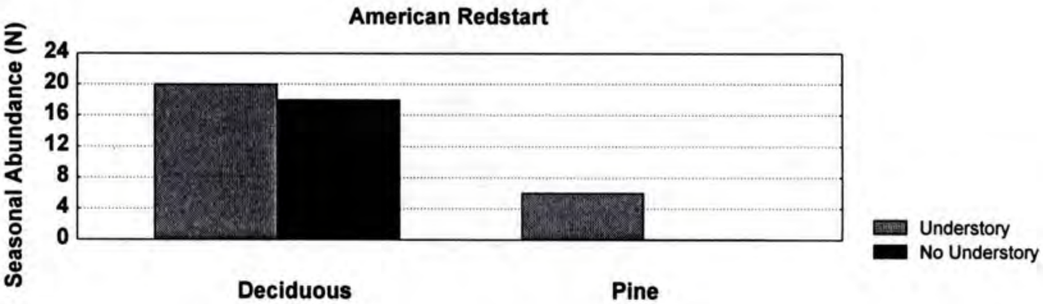
Figure 14. Habitat use patterns for selected species of temperate migrants. Values are based on cumulative detections from point counts conducted during 1996.

Figure 14 **Habitat Associations**









FORAGING STUDY

A total of 14,907 seconds of foraging observations were recorded for 114 individuals (Table 13). All three focal species achieved greater foraging success rates in deciduous compared to pine habitat (Table 14). Foraging rates for both Black-throated-blue Warblers and Ovenbirds were nearly 3 times greater in deciduous compared to pine habitats. Similarly, Black-and-white Warblers exhibited a 2-fold difference in foraging success rate between habitat types.

The 3 focal species utilized different substrates for foraging. Black-and-white Warblers gleaned insects directly from the bark and branch surfaces. This species foraged on both deciduous and pine bark surfaces depending on availability. Within deciduous habitat, prey attacks were directed entirely to deciduous plant species. In contrast, when in pine habitat, 92% of prey attacks were directed to pine tree surfaces. Black-throated-blue Warblers primarily gleaned insects from the underside of leaf surfaces (74% of prey attacks) and to a lesser extent from the ground (10% of prey attacks). Within both deciduous and pine habitats, all prey attacks directed to plant surfaces were on deciduous species. For Ovenbirds, the majority of insect prey were taken from the ground (76% of observations) and to a lesser extent from the underside of leaf surfaces near the ground (22% of observations). The proportion of prey attacks that involved leaf surfaces was higher in deciduous habitats compared to pine (34% vs 10%). However, this difference was not statistically significant ($\chi^2 = 1.56$, $P > 0.10$).

The 3 focal species utilized slightly different vegetational strata. Black-and-white Warblers foraged mostly in the mid and lower sucanopy layers. Black-throated-blue Warblers used mostly the lower subcanopy, shrub and ground layers of the vegetation. Finally, Ovenbirds foraged mostly on or near the ground in both habitat types.

Table 13. Sample sizes of focal species selected for the foraging behavior study.

Species	N	Total seconds of observation	Obsevation time (s) mean $\pm$ SD	Range (s)
Black-and-White Warbler	36	3639	101.0 $\pm$ 48.3	34-236
Black-throated Blue Warbler	55	6093	122.0 $\pm$ 78.0	45-420
Ovenbird	28	4052	144.7 $\pm$ 71.9	48-360

Table 14. Foraging perfomance statistics for three selected migrant species.

Species	Foraging Rate (success/100s) mean $\pm$ SD		Movement Rate (perch changes/100s) mean $\pm$ SD		Median distance (m) travelled/100s	
	Deciduous	Pine	Deciduous	Pine	Deciduous	Pine
Black-and-White Warbler	2.4 $\pm$ 1.3	1.3 $\pm$ 0.9*	11.3 $\pm$ 4.0	12.5 $\pm$ 4.0	8.0	22.7**
Black-throated Blue Warbler	3.4 $\pm$ 2.2	1.2 $\pm$ 0.7*	24.4 $\pm$ 9.4	21.2 $\pm$ 7.9	8.6	18.7**
Ovenbird	1.9 $\pm$ 1.2	0.7 $\pm$ 0.3*	6.4 $\pm$ 2.1	7.1 $\pm$ 2.4	8.6	12.9**

* result of t-test for comparison between habitat types, $p < 0.05$

**result of Mann-Whitney U test for comparison between habitat types, $p < 0.05$

Movement patterns varied with habitat type. The rate of perch change was similar between habitat types (Figure 14). However, the frequency of movement types was different between habitats for both Black-and-white Warblers and Black-throated-blue Warblers (both $\chi^2 > 56$, $P < 0.01$). The frequency of medium and long-distance flights was higher in pine compared to deciduous habitat. Short hops were more frequently observed in deciduous patches. The result of these differences is that movement rates were higher in pine patches. Movement types for the Ovenbird were similar between habitat types ($\chi^2 = 1.4$, $P > 0.20$. However, they were observed traveling nearly twice as far per unit time in pine versus deciduous habitats. Ovenbirds observed foraging in pine habitats tended to travel in straighter lines in pine patches compared to frequent turning after prey encounters in deciduous patches.

DISCUSSION

Seasonal patterns of abundance as revealed by both banding and point count data were different between the two migration classes. Neotropical migrants were detected and captured with higher frequency early in the fall compared to temperate migrants. This pattern is consistent with other fall migration data collected in the mid-Atlantic region (Sykes 1986, Watts and Mabey 1993, 1994, Unpub. data from Kiptopeke Banding Station). The disparity in movement times between the two groups is generally believed to reflect both the differences in food items utilized and the different set of demands associated with migrating over different distances. The majority of neotropical migrant species that pass through the mid-Atlantic feed on insects. Insects are most abundant in the late summer and early fall. In contrast, most temperate migrants feed on fruits or seeds. These food items are most abundant in the mid to late fall.

The suite of dominant species for respective migration groups was also consistent with previous studies within the region. For neotropical migrants, this suite represents species that breed in northeastern North America and spend the winter primarily in the Caribbean. Habitats within the mid-Atlantic lie between these two ranges and so support these species as they move south in the fall. For temperate migrants, this suite represents abundant species with breeding populations in northeastern North America and wintering areas in the southeast.

The Chesapeake Bay is one of the most significant natural barriers to southbound migrants along the Atlantic Flyway. Due to its geographic position relative to both the Chesapeake Bay and the direction of travel for fall migrants, Little Creek receives a lower volume of migrants than comparable lands on the opposite side of the Bay. Nocturnal migrants that reach the mouth of the Chesapeake Bay in the early morning hours settle out near the tip of the Delmarva Peninsula rather than attempting to cross the open expanse of water. Because of this, the early morning flight of migrants into Little Creek is truncated. Whereas, most land areas continue to receive movements of migrants throughout the morning hours, Little Creek typically only receives migrants from across the Bay in the very early morning. Birds that would normally settle in these habitats are concentrated on the Delmarva Peninsula.

In a very real sense, the Chesapeake Bay casts a "migration shadow" on the lands situated along its southern shoreline. A comparison of banding results from Kiptopeke Banding Station with those of Little Creek during the 1995 and 1996 seasons illustrate the differences in migrant volumes from the two areas. Average capture rates over the two years for neotropical and temperate migrants were 18.2 and 18.9 birds/100 net-h respectively for Kiptopeke. This may be compared to capture rates of 4.3 and 9.4 birds/100 net-h for Little Creek.

Habitat type had a significant influence on the use of forest patches by neotropical migrants. Capture rates were several times higher in live oak and deciduous patches compared to pine. Similarly, survey data show that both species richness and migrant abundance were significantly higher in deciduous patches when compared to pine. Collectively, these results suggest that migrants "prefer" deciduous and live oak habitats over pine habitats during migration. These results are consistent with studies in other locations showing that migrants differentiate between habitat types and appear to be selective (e.g. Parnell 1969, Martin and Karr 1985, Blake and Hoppes 1986).

In addition to patterns of habitat use, foraging observations on 3 migrant species suggest that, when compared to pine patches, deciduous patches are more profitable to migrants. For all 3 species, foraging success was 2-3 times higher in deciduous when compared to pine stands while movement rates were higher in pine. Taken together, these patterns suggest that foraging efficiency differs between habitat types. These results combined with patterns of habitat use, support other work showing that the use of high quality patches by migrants results in higher foraging rates (Graber and Graber 1983).

For neotropical migrants, both species richness and overall abundance were positively and significantly influenced by the presence of understory vegetation. Although individual species vary in this regard, the collective pattern supports the widely held view for breeding bird communities that both diversity and abundance are positively related to vegetation density/diversity (MacArthur and MacArthur 1961, Karr and Roth 1971, Moss 1978, Mills et al. 1991). Our data also support previous studies with migrants that suggest a similar relationship. For example, studies comparing migrant use of tree-fall gaps (patches with high understory densities) to undisturbed forest patches (patches with relatively low understory density) have shown that migrants selectively use gaps (Willson et al. 1982, Martin and Karr 1986, Blake and Hoppes 1986). Work with neotropical migrants on the lower Delmarva Peninsula showed a strong relationship between understory density and both migrant diversity and abundance (Watts and Mabey 1993, 1994).

MANAGEMENT RECOMMENDATIONS

The results of this study provide insights into the habitat requirements of land bird migrants that are important to the development of appropriate land management strategies. The most significant finding in this regard is that forested habitats are not equal with respect to migration habitat. Neotropical migrants were captured and detected in larger numbers in deciduous and live oak habitats compared to pine. In addition, deciduous patches seem to provide representative species with greater foraging opportunities. The result of this is that deciduous habitats may allow migrants to more easily meet their energetic requirements and presumably to complete migration. This fundamental difference between forest patches, suggests that habitat type should be a primary consideration in developing forest management plans.

A second consideration important for the development of management guidelines is that collectively, neotropical migrants appear to prefer forest stands with natural understory vegetation. Many species were exclusive to stands with understory vegetation. The 3 focal species examined, utilized understory vegetation as foraging substrate. The dependence of neotropical migrants on understory vegetation points to how forested habitats should be managed if they are intended to benefit this group of birds. Management techniques should be used that promote or maintain understory plants.

SPECIFIC RECOMMENDATIONS

1. Maintain existing forested habitat.

Within the installation, as a whole, forested patches are relatively uncommon. Management plans should minimize further reductions in forest area. Where feasible, restoration of forest cover on vacant parcels should be attempted.

2. Protect existing deciduous and live oak forest.

Both deciduous and live oak habitats appear to be preferred stopover habitat for neotropical migrants. Only 5 deciduous patches with reasonably intact understory vegetation remain. These patches should be protected from further encroachment. Where feasible, forest restoration or replacement should utilize canopy-forming hardwoods. The live oak patches along the inner dune system are some of the last remaining within the immediate area. These patches should be managed to prevent further encroachment.

3. Promote and maintain understory vegetation.

Most of the deciduous patches and a portion of the pine patches that are present, currently exist as parks or residential areas. The majority of the remaining patches have experienced substantial understory disturbance for recreational and/or training activities. Understory vegetation should be considered in the planning of future activities that include forested patches. Efforts should be made to minimize the loss of understory plants. Where feasible, forest patches should be managed to enhance understory development. For example, young pine stands should be thinned to allow for the release and development of understory shrubs and trees.

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APPENDIX: 1. List of species captured during banding operations (1995 and 1996 combined) or detected while conducting point counts. Migration categories are: 1) resident species, 2) temperate migrants, and 3) neotropical migrants. See methods section for definitions of these categories.

APPENDIX 1

Common Name	Scientific Name	Category 1	Category 2	Category 3
Sharp-shinned Hawk	*Accipiter striatus*			x
Red-tailed Hawk	*Buteo jamaicensis*		x	
American Kestrel	*Falco sparverius*		x	
Merlin	*Falco columbarius*			x
Great-horned Owl	*Bubo virginianus*	x		
Rock Dove	*Columba livia*	x		
Mourning Dove	*Zenaida macroura*	x		
Yellow-billed Cuckoo	*Coccyzus americanus*			x
Red-headed Woodpecker	*Melanerpes erythrocephalus*	x		
Red-bellied Woodpecker	*Melanerpes carolinus*	x		
Yellow-bellied Sapsucker	*Sphyrapicus varius*		x	
Downy Woodpecker	*Picoides pubescens*	x		
Hairy Woodpecker	*Picoides villosus*	x		
Pileated Woodpecker	*Dryocopus pileatus*	x		
Northern Flicker	*Colaptes auratus*		x	
Eastern Wood Pewee	*Contopus virens*			x
Acadian Flycatcher	*Empidonax virescens*			x
Great-crested Flycatcher	*Myiarchus crinitus*			x
Least Flycatcher	*Empidonax minimus*			x
Yellow-bellied Flycatcher	*Empidonax flaviventris*			x
Eastern Phoebe	*Sayornis phoebe*			x
Blue Jay	*Cyanocitta cristata*		x	
American Crow	*Corvus brachyrhynchos*	x		
Fish Crow	*Corvus ossifragus*	x		
Carolina Chickadee	*Parus carolinensis*	x		
Brown Creeper	*Certhia americana*		x	
Tufted Titmouse	*Parus bicolor*	x		
White-breasted Nuthatch	*Sitta carolinensis*	x		
Red-breasted Nuthatch	*Sitta canadensis*		x	
House Wren	*Troglodytes aedon*			x
Winter Wren	*Troglodytes troglodytes*		x	
Carolina Wren	*Thryothorus ludovicianus*	x		
Ruby-crowned Kinglet	*Regulus calendula*		x	
Golden-crowned Kinglet	*Regulus satrapa*		x	
Eastern Bluebird	*Sialia sialis*	x		
Wood Thrush	*Hylocichla mustelina*			x
Swainson's Thrush	*Catharus ustulatas*			x
Gray-cheeked Thrush	*Catharus minimus*			x
Hermit Thrush	*Catharus guttata*		x	
Veery	*Catharus fuscescens*			x
American Robin	*Turdus migratorius*		x	
Gray Catbird	*Dumetella carolinensis*			x
Mockingbird	*Mimus polyglottis*	x		
Brown Thrasher	*Toxostoma rufum*	x		
European Starling	*Sturnus vulgaris*	x		
White-eyed Vireo	*Vireo griseus*			x
Solitary Vireo	*Vireo solitarius*			x
Red-eyed Vireo	*Vireo olivaceus*			x

APPENDIX 1 - CONTINUED-

Common Name	Scientific Name	Category 1	2	3
Blue-winged Warbler	Vermivora pinus			x
Tennessee Warbler	Vermivora peregrina			x
Nashville Warbler	Vermivora ruficapilla			x
Northern Parula	Parula americana			x
Black-and-white Warbler	Mniotilta varia			x
Black-throated Blue Warbler	Dendroica caerulescens			x
Cerulean Warbler	Dendroica cerulea			x
Blackburnian Warbler	Dendroica fusca			x
Chestnut-sided Warbler	Dendroica pensylvanica			x
Cape May Warbler	Dendroica tigrina			x
Magnolia Warbler	Dendroica magnolia			x
Yellow-rumped Warbler	Dendroica coronata		x	
Black-throated Greed Warbler	Dendroica virens			x
Yellow-throated Warbler	Dendroica dominica			x
Prairie Warbler	Dendroica discolor			x
Blackpoll Warbler	Dendroica striata			x
Pine Warbler	Dendroica pinus			x
Yellow Warbler	Dendroica petechia			x
Connecticut Warbler	Oporornis agila			x
Canada Warbler	Wilsonia canadensis			x
Hooded Warbler	Wilsonia citrina			x
Worm-eating Warbler	Helmitheros vermivorus			x
Ovenbird	Seiurus aurocapillus			x
Northern Waterthrush	Seiurus noveboracensis			x
Common Yellowthroat	Geothlypis trichas			x
Yellow-breasted Chat	Icteria virens			x
American Redstart	Setophaga ruticilla			x
Northern Cardinal	Cardinalis cardinalis	x		
Indigo Bunting	Passerina cyanea			x
Rufous-sided Towhee	Pipilo erythrophthalmus		x	
Song Sparrow	Melospiza melodia		x	
Lincoln's Sparrow	Melospiza lincolnii		x	
Field Sparrow	Spizella pusilla		x	
White-throated Sparrow	Zonotrichia albicolis		x	
White-crowned Sparrow	Zonotrichia leucophrys		x	
Swamp Sparrow	Melospiza georgiana		x	
Sharp-tailed Sparrow	Ammospiza caudacuta		x	
Dark-eyed Junco	Junco hyemalis		x	
Brown-headed Cowbird	Molothrus ater	x		
Common Grackle	Quiscalus quiscula	x		
Boat-tailed Grackle	Quiscalus major		x	
Orchard Oriole	Icterus spurius			x
Northern Oriole	Icterus galbula			x
Scarlet Tanager	Piranga olivacea			x
American Goldfinch	Carduelis tristis	x		

APPENDIX: 2. Weeks of capture and sample sizes for species banded during the fall of 1995. Values represent all habitats combined. Weeks begin with the forth week of August and end after the second week of November.

APPENDIX: 2

Species	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Total
Mourning Dove	0	0	0	1	0	0	0	0	0	0	0	0	1
Yellow-billed Cuckoo	0	0	0	0	0	1	0	0	0	0	0	0	1
Red-bellied Woodpecker	0	0	0	0	0	0	1	0	0	0	1	0	2
Downy Woodpecker	0	0	2	1	0	0	0	0	0	0	1	0	4
Hairy woodpecker	0	0	0	0	0	0	0	1	0	0	0	0	1
Northern Flicker	0	0	0	4	1	2	1	0	0	0	0	0	8
Acadian Flycatcher	0	0	1	0	0	0	0	0	0	0	0	0	1
Least Flycatcher	0	0	0	0	1	0	0	0	0	0	0	0	1
Eastern Phoebe	0	0	0	0	0	0	1	0	0	3	0	0	4
Blue Jay	0	0	2	2	7	3	3	6	0	2	1	0	26
Carolina Chickadee	0	0	3	3	2	0	1	1	1	3	8	0	22
Brown Creeper	0	0	0	0	1	0	1	0	0	1	2	0	5
Tufted Titmouse	0	0	2	1	1	0	1	0	0	1	7	0	13
House Wren	0	0	0	0	1	0	1	0	0	1	0	0	3
Winter Wren	0	0	0	0	0	0	0	1	0	5	0	0	6
Carolina Wren	0	0	6	5	3	0	0	0	0	0	8	0	22
Ruby-crowned Kinglet	0	0	0	0	0	0	0	0	1	41	6	0	48
Golden-crowned Kinglet	0	0	0	0	0	1	0	0	0	39	6	0	46
Eastern Bluebird	0	0	0	0	1	0	0	0	0	0	0	0	1
Wood Thrush	0	0	0	0	0	0	2	0	0	0	0	0	2
Swainson's Thrush	0	0	1	0	3	1	2	2	0	0	0	0	9
Gray-cheeked Thrush	0	0	0	0	0	0	1	0	0	0	0	0	1
Hermit Thrush	0	0	0	0	0	0	1	1	8	40	9	0	59
Veery	0	0	3	0	0	0	0	0	0	0	0	0	3

APPENDIX: 2 - CONTINUED -

Species	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Total
Hermit Thrush	0	0	0	0	0	0	1	1	8	40	9	0	59
Veery	0	0	3	0	0	0	0	0	0	0	0	0	3
American Robin	0	0	5	0	1	0	0	0	0	0	2	0	8
Gray Catbird	0	0	0	1	4	1	6	2	0	0	0	0	14
Northern Mockingbird	0	0	1	0	0	0	0	0	0	0	0	0	1
Brown Thrasher	0	0	0	2	6	0	1	1	0	0	0	0	10
White-eyed Vireo	0	0	0	0	1	0	0	0	0	0	0	0	1
Solitary Vireo	0	0	0	0	1	0	1	0	0	0	0	0	2
Red-eyed Vireo	0	0	2	0	6	0	0	0	0	0	0	0	8
Blue-winged Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern Parula	0	0	1	0	3	2	0	0	0	0	0	0	6
Bl-and-Wh Warbler	0	0	6	2	3	0	0	0	0	0	0	0	11
Bl-thr-Blue Warbler	0	0	8	2	13	4	27	1	3	0	0	0	58
Cerulean Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0
Cape May Warbler	0	0	0	1	0	0	0	0	0	0	0	0	1
Magnolia Warbler	0	0	1	0	0	0	1	0	0	0	0	0	2
Yellow-rumped Warbler	0	0	0	0	0	1	6	18	59	34	5	0	123
Bl-thr-Green Warbler	0	0	0	0	0	1	0	0	0	0	0	0	1
Prairie Warbler	0	0	1	1	0	0	0	0	0	0	0	0	2
Blackpoll Warbler	0	0	0	0	3	1	4	1	0	0	0	0	9
Pine Warbler	0	0	0	0	1	1	0	0	0	0	0	0	2
Connecticut Warbler	0	0	2	0	0	1	0	0	0	0	0	0	3

APPENDIX: 2 - CONTINUED -

Species	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Total
Canada Warbler	0	0	1	0	0	0	0	0	0	0	0	0	1
Hooded Warbler	0	0	1	0	0	0	0	0	0	0	0	0	1
Worm-eating Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0
Ovenbird	0	0	5	3	1	2	1	1	0	0	0	0	13
Northern Waterthrush	0	0	2	1	1	0	0	0	0	0	0	0	4
Common Yellowthroat	0	0	2	1	1	0	0	0	0	0	0	0	4
Yellow-breasted Chat	0	0	2	2	3	0	0	1	0	0	0	0	8
American Redstart	0	0	15	6	13	3	1	0	0	0	0	0	38
Northern Cardinal	0	0	7	4	4	2	1	0	0	1	4	0	23
Indigo Bunting	0	0	0	0	0	0	0	1	0	0	0	0	1
Rufous-sided Towhee	0	0	0	0	1	0	0	2	0	0	3	0	6
Song Sparrow	0	0	0	0	0	0	0	0	1	0	0	0	1
Field Sparrow	0	0	0	0	0	0	0	0	0	1	0	0	1
White-throated Sparrow	0	0	0	0	0	0	1	0	0	6	0	0	7
Swamp Sparrow	0	0	0	0	0	0	0	0	0	1	0	0	1
Dark-eyed Junco	0	0	0	0	0	0	0	0	0	0	0	0	0
Lincoln's Sparrow	0	0	0	0	0	0	0	0	0	0	1	0	1
Sharp-tailed Sparrow	0	0	0	0	0	0	0	0	0	1	0	0	1
Sharp-shinned Hawk	0	0	2	0	0	0	0	1	2	1	0	0	5
Merlin	0	0	0	0	0	0	0	0	1	0	0	0	1

APPENDIX: 3. Weeks of capture and sample sizes for species banded during the fall of 1996. Values represent all habitats combined. Weeks begin with the forth week of August and end after the second week of November.

APPENDIX: 3

Species	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Tot
Mourning Dove	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow-billed Cuckoo	0	0	1	0	0	0	0	0	0	0	0	0	1
Red-bellied	0	0	0	0	0	0	0	2	0	0	0	0	2
Downy Woodpecker	0	0	2	0	2	0	0	0	0	0	0	0	4
Hairy woodpecker	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern Flicker	0	0	0	0	0	2	2	1	0	0	0	0	5
Acadian Flycatcher	0	0	0	0	0	0	1	0	0	0	0	0	1
Least Flycatcher	0	0	0	0	0	0	0	0	0	0	0	0	0
Eastern Phoebe	0	0	0	0	0	1	0	1	0	0	0	0	2
Blue Jay	0	0	1	0	5	4	5	1	0	0	0	0	16
Carolina Chickadee	1	6	7	0	1	2	4	0	0	1		0	22
Brown Creeper	0	0	0	0	0	1	2	0	0	0	0	0	3
Tufted Titmouse	1	3	4	0	4	2	4	1	0	0	1	0	20
House Wren	0	0	1	0	0	0	1	1	1	0	0	0	4
Winter Wren	0	0	0	0	0	0	4	11	1	2	0	0	18
Carolina Wren	10	5	10	0	1	0	1	1	0	0	2	0	30
Ruby-crowned Kinglet	0	0	0	0	0	0	0	0	0	0	0	0	0
Golden-crowned	0	0	0	0	0	0	0	0	0	1	0	0	1
Eastern Bluebird	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood Thrush	0	0	0	0	0	0	1	1	0	0	0	0	2
Swainson's Thrush	0	0	0	0	0	1	6	0	0	0	0	1	8
Gray-cheeked Thrush	0	0	0	0	0	0	0	0	0	0	0	1	1
Hermit Thrush	0	0	0	0	0	0	1	1	8	40	9	0	59
Veery	0	0	3	0	0	0	0	0	0	0	0	0	3

APPENDIX: 3 - CONTINUED -

Species	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Total
Hermit Thrush	0	0	0	0	0	0	4	7	3	6	2	2	24
Veery	0	2	3	1	1	0	0	0	0	0	0	0	7
American Robin	5	2	8	7	17	1	1	0	0	0	0	1	42
Gray Catbird	0	0	0	0	0	0	6	0	0	0	0	1	7
Northern Mockingbird	0	0	0	0	0	0	0	0	1	0	0	0	1
Brown Thrasher	0	0	0	0	0	1	0	1	0	0	0	0	2
White-eyed Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0
Solitary Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-eyed Vireo	0	1	1	0	1	0	0	0	0	0	0	0	3
Blue-winged Warbler	0	0	1	0	0	0	0	0	0	0	0	0	1
Northern Parula	0	0	0	0	0	1	0	0	0	0	0	0	1
Bl-and-Wh Warbler	2	1	9	1	2	0	0	0	0	0	0	0	15
Bl-thr-Blue Warbler	1	1	5	1	3	6	7	2	2	0	0	2	30
Cerulean Warbler	0	0	1	0	0	0	0	0	0	0	0	0	1
Cape May Warbler	0	0	0	0	0	0	0	0	0	0	0	0	1
Magnolia Warbler	0	0	1	0	1	0	0	0	0	0	0	0	2
Yellow-rumped	0	0	0	0	0	0	0	31	75	151	90	0	347
Bl-thr-Green Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0
Prairie Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0
Blackpoll Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0
Pine Warbler	0	0	0	0	1	0	0	0	0	0	0	0	0
Connecticut Warbler	0	0	0	0	1	1	0	0	0	0	0	0	2

APPENDIX: 3 - CONTINUED -

Species	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Total
Canada Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0
Hooded Warbler	1	0	0	0	0	0	0	0	0	0	0	0	0
Worm-eating Warbler	1	1	0	0	0	0	0	0	0	0	0	0	2
Ovenbird	2	2	2	2	7	1	2	0	0	0	0	0	18
Northern Waterthrush	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Yellowthroat	0	2	3	0	2	2	2	0	1	0	0	0	12
Yellow-breasted Chat	0	1	1	0	0	0	0	1	0	0	0	0	3
American Redstart	1	0	2	0	1	1	1	0	0	0	0	0	6
Northern Cardinal	4	2	7	1	1	2	1	1	0	0	1	1	21
Indigo Bunting	0	0	0	0	0	0	0	0	0	0	0	0	0
Rufous-sided Towhee	0	0	0	0	0	0	0	3	0	0	0	0	3
Song Sparrow	0	0	0	0	0	0	0	2	0	1	0	0	3
Field Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0
White-throated Sparrow	0	0	0	0	0	0	0	0	0	7	0	3	10
Swamp Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0
Dark-eyed Junco	0	0	0	0	0	0	0	2	0	1	0	0	3
Lincoln's Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0
Sharp-tailed Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0
Sharp-shinned Hawk	0	0	0	0	0	0	0	1	0	0	0	0	1
Merlin	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX: 4. Weeks of detection and sample sizes for species surveyed during point counts conducted during the fall of 1996. Values represent all habitats combined. Weeks begin with the second week of September and end after the second week of November.

APPENDIX: 4

Species	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Total
Rock Dove	5	11	0	15	7	1	0	0	5	0	44
Mourning Dove	34	16	6	15	4	0	0	0	0	10	85
Sharp-shinned Hawk	0	0	0	0	1	0	0	0	0	2	3
Red-tailed Hawk	1	0	0	0	0	1	0	0	0	0	2
American Kestrel	1	1	0	0	1	0	0	0	0	0	3
Great-horned Owl	1	0	0	0	1	0	0	0	0	0	2
Yellow-billed	1	0	0	1	0	0	0	0	0	0	2
Red-headed	0	0	0	0	2	0	0	0	0	1	3
Red-bellied	4	5	10	7	8	8	5	9	7	2	65
Downy Woodpecker	4	3	6	7	4	8	1	2	5	1	41
Pileated	0	1	0	1	3	1	0	0	0	1	7
Common Flicker	6	6	3	9	18	11	7	17	10	7	70
Eastern Wood	2	1	0	0	0	0	0	0	0	0	3
Great-crested	0	1	1	0	0	0	0	0	0	0	2
Yellow-bellied	0	0	0	1	0	0	0	0	0	0	1
Blue Jay	16	19	20	30	40	11	7	3	6	3	155
American Crow	39	12	12	17	20	11	25	10	13	16	175
Fish Crow	0	0	0	0	3	6	3	5	6	1	24
Carolina Chickadee	23	19	16	7	34	20	7	7	15	4	152
Brown Creeper	0	1	0	2	5	2	2	0	2	1	15
Tufted Titmouse	15	6	6	5	6	5	0	1	0	0	44
White-breasted	0	0	0	0	1	0	0	0	0	0	1
Red-breasted	0	0	0	0	0	0	0	1	0	0	1
Winter Wren	0	0	0	0	0	9	3	0	2	2	16

APPENDIX: 4 - CONTINUED -

Species	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Total
Carolina Wren	7	5	2	2	2	6	1	5	3	3	36
Ruby-crowned	0	0	0	0	0	2	8	0	1	0	11
Golden-crowned	0	0	0	2	7	16	21	8	12	3	69
Swainson's Thrush	0	0	0	0	2	0	0	0	0	0	2
Gray-cheeked	0	0	0	0	3	0	0	0	0	0	3
Hermit Thrush	0	0	0	0	0	3	1	5	1	5	15
Veery	0	1	0	0	1	0	0	0	0	0	2
American Robin	93	118	131	13	22	8	21	15	13	23	459
Gray Catbird	1	0	0	2	2	1	0	0	0	0	6
Northern	1	0	0	0	1	0	0	0	0	0	2
European Starling	102	89	41	7	13	2	27	2	3	7	293
Solitary Vireo	0	0	0	0	0	0	0	1	0	0	1
Red-eyed Vireo	5	5	4	4	7	0	0	0	0	0	25
Blue-winged	1	0	0	0	0	0	0	0	0	0	1
Tennessee Warbler	1	0	1	0	0	0	0	0	0	0	2
Nashville Warbler	0	2	0	0	0	0	0	0	0	0	2
Northern Parula	0	2	2	6	4	1	0	0	0	0	15
Bl-and-white	3	11	2	2	0	0	0	0	0	0	18
Bl-thr-blue Warbler	1	5	4	7	3	3	2	0	0	0	25
Blackburnian	0	1	2	0	0	0	0	0	0	0	3
Chestnut-sided	0	2	0	0	0	0	0	0	0	0	2
Cape May Warbler	0	2	0	1	0	0	0	0	0	0	3
Magnolia Warbler	1	2	1	1	0	0	0	0	0	0	5
Yellow-rumped	0	0	0	1	2	42	39	42	32	7	165

APPENDIX: 4 - CONTINUED -

Species	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Total
Bl-thr-green Warbler	0	3	0	0	0	0	0	0	0	0	3
Yellow-throated	1	0	0	0	0	0	0	0	0	0	1
Prairie Warbler	2	0	0	0	0	0	0	0	0	0	2
Blackpoll Warbler	0	0	0	0	5	1	0	0	0	0	6
Pine Warbler	5	0	2	0	10	2	0	0	0	0	19
Yellow Warbler	1	1	0	0	0	0	0	0	0	0	2
Canada Warbler	1	0	0	0	0	0	0	0	0	0	1
Worm-eating Warbler	1	0	0	0	0	0	0	0	0	0	1
Ovenbird	1	4	0	3	1	0	0	0	0	0	9
Common Yellowthroat	1	0	0	0	0	0	0	0	0	0	1
Yellow-breasted Chat	1	0	0	0	0	0	0	0	0	0	1
American Redstart	12	19	6	3	6	0	0	0	0	0	46
Northern Cardinal	10	9	5	3	8	1	0	3	3	0	42
Rufous-sided Towhee	0	0	0	0	0	0	0	0	1	0	1
White-throated Sparrow	0	0	0	0	0	0	0	4	0	7	11
Dark-eyed Junco	0	0	0	0	0	4	0	2	0	2	8
Brown-headed Cowbird	0	0	0	0	1	0	0	0	0	0	1
Common Grackle	3	36	40	229	23	160	10	14	6	0	521
Boat-tailed Grackle	0	8	0	0	0	0	0	0	0	0	8
Orchard Oriole	3	0	0	0	0	0	0	0	0	0	3
Northern Oriole	2	0	0	0	0	0	0	0	0	0	2
Scarlet Tanager	0	1	0	0	0	0	0	0	0	0	1
American Goldfinch	0	0	0	1	0	0	0	0	0	0	1