NORTHAMPTON MIGRATORY BIRD PROJECT

INTERIM REPORT

Submitted by

Virginia Department of Conservation and Recreation
Division of Natural Heritage

Virginia Department of Game and Inland Fisheries
Nongame Program

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Submitted to:

Virginia Coastal Resources Management Program
Virginia Department of Environmental Quality
903 Ninth Street Office Building
Richmond, Virginia 23219

Written by:

Bryan D. Watts
Center for Conservation Biology
College of William and Mary
Williamsburg, VA 23185

Sarah E. Mabey
Department of Conservation and Recreation
Division of Natural Heritage
Main Street Station, Suite 312
Richmond, VA 23219

Submitted by:

Virginia Department of Conservation and Recreation
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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. While researchers and conservationists have focused their energies on understanding the behavioral and ecological dynamics of these population during the breeding and wintering season, migration ecology has remained largely neglected. Migration must be endured twice annually and is a particularly stressful event for birds. Comprehensive conservation efforts on behalf of migratory birds must include this critical phase of life if they are to succeed in protecting whole populations.

The two-year Northampton Migratory Bird Project (NMBP) was initiated under Northampton County's Special Area Management Plan (SAMP) to provide this rural, coastal county with sound scientific data to guide the development of enforceable policies that will protect and enhance migratory songbird habitat. Conserving migratory birds and their habitat in lower Northampton County will serve to generate the basis of a burgeoning nature tourism industry, help to protect water quality and moderate secondary impacts of coastal development.

Results from the first season of the study show some strong spatial and temporal patterns. In summary our data indicate that:

1. Long-distance migrants are most abundant during the first half of the migratory period while short-distance migrants are most abundant during the last half of the season.
2. More birds were observed during the morning compared to the afternoon.
3. If birds spatially redistribute during the course of a day, this activity occurs before dawn.
4. Both long- and short-distance migrants are more abundant along the bayside and near the tip of the peninsula. Resident species tend to be least abundant near the peninsula tip.
5. There is no clear relationship between bird abundance and patch size.
6. Birds from both migrant groups were more abundant in edge plots than interior plots.
7. Most species were more abundant at plots with high vegetation density.
8. Individual species are associated with particular vertical strata within the forest. The vertical distribution of species is in general agreement with associations known for the breeding and wintering seasons.

The results of the first year provide a critical step toward policy development and land use planning for the protection of migratory songbirds and their habitat in Northampton County, Virginia.

INTRODUCTION

The recent surge of interest in neotropical migratory songbirds spans the realms of science, conservation and the general public and has provided a common ground for the interaction of these diverse circles. Reports of population declines for many eastern neotropical migratory songbird species (Hill and Hagan 1991, Askins et al. 1990, Robbins et al. 1989) have focused attention on the problems of temperate forest fragmentation and tropical deforestation (Hagan and Johnston 1992).

The general environmental degradation rapidly occurring in the birds' North American breeding grounds and their Latin American wintering grounds is indeed cause for concern. Fragmentation of temperate forests has been shown to negatively affect many migrant species by exposing them to higher predation pressure and cowbird nest parasitism (Hagan and Johnston 1992, Askins et al. 1990). Additionally, the restricted winter ranges of most 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 (Hagan and Johnston 1992, Keast and Morton 1980).

The threats to neotropical migrants during the breeding and wintering seasons reflect seasonal changes in vulnerability. But breeding and wintering constitute no more than two-thirds of a migrant's life. The migratory period also poses great ecological, behavioral, and physiological challenges to birds (Kaiser 1992, Winker et al. 1992a, Moore and Yong 1991, Gill 1990). Risks during migration are great. Birds that travel hundreds or thousands of kilometers need to rest and refuel. During these stop-overs, migrants must be able to overcome the obstacles of new and unknown habitats and unpredictable resources (i.e., food and cover) while maintaining or increasing fat reserves and avoiding predators. An understanding of this phase is also critical to comprehensive conservation efforts on behalf of migratory landbirds. Yet, the ecology of migration remains inadequately studied and its relevance to conservation is only beginning to be recognized (Moore et al. *in press*).

Migratory landbirds employ a variety of migration strategies. The timing, routes and distances of migratory flight may differ from species to species and even from individual to individual (Gauthreaux 1982). During the spring and fall, migrants can be seen all over North America. There are, however, sites known to experience predictably heavy visitation by migrants. These stop-over areas are generally related to a major physiographic element such as large peninsulas, bays, lakes, mountains, or ecological barriers (i.e., the Gulf of Mexico).

Two factors combine to make stop-over concentration sites both ecologically interesting and important to conservation. First, high densities of migrants increase the potential for direct and indirect competition and increase the relative importance of all available resources (Winker et al. 1992b, Moore and Yong 1991). It follows that loss of resources through human manipulation of the environment could affect a large proportion of the entire population. Second, the majority of the concentration sites in North America are found in coastal areas that are experiencing the fastest human population growth on the continent.

In this report we present an overview and results of the first phase of a two-year ecological study of fall migrants at a known stop-over concentration site on the lower Delmarva Peninsula (Northampton County, Virginia).

STUDY BACKGROUND AND JUSTIFICATION

Bounded by the Chesapeake Bay to the west and undeveloped Atlantic barrier islands to the east, the lower Delmarva Peninsula has long been recognized as a significant stop-over area for migrating birds of all kinds (Rusling 1936). This area is included in the Western Hemisphere Shorebird Reserve Network and is home to the Kiptopeke songbird banding and hawk observation station established by the Virginia Society of Ornithology 29 years ago. Giving further confirmation of the ecological value of the lower Delmarva for fall migrants, the U.S. Fish and Wildlife Service established the Eastern Shore National Wildlife Refuge at the peninsula tip specifically for the conservation of migratory birds.

Unlike the Cape May Peninsula to the north, intensive study of fall migrants on the lower Delmarva did not begin until 1991. A regional study of the geographic distribution of fall migrants on the Cape May and Delmarva peninsulas was initiated in that year (Mabey et al. *in prep.*). While some general regional patterns of migrant abundance were identified in that study, local landscape and habitat associations were obscured by the study's large scale geographic approach (McCann et al. *in prep.*).

Stop-over concentrations on the lower Delmarva differ from other coastal concentration areas such as the northern Gulf Coast and the Cape May Peninsula for at least two reasons. First, neotropical migrants that stop on the Delmarva do not appear to face any immediate major ecological barriers that would necessitate extremely long non-stop flights. Second, relatively more short-distance migrants (those birds that winter in southern U.S.) appear to use the Delmarva as a stop-over site than use the Cape May peninsula or the Gulf Coast (P. Kerlinger *pers. comm.*, M. Woodrey *pers. comm.*). Although this is likely to be a result of simple geography, the large numbers of short distance migrants add a unique dimension to stop-over ecology on the lower Delmarva. The presence of short-distance migrants increases the overall ecological value of eastern shore habitat and may provide more potential prey for raptor species. Interactions between short- and long-distance migrants during stop-over has never been thoroughly addressed (Winker et al. 1992b).

Further studies of stop-over ecology on the lower Delmarva will not only be important to a broader understanding of migration but will play a significant role in Northampton County's conservation initiatives. With the adoption of their comprehensive plan in 1990, Northampton officially recognized the value of the area's unique natural resources as the current and historical base of the county's economy and culture (Northampton County Joint Local Planning Commission 1990). Shell and finfishing are the county's leading industries representing a value of $62,096,849 in 1988 (Northampton Co. Planning and Zoning Dept. 1989). Agriculture is also critical to the economy; in 1987, the county's 119 commercial farms generated $43,085,703. Forestry has the potential for being the third most important economic base in the county but provided only $500,000 directly to the community in 1988, although the estimated "value" of timber sales for that year is over fourteen million dollars (Northampton Co. Planning and Zoning Dept. 1989). There is also potential for growth in the nature- and historic-based tourism.

Land use patterns in Northampton County have remained relatively stable over the past century. In 1986 about 35% of land area was in cropland, 20% in forest, 39% in marsh/wetland, and only 5% was classified as urban, industrial, or other (Northampton Co. Planning and Zoning Dept. 1989). Agricultural lands do not appear to be increasing because the best soils are already in cultivation. Forest lands are decreasing slowly as they are transferred into "alternate uses", mostly home sites.

Rapid change in the landscape is, however, on the horizon. In eleven miles of bayside shoreline from the tip of the peninsula north, almost seven have already been subdivided for development. The majority of this land is forested and may be one of the most important areas for migrating landbirds on the entire Delmarva Peninsula (McCann et al. *in prep.*). Northampton County will face a radical population shift as vacation and retirement homes are built over the next 5-10 years.

In keeping with the Northampton County comprehensive plan's commitment to managed growth, a Special Area Management Plan (SAMP) was initiated in 1992 with funding from the National Oceanic and Atmospheric Administration's (NOAA) Office of Coastal Resource Management. In the context of the SAMP, Northampton County has acknowledged migratory landbirds and their habitats to be of significant conservation value. By including neotropical migrants as a resource to protect and enhance through new, enforceable policies, Northampton County is recognizing the international importance of the Delmarva Peninsula as a stop-over concentration area as well as the integral role birds and their habitat play in the ecological health of the region. The SAMP seeks to control the cumulative and secondary impacts of coastal development by "maintaining maximum vegetation cover for wildlife habitat and nutrient removal from non-point runoff" and by steering development away from sensitive wildlife habitat and groundwater recharge areas and toward areas with greatest carrying capacity" (Virginia Coastal Resources Management Program: Coastal Zone Management Act Section 309 Final Strategy, VACOE, Grant No. NA17OZ0359-01). The SAMP effort will also be directed toward increasing public access and promoting appropriate nature tourism for the area. To achieve its goals, Northampton County has identified the need for detailed scientific data that will classify sensitive wildlife areas and assess the value of native vegetation in relation to wildlife. The continuing project introduced here has been designed to fill that need.

STUDY OVERVIEW

The overriding objective of our study is to determine distribution patterns and habitat associations of fall migrant landbirds on the lower Delmarva Peninsula. The strength and scope of many of the SAMP's policy goals will rest on answers to the following questions:

1. Are there any geographically defined concentrations of migrants within the lower Delmarva and where are they?

2. On a habitat level, what are the characteristics of forested areas (native vegetation) that are strongly associated with fall migrants?

3. Is there any biologically significant interaction between geographic and vegetation factors that are relevant to policy development?

The inherent spatial and temporal variability of migration has further dictated several aspects of the study design. We have chosen to approach the above questions with a hierarchy of temporal and spatial scales to control for the potential variation and clearly define real distribution patterns.

Temporal variability in migrant abundances is relevant to a comprehensive understanding of migration but is not generally important to land management practices. The ecological value of a given area or habitat must be defined by its utility to migrants over the entire migration period. Migrant distribution and abundance is likely to be influenced by seasonal (both between and within migration periods) and time of day (morning versus afternoon) effects. These temporal scales are included in our study.

We considered several spatial scales relevant to the ultimate policy objectives of Northampton County's SAMP: an area-wide, geographic level; the landscape level (woodlot size and distribution); and the internal woodlot level which includes distribution within patch in relation to edge, vertical strata and vegetation structure.

For all of the temporal and spatial independent variables discussed above we have looked for possible relationships to the bird data. The complete bird abundance information collected in the field has been separated into five dependent variable groups:

1. All birds and species
2. Resident birds
3. Short-distance migrants
4. Long-distance migrants
5. Individual species with greater than 70 observations in the field.

For the purposes of this study, resident species are those that have stable, year-round populations in our study area. Short-distance migrants are those species that generally do not migrate south of North America and may have both breeding and wintering populations in our study area. Long-distance migrants spend the winter in tropical and subtropical America, generally south of the United States, and may have breeding populations in our study area. (See Appendix I for a complete list of species and their classifications.) We have attempted to classify these species based on ecological factors. It is, therefore, important to note that not all species fit cleanly into these groups. Some species (e.g., Yellow-rumped or Pine Warbler) have extensive winter ranges that stretch from Virginia to sub-tropical America while others (e.g., Blue Jay) may have resident individuals and short-distance migrants wintering within our study area.

METHODS

The first research phase of this two-year project was conducted over an eleven week period from August 17 through October 30, 1992 on the lower Delmarva Peninsula (Northampton County, Virginia). The study area is confined to the mainland portion of the county from Eastville-Indiantown (Lat. 37° 21') south to the tip of the peninsula (Lat. 37° 07').

Study Design -- The study was designed to provide several levels of information regarding the spatial distribution of fall migrants within the forests of lower Northampton County and control for the inherent temporal variation of migration. These levels included large-scale geographic patterns as well as patterns related to the three dimensional forest patch structure.

We arbitrarily defined six geographic zones within the study area. Based on a forest patch inventory, we selected three patch size classes for study: 5-6 ha (Class A/small), 10-12 ha (Class B/large), and > 20 ha (Class C/big). Each of the six zones contained two Class A and two Class B patches. Four Class C patches were located in zones 1, 2, 5, and 6. In addition, we used the forested corridors along the bay- and seaside coasts of the study area.

Within each patch, we established routes with six sampling plots 0.25 ha in size (30 m fixed radius). Each route had three plots tangential to the forest edge (edge plots) and three plots > 60 m from the edge (interior plots), except in the few cases where the geometry of a patch was prohibitive. Plot centers were separated by a minimum of 75 m. Class A and B patches contained single routes while Class C patches each held two routes and each corridor had six routes. A total of 44 routes and 264 plots were distributed throughout the study area.

Observations -- We conducted 5 min counts at each of the 264 plots twice a day, two times a week. To control for daily variation in the number of migrants present, we surveyed Class A and B patches on Mondays and Wednesdays and Class C patches and Corridors on Tuesdays and Thursdays. We began morning counts 0.5 h after sunrise and concluded them within 4 h. We timed afternoon counts so that they were completed at least 0.5 h before sunset.

During the 5 min point count period, a single observer quietly searched the plot and recorded the species and number of all birds seen. Aural identification was allowed for resident species only. In addition, the observer recorded the vertical location of every individual based on the following strata categories: 0-2 m, 2-4 m, 4-6 m, 6-8 m, subcanopy, and canopy. We used the subcanopy and canopy classification only when the canopy was > 8 m in height.

Observations were not made during heavy winds or rain. During the 1992 season we were able to complete all planned morning surveys (22 surveys/plot) and missed only 4-6 afternoon surveys (16-18 surveys/plot).

Vegetation Description -- We measured vegetation at all 264 plots using a modification of the vegetation volume technique introduced by Mills et al. 1991. At each plot, we randomly selected the compass direction for a transect that would bisect the circle. A second transect was then oriented to intersect the first at right angles. Ten sample points were taken at 6 m intervals along each of the transects. To measure vegetation volume, we employed an 8 m pole that was clearly marked every 10 cm and again at 0.5 and 1 m intervals. The pole represents a cylinder with a diameter of 10 cm. Within each 0.5 m interval, we recorded the number of 10 cm sectors that were "hit" by vegetation and the species of plant represented by the "hit." A maximum of 80 "hits" are possible for one sample. The 20 samples taken for each plot were combined to determine the average vegetation volume.

RESULTS

During the course of the 11-week study period nearly 10,800 point counts were conducted within forest patches. Surveys resulted in the detection of over 22,500 birds, representing 119 species. Greater than 98% of the birds detected were identified to species. Remaining individuals could not be positively identified due to unavoidable circumstances (e.g. visual obstructions, poor visibility conditions, movement of birds away from the observer). All species with positive identifications were categorized according to migration status (see Appendix I for complete species list and residency/migration status).

Of the three bird categories used, long-distance migrants were the most diverse (62 species, 52.1% of total) followed by short-distance migrants (31, 26.0%) and permanent residents (26, 21.8%). However, in terms of overall abundance, just the opposite pattern was observed. Permanent residents accounted for nearly half of all individuals detected (10,805, 48.6%) followed by short-distance (7,998, 36.0%) and long-distance migrants (3,416, 15.4%) respectively. Within individual migration categories, as well as for the entire species list as a whole, species were not equally abundant. All three bird categories were numerically dominated by relatively few species (see Figure 1 for species abundance curves). For example, 80% of the short-distance migrants were accounted for by only 4 species (including the Blue Jay, Yellow-rumped Warbler, American

Robin, and Golden-crowned Kinglet) Similarly, Carolina Wrens, Carolina Chickadees, Common Grackles, and Northern Cardinals combined represented over 70% of the resident birds detected. For long-distance migrants, the American Redstart was by far the most abundant species observed representing nearly one quarter of the entire category.

Abundance patterns were used to select a representative subset of species for further analysis. All migrant species were included in subsequent analysis if they were detected 70 times or more. In addition, those resident species that were detected 70 times and were believed to be relatively sedentary were also included (see Appendix 1). Those species that were relatively common but tend to move over large areas in flocks during the fall (e.g. Common Grackles, American Crows) were excluded. What follows is a series of temporal and spatial analyses of the three general migration groups and those individual species that were detected with enough frequency to stand alone.

Temporal Patterns

Seasonal -- The frequency of detection for all bird groups and many of the individual species varied with season. Figure 2 illustrates the seasonal patterns in species richness and abundance for individual groups. If we split the field season into an early (weeks 1 - 6) and late period (weeks 7 - 11), all of the bird groups exhibit a significant seasonal pattern in detection frequency (all G-statistics > 200, $P < 0.001$). For the two migration groups, the patterns indicate that long-distance migrants tend to move through the study area early in the season to be followed by short-distance migrants somewhat later in the fall. Nearly 95% of the short-distance migrants were detected after week 7 as compared to less than 25% for long-distance migrants. As with long-distance migrants, resident species were detected significantly more often in the early period compared to the late period. We believe that this pattern reflects a seasonal change in detectability (due to changes in activity levels) rather than a reduction in overall abundance.

Most of the individual species showed seasonal patterns similar to those of their respective groups. However, some exceptions did occur. Figures 3 - 5 present a general overview of seasonal patterns for selected species. All of the resident species were detected significantly more often during the early period (defined as above) than expected based on the number of surveys (all chi-squared statistics > 14.3, $P < 0.001$) except Red-bellied Woodpeckers. Red-bellied Woodpeckers were observed with significantly greater frequency during the late period (chi-squared statistic > 200, $P < 0.001$). All of the short-distance migrants were detected comparatively more often during the late period (all chi-squared statistics > 95, $P < 0.001$) with five of nine species having no observations during the early period. Seven of nine species of long-distance migrants were detected significantly more often during the early period (all chi-squared statistics > 46, $P < 0.001$) with only Black-throated-blue Warblers and Gray Catbirds moving through later in the season (both chi-squared statistics > 70, $P < 0.001$). An accounting of seasonal patterns for all species detected is presented in Appendix II.

Daily -- Despite a very strong morning bias in detection frequency for all three bird groups, none of the groups exhibited a significant time of day pattern (Table 1). This result is due to the high degree of site to site variation in detection frequency. In other words, although more birds were detected in the morning for all sites, the total number of birds detected varied considerably between patches.

Although 20 of 23 species were detected with higher frequency in the morning rather than afternoon survey periods, time of day had a statistically significant influence on relatively few of the species (see Table 1). Carolina Chickadee, Blue Jay, Golden-crowned Kinglet, Yellow-billed Cuckoo, and Pine Warbler showed a significant morning bias with Northern Flicker, Yellow-rumped Warbler, and Gray Catbird having notable trends. Carolina Wrens and Northern Cardinals showed a significant afternoon bias in detection frequency.

Spatial Patterns

Geographic Patterns -- All three of the general bird groups showed distribution patterns on a geographic scale that were significantly different from that expected by chance (all chi-squared statistics > 90, $P < 0.001$), (see Figure 6). Both short and long distance migrants, as a whole, seemed to be concentrated within 10 km of the peninsula tip with relatively fewer birds detected with increasing distance away from the tip. This distribution pattern is consistent with the idea that migrants of both types are using habitats near the tip of the peninsula before crossing the mouth of the Chesapeake Bay. Resident birds, as a group, showed the opposite distribution and reached their highest densities in those areas furthest from the tip. A clear explanation of this tip-avoidance pattern is not readily apparent except that forested habitats within the lower, narrow portion of the peninsula may be of poor quality due to low soil moisture and frequent salt spray.

With relatively few exceptions, distribution patterns for the individual species examined were in agreement with their respective groups. All of the resident species were either evenly distributed across the study area (as was the case for Red-bellied Woodpeckers) or were skewed away from the tip (see Figure 7). Most of the short-distance migrant species were concentrated near the tip with the notable exception of Golden-crowned Kinglets and Hermit Thrushes that were distributed away from the tip and White-throated Sparrows that were evenly distributed (Figure 8). All of the long-distance migrants except Ovenbirds and Pine Warblers were concentrated near the tip (Figure 9). Both these exceptions were detected most frequently in the center of the study area.

With only one notable exception, none of the selected species exhibited an interaction between geographic distribution and time of day. This result indicates that very little directional redistribution occurred after the initiation of morning surveys. This is an important result that suggests that most migrants have reached their stop-over habitats by 7:00 AM and that morning surveys after this time give reasonable reflections of habitat utilization patterns. The result also suggests that the time of day effect discussed earlier is primarily caused by changes in activity levels (and related detection rates) rather than significant, within-day movements out of the study area.

The Golden-crowned Kinglet was the only species that appeared to relocate throughout the day. This species showed a significant time of day effect, a significant distribution away from the tip, and a time of day by geographic distribution interaction. By examining the relative distribution of kinglets observed during the morning and afternoon survey periods, there appears to be a net redistribution of birds to the north. The combination of these distribution patterns seems to suggest that kinglets are moving to the north in the early morning (before 7:00 AM) and that they are continuing this movement later into the morning when compared to the other migrants.

Within the forested corridors along the edge of the peninsula, all three bird groups had significantly higher detection frequencies within the bayside plots (all chi-squared statistics > 100, $P < 0.001$). Long-distance migrants, as a whole, had the largest bias with nearly 65% detected along the bayside. Individual species exhibited all possible patterns but of the species with significant patterns, 75% were detected more frequently along the bayside (including Red-bellied Woodpeckers, Blue Jays, Chickadees, Titmice, Golden-crowned Kinglets, Robins, Black-and-white Warblers, Black-throated-blue Warblers, and Redstarts). Robins showed the greatest bias with over 95% of the individuals detected along the bayside. Some notable species also showed a significant bias for the seaside corridor (including Yellow-billed Cuckoos, Catbirds, and Yellow-rumped Warblers).

Influence of Patch Size -- Within the relatively narrow range of patch sizes examined, patch size was not a significant determinant of patch use for any of the three bird groups (Table 2). Species richness and overall abundance was not influenced by patch size. Similarly, although many of the selected species exhibited a positive or negative trend in abundance with increasing patch size, relatively few patterns were statistically significant. Red-bellied Woodpeckers, Yellow-billed Cuckoos, and Red-eyed Vireos were the exception to this rule. These three species were detected with higher frequencies in larger forest patches when compared to smaller. This pattern suggests that the use of a given forest patch for these species is area-dependent. However, the biological significance of this pattern during migration remains unclear.

Distribution Within Patches -- The location of census plots in relation to the edge or interior of the forest patch had a significant influence on the number of species and individuals detected (Table 3). Overall, bird abundance and species richness was significantly higher within census plots that were positioned along patch edges. This pattern along with the observation that many of the birds were detected directly along the edge suggest that patch edges accounted for a disproportionate number of the total birds detected.

Consistent with the overall patterns of abundance, many of the selected species exhibited a significant edge/interior bias in distribution. All but two of these species were detected with higher frequency along patch edges and many were over twice as common there. Only Carolina Wrens and Black-throated-blue Warblers showed notable distributions away from patch edges.

Influence of Vegetation Density -- In order to examine the influence of vegetation density on space use, vegetation measurements were summed within the four 2 m vertical strata for each census point. Summary data for all four strata were then run through a principal component analysis to determine the dominant sources of variation (in vegetation density) across all census plots. The PCA defined two distinct sources of variation including: 1) meters 0 - 4 hereafter referred to as understory, and 2) meters 4 - 8 hereafter referred to as subcanopy. For this reason, the following analyses will focus on vegetation data summarized for the understory and subcanopy categories.

Across the set of census plots, vegetation density within both the understory and subcanopy varied by several fold. The overall density of vegetation was considerably higher in the understory compared to the subcanopy, however, vegetation density was skewed to low values for both strata. In order to examine the availability of vegetation conditions, the range of variation for both strata were subdivided into 10 discrete categories. A frequency distribution of census points based on vegetation density was then generated for both categories (Figure 10). These distributions indicate the number of points surveyed that fall within a given vegetation range and were used as the null distribution in testing for bird/vegetation relationships. In order to evaluate how vegetation density influenced point use, the number of observations of selected species were summed for each point and tested against the expected based on the vegetation categories. Figures 11 - 13 illustrate the patterns in deviations between the observed and expected use of understory and subcanopy values.

Most of the selected species examined exhibited significant deviations from expected distribution patterns based on both the understory and subcanopy. However, deviation patterns were generally more easily interpreted with regards to the understory density. For resident species, all but one under-utilized plots with relatively low density understories and over-utilized areas with high density understories. This same general pattern was observed for both groups of migrants. Although a few species showed significant deviations that were not easily interpreted, only the Tufted Titmouse, Hermit Thrush, and Yellow-billed Cuckoo appeared to prefer areas with relatively low understory density. These general patterns seem to suggest that most species are selecting areas based on the characteristics of understory vegetation and that most species prefer areas where vegetation is relatively dense.

In comparison to the understory patterns, many of the species examined do not appear to be as selective for subcanopy characteristics (Figures 14 - 16). Many of the deviation patterns do not lend themselves to clear interpretation. However, some notable patterns were observed. Cardinals, Flickers, Blue Jays, Robins, Black-and-white Warblers, Pine Warblers, and Redstarts all seem to prefer high density vegetation in the subcanopy. Redstarts in particular showed a high preference for plots with relatively dense subcanopies. As with the understory vegetation, Tufted Titmice and Yellow-billed Cuckoos appear to prefer low density areas.

Patterns in Strata Use -- All of the selected species showed significant patterns in the use of vertical strata (Figures 17 - 19). Although intergrades do exist, species generally fall into four groups. These groups include: 1) canopy species, 2) subcanopy species, 3) understory species, and 4) ground species. The majority of the species would be considered subcanopy or understory species with relatively few being restricted to either the canopy or the ground. In general, strata use complements the patterns observed in plot use. Most of the species that primarily use the understory or ground are found in plots containing high density understory vegetation. Likewise, many of the species that utilize the subcanopy seem to prefer areas with dense vegetation in the subcanopy.

DISCUSSION

Seasonal patterns of abundance were quite clear for all three groups of species. Neotropical migrants were more abundant during the first half of the migration season than they were later. Short-distance migrants display the opposite pattern. In fact, although our data indicate that we adequately covered peak movement periods for long-distance migrants, this was not the case for short-distance migrants. This result suggests that it will be necessary to continue sampling through mid-November in order to thoroughly incorporate the heaviest periods of movement for this group in our study. Detection of residents peaked late in the first half of the study period and then tapered off. This is likely due to dispersal of young and post-breeding behavioral changes that decrease the detectability of resident birds. This result has important implications for planning tourism events around migration. A second year of data that covers the entire migration period will add to the reliability of predicting the peaks of fall migration.

On a geographic scale, we found that there was a trend towards highest abundances of both long- and short-distance migrants close to the peninsula tip. In contrast, residents tended to have the reverse distribution with their lowest densities close to the peninsula tip. Migrants were also found to be more abundant on the bayside of the peninsula while residents were more evenly distributed. These geographic distribution patterns may be important to the SAMP's goal of directing further development away from sensitive wildlife areas. The development of zoning ordinances to protect native vegetation would be facilitated by the delineation of areas with heaviest bird use in lower Northampton County. We will investigate these patterns further in the coming field season so that they can be more fully defined.

Within the parameters of our study, the size of a woodlot did not appear to have any strong relationship to the abundance of any of the bird groups or most individual species. Yellow-billed Cuckoo, Red-eyed Vireo, and Red-bellied Woodpeckers all seemed to respond positively to larger woodlots and showed significant differences in abundance from small to large to big patches. The fragmented character of the lower Delmarva's landscape and the relatively similar size of all woodlots in the area may explain this result. It is possible that below a certain size, birds do not react to differences in forest area. An alternative hypothesis is that forest area alone is not as meaningful a parameter for most birds during migration as it appears to be during the breeding season.

Within forest patches, more birds were counted at edge plots than interior plots. Further, we found that most species were under-represented in plots with low density vegetation and appeared to be selecting for those plots with high density vegetation. Vegetation density differs between edge and interior plots only within the first 2 m of the ground (Strata 1) where it is significantly higher for edge plots. Within plots, however, most species analyzed demonstrated strata associations that correspond to their known breeding and wintering behavior. These results will play an integral role in creating meaningful vegetation ordinances and Memoranda of Understanding (MOUs) between Northampton County and the Virginia Department of Transportation or the power companies. After the completion of the study, results such as these may be shared with the public so that they can be incorporated in land management decisions of private citizens.

The future direction of this study will guided by the results of the first year. Two principal themes will be pursued in the coming field season: a continuation of the current emphasis on spatial and temporal distributions and an investigation of possible underlying causes of these distributional patterns.

Although the importance of testing the resilience of the patterns identified here should not be overlooked, the second field season will also allow us to move to a finer geographic scale. For example, observations suggest that migrant concentrations on the bayside of the lower Delmarva may be a "veneer" phenomenon, occurring only within a thin section of woodlands directly adjacent to the coast. Such detailed resolution of the distribution of fall migrants within the heavy use areas of the bayside and peninsula tip will be highly beneficial to land use planning efforts.

Also of value to long-term planning for the protection of migrants and their habitats is an understanding of *why* the birds stop-over on the lower Delmarva and *what* they need from habitats there. Obviously, the full scope of those questions is beyond the constraints of this study. However, data from the first year indicate that the importance of the lower Delmarva varies for different species. Some species (e.g., American Redstart and Golden-crowned Kinglet) are common in the area and are likely to be using the area for longer stop-overs than other species. We will address this further in the coming field season, focusing primarily on habitat use by different species.

ACKNOWLEDGEMENTS

Funding for this study was provided through grant # NA17OZ0359-01 from NOAA's Office of Coastal Resource Management and administered by the Virginia Department of Environmental Quality's Coastal Resources Management Program. This study would not have been possible without the support and hard work of numerous individuals and agencies. We thank Melissa Donoff, Peter Leimgruber, Debbie Orr, Sharon Torgersen, and Sean Smith for assistance in the field and Georgia Kratimenos and Daryl Thomas for both field assistance and help with the graphics. Thomas Smith and Karen Terwilliger assisted with fiscal management responsibilities. Toni Harrison, Pat Jarrell, and Faye McKinney provided critical administrative support. We appreciate the private landowners of Northampton County who generously gave us permission to work in their woodlots; Dr. George Ortel and the Oceanography Department of Old Dominion University for use of the Oyster Field Station; Sherman Stairs, Eastern Shore National Wildlife Refuge for access to refuge property; the staff of The Nature Conservancy's Virginia Coast Reserve for logistical support; and the Northampton County Planning Office for technical assistance.

TABLE 1: Comparisons between morning and afternoon surveys for bird groups and selected species. Data for stands within the six geographic zones only were used in analysis.

Bird Group	Morning X ± S.E.	Afternoon X ± S.E.	F	P
Resident				
Red-bellied	7.0 ± 1.27	5.2 ± 0.93	1.36	NS
Chickadee	32.2 ± 2.22	20.3 ± 1.63	21.97	<0.001
Car. Wren	15.8 ± 3.23	25.6 ± 1.89	34.72	<0.001
Cardinal	9.6 ± 1.96	10.4 ± 1.51	10.03	<0.01
Richness	10.8 ± 0.34	9.6 ± 0.35	0.32	NS
Abundance	173.3 ± 17.47	111.8 ± 16.51	0.17	NS
Short-distance				
Flicker	11.3 ± 2.23	6.6 ± 1.43	3.10	0.05<<0.1
Blue Jay	31.3 ± 3.25	19.8 ± 3.10	6.51	<0.05
Win. Wren	1.2 ± 0.35	0.8 ± 0.24	0.94	NS
G-c Kinglet	22.1 ± 2.80	13.5 ± 2.39	5.49	<0.05
Hermit Thr.	2.3 ± 0.48	1.3 ± 0.58	1.91	NS
Robin	16.5 ± 5.24	28.4 ± 8.06	1.53	NS
Y-r Warbler	28.8 ± 8.75	13.0 ± 2.84	2.92	0.05<<0.1
Towhee	1.0 ± 0.27	0.8 ± 0.26	0.11	NS
Wh-th Sparrow	2.9 ± 1.04	2.7 ± 0.94	0.02	NS
Richness	10.1 ± 0.60	8.9 ± 0.52	0.01	NS
Abundance	120.4 ± 14.52	97.5 ± 9.25	0.56	NS
Long-distance				
Y-b Cuckoo	0.8 ± 0.16	0.2 ± 0.09	4.36	<0.05
Gnatcatcher	0.6 ± 0.26	0.7 ± 0.28	0.05	NS
Catbird	4.0 ± 1.03	2.0 ± 0.48	2.97	0.05<<0.1
Red-e Vireo	2.8 ± 0.55	1.2 ± 0.27	7.10	<0.05
Bl&Wh Warbler	4.9 ± 0.77	4.0 ± 0.73	0.56	NS
Bl-th-bl Warbler	2.2 ± 0.40	1.5 ± 0.32	1.98	NS
Pine Warbler	6.7 ± 1.41	3.3 ± 0.79	4.47	<0.05
Ovenbird	1.5 ± 0.32	1.0 ± 0.16	1.66	NS
Redstart	13.0 ± 3.41	8.8 ± 2.18	1.26	NS
Richness	14.9 ± 1.28	11.0 ± 0.60	1.05	NS
Abundance	48.6 ± 7.40	30.3 ± 3.78	0.277	NS

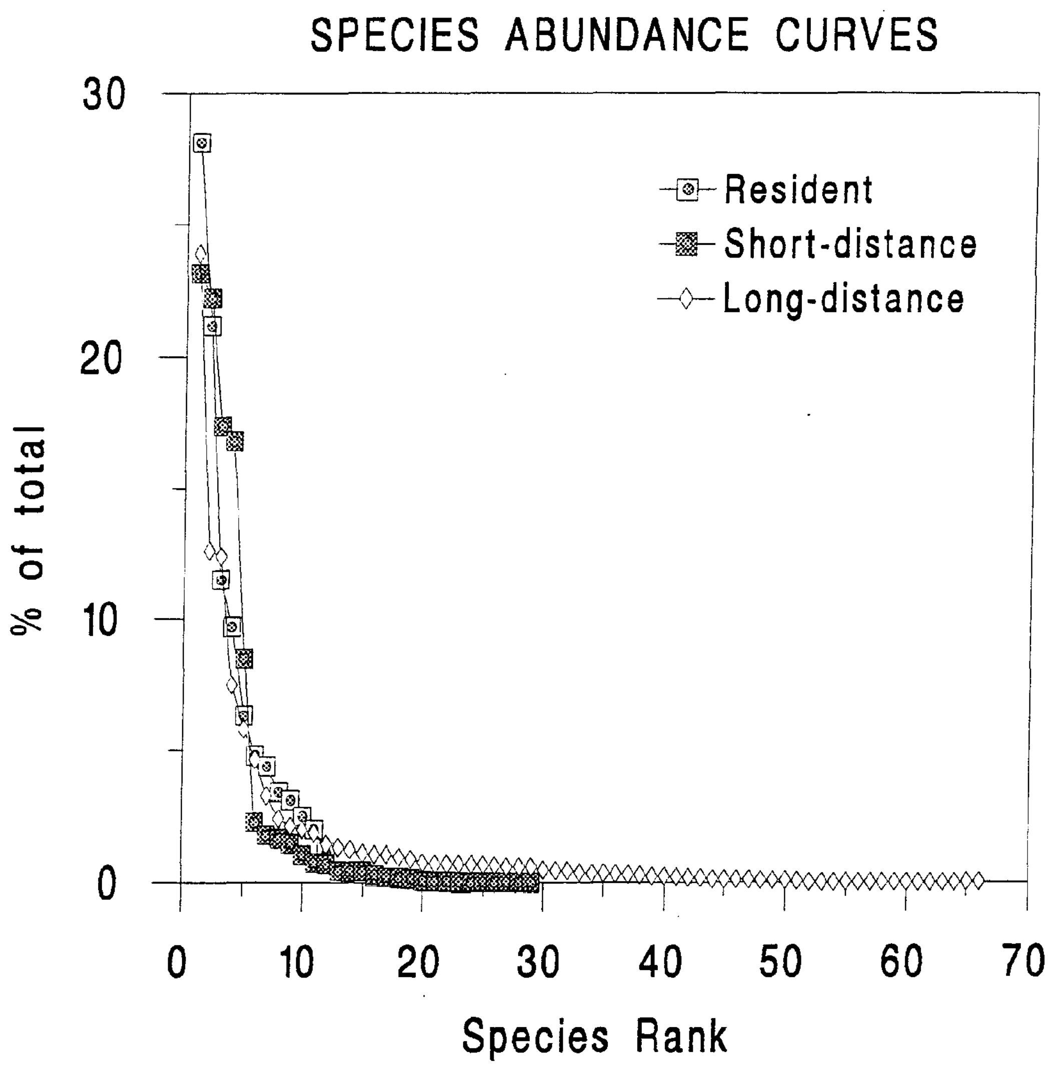
TABLE 2: Descriptive statistics and results of one-way analysis of variance between small, medium, and large forest patches. Sample sizes = 12, 12 and 8 for small, medium, and large patches respectively.

Bird Group	Small X ± S.E.	Medium X ± S.E.	Large X ± S.E.	F	P
Resident					
Red-bellied	5.2±1.94	8.8±1.55	12.3±1.42	3.86	<0.05
Chickadee	33.0±2.76	33.4±3.61	34.5±3.98	0.04	NS
Car. Wren	43.2±4.02	52.1±4.88	48.6±6.47	0.92	NS
Cardinal	17.8±3.08	18.6±2.56	11.6±3.02	1.45	NS
Richness	11.0±0.58	10.6±0.38	10.8±0.56	0.19	NS
Abundance	170.3±26.00	176.3±24.53	126.5±18.91	1.03	NS
Short-distance					
Flicker	9.8±3.29	12.7±3.10	17.3±3.30	1.16	NS
Blue Jay	32.7±5.80	29.8±3.20	19.6±3.33	1.94	NS
Win. Wren	1.0±0.51	1.3±0.51	1.9±0.74	0.54	NS
G-c Kinglet	23.3±4.44	20.9±3.58	17.9±2.72	0.44	NS
Hermit Thr.	2.1±0.75	2.5±0.62	1.3±0.25	2.91	NS
Robin	18.2±7.65	14.8±7.47	8.5±6.26	0.38	NS
Y-r Warbler	32.3±9.94	25.2±14.80	25.8±6.69	0.12	NS
Towhee	1.1±0.43	0.8±0.32	0.5±0.33	0.53	NS
Wh-th Sparrow	2.0±1.04	3.8±1.82	0.9±0.35	1.05	NS
Richness	10.0±1.07	10.2±0.60	8.5±0.50	1.04	NS
Abundance	121.5±23.33	119.3±18.35	93.5±9.98	0.52	NS
Long-distance					
Y-b Cuckoo	0.2±0.17	1.0±0.21	1.1±0.40	4.64	<0.05
Catbird	4.3±1.66	3.8±1.30	2.5±0.89	0.35	NS
Red-e Vireo	1.3±0.43	4.3±0.82	4.6±1.30	4.99	<0.05
Bl&Wh Warbler	4.4±0.87	5.2±1.31	7.9±3.18	0.98	NS
BlThBl Warbler	1.7±0.53	2.8±0.57	1.8±0.41	1.36	NS
Pine Warbler	5.7±1.93	7.8±2.10	5.1±1.97	0.46	NS
Ovenbird	1.3±0.31	1.6±0.57	1.6±0.48	0.12	NS
Redstart	14.5±6.39	11.6±2.71	9.6±3.48	0.25	NS
Richness	14.2±2.32	15.6±1.17	11.6±1.21	1.13	NS
Abundance	45.6±14.04	51.6±5.48	46.0±9.71	0.11	NS

TABLE 3: Results of Mann-Whitney U comparisons between edge and interior points. Sample sizes = 129 and 135 for edge and interior point respectively.

Bird Group	Edge X ± S.E.	Interior X ± S.E.	U	P
Resident				
Red-bellied	2.88 ± 0.256	2.27 ± 0.204	9095	NS
Chickadee	8.89 ± 0.527	8.42 ± 0.506	9095	NS
Car. Wren	7.28 ± 0.641	8.67 ± 0.481	12698	<0.001
Cardinal	5.50 ± 0.446	2.49 ± 0.247	12350	<0.001
Short-distance				
Flicker	2.87 ± 0.325	2.27 ± 0.208	9267	NS
Blue Jay	8.59 ± 0.727	5.43 ± 0.427	11099	<0.001
Win. Wren	0.49 ± 0.080	0.31 ± 0.168	10345	<0.001
G-c Kinglet	4.78 ± 0.435	5.35 ± 0.560	8777	NS
Hermit Thr.	0.55 ± 0.117	0.44 ± 0.098	9231	NS
Robin	6.29 ± 1.258	4.23 ± 1.077	10085	<0.05
Y-r Warbler	8.68 ± 1.403	4.80 ± 0.840	10405	<0.01
Towhee	0.41 ± 0.092	0.12 ± 0.035	9615	<0.05
Wh-thr Sparrow	1.39 ± 0.375	0.02 ± 0.017	10889	<0.001
Long-distance				
Y-b Cuckoo	0.24 ± 0.044	0.30 ± 0.057	8453	NS
Gnatcatcher	0.26 ± 0.063	0.36 ± 0.094	8864	NS
Catbird	1.46 ± 0.278	0.48 ± 0.096	10788	<0.001
Red-e Vireo	0.81 ± 0.101	0.66 ± 0.089	9345	NS
B&W Warbler	1.85 ± 0.237	1.39 ± 0.165	9840	0.05<<0.1
Bl-th-bl Warbler	0.52 ± 0.085	0.70 ± 1.393	7815	0.05<<0.1
Pine Warbler	1.80 ± 0.318	1.42 ± 0.154	8463	NS
Ovenbird	0.51 ± 0.067	0.34 ± 0.051	9612	0.05<<0.1
Redstart	3.63 ± 0.758	2.53 ± 0.259	9136	NS
Total Richness	19.50 ± 0.510	16.42 ± 0.346	11573	<0.001
Total Abundance	102.83 ± 7.152	68.83 ± 2.842	11765	<0.001

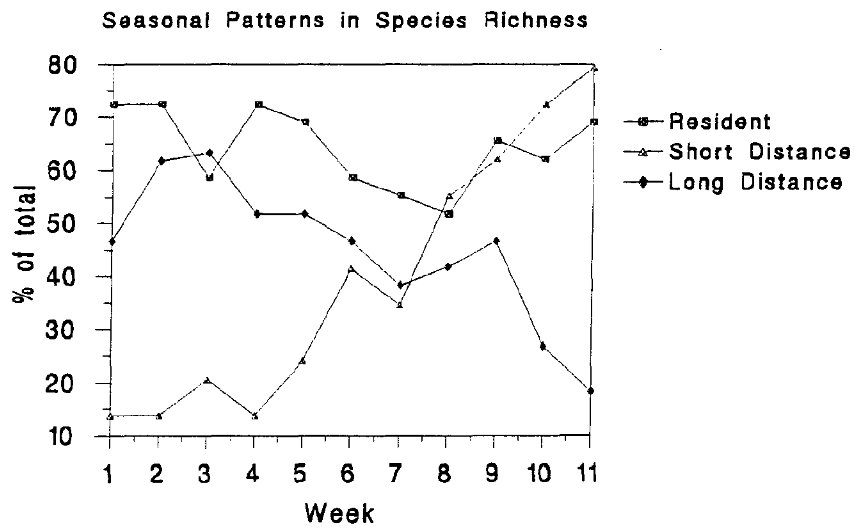
Figure 1: Species abundance curves for resident, short-distance migrants, and long-distance migrants. Percent indicates the relative proportion of total observations accounted for by each species. Species rank is an ordering of the species within each group based on their absolute abundance (ordered from highest to lowest abundance).



SPECIES ABUNDANCE CURVES
Resident
Short-distance
Long-distance
% of total
30
20
10
0
0
10
20
30
40
50
60
70
Species Rank

Figure 1

Figure 2: Seasonal patterns in species richness and overall abundance for residents, short-distance migrants, and long-distance migrants. Percent indicates the relative proportion of total observations (for the entire field season) for each group accounted for during a given week. Week one is the third week of August and week 11 is the last week of November.


Seasonal Patterns in Species Richness
80
70
60
50
40
30
20
10
% of total
1 2 3 4 5 6 7 8 9 10 11
Week
Resident
Short Distance
Long Distance

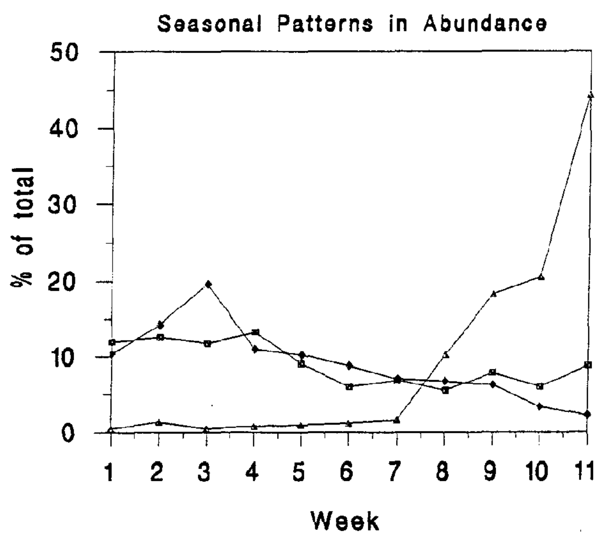

Seasonal Patterns in Abundance
50
40
30
20
10
0
% of total
1 2 3 4 5 6 7 8 9 10 11
Week

Figure 2

Figures 3 - 5: Seasonal patterns in detection rates for selected resident, short-distance migrants, and long-distance migrants. Percent indicates the relative proportion of total observations accounted for by a given week. Week one is the third week of August and week 11 is the last week of November.

Seasonal Patterns in Detection Frequency For Selected Resident Species

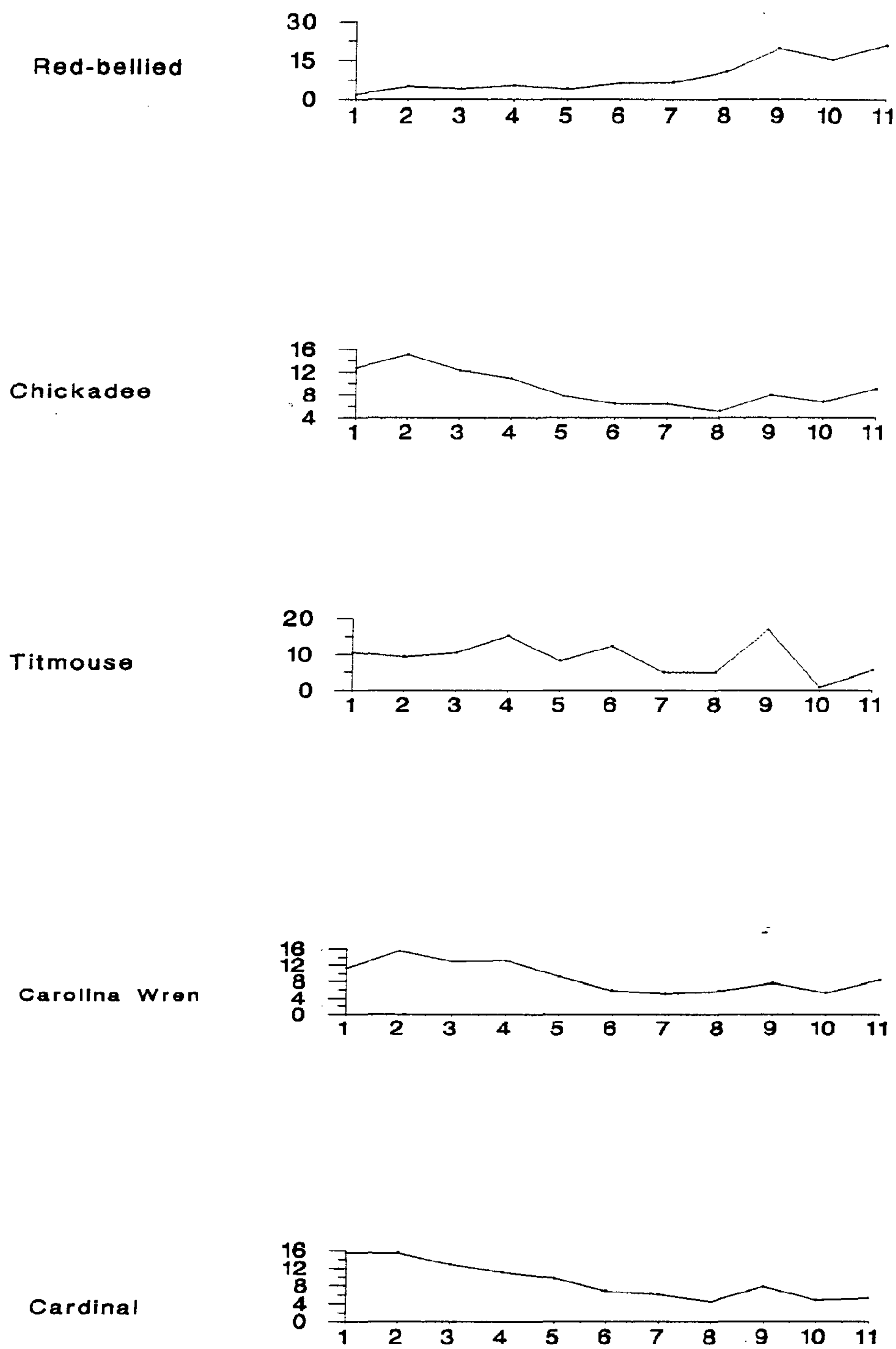


Figure 3

Seasonal Patterns in Detection Frequency For Selected Short-distance Migrants

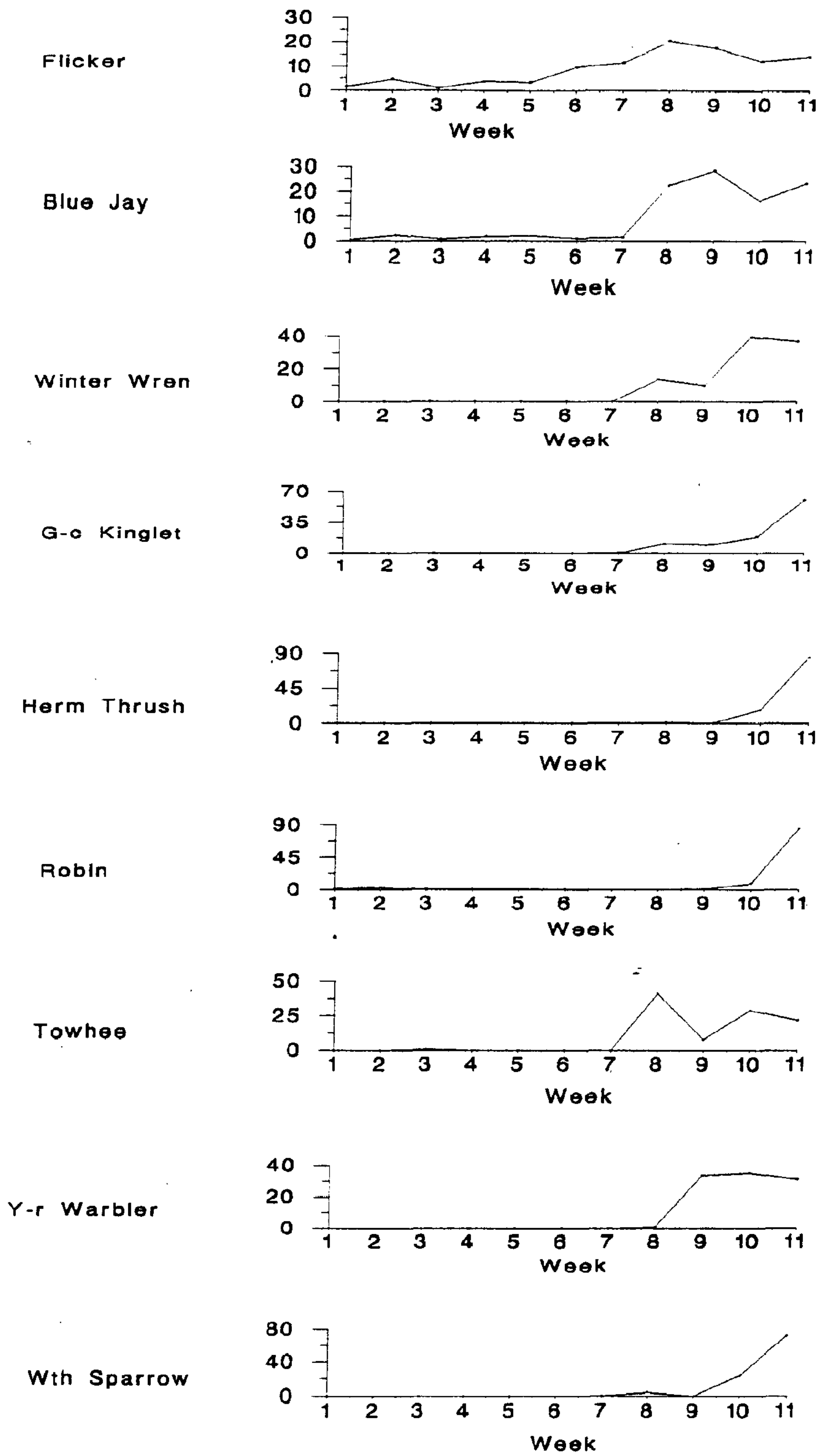


Figure 4

Seasonal Patterns in Detection Frequency For selected Long-distance Migrants

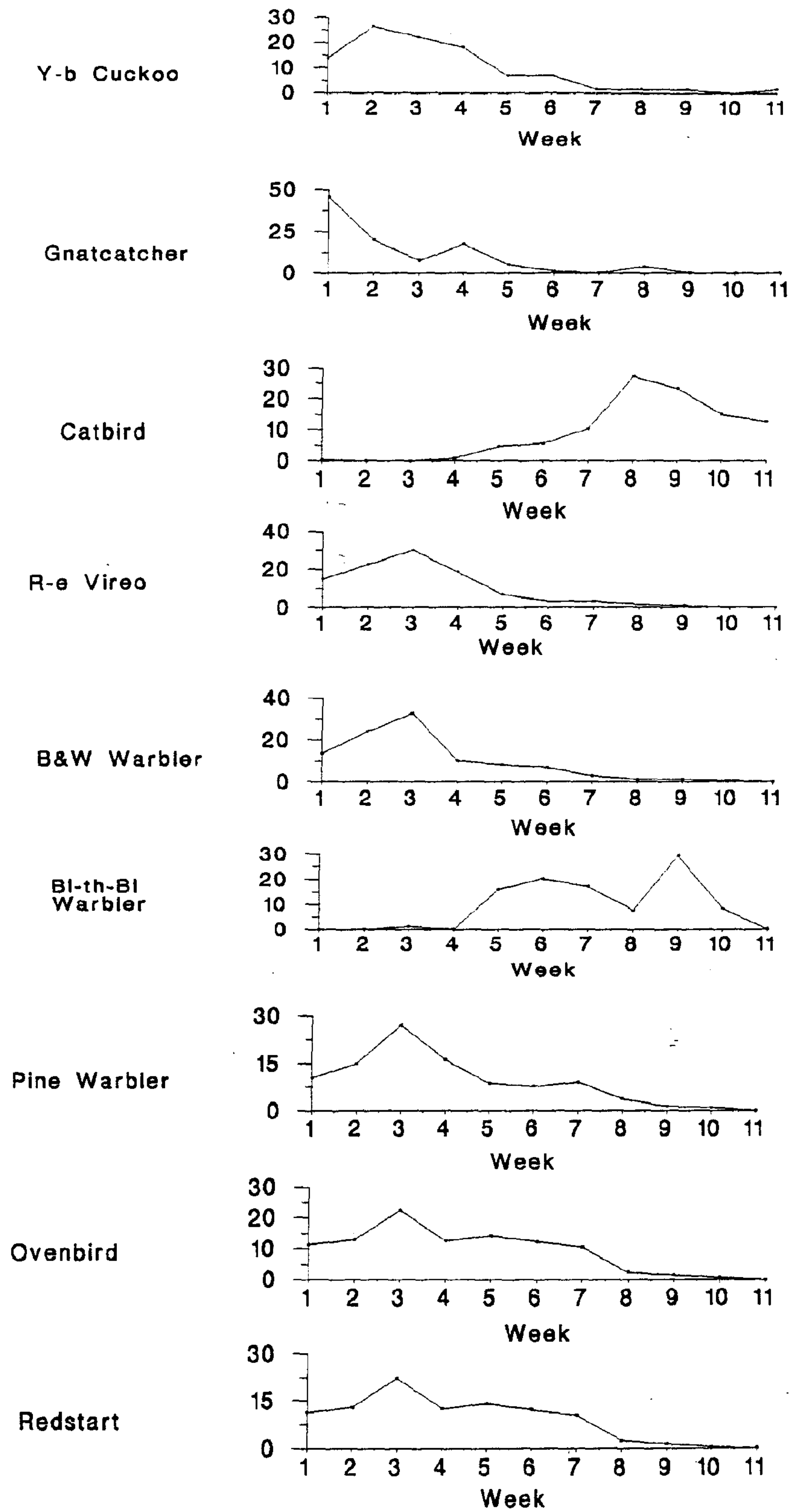
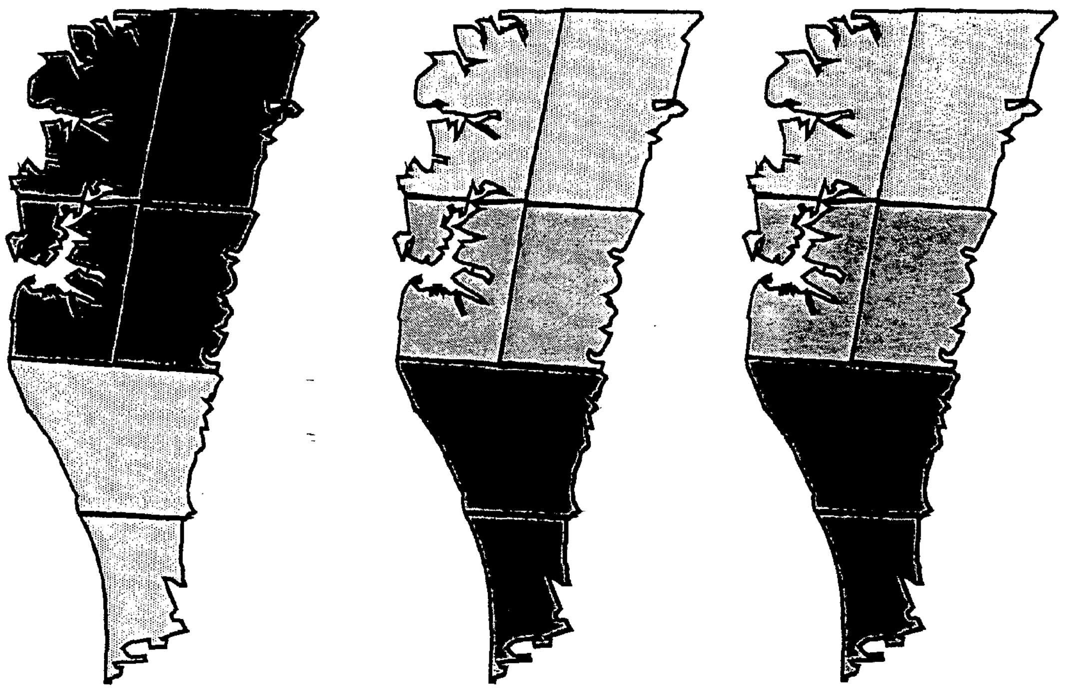


Figure 5

Figure 6: Geographic patterns for resident, short-distance migrants, and long-distance migrants. Percentage values indicate the relative proportion of birds within the entire study area that were accounted for by particular regions. The symbols *** beside group names indicate significance to the 0.001 level for Chi-squared statistics comparing observed distribution patterns with an expected even distribution.

Geographic Patterns for Bird Groups

Resident ***   Short-distance ***   Long-distance ***



Key to Color Codes for Geographic Maps

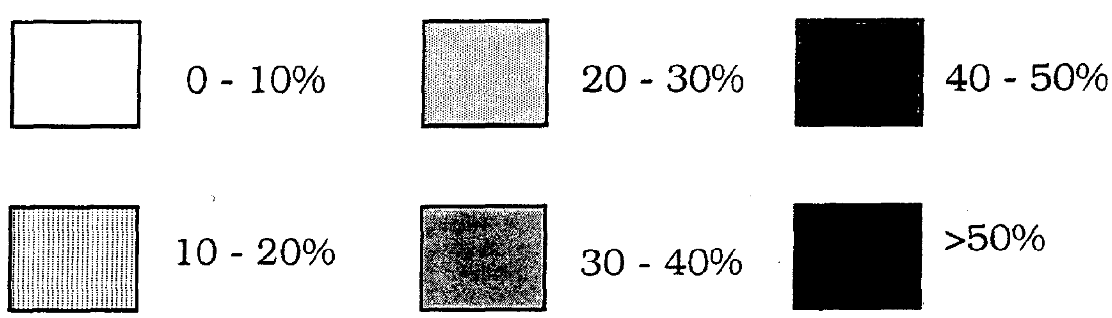


Figure 6

Figures 7 - 9: Geographic patterns for selected species. Percentage values indicate the relative proportion of birds within the entire study area that were accounted for by particular regions. Significance values (generated from Chi-square tests) are given by symbols located beside species names: no symbol indicates no significant difference from expected, (*) indicates significance to the 0.05 level, (**) indicates significance to the 0.01 level, and (***) indicates significance to the 0.001 level.

Geographic Patterns for Selected Resident Species

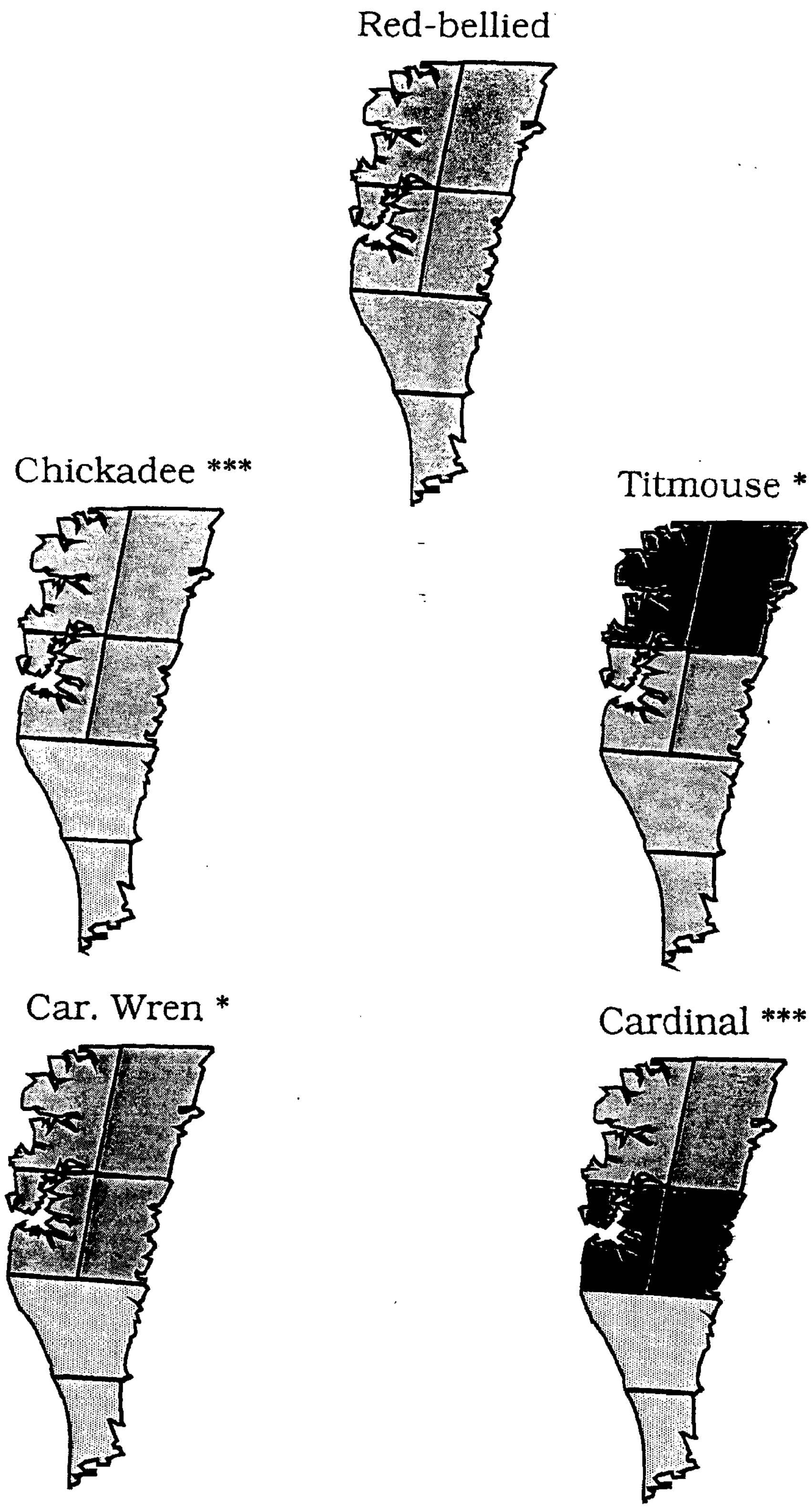


Figure 7

Geographic Patterns for Selected Short-distance Migrants

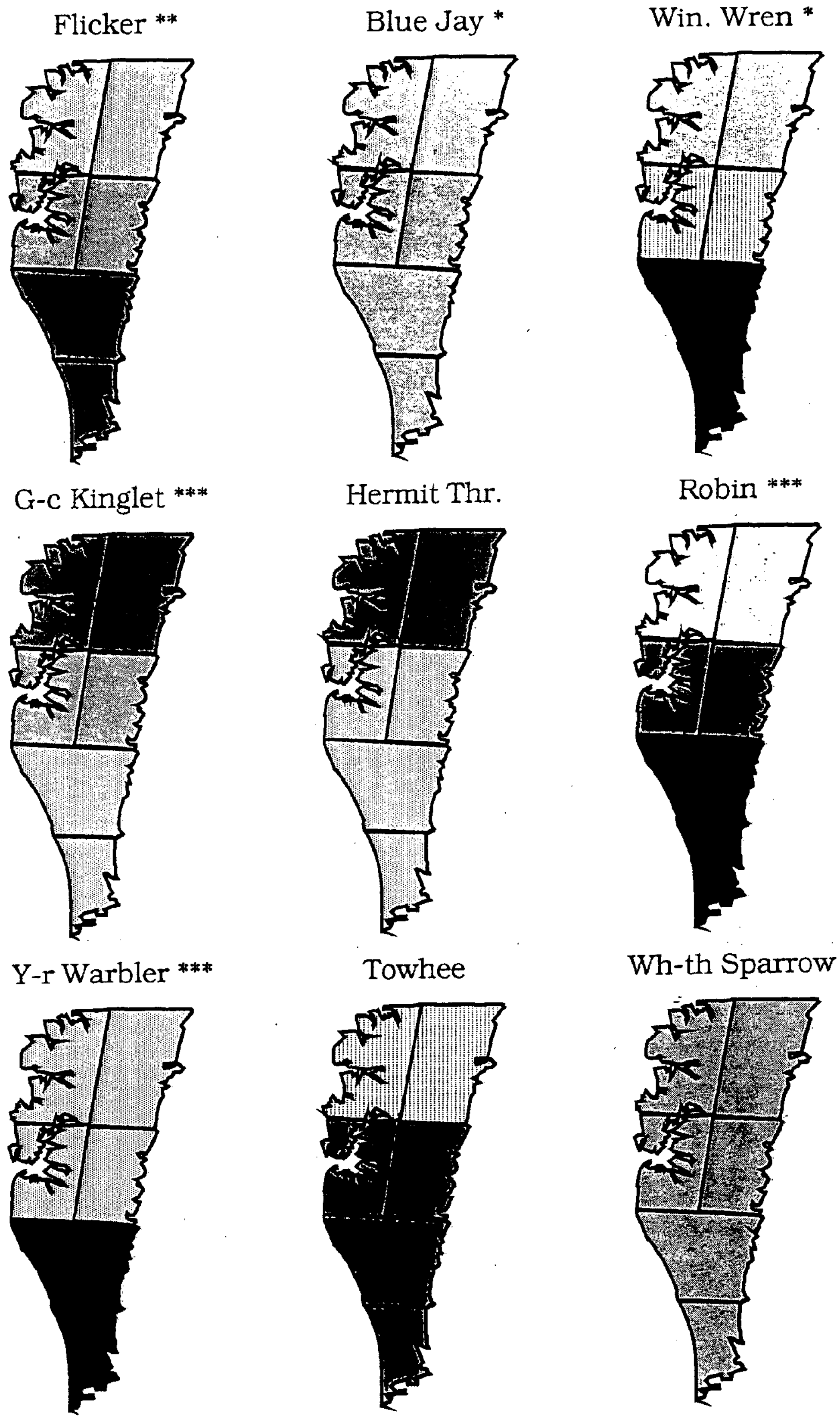


Figure 8

Geographic Patterns for Selected Long-distance Migrants

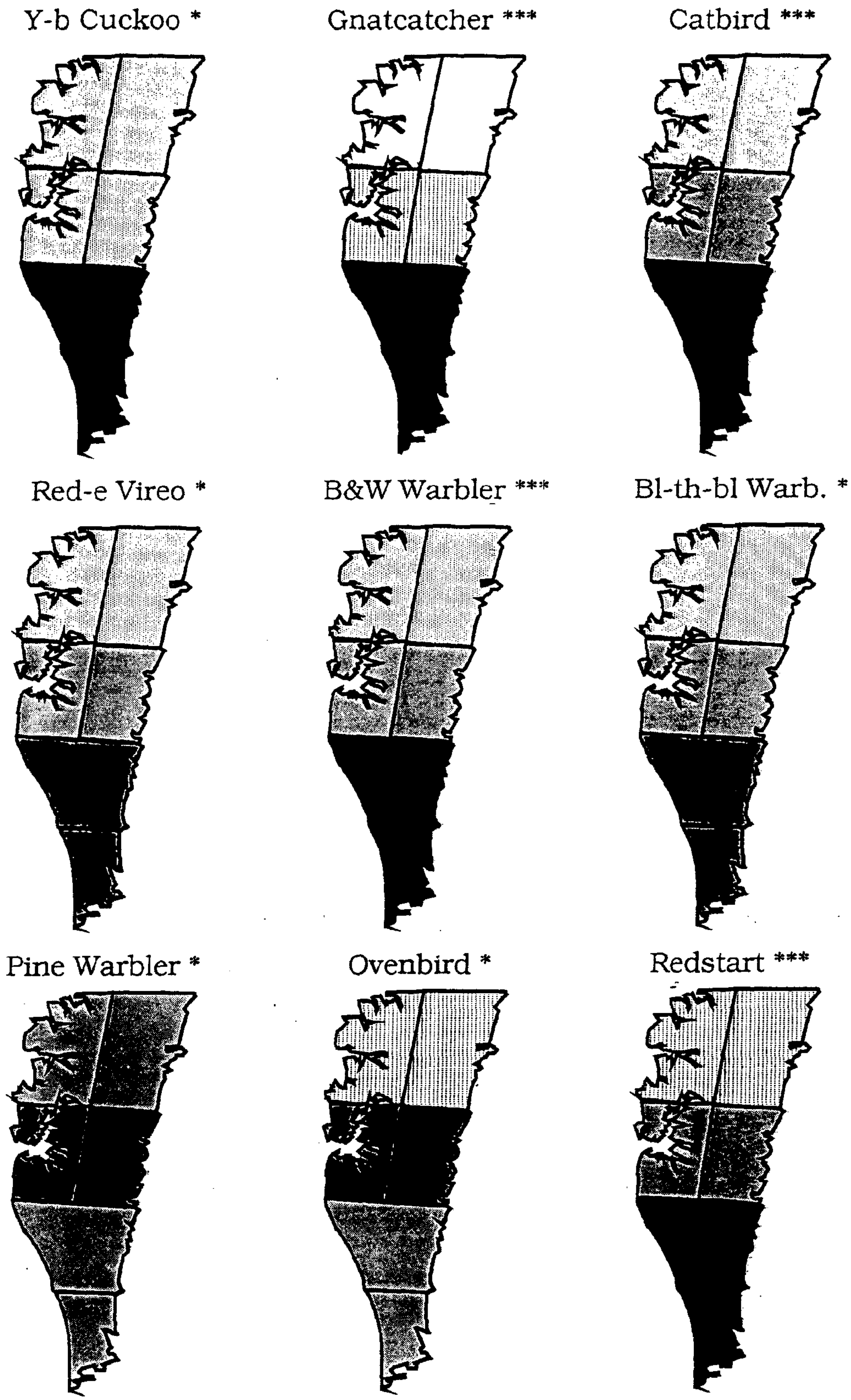
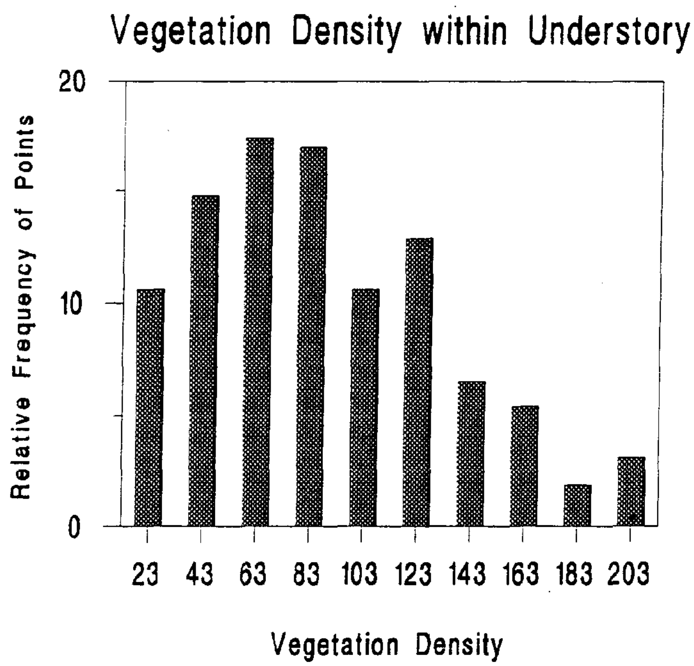
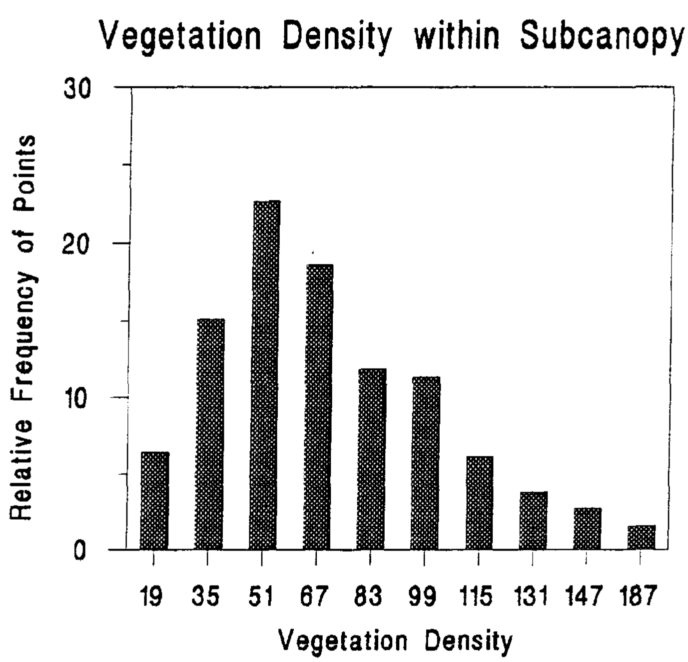


Figure 9

Figure 10: Frequency distribution for census plots across the observed range of density for understory and subcanopy vegetation. Understory refers to the area from ground level to a height of 4 m. Subcanopy refers to the area from 4 to 8 meters above the ground. Density categories presented indicate the midpoint for a range of density values. Density values indicate the sum of vegetation measurements within the understory and subcanopy for each census plot.



Vegetation Density within Understory
20
10
0
Relative Frequency of Points
23 43 63 83 103 123 143 163 183 203
Vegetation Density



Vegetation Density within Subcanopy
30
20
10
0
Relative Frequency of Points
19 35 51 67 83 99 115 131 147 187
Vegetation Density

Figure 10

Figures 11 -13: Deviation patterns for selected resident, short-distance migrants, and long-distance migrants. Bars indicate the difference between bird utilization patterns and those expected based on the availability of census points within a given range in understory density. Negative values indicate that points within the given vegetation range were under-utilized relative to their availability. Positive values indicate that points within the given vegetation range were over-utilized relative to their availability. Significance values (generated from Chi-square tests) are given by symbols located beside species names: no symbol indicates no significant difference from expected, (*) indicates significance to the 0.05 level, (**) indicates significance to the 0.01 level, and (***) indicates significance to the 0.001 level.

Space-use Across an Understory Gradient
For Selected Resident Species

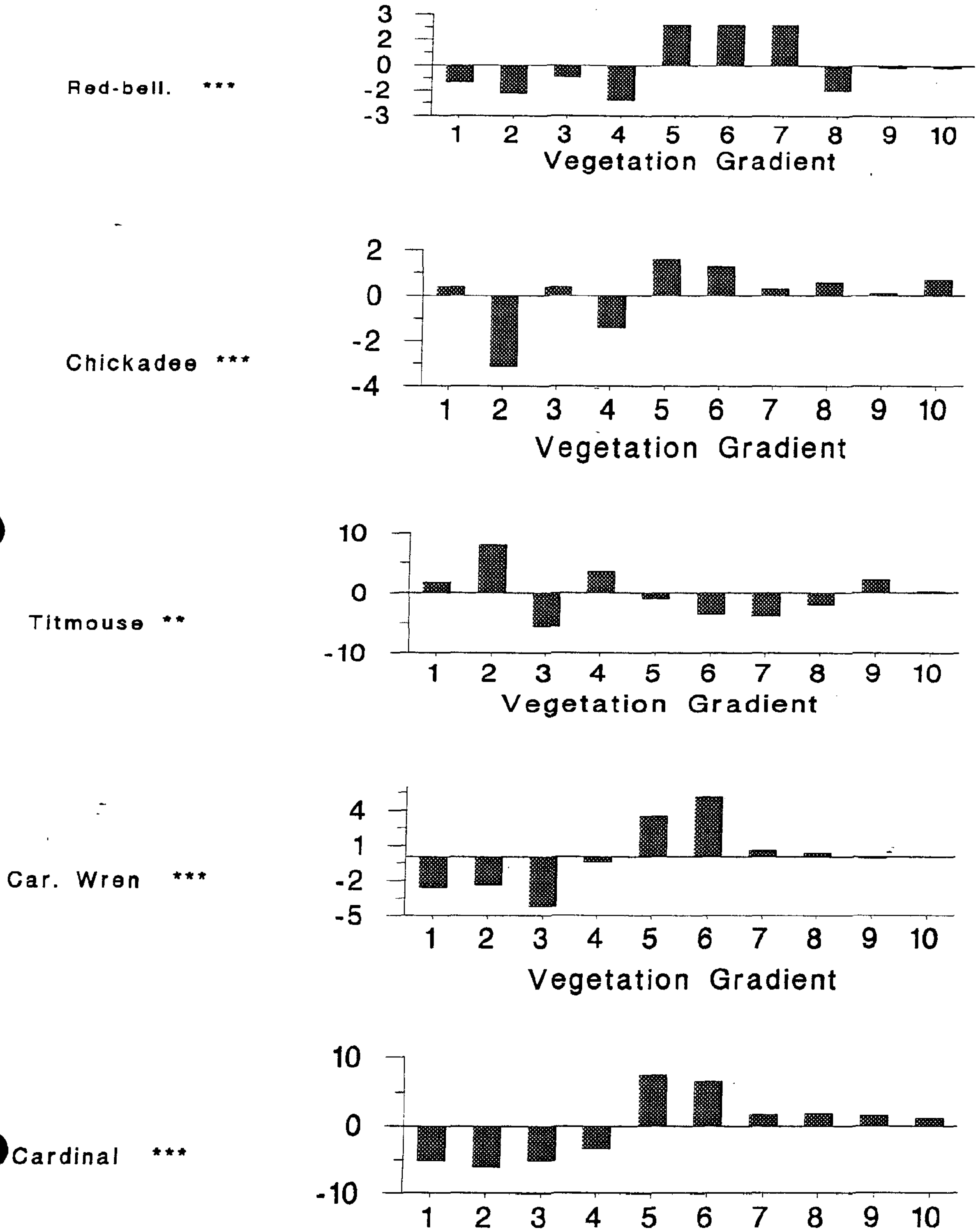


Figure 11

Space-use Across an Understory Gradient For Selected Short-distance Migrants

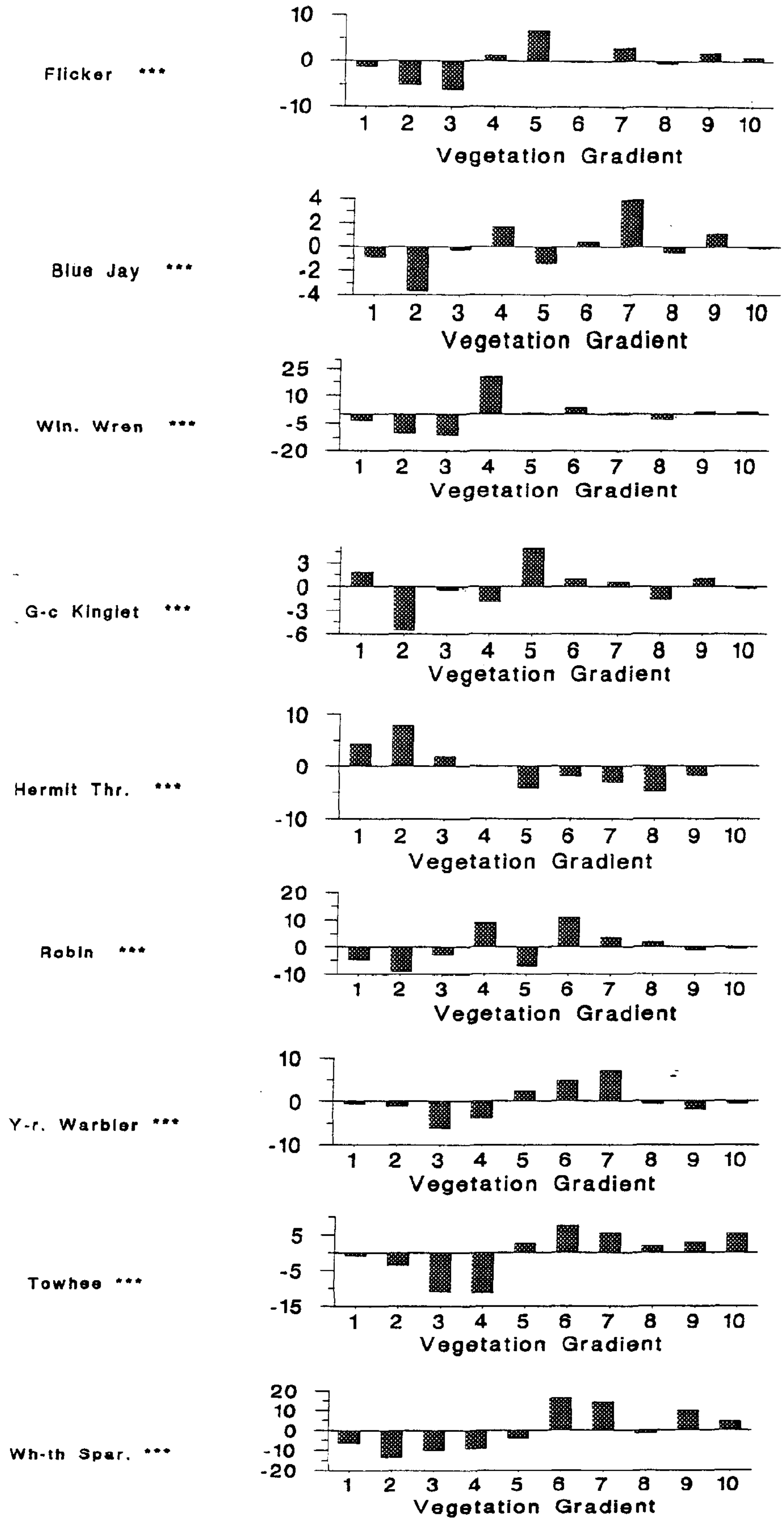


Figure 12

Space-use Across an Understory Gradient For Selected Long-distance Migrants

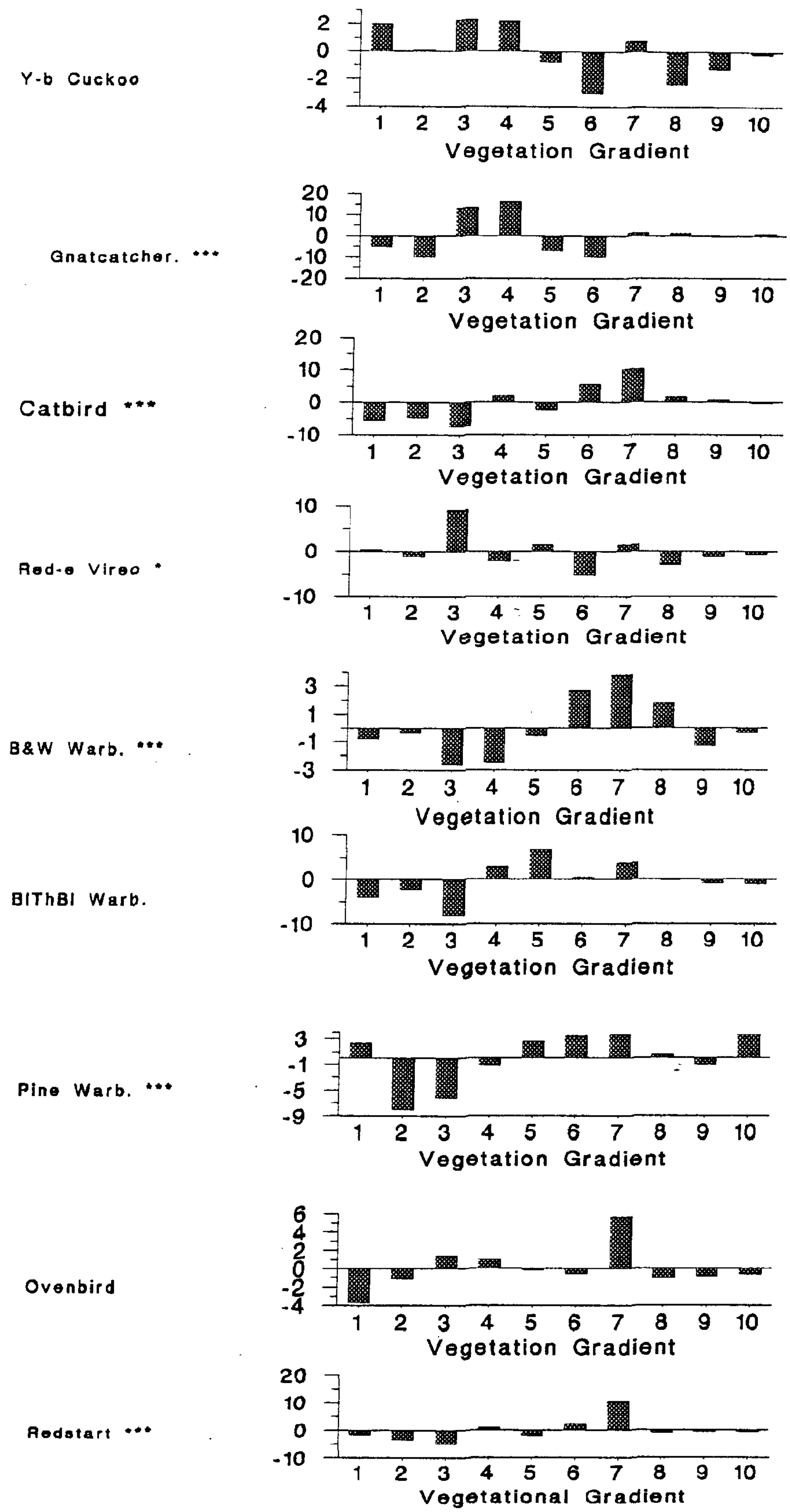


Figure 13

Figures 14 - 16: Deviation patterns for selected resident, short-distance migrants, and long-distance migrants. Bars indicate the difference between bird utilization patterns and those expected based on the availability of census points within a given range in subcanopy density (refer to Figure 10). Negative values indicate that points within the given vegetation range were under-utilized relative to their availability. Positive values indicate that points within the given vegetation range were over-utilized relative to their availability. Significance values (generated from Chi-square tests) are given by symbols located beside species names: no symbol indicates no significant difference from expected, (*) indicates significance to the 0.05 level, (**) indicates significance to the 0.01 level, and (***) indicates significance to the 0.001 level.

Space-use Across a Subcanopy Gradient
For Selected Resident Species

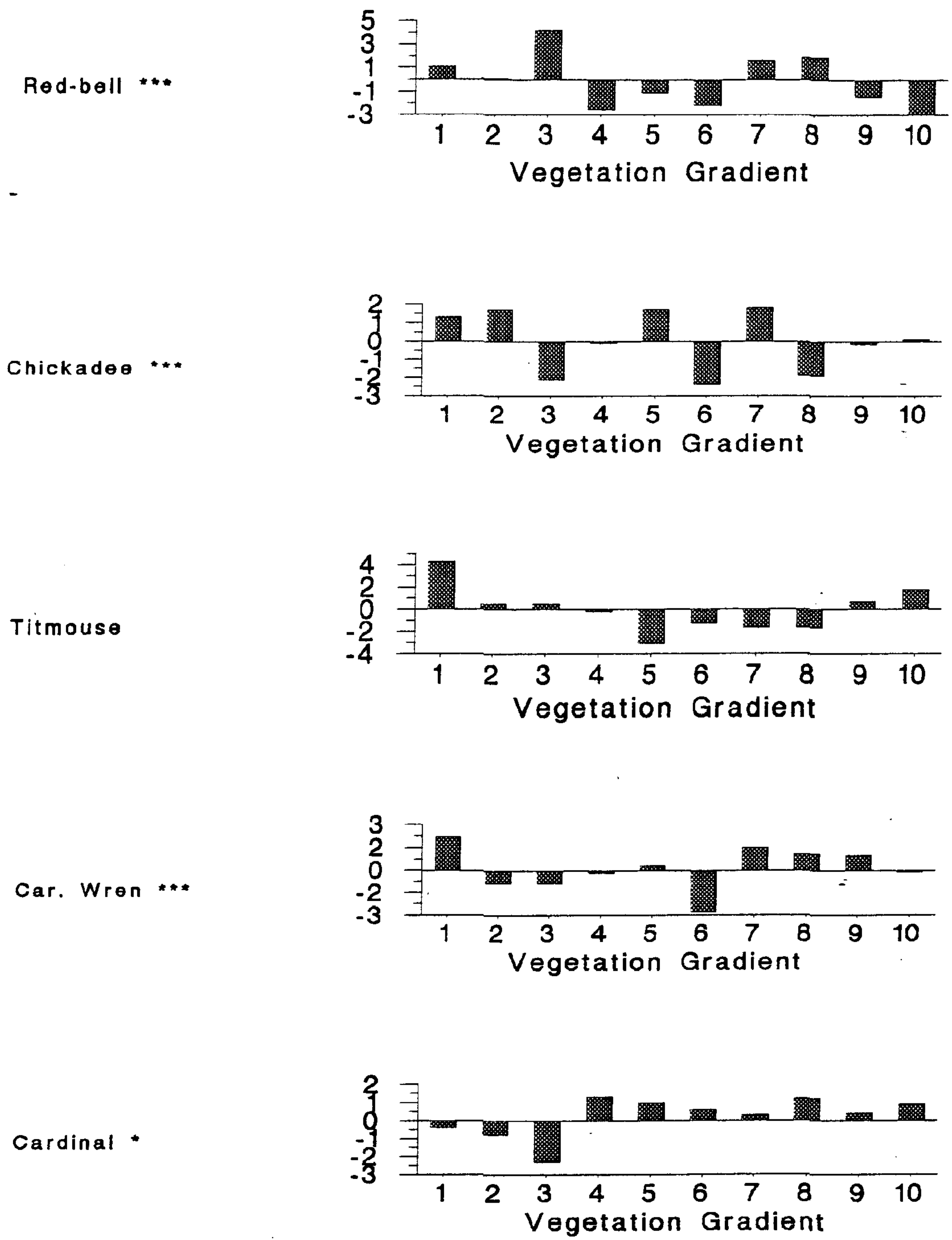


Figure 14

Space-use Across a Subcanopy Gradient For Selected Short-distance Migrants

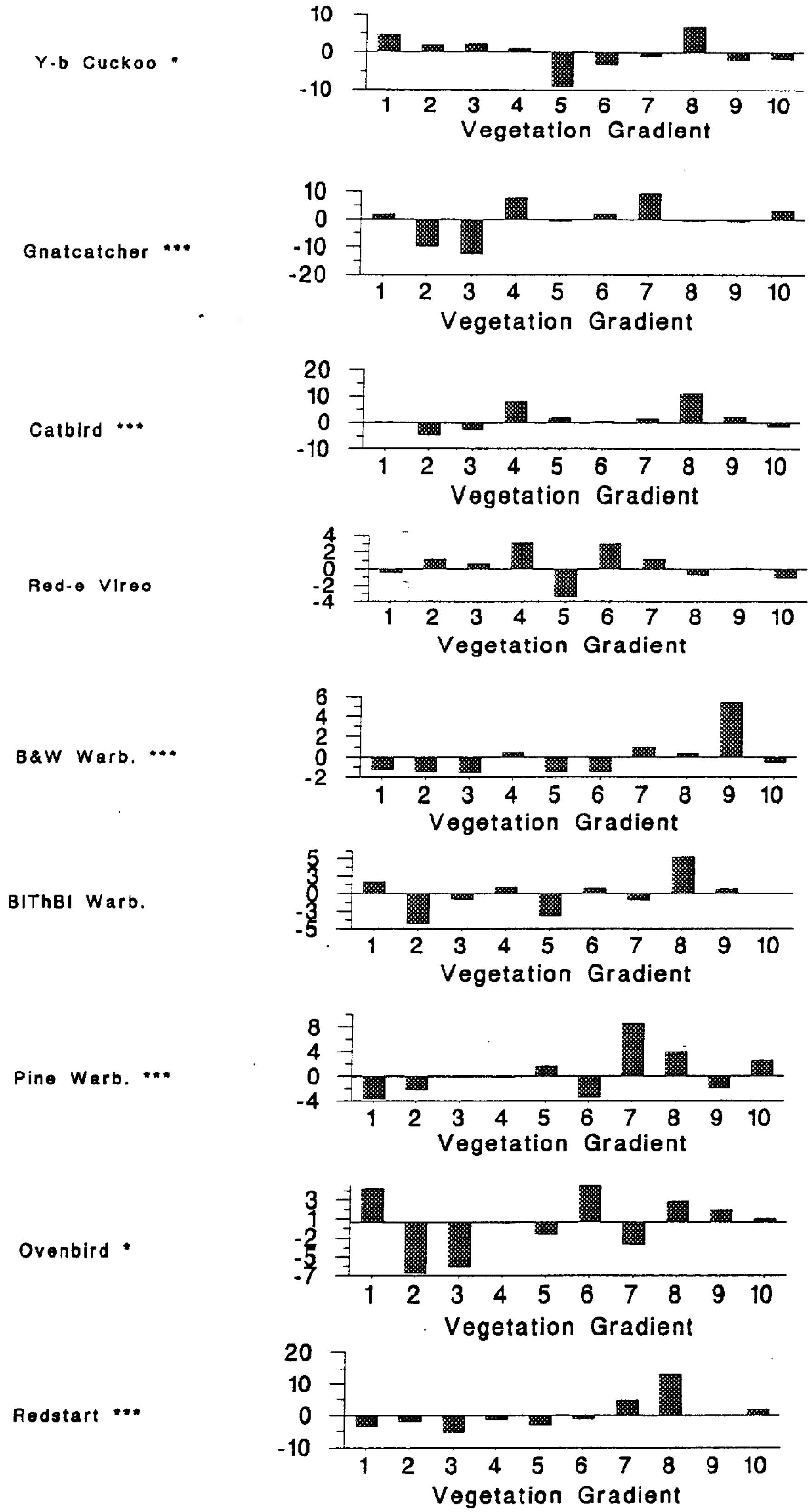


Figure 15

Space-use Across a Subcanopy Gradient For Selected Long-distance Migrants

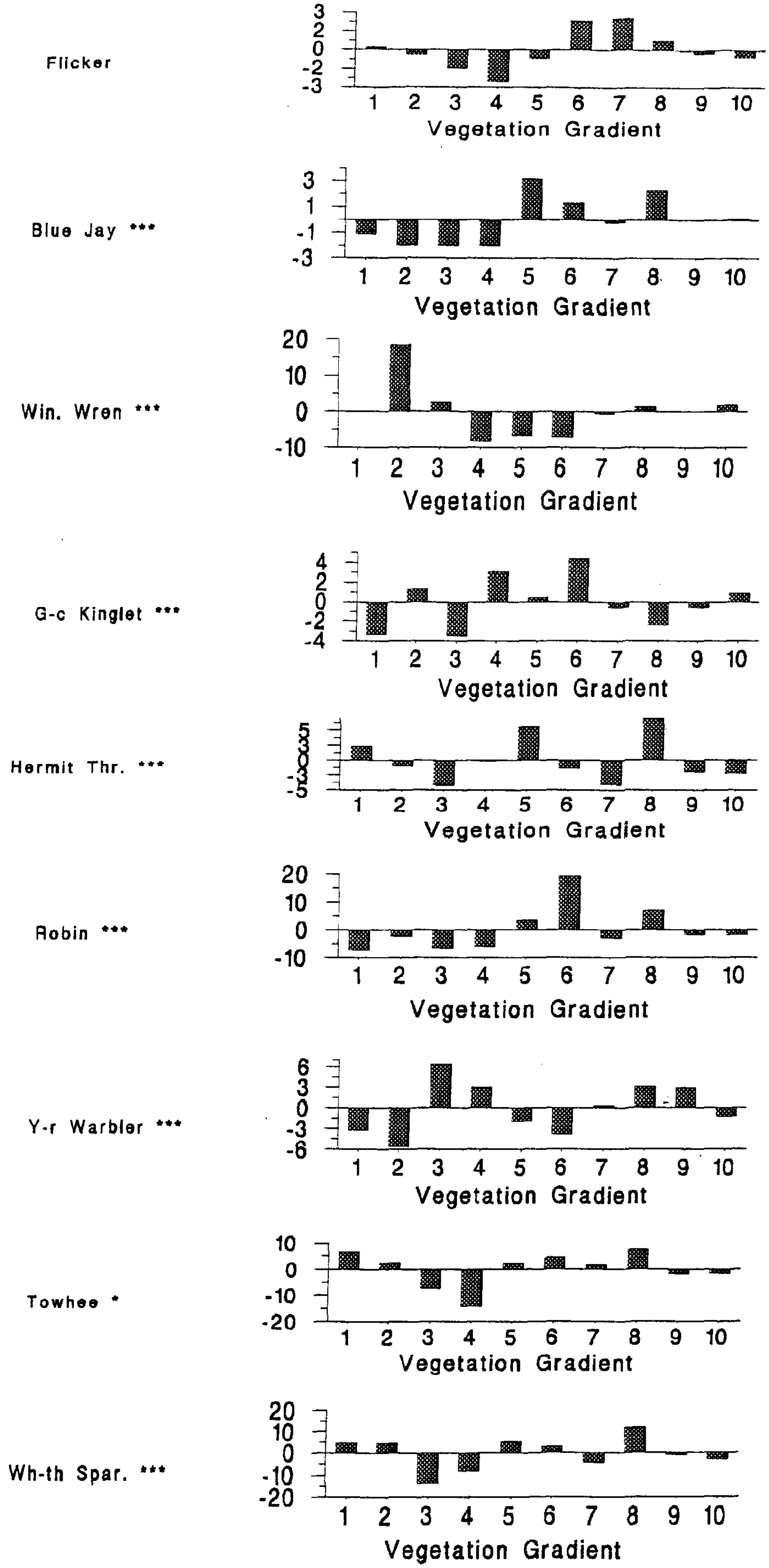


Figure 16

Figures 17 - 19: Relative use of vertical strata by selected resident, short-distance migrants, and long-distance migrants. Strata categories included are as follows: 1 indicates 0 - 2 m above the ground, 2 indicates 2 - 4 m above the ground, 3 indicates 4 - 6 m above the ground, 4 indicates 6 - 8 m above the ground, 5 indicates remaining subcanopy above 8 m, and 6 indicates the forest canopy. Significance values represent the results of Chi-square tests comparing observed strata use to an expected even distribution and are given by symbols located beside the species name: no symbol indicates no significant difference from expected, (*) indicates significance to the 0.05 level, (**) indicates significance to the 0.01 level, and (***) indicates significance to the 0.001 level.

Patterns in Vertical Distribution For Selected Resident Species

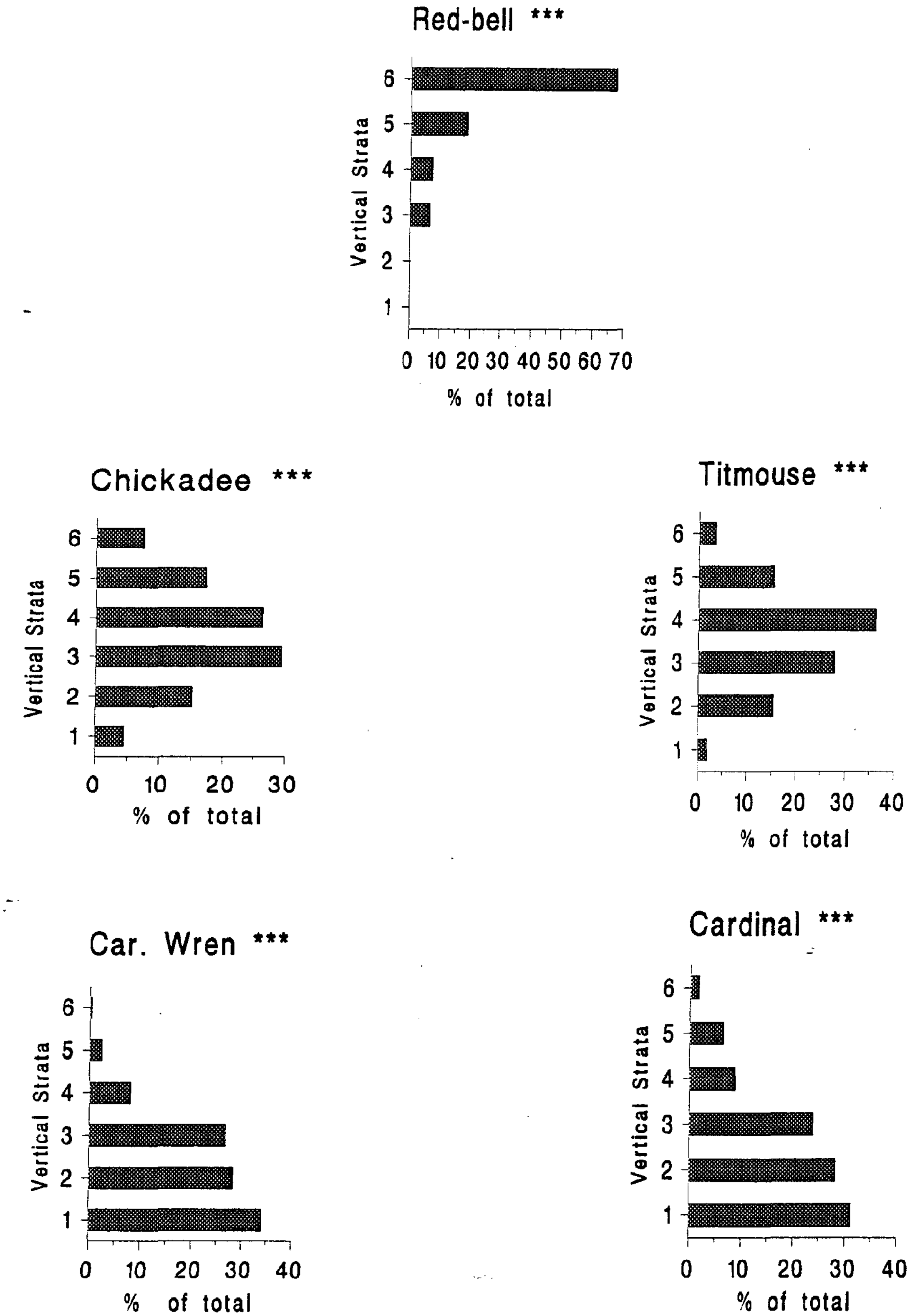


Figure 17

Patterns in Vertical Distribution For Selected Short-distance Migrants

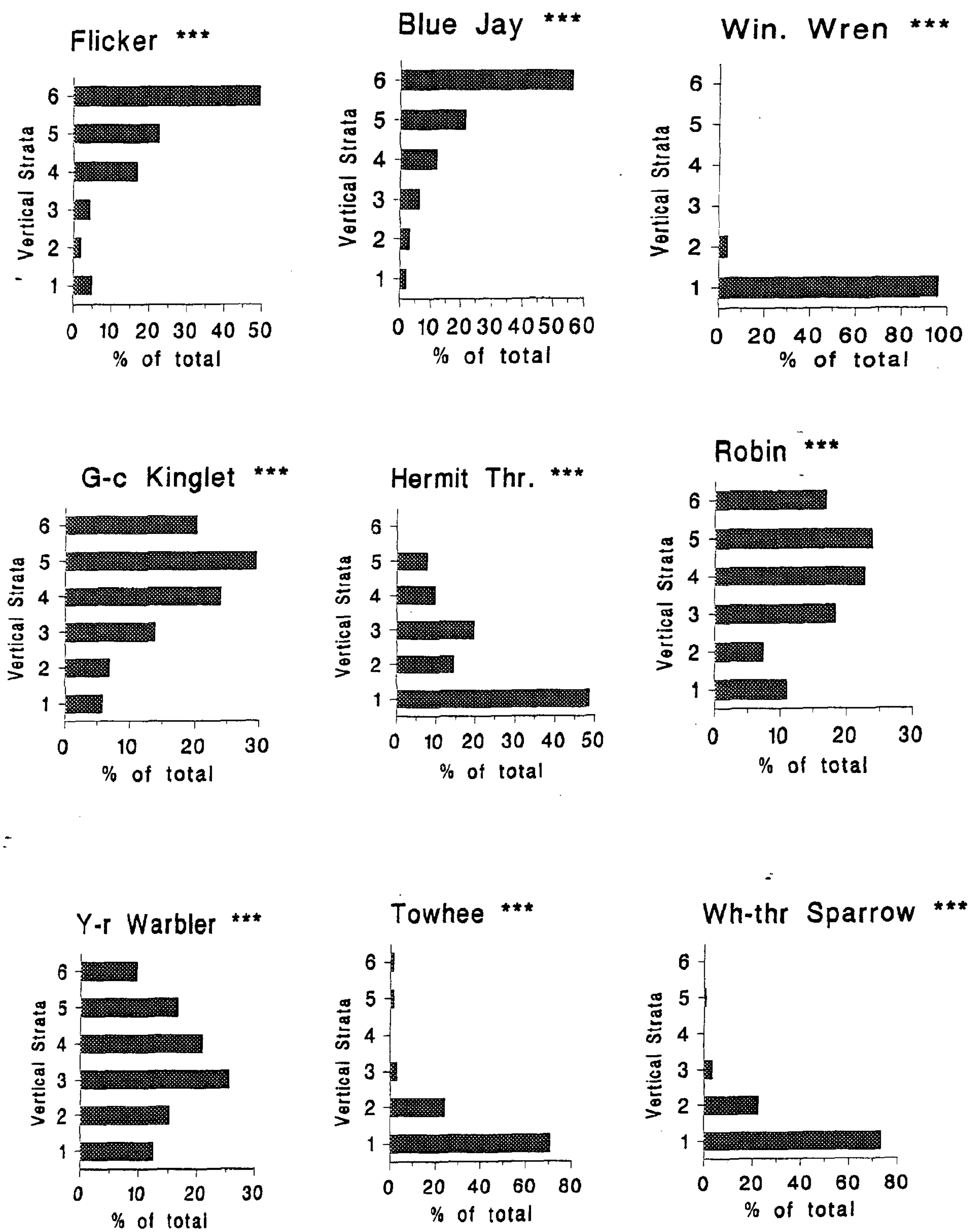


Figure 18

Patterns in Vertical Distribution For Selected Long-distance Migrants

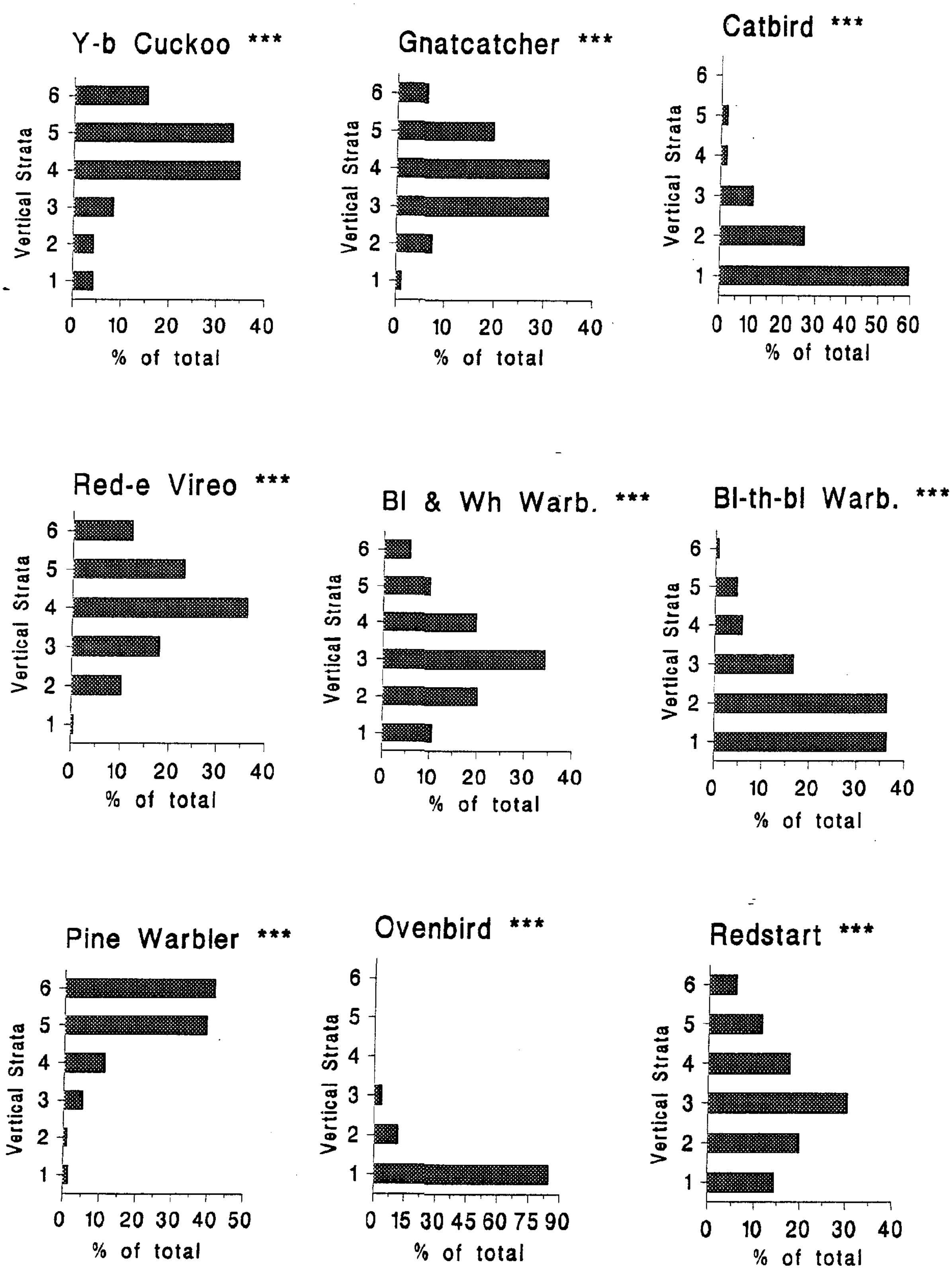


Figure 19

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Appendix I: List of species detected, their scientific names, and bird category in which they were placed. Bird categories are as follows: 1) permanent resident, 2) short-distance migrant, 3) long-distance migrant.

Common Name	Scientific Name	Category 1	2	3
Green-backed Heron	Butorides Striatus		x	
American Woodcock	Scolopax minor		x	
Common Bobwhite	Colinus virginianus	x		
Sharp-shinned Hawk	Accipiter striatus			x
Cooper's Hawk	Accipiter cooperi			x
Red-tailed Hawk	Buteo jamaicensis		x	
Broad-winged Hawk	Buteo platypterus			x
Bald Eagle	Haliaeetus leucocephalis	x		
Osprey	Pandion haliaetus			x
Turkey Vulture	Cathartes aura	x		
Black Vulture	Coragyps atratus	x		
American Kestrel	Falco sparverius		x	
Merlin	Falco columbarius			x
Northern Harrier	Circus cyaneus		x	
Great-horned Owl	Bubo virginianus	x		
Mourning Dove	Zenaida macroura	x		
Yellow-billed Cuckoo	Coccyzus americanus			x
Black-billed Cuckoo	Coccyzus erythropthalmus			x
Chuck-will's Widow	Caprimulgus carolinensis			x
Ruby-throated Hummingbird	Archilocus colubris			x
Belted Kingfisher	Ceryle alcyon	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
Eastern Kingbird	Tyrannus tyrannus			x
Tree Swallow	Tachycineta bicolor			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	

Appendix I: ----continued----

Brown-headed Nuthatch	Sitta pusilla	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	
Blue-gray Gnatcatcher	Polioptila caerulea			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		
Cedar Waxwing	Bombycilla cedrorum		x	
Eastern Meadowlark	Sternella magna		x	
European Starling	Sturnus vulgaris	x		
White-eyed Vireo	Vireo griseus			x
Solitary Vireo	Vireo solitarius			x
Red-eyed Vireo	Vireo olivaceus			x
Warbling Vireo	Vireo gilvus			x
Philadelphia Vireo	Vireo philadelphicus			x
Blue-winged Warbler	Vermivora pinus			x
Golden-winged Warbler	Vermivora chrysoptera			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
Bay-breasted Warbler	Dendroica castanea			x
Blackpoll Warbler	Dendroica striata			x
Pine Warbler	Dendroica pinus			x
Palm Warbler	Dendroica palmarum			x
Mourning Warbler	Oporornis philadelphia			x
Connecticut Warbler	Oporornis agila			x
Kentucky Warbler	Oporornis formosus			x

Canada Warbler	Wilsonia canadensis			x
Wilson's Warbler	Wilsonia pusilla			x

Appendix I: ----continued----

Worm-eating Warbler	Helmitheros vermivorus			x
Ovenbird	Seiurus aurocapillus			x
Louisiana Waterthrush	Seiurus motacilla			x
Northern Waterthrush	Seiurus noveboracensis			x
Common Yellowthroat	Geothlypis trichas			x
Yellow-breasted Chat	Icteria virens			x
American Redstart	Setophaga ruticilla			x
Blue Grosbeak	Guiraca caerulea			x
Rose-breasted Grosbeak	Pheucticus melanocephalus			x
Northern Cardinal	Cardinalis cardinalis	x		
Indigo Bunting	Passerina cyanea			x
Rufous-sided Towhee	Pipilo erythrophthalmus		x	
Song Sparrow	Melospiza melodia		x	
Field Sparrow	Spizella pusilla		x	
Chipping Sparrow	Spizella passerina		x	
White-throated Sparrow	Zonotrichia albicolis		x	
White-crowned Sparrow	Zonotrichia leucophrys		x	
Swamp Sparrow	Melospiza georgiana		x	
Savannah Sparrow	Passerculus sandwichensis		x	
Dark-eyed Junco	Junco hyemalis		x	
Red-winged Blackbird	Agelaius phoeniceus	x		
Brown-headed Cowbird	Molothrus ater	x		
Common Grackle	Quiscalus quiscula	x		
Orchard Oriole	Icterus spurius			x
Northern Oriole	Icterus galbula			x
Scarlet Tanager	Piranga olivacea			x
Summer Tanager	Piranga rubra			x
American Goldfinch	Carduelis tristis	x		

Appendix II Weekly summary of species detected. Numbers indicate total number of individuals detected (standardized number detected). Numbers were standardized as follows: (Total individuals detected/Total survey routes completed) X 10.

SPECIES	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	TOTAL
Green-backed Heron							1 (0.07)					1
American Woodcock										4 (0.26)	11 (0.63)	15
Common Bobwhite	1 (0.06)	5 (0.28)	1 (0.06)		3 (0.17)				2 (0.12)			12
Sharp-shinned Hawk					4 (0.23)	1 (0.06)	1 (0.07)	5 (0.45)	4 (0.23)	2 (0.13)	5 (0.28)	22
Cooper's Hawk					1 (0.06)			2 (0.18)		1 (0.07)	1 (0.06)	5
Red-tailed Hawk			2 (0.11)	3 (0.17)		3 (0.19)			2 (0.12)	2 (0.13)	3 (0.17)	15
Broad-winged Hawk		1 (0.06)				1 (0.06)			1 (0.06)		1 (0.06)	4
Bald Eagle											1 (0.06)	1
Osprey		1 (0.06)										1
Turkey Vulture			2 (0.11)	1 (0.06)						1 (0.07)	4 (0.23)	8
Black Vulture	1 (0.06)											1
American Kestrel					1 (0.06)				1 (0.06)		2 (0.11)	4
Merlin											2 (0.11)	2
Northern Harrier						1 (0.06)						1
Great-horned Owl	2 (0.11)	3 (.017)		1 (0.06)	4 (0.23)	1 (0.06)	1 (0.07)	1 (0.09)		1 (0.07)		14
Mourning Dove	6 (0.34)	18 (1.02)	20 (1.14)	25 (1.42)	9 (0.51)	15 (0.96)	11 (0.73)	11 (0.98)	23 (1.34)	56 (3.68)	20 (1.14)	214
Yellow-billed Cuckoo	10 (0.57)	19 (1.08)	16 (0.91)	13 (0.74)	5 (0.28)	5 (0.32)	1 (0.07)	1 (0.09)	1 (0.06)		1 (0.06)	72
Black-billed Cuckoo		1 (0.06)	1 (0.06)									2
Chuck-will's Widow	2 (0.11)		2 (0.11)	4 (0.23)		1 (0.06)			3 (0.17)			12
Ruby-throated Hummingbird	13 (0.74)	13 (0.74)	8 (0.45)	6 (0.34)	1 (0.06)	1 (0.06)						42
Belted Kingfisher									1 (0.06)			1
Red-headed Woodpecker	14 (0.80)	11 (0.63)	18 (1.02)	28 (1.59)	8 (0.45)	8 (0.51)	4 (0.26)	3 (0.27)	4 (0.23)	7 (0.46)	18 (1.02)	123
Red-bellied Woodpecker	12 (0.68)	35 (1.99)	28 (1.59)	37 (2.10)	27 (1.53)	43 (2.76)	45 (2.98)	73 (6.52)	134 (7.79)	104 (6.84)	142 (8.07)	680
Yellow-bellied Sapsucker					1 (0.06)			5 (0.45)	9 (0.52)	1 (0.07)	6 (0.34)	22
Downy Woodpecker	50 (2.84)	43 (2.44)	57 (3.24)	59 (3.35)	42 (2.39)	20 (1.28)	13 (0.86)	15 (1.34)	34 (1.98)	13 (0.86)	24 (1.36)	370
Hairy Woodpecker	2 (0.11)	3 (0.17)	6 (0.34)	1 (0.06)	5 (0.28)	3 (0.19)	3 (0.20)	4 (0.36)	2 (0.12)	3 (0.20)	3 (0.17)	35
Pileated Woodpecker	5 (0.28)		1 (0.06)	1 (0.06)	11 (0.63)	2 (0.13)	7 (0.46)	5 (0.45)	4 (0.23)	1 (0.07)	1 (0.07)	38
Northern Flicker	11 (0.63)	32 (1.82)	7 (0.40)	26 (1.48)	24 (1.36)	66 (4.23)	78 (5.17)	138 (12.32)	119 (6.92)	81 (5.33)	95 (5.40)	677
Eastern Wood Pewee	7 (0.40)	9 (0.51)	2 (0.11)	3 (0.17)		1 (0.06)	2 (0.13)	5 (0.45)			6 (0.35)	35
Acadian Flycatcher	2 (0.11)	3 (0.17)		3 (0.17)								8
Great-crested Flycatcher	2 (0.11)	5 (0.28)	3 (0.17)	7 (0.40)	4 (0.23)			2 (0.18)	1 (0.06)			24
Least Flycatcher								1 (0.09)	1 (0.06)			2
Yellow-bellied Flycatcher				3 (0.17)					6 (0.35)			9
Eastern Phoebe	1 (0.06)	3 (0.17)	1 (0.06)	1 (0.06)		1 (0.06)	7 (0.46)	12 (1.07)	6 (0.35)	18 (1.18)	13 (0.74)	63
Eastern Kingbird		18 (1.02)	4 (0.23)	1 (1.06)	1 (0.06)							24
Tree Swallow	1 (0.06)						2 (0.13)					3
Blue Jay	9 (0.51)	40 (2.27)	17 (0.97)	33 (1.88)	35 (1.99)	19 (1.22)	28 (1.85)	414 (36.96)	523 (30.41)	301 (19.80)	428 (24.32)	1847
American Crow	24 (1.36)	76 (4.32)	25 (1.42)	52 (2.95)	54 (3.07)	60 (3.85)	43 (2.85)	22 (1.96)	51 (2.97)	40 (2.63)	67 (3.81)	514
Fish Crow	26 (1.48)	30 (1.70)	82 (4.66)	102 (5.80)	39 (2.22)	18 (1.15)	18 (1.19)	1 (0.09)	1 (0.06)	7 (0.46)	12 (0.68)	336
Carolina Chickadee	289 (16.42)	344 (19.55)	280 (15.91)	250 (14.20)	178 (10.11)	145 (9.29)	145 (9.60)	114 (0.18)	180 (10.47)	153 (10.07)	205 (11.65)	2283
Brown Creeper							6 (0.40)	4 (0.36)	7 (0.41)	15 (0.99)	25 (1.42)	57
Tufted Titmouse	28 (1.59)	25 (1.42)	28 (1.59)	41 (2.33)	22 (1.25)	33 (2.12)	13 (0.06)	13 (1.16)	45 (2.68)	5 (0.33)	15 (0.85)	268
White-breasted Nuthatch	1 (0.06)	1 (0.06)										2
Red-breasted Nuthatch								1 (0.09)	1 (0.06)	2 (0.13)		4
Brown-headed Nuthatch		1 (0.06)										1

Appendix II cont.

SPECIES	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	TOTAL
House Wren				1 (0.06)	10 (0.57)	7 (0.45)	10 (0.66)	3 (0.27)	4 (0.23)	3 (0.20)	11 (0.63)	49
Winter Wren								11 (0.98)	8 (0.47)	32 (2.11)	30 (1.70)	81
Carolina Wren	342 (19.43)	470 (26.70)	391 (22.22)	399 (22.67)	277 (15.74)	177 (11.35)	152 (10.07)	174 (15.54)	229 (13.31)	160 (10.53)	256 (14.55)	3027
Ruby-crowned Kinglet								20 (1.79)	25 (1.45)	78 (5.13)	18 (1.02)	141
Golden-crowned Kinglet							3 (0.20)	143 (12.77)	128 (7.44)	256 (16.84)	810 (46.02)	1340
Blue-gray Gnatcatcher	37 (2.10)	16 (0.91)	6 (0.34)	14 (0.80)	4 (0.23)	1 (0.06)		3 (0.27)				81
Eastern Bluebird		1 (0.06)		5 (0.28)								6
Wood Thrush		2 (0.11)	1 (0.06)		1 (0.06)			4 (0.36)	6 (0.35)	2 (0.13)		16
Swainson's Thrush			3 (0.17)	1 (0.06)		7 (0.45)	1 (0.07)		5 (0.29)	2 (0.13)	1 (0.06)	20
Gray-cheeked Thrush			1 (0.06)	1 (0.06)		1 (0.06)	1 (0.07)	5 (0.45)	8 (0.47)	3 (0.20)	1 (0.06)	21
Hermit Thrush								1 (0.09)		23 (1.51)	108 (6.14)	132
Veery	1 (0.06)	1 (0.06)	8 (0.45)		19 (1.08)	4 (0.26)		1 (0.09)	1 (0.06)	2 (0.13)		37
American Robin	16 (0.91)	36 (2.05)	9 (0.51)	5 (0.28)	8 (0.45)	4 (0.26)	1 (0.07)		10 (0.58)	120 (7.89)	1177 (66.88)	1386
Gray Catbird	1 (0.06)			2 (0.11)	12 (0.68)	14 (0.90)	26 (1.72)	69 (6.16)	59 (3.43)	38 (2.50)	32 (1.82)	253
Mockingbird	4 (0.23)	3 (0.17)		3 (0.17)	2 (0.11)	1 (0.06)	1 (0.07)	2 (0.18)	1 (0.06)		3 (0.17)	20
Brown Thrasher		3 (0.17)			7 (0.40)	10 (0.64)	2 (0.13)	15 (1.34)	7 (0.41)	2 (0.13)	1 (0.06)	47
Cedar Waxwing	6 (0.34)	2 (0.11)	3 (0.17)		3 (0.17)	1 (0.06)	4 (0.26)		9 (0.52)	8 (0.53)		36
Eastern Meadowlark											1 (0.06)	1
European Starling	66 (3.75)	88 (5.00)	60 (3.41)	93 (5.28)	3 (0.17)	26 (1.67)	17 (1.13)		39 (2.27)	35 (2.30)	45 (2.56)	472
White-eyed Vireo	4 (0.23)	5 (0.28)	4 (0.23)	5 (0.28)	2 (0.11)							20
Solitary Vireo	1 (0.06)							2 (0.18)	8 (0.47)	10 (0.66)	4 (0.23)	25
Red-eyed Vireo	29 (1.65)	44 (2.50)	59 (3.35)	36 (2.05)	13 (0.74)	6 (0.38)	6 (0.40)	2 (0.18)	1 (0.06)			196
Warbling Vireo		1 (0.06)										1
Philadelphia Vireo		8 (0.45)	1 (0.06)	2 (0.06)	2 (0.11)		4 (0.26)		3 (0.17)			20
Blue-winged Warbler	1 (0.06)	3 (0.17)	6 (0.34)	2 (0.11)								12
Golden-winged Warbler		1 (0.06)			2 (0.11)							3
Tennessee Warbler							2 (0.13)	4 (0.36)				6
Nashville Warbler						1 (0.06)						1
Northern Parula					3 (0.17)	13 (0.83)	6 (0.40)	4 (0.36)	6 (0.35)			32
Black-and-white Warbler	58 (3.30)	102 (5.80)	140 (7.95)	43 (2.44)	34 (1.93)	29 (1.86)	11 (0.73)	4 (0.36)	4 (0.23)	2 (0.13)		427
Black-throated Blue Warbler			2 (0.11)		25 (1.42)	32 (2.05)	27 (1.79)	12 (1.07)	46 (2.67)	13 (0.86)		157
Cerulean Warbler			3 (0.17)									3
Blackburnian Warbler		2 (0.11)	1 (0.06)						1 (0.06)			4
Chestnut-sided Warbler						1 (0.06)	1 (0.07)					2
Cape May Warbler						1 (0.06)	1 (0.07)					2
Magnolia Warbler		1 (0.06)	4 (0.23)		2 (0.11)	8 (0.51)	2 (0.13)		6 (0.35)			23
Yellow-rumped Warbler								12 (1.07)	594 (34.53)	619 (40.72)	547 (31.08)	1772
Black-throated Green Warbler		1 (0.06)	1 (0.06)	1 (0.06)	1 (0.06)		3 (0.20)	1 (0.09)	5 (0.29)			13
Yellow-throated Warbler		3 (0.17)	3 (0.17)		3 (0.17)	1 (0.06)			1 (0.06)			11
Prairie Warbler				2 (0.11)	1 (0.06)	1 (0.06						4
Bay-breasted Warbler						3 (0.19)		2 (0.18)		1 (0.07)		6
Pine Warbler	44 (2.50)	63 (3.58)	114 (6.48)	68 (3.86)	36 (2.05)	32 (2.05)	38 (2.52)	15 (1.34)	6 (0.35)	4 (0.26)		420
Palm Warbler									10 (0.58)	3 (0.20)	2 (0.11)	15
Mourning Warbler				1 (0.06)								1
Connecticut Warbler		1 (0.06)							1 (0.06)			2
Kentucky Warbler	1 (0.06)	1 (0.06)										2

Appendix II cont.

SPECIES	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	TOTAL
Canada Warbler	2 (0.11)		5 (0.28)	1 (0.06)								8
Wilson's Warbler			1 (0.06)		1 (0.06)							2
Worm-eating Warbler	8 (0.45)	2 (0.11)	4 (0.23)		1 (0.06)							15
Ovenbird	4 (0.23)	5 (0.28)	21 (1.19)	10 (0.57)	33 (1.88)	20 (1.28)	3 (0.20)	9 (0.80)	1 (0.06)	5 (0.33)		111
Louisiana Waterthrush	7 (0.40)	1 (0.06)	1 (0.06)			1 (0.06)						10
Northern Waterthrush	6 (0.34)	3 (0.17)	9 (0.51)	1 (0.06)	4 (0.23)		1 (0.07)					24
Common Yellowthroat	2 (0.11)	4 (0.23)	5 (0.28)	4 (0.23)	9 (0.51)	6 (0.38)	4 (0.26)	3 (0.27)	5 (0.29)	3 (0.20)		45
American Redstart	91 (5.17)	104 (5.91)	180 (10.23)	101 (5.74)	115 (6.53)	99 (6.35)	84 (5.56)	19 (1.70)	11 (0.64)	4 (0.26)		808
Blue Grosbeak	2 (0.11)	4 (0.23)	7 (0.40)					48 (1.2)				13
Rose-breasted Grosbeak		2 (0.11)				2 (0.13)						4
Northern Cardinal	162 (9.20)	161 (9.15)	135 (7.67)	115 (6.53)	102 (5.80)	71 (4.55)	64 (4.24)	48 (1.29)	82 (4.77)	51 (3.36)	57 (3.24)	1048
Indigo Bunting	11 (0.63)	17 (0.97)	1 (0.06)		1 (0.06)							30
Rufous-sided Towhee			1 (0.06)					48 (4.29)	9 (0.52)	34 (2.24)	26 (1.48)	118
Song Sparrow									1 (0.06)	10 (0.66)	48 (2.73)	59
Field Sparrow											12 (0.68)	12
Chipping Sparrow								1 (0.09)				1
White-throated Sparrow							1 (0.07)	8 (0.71)		43 (2.83)	128 (7.27)	180
White-crowned Sparrow										1 (0.07)	2 (0.11)	3
Swamp Sparrow									1 (0.06)	4 (0.26)	29 (1.65)	34
Savannah Sparrow									1 (0.06)			1
Dark-eyed Junco								2 (0.18)		2 (0.13)	29 (1.65)	33
Red-winged Blackbird	2 (0.11)			30 (1.70)							12 (0.68)	44
Brown-headed Cowbird	1 (0.06)		20 (1.14)	1 (0.06)							1 (0.06)	23
Common Grackle	263 (14.94)	42 (2.39)	123 (6.99)	191 (10.85)	220 (12.50)	20 (1.28)	203 (13.44)	93 (8.30)	16 (0.93)	7 (0.46)	68 (3.86)	1246
Northern Oriole		3 (0.17)	22 (1.25)	8 (0.45)				2 (0.18)				35
Scarlet Tanager			1 (1.06)	5 (0.28)	1 (0.06)							7
Summer Tanager	7 (0.40)	14 (0.80)	19 (1.08)	25 (1.42)	2 (0.11)							67
American Goldfinch		1 (0.06)		1 (0.06)								2
UID Flycatcher		1 (0.06)	3 (0.17)	2 (0.11)	2 (0.11)	5 (0.32)	8 (0.53)	7 (0.63)	1 (0.06)	3 (0.20)		32
UID Crow			9 (0.51)	1 (0.06)		1 (0.06)	13 (0.86)	5 (0.45)	3 (0.17)	5 (0.33)	1 (0.06)	38
UID Thrush	1 (0.06)	1 (0.06)	1 (0.06)	1 (0.06)	5 (0.28)	10 (0.64)	1 (0.07)		12 (0.70)	9 (0.59)	5 (0.28)	46
UID Vireo	1 (0.06)		2 (0.11)	1 (0.06)	1 (0.06)		1 (0.07)					6
UID Warbler	4 (0.23)	6 (0.34)	15 (0.85)	3 (0.17)	13 (0.74)	45 (2.88)	44 (2.91)	4 (0.36)	44 (2.56)	15 (0.99)	1 (0.06)	194
UID Sparrow							3 (0.20)	5 (0.45)		3 (0.20)	9 (0.51)	20
UID Tanager	2 (0.11)											2
UID Bird	12 (0.68)	6 (0.34)	5 (0.28)	10 (0.57)	11 (0.63)	13 (0.83)	50 (3.31)	7 (0.63)	17 (0.99)	15 (0.99)	22 (1.25)	168
UID Hawk					5 (0.28)	7 (0.45)	1 (0.07)		4 (0.23)		1 (0.06)	18
UID Kinglet								9 (0.80)			10 (0.57)	19
UID Owl				2 (0.11)			1 (0.07)		2 (0.12)			5
UID Accipiter					1 (0.06)							1
UID Woodpecker	1 (0.06)	1 (0.06)		2 (0.11)	1 (0.06)	3 (0.19)			1 (0.06)			9
UID Waterthrush	1 (0.06)	1 (0.06)										2