NEOTROPICAL MIGRATORY SONGBIRD REGIONAL COASTAL CORRIDOR STUDY

FINAL REPORT

Prepared by:

Virginia Department of Conservation and Recreation
Division of Natural Heritage

June 1992

A report of the Virginia Council on the Environment to the National Oceanic and Atmospheric Administration pursuant to NOAA Award No. NA90AA-H-CZ839

NEOTROPICAL MIGRATORY SONGBIRD

REGIONAL COASTAL CORRIDOR STUDY

FINAL REPORT

Submitted to:

Virginia Coastal Resources Management Program
Council on the Environment
903 Ninth Street Office Building
Richmond, Virginia 23219

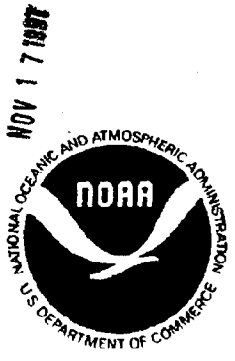
Written by:

Sarah E. Mabey - Va. DCR-Division of Natural Heritage
Jim McCann - MD Nongame & Urban Wildlife Program
Lawrence J. Niles - NJ Endangered & Nongame Program
Charles Bartlett - Delaware Natural Heritage Program
Paul Kerlinger - New Jersey Audubon Society

Prepared by:

Virginia Department of Conservation and Recreation
Division of Natural Heritage

June 1992



This paper is funded in part by a grant from the National Oceanic and Atmospheric Administration. The views expressed herein are those of the author(s) and do not necessarily reflect the views of NOAA or any of its sub-agencies.

EXECUTIVE SUMMARY

Repeated accounts of population declines for many neotropical migratory songbird species are awakening widespread concern over this deterioration of biodiversity and sparking national and international conservation initiatives. To date the majority of research and protection efforts have focused on the fragmentation and loss of breeding and wintering habitat. Migratory stopover ecology, however, is in need of comparable attention. Migration is a physiologically stressful time when all resources, including food and shelter, take on added significance. From the human perspective, migration is an aesthetically spectacular event that has inspired awe for thousands of years. The existing and potential economic value of protecting migratory habitat is significant for the tourism-based and rural communities of the Cape May and Delmarva peninsulas.

The Neotropical Migratory Songbird Coastal Corridor Study (NMSCC) examined the distributions and local habitat associations of fall migrating landbirds within the coastal region of the Cape May and Delmarva peninsulas. This regional approach addressed the fundamental nature of *migrating* birds; they are mobile, paying no heed to political boundaries. The NMSCC has been a cooperative project involving governmental agencies, non-governmental organizations, academicians, and many individual landowners and volunteers in New Jersey, Delaware, Maryland, and Virginia.

The study results show that neotropical migrants stopping over on the Cape May and Delmarva peninsulas are:

- More abundant within 0-1.5 km (0-0.9 mi) of the shoreline than in equivalent areas 1.5-3.0 km (0.9-1.9 mi) away from the coast.
- More abundant within the bayside coastal zones than the seaside coastal zones or interior regions.
- More abundant on barrier islands than the coastal mainland.
- Associated with particular habitats on a species-specific basis.

Based on these results we recommend that the protection of migrants should become an additional objective of habitat conservation measures currently acting within the coastal regions of the Delmarva and Cape May peninsulas.

TABLE OF CONTENTS

LIST OF TABLES

ACKNOWLEDGEMENTS

The Neotropical Migratory Songbird Coastal Corridor study was funded jointly by the National Oceanographic and Atmospheric Administration's (NOAA) Office of Coastal Resource Management, The Nature Conservancy, the National Fish and Wildlife Foundation, and the U.S. Fish and Wildlife Service. Support from NOAA was provided by grant monies through Section 306 of the Coastal Zone Management Act (1972).

The complexity and regional nature of the study necessitated a cooperative effort, involving a team of people with diverse backgrounds and affiliations. The study team included biologists and land use policy advisors from various state and federal conservation agencies, academia, and nonprofit conservation groups. State conservation agencies and non-governmental organizations in each of the four states coordinated and implemented the study (Appendix A). In addition, hundreds of skilled birdwatchers volunteered their expertise as field observers.

INTRODUCTION

THREATS TO NEOTROPICAL MIGRATORY SONGBIRD POPULATIONS

In the past decade evidence has surfaced suggesting that populations of many neotropical migratory songbird species are dwindling (see Appendix D for definition of neotropical migrant). Researchers tracking birds during migration began reporting declines in the numbers of birds caught at banding stations. The strongest information, however, comes from long term monitoring studies of breeding birds. The most widely cited of these is the Breeding Bird Survey (BBS) that has conducted standardized surveys for 27 years. Analysis of the data from the late 1970's and 1980's indicates consistent annual population declines of 0.2-3.0 % in many species (Robbins et al. 1989).

Longterm studies at many sites have detected even more precipitous declines in migrant populations (Askins et al. 1990). In most of these cases the study sites have undergone noticeable, if not dramatic, changes in internal habitat (i.e. ageing of forests that can lead to changes in bird species composition) or external factors (i.e. fragmentation and isolation) (Askins et al. 1990). The declines may be related to these changes, particularly fragmentation of surrounding forests and the isolation of the study areas.

Although there is some debate over the explanations of reported population declines, most researchers agree that the repeated detection of declines is cause for concern (Hagan and Johnston 1992, Askins et al. 1990). We are still far from determining the relative importance of the underlying causes of changes in neotropical migrant populations. Several credible hypotheses have been proposed to explain the declines. They all fall under the general umbrellas of habitat loss and degradation. In North America, the birds' northern homeland, this takes the form of forest fragmentation and suburban sprawl, resulting in an increase of predation and nest parasitism. In the migrants' southern homeland, tropical deforestation is rapidly changing the landscape.

The vulnerability of neotropical migratory songbirds during migration has been largely ignored by major professional reviews (Askins et al. 1990) and initiatives on the problem of population declines. However, the generalized life history of neotropical migrants reveals that vulnerabilities exist during all life phases. In fact, due to the extreme stresses and demands of migration, this period is particularly critical to the maintenance of viable populations.

LIFE HISTORY OF NEOTROPICAL MIGRATORY SONGBIRDS

Neotropical migratory songbirds alternate between northern and southern homes in order to take advantage of resources that vary predictably through time over two continents. Subsequently, every year of a migrant's life must be divided into two periods of residency separated by two periods of migration.

Of the two residential periods, the breeding season is spent in North America. Neotropical migrants return to their northern homes by April/June. In forests and fields from northern Mexico to northern Canada, migratory birds comprise 60-80% of all breeding bird species (Greenberg 1990b). Individual birds demonstrate a high degree of site-fidelity, often returning to the previous year's territory. Young birds, breeding for the first time, generally find new places to call their own. As pairs are formed and nests are built, the birds take advantage of the great abundance of insects in the temperate zone during the spring and summer. A pair of warblers needs many thousands of insects to raise its young.

By late July and August, the young of the year disperse from their parents. Soon afterwards, adults vacate their breeding territories and the entire population prepares for the long trip south. Most neotropical migrants molt their old feathers at this time. This serves to provide them with the best equipment for flying as well as allowing the males of some species to remove their vibrant breeding colors, becoming less conspicuous to predators.

The process of migration is complex. The individual bird relies on innate (genetic), ecological, geographical, meteorological, and social cues to travel thousands of miles. Navigating by the stars and the earth's magnetism, migratory songbirds fly at night and may adjust their course at dawn (Emlen 1975, Morse 1989). When obstacles such as bad weather or large bodies of water are encountered, migratory birds display a tendency to delay migratory flight. During these short periods, the birds conserve and add to their energy stores by resting and eating. Migratory songbirds can increase their weight by more than 5% in a single day (Moore and Kerlinger 1987). When conditions become favorable (i.e. weather changes and the bird has stored sufficient energy), the migrants move on.

The migration of several thousand miles demands tremendous energy from birds that weigh less than a fraction of an ounce. Although there is evidence that neotropical migrants can fly non-stop from Canada to the Caribbean in only a few days (Emlen 1975), most migrants take several weeks. Traveling at night in unpredictable weather can lead to exhaustion and death by starvation (Moore and Kerlinger 1987). Yet, most migrants survive, evidence of their dependence on stopover and staging areas where food and shelter must be readily attainable.

By October or early November, the second period of residency begins as neotropical migrants reestablish themselves in their southern homes. From the

vast continent of North America, millions of migratory songbirds pack into the relatively small land mass found in Central America, the Caribbean, and northern South America (Lovejoy 1983). Migrants must always compete with birds that are resident year-round. There are, however, a much greater number of species and individual resident birds in the tropics. In most areas, neotropical migrants constitute only 20-50 % of all birds (Greenberg 1990). Despite the potential for competition, the mild, consistent climate and the variety of food resources appear to provide ample compensation for the rigors of migration.

New neighbors are only part of what makes the southern home so different from that in the north. The climate and plant communities are also vastly dissimilar. As a result, during the five to seven months spent in the south, many migratory songbird species take on new lifestyles. Birds, like the White-eyed Vireo and the Eastern Kingbird, that were eating insects just weeks before turn to fruit. Others, like the Tennessee Warbler, find a taste for nectar. Some species join large foraging flocks with tropical residents, while others maintain individual territories. There is growing evidence that wintering migrants display site-fidelity similar to that of the breeding season (Keast and Morton 1980).

By late March it is time to build up fat reserves and replace the dull winter feathers with breeding colors, once again in preparation for another extensive trip. The northern migration differs from the southern migration in duration and concentration. Migratory paths are more diffuse at this time, due to seasonal changes in prevailing weather patterns. Migratory songbirds move quickly towards their breeding territories where competition for food, space, and mates will be intense.

THE NEOTROPICAL MIGRATORY SONGBIRD COASTAL CORRIDOR STUDY

STUDY JUSTIFICATION

The Atlantic migratory flyway covers the entire Atlantic coastal area. Perhaps the most significant stopover areas for landbirds in this flyway, however, are coastal habitats from Cape May, New Jersey to Cape Charles, Virginia. Although the Delaware and Chesapeake bays are best known for the large concentrations of waterfowl and shorebirds found there, these areas are also thought to be critical to the future existence of eastern neotropical migratory landbirds. The prominant land features of the Cape May and Delmarva peninsula naturally consolidate southbound migrants that are reluctant to cross large bodies of water unless weather conditions are advantageous. A combination of factors related to geography, the direction of prevailing

winds, and innate behavior are likely responsible for such a phenomenon (Dunne et al. 1989).

Preliminary observations have suggested that landbird migrants rest, feed, and seek cover in a relatively narrow strip of shrubby and wooded habitat along the coasts and near the peninsula tips. These habitats, not yet adequately defined or delineated, are facing unprecendented development pressures, especially on waterfront properties. The loss and fragmentation of habitats where large numbers of birds concentrate in small areas could have serious repurcussions on population viability. Piecemeal and uninformed approaches to protection of habitats within the migratory corridor will not address the conservation needs of neotropical migrants. This study attempts to identify the breadth, extent, and componants of a migratory landbird corridor on the Cape May and Delmarva peninsulas (Fig. 1).

STUDY GOALS

The goal of the study was to characterize coastal areas on the Delmarva and Cape May peninsulas that support the greatest abundance and species richness of migrating songbirds. Five questions were examined:

1. ***Are migrant abundance and species richness (i.e., the number of migrant species) greater immediately near the mainland coast than farther inland? (I.e., is there a coastal effect?)***

Although never quantified, the mid-Atlantic coast has long been considered an important concentration area for migrating songbirds. To address the hypothesis, we compared songbird numbers near the coast (0 - 0.9 mi [0 - 1.5 km] from the coastline) with inland areas (0.9 - 1.9 mi [1.5 - 3.0 km] from the coastline); (see Study Design, p. 5).

2. ***Are there differences in migrant abundance and species richness between the bay coast, ocean coast, and mainland interior?***

If a coastal effect is identified, we are interested in knowing if all coasts are equal to migrants. Birds reluctant to cross large bodies of water may follow the coast around the tips of peninsulas and then northward up the bay coasts in search of a narrower overwater crossing point (USFWS 1984). At the same time, some birds may disperse inland, in search of habitats where there are fewer predators and reduced competition for food and cover (Wiedner et al. 1992). To examine simultaneously each of these possibilities, migrant abundance and species richness along the Chesapeake and Delaware Bay coasts was compared to that along the four-state ocean coast and in mainland interior areas. Landscape features of interior areas were not specifically examined for comparison with coastal areas.

3. ***Do migrants concentrate near the tips of peninsulas?***

Observations of bird migration stopovers at two well-known bird research stations (Cape May Bird Observatory and Kiptopeke Bird Banding Station), suggest that as birds move southward and eastward towards the coast, they tend to become funneled towards the southern points of peninsulas (VA Heritage 1988, USFWS 1984). Consequently, they may become concentrated at these narrow tips of land. The presence of stopover concentrations would have important conservation implications for lower portions of peninsulas. Therefore, we examined this possible concentration effect by comparing migrant abundance among coastal area located 0 - 6.2 mi (0 - 10 km), 6.2-18.6 mi (10-30 km), and 18.6 - 31 mi (30 - 50 km) from the southern tips of the Cape May and Delmarva Peninsulas.

4. ***Are migrant abundance and species richness greater on barrier islands than along the adjacent mainland coast?***

Compared to mainland areas, barrier islands are unique, both in terms of their geographic position and vegetation. Barrier islands also represent a significant portion of the coastal landscape. Therefore, to assess the relative importance of barrier islands as stopover habitat, we compared migrant abundance between barrier islands and the adjacent mainland coasts.

5. ***Are migrant abundance and species richness related to habitat type?***

Individual species of neotropical migrants use specific habitats on both their breeding and "wintering" grounds (Keast and Morton 1980). Specific habitats may also be required by individual species during migration (Moore and Simons 1992). Habitat associations may dampen or override geographic factors if there is a strong bias in the distribution of different habitat types. Bird abundance and species richness were compared among four general habitat types (deciduous forest, coniferous forest, mixed deciduous-coniferous forest, and scrub-shrub habitat) and seventeen specific plant communities (Appendix C). Species-specific habitat associations were examined for the seven most abundant species in our sample and ten species with reported population declines.

STUDY DESIGN

The Neotropical Migratory Songbird Coastal Corridor Study was conducted within the bay and Atlantic coastal regions of Virginia, Maryland, Delaware, and New Jersey, including the islands of Fisherman's (VA), Smith (VA), Parramore (VA), Assateague (VA/MD), and five resort islands from Sea Isle City to Cape May (NJ) (Fig. 1). We designated the coastal zone as a 1.9 mi (3.0 km) wide district running parallel to both bay and sea shores. The mean high

tide (mht) line defined the zero mi border of the coastal zone. The coastal zone was split into two bands: the near-coast band 0.0 - 0.9 mi (0 - 1.5 km) from mht and the inland band 0.9 - 1.9 mi (1.5 - 3.0 km) from mht; and then further subdivided latitudinally every 6.2 mi (10 km) to form 1.9 x 6.2 mi (3.0 x 10 km) blocks (Fig. 2). Interior blocks (1.9 x 6.2 mi) were established 6.2 - 14.3 mi (10 - 23 km) from the shoreline in Maryland, Delaware, and New Jersey. Within each block, we randomly selected eight survey sites with fixed radii of 82 ft (25 m) (four within the near-coast band, four within the inland band) (Fig. 2). Although we were unable to establish blocks of 1.9 x 6.2 mi on all islands included in our study, sites were selected to match a density of 8 per 9.98 mi^2.

In an effort to maximize uniformity between all sites, random selection of survey sites was conducted under the following guidelines: the habitat was dominated by woody vegetation greater than 1.5 ft (0.5 m) in height; habitat patches were a minimum of 1 ha in size and no less than 492 ft (150 m) wide; and each site was located at least 164 ft (50 m) from the habitat edge.

Birds were counted at each survey site twice a week from the beginning of August to the end of October 1991. We employed a modified point count method to determine the relative density of migratory birds at sites. A standardized audio tape of chickadee alarm notes and human pshing and squeaking was played during the survey period to draw birds closer and facilitate identification. For each survey, a single observer recorded the species and number of individuals seen within a 10 min period. Individual birds that could not be identified to the species level were grouped into broad categories (e.g., Unidentified Vireo or Unidentified Tanager). Raptors were also recorded because they may influence the presence and detectability of songbirds (Appendix B).

To minimize biases and variance within the data, observers were rotated among study areas. All surveys were conducted between two hours after sunrise and one hour before sunset. Additional data collected for each survey period include weather parameters (temperature, precipitation, and wind index) and time of day. Surveys were not conducted during heavy rain.

Habitat parameters and plant community types were evaluated at all survey sites. Based on these thorough descriptions, each site was assigned to one of four general habitat types (coniferous forest, deciduous forest, mixed forest, or scrub-shrub) (Figs. 3 & 4) and further classified into one of 17 specific community types (Appendix C). See state technical documents on best remaining natural communities within the study area (Clancy 1992, MDNHP 1992, Windisch 1992, Zebryk and Rawinski 1992)

In all, we had 487 survey sites over the four-state region and conducted more 12,000 point counts during the migratory period. Over 36,000 birds of 91 species were counted. Analyses of these data used the mean number of birds

per survey (bird abundance), and the mean number of species per survey (species richness) as variables of interest. We also analyzed the abundance for the seven species that were most frequently observed (Yellow-rumped Warbler, Red-eyed Vireo, American Redstart, Pine Warbler, Black-and-white Warbler, Gray Catbird, and Ruby-crowned Kinglet); (see Fig. 5). In addition, we selected ten neotropical migrant species that are reported to be declining (Robbins et al. 1989, Askins et al. 1990) and are represented in our sample by more than 150 sightings. We examined the habitat associations for these and the seven most abundant species listed above.

All significance tests are based on analysis of variance tests (ANOVA SAS). Any analyses differing from the above standards are discussed in the Findings section. For more details on the study design and statistical analyses see McCann et al. *in prep*.

FINDINGS

- ***Bird abundance and species richness were greater near the coast than farther inland.***

As described above, a 1.9 mi (3 km) coastal zone was delineated and divided into two equal sectors 0.9 mi (1.5 km) wide (near-coast sector and inland sector). The results of surveys conducted within the near-coast sector and the inland sector were compared to determine whether disparities in bird density and in species richness exist between these sectors. The regional data reveal a greater average number of birds seen per site in the near-coast sector than the inland sector (Table 1). In addition, there was, on average, a higher number of different species counted at near-coast sites than inland sites (Fig. 6). This demonstrates that on a regional scale, migratory songbirds are concentrating within 0.9 mi (1.5 km) of the coast on both the bay and sea sides of the peninsulas during migratory stopovers.

- ***Migrant abundance and species richness are greater on bay coasts than either ocean coasts or peninsula interiors.***

Migrant abundance and species richness (Figs. 7 & 8) are both significantly greater along the Chesapeake and Delaware Bay coasts than either the Atlantic coasts or peninsula interior areas. In separate comparisons of seven individual species, four species (American Redstart, Black-and-white Warbler, Ruby-crowned Kinglet, and Gray Catbird) are also significantly more abundant on bay coasts (Table 2). Notably, none of these seven species are significantly lowest in abundance on the bay coasts.

The greater abundance of migrants on bay coasts may be due to re-orientation behavior by migrants - a factor which results in daytime movement

by neotropical migratory landbirds. As birds arrive on the coast, many tend to disperse in a northward or westward direction (Baird and Nisbet 1960, Drury 1960, Drury and Keith 1962, Drury and Nisbet 1964). Birds arriving near the tips of the Cape May and Delmarva Peninsulas may circle westward around the peninsulas and then head northwestward up the Delaware and Chesapeake Bay coasts.

Delaware presents a unique situation since no major peninsula tip occurs in this state. However, birds may move diurnally towards the western coast of the Delaware Bay as birds head northward and northwestward from the ocean coast.

The lack of difference between ocean coasts and interior sites may be due to several factors. Neotropical migrants tend to exhibit a "morning flight", whereby large numbers of newly arriving birds move from shoreline habitats to more interior areas during the first few hours after sunrise (Wiedner et al. 1991). The purpose of the morning flight may be to search for areas where resource competition is reduced or possibly to locate more suitable feeding, resting, and roosting habitat.

- ***Birds may concentrate near the coasts of the lower Cape May and Delmarva peninsulas.***

Birds migrating in a southerly direction would be expected to concentrate at any barrier to southerly flight. Such obstacles are well documented for diurnal migrants such as raptors where large stretches of water can increase risks or energy expenditures (Kerlinger 1990, Niles et al. 1992). The influence of water barriers such as the Delaware Bay and Chesapeake Bay has only been speculated for migrant passerines.

No clear regional relationship was apparent between bird abundance and the distance to the ends of peninsulas (Table 3). On the Delmarva peninsula, both bird abundance and species richness were significantly greater 6.2 - 18.6 mi from the peninsula tip. However, no significant relationship existed between bird abundance and distance from the tip of the Cape May peninsula while species richness was significantly highest 18.6 - 31.0 mi from the tip (Table 4).

In New Jersey, the total of all species was highest close to the peninsula points but the variation in counts was so great that no significant difference was found. But Red-eyed Vireo, Black-and-White Warbler, and Ruby-crowned Kinglet were significantly more abundant in the 0 - 6.2 mi region.

In contrast, abundances in the Virginia surveys were higher in the 10-30 km region of the peninsula. Red-eyed Vireos, American Redstarts, Black-and-White Warblers, and Pine Warblers were unevenly distributed but followed the same general trend.

The relationship between bird densities and distance to the tip of the peninsula may be stronger than the data suggest due to the artifacts of the sampling procedure and the peculiarities of habitat distribution. In New Jersey, birds clearly concentrated in the near-coast sectors of the lower 12.4 mi of the Cape May peninsula (Table 3). This relationship was obscured, however, by the even distribution of birds in the inland sectors of the same area. On the Delmarva peninsula, the random selection of survey points resulted in no points within 1.9 mi of the peninsula tip. However, in an ancillary study, Virginia biologists found nearly twice as many birds within the lowest 1.9 mi as within the next 4.3 mi (Mabey unpubl. data).

The distribution of birds in Virginia suggests the availability of habitat modifies the effect of distance to the point. In New Jersey the survey sites were evenly distributed across the four main habitat types in lower, middle and upper peninsulas areas and densities generally increased toward the point. In Virginia, however, the proportion of sites in each habitat varied considerably. The greatest amount of deciduous and mixed forest occurs in the middle portion where the bird counts were also high. The high proportion of deciduous and mixed forest may be the reason for high bird counts (data in analysis).

Unfortunately, no definite conclusions regarding stopover concentrations at peninsula tips can be drawn from this study. This question merits further research as it could have clear conservation implications.

- ***Migrant abundance and species richness are greater on barrier islands than on adjacent mainland coasts.***

The relative abundance of neotropical migrants is over two times greater on barrier islands than on the adjacent peninsula coasts. Species richness is also substantially higher on barrier islands (Fig. 9). Moreover, four of seven species (Yellow-rumped Warbler, American Redstart, Ruby-crowned Kinglet, and Gray Catbird) analyzed separately are also significantly more abundant on barrier islands; none of the seven species are significantly more abundant on the mainland coast (Table 5).

These findings point to the importance of coastal habitats for migrating landbirds. Barrier islands are essentially "a coastline lying off the coast". Like the coastal mainland, barrier islands serve as a stopover concentration area. Perhaps more importantly, they are the first potential landfall for birds attempting to return to the Atlantic coast during the early morning hours (Murray 1976, Wiedner et al. 1992). This placement may in part account for the remarkably high abundance of migrants on barrier islands.

Migrant concentrations on barrier islands also may have been related to habitat features. Most barrier islands in this study contain extensive, undisturbed areas of dune woodland and interdune scrub vegetation. These

habitats offer an abundance of insects and fruit. The extremely dense vegetation provides excellent cover from predators and adverse weather conditions. Such areas support very high densities of migrant scrub-shrub dwellers such as Yellow-rumped Warbler and Gray Catbird. In fact, these two species are 3 to 5 times more abundant on barrier islands than on the mainland coast (Table 5). Barrier islands also support a greater abundance of American Redstart and Ruby-crowned Kinglet. Some migrant species, however, are uncommon or absent on barrier islands even though they are frequently observed on the mainland. One such species is the wood thrush which appear to require larger, more mature tracts of deciduous or mixed forest.

• ***Species occurrence is related to habitat type.***

Several significant differences exist in the associations of migrant species and habitats. Our results fall into two broad classes. First, species richness varies with habitat type and vegetation community; and second, individual species are associated with particular habitats.

The cumulative species richness (total number of species observed over migratory period) was greatest for mixed and deciduous forests. Scrub habitats also rank high in cumulative species richness. The number of species counted in coniferous forests during the study, however, is less than one half that for any other habitat (Fig. 10). The same variable was assessed for the sixteen vegetation communities that comprise the survey sites. The cumulative species richness varies significantly among all vegetation communities (Fig. 11). Two communities, mesic mixed hardwood/sweet pepperbush forest (deciduous variant) and old field forest are most species rich.

That some habitat types (i.e., coniferous forests) and vegetation communities (i.e., black willow/alder swamp) are relatively less species rich than others does not necessarily mean that they are unimportant to migrating birds. In fact, many species have significant associations with particular habitats. We examined species-specific habitat associations for the seven most abundant species in our sample (Table 6) and ten neotropical migratory songbird species with reported population declines over the past two decades (Figs. 12 & 13). Analyses are based on the average number of individuals of a given species for each of the four habitat types. Several of these species ( ) show significant associations with one or more habitat types. For all species, however, there is a distinctive trend of association with habitats similar to those used during the breeding and/or wintering season. Based on this analysis, coniferous forests have the weakest associations with the migrant species (Figs. 12 & 13).

We have established that species richness varies with habitat type and between vegetation communities and that specific species are strongly associated with certain habitat types. A habitat mosaic is likely to offer

the best support for neotropical migrants. This information focuses attention on the interpretation of the geographic patterns identified by this study. Specifically, the distribution of habitats and vegetation communities between coastal and inland areas, and the baysides and seasides of the Cape May and Delmarva peninsula probably has some impact on the distribution of the migrants between these geographic regions. Further analyses and, perhaps, research is necessary to discern the relative influence of geography and habitat on stopover concentrations of neotropical migrants.

REGIONAL MANAGEMENT AND POLICY RECOMMENDATIONS

We recommend that wherever special initiatives solely on behalf of migrating songbirds are feasible, that they be established. We recognize, however, that the body of protection for migrants and their habitat will originate from connecting these concerns with existing environmental conservation policies.

The results of this study indicate that species richness, an important factor of biodiversity, is greatest in the mixed forest, deciduous forest, and scrub/shrub habitat categories. Across all species, however, it is clear that all four habitat types are utilized. A habitat mosaic likely provides the greatest resources to the greatest number of species. In general then, native vegetation of all types should be considered primary habitat for migrating songbirds. In cases of habitat restoration, we recommend that a mix of habitats be replanted with an emphasis on mixed forests and shrub-scrub communities (see Appendix C).

Within the four-state region, we recommend the broadly defined policy and management actions listed below. State-specific issues are considered in a separate section (see p. 12-16) and a resource list including some examples of recommended actions can be found in Appendix D.

- **Include habitat requirements for greatest migrant species richness in Best Management Practice (BMP) guidelines for Conservation and Watershed districts.**

- **Expand forest stewardship plans to include migrating songbird habitat needs, especially with respect to habitat diversity and avoidance of monoculture forests.**

- **Amend shoreline stabilization strategies to consider habitat values, especially the habitat requirements of migrants;**

establish and implement alternatives to grading shores and replanting with non-native vegetation; where alternative methods are unsuitable, institute mechanisms to protect equivalent inland area with native vegetation.

- **Include considerations for habitat requirements for migrant species richness in management of U.S. Fish and Wildlife Service lands, national parks, state parks, and state wildlife management areas.**

- **Introduce neotropical migrants and migrating songbird habitats as significant coastal resources into state Coastal Zone Management Program plans as they are revised.**

- **Include habitat considerations for migrant species richness in governmental and non-governmental land conservation easements; create standard easement management guidelines for various habitat types.**

- **Initiate programs to educate local and state land planners and field personnel from such agencies as forestry and soil and water conservation regarding the value of neotropical migratory songbirds and their habitat requirements.**

STATE POLICY AND MANAGEMENT RECOMMENDATIONS

DELAWARE

The management of land and water resources in Delaware is shared by various levels of government, and among many separate agencies. The State government assumes the responsibility for the resources determined to be worthy of regulation for the general public benefit. There is, however, a strong emphasis from the county and municipal governments for local land use planning efforts.

The data collected under the NMSCC will be incorporated into the efforts undertaken primarily by the Department of Natural Resources and Environmental Control, although other avenues will not be excluded.

There are numerous programs currently underway that address many facets of protection of species and habitats statewide. Specific language may need to be incorporated in these on-going efforts to address the need for

protection of habitat for songbird species. In some instances, new efforts may need to be undertaken.

Currently three major programs are addressing status and recovery for the coastal portion of the state for the protection of habitat most critical to the migratory species discussed. These are:

- Inland Bay Estuary Recovery Program
- Delaware Estuary Comprehensive Plan
- Delaware Coastal Zone Management Plan

Each of these deal with specific geographical regions of the state, and are directed at separate and unique activities contained within that region. It is critical that as these plans are revised, inclusion of the importance of the Deaware coastaline as habitat for neotropical migrants be addressed. Projects which are funded through these programs may be encouraged to include protection, enhancement, or restoration of habitat for utilization by migratory songbird species. An example may be wetland rehabilitation projects to consider multiple species management actions.

Activities under the Land Protection Act should reflect the importance of certain habitat types for the benefit of migratory songbirds. One of the weighting factors in the rating system may include the value of the parcel for migratory songbird species as a stand alone category.

There are many efforts statewide that are directed at land protection. Inclusion of consideration of the importance of the Delmarva as critical habitat for the songbird migration should be incorporated into the protection strategy. Efforts such as the Greenway program, and more specifically the Coastal Heritage Greenway, can address the core issue of habitat protection through minimization of habitat fragmentation. The Natural Areas Program may want to include migratory bird habitat in the array of factors addressed with land owners for inlcusion in a Natural Area or state recognized Nature Preserve

As funds become available from the state under the Deaware Land and Water Conservation Trust Fund for purchase of land, efforts may be focused on inclusion of land spcifically for the protection of habitat for migratory bird species.

All State lands, such as Wildlife Management Areas, Forests, and Parks should include as part of their management plans actions which will protect habitat for usage by migratory songbirds.

To achieve broadbased success for habitat and specie protection many activities that occur in multiple departments within the State may be encouraged to include migratory species habitat as a componant to their mission. Increased exposure to habitat protection under the Forestry Stewardship Plans may be warranted within the Department of Agriculture, Division of Forestry. Consideration by the Department of Transportation into

highway corridors that minimze habitat fragmentation would be explored. Consultations with the Wetland Branch to encourage inclusion of songbird habitat into the Wetlands Best Management Practices should occur.

Many avenues for land protection originate at the county level. As each county revises their master plans, language may be included that addressed the critical importance of these areas within each county. In addition, the county Conservation Districts may include consideration for a Best Management Practice to include protection of habitat for songbird species.

MARYLAND

The study demonstrates that forested areas within 1.5 km of the coastline are of critical importance as stopover habitat for neotropical migrants. Bay coasts and barrier islands are particularly significant. In addition, of the four major habitat types (deciduous, coniferous, and mixed forest, scrub-shrub), coniferous forest represents the least important habitat for migrants.

Based on these findings, the following is recommended for coastal areas of Maryland to help insure the protection of suitable habitat for neotropical migrants:

1. <u>Maintain forested and scrub-shrub habitats, particularly large</u>

These habitats are most crucial as staging and resting areas for migratory landbirds. Large forest blocks, particularly deciduous and mixed forests, will provide suitable habitat for the greatest number of species. Thrushes, for example will utilize the older interior forest areas while scrub-shrub dwellers like gray catbird and yellow-rumped warbler will be most abundant along forest edges. Large forest blocks also provide nesting habitat for a variety of neotropical migrants during the spring and summer. In fact, many of these species (known collectively as Forest Interior Dwelling Birds - FIDS) nest exclusively in large undisturbed forest blocks and are among those species experiencing the most serious population declines in eastern North America. (See Guidance paper No. 1 of the Chesapeake Bay Critical Area Commission and Bushman and Therres (1988) for further information.)

2. <u>Avoid conversion of deciduous and mixed forests into coniferous forest (i.e., loblolly pine).</u>

As described earlier, conifer stands provide habitat for the fewest number of birds as well as the fewest species.

3. <u>Maintain natural scrub-shrub habitats such as those occurring long</u>

shorelines and dominated by bayberry and high tide bush.

Some species of neotropical migrant, such as common Yellowthroat, gray catbird, and brown thrasher, will also use these habitats for nesting during the spring and summer.

4. Encourage deciduous or mixed tree plantings in areas such as filter strips.

The habitats created by filter strip plantings will, at first, benefit scrub-shrub dwelling migrant species and as the trees mature, they will be utilized by forest dwelling migrants. Ideally, these plantings should consist of locally native plant species.

5. If wooded habitat must be developed minimize removal of trees and shrubs to the fullest extent possible.

Encourage planting of native vegetation.

The above recommendations can be implemented through the:

1. Local Chesapeake Bay Critical Area Programs in Dorchester, Queen Anne's, Talbot, and Worcester Counties. In particular, the recommendations should be incorporated into Forest Management Plans and Habitat Protection Area Plans (i.e., for Buffers, forested and shrub Non-tidal Wetlands, FIDS, other plant and wildlife habitat of local significance).
2. Forest Conservation Act.
3. State and federal farmer incentive programs, such as Conservation Reserve Programs (CRP) and the Acreage Conservation Reserve Program (ACR).
4. Forest Stewardship Programs.
5. Wildlife management plans for Wildlife Management Areas (WMA), state forests, and national, state, and local parks.
6. Local Open Space Requirements.
7. Local Comprehensive Plans
8. Local Subdivision Ordinances and Landscaping requirements.
9. Nontidal Wetlands Act.

In addition, the study results reaffirm the high ecological importance of barrier islands such as Assateague Island which is under state (MD Department of Natural Resources, Assateague Island State Park) and federal protection (National Park Service, Assateague Island National Seashore; U.S. Fish and Wildlife Service, Chincoteague National Wildlife Refuge). Scrub-shrub and forested habitats on barrier islands should be maintained and protected to provide appropriate habitat for all migrants.

NEW JERSEY

The consentration of migratory passerines adds to the overall significance of the Cape May Peninsula as a critical area for migratory birds. Currently there are major land acquisition and regulatory programs protecting critical habitats for migratory raptors, migratory shorebirds and woodcock on the Cape May Peninsula and the Delaware Bayshore. This includes the Maurice River project, the new Cape May Refuge, expansions to the Higbee WMA, and the new Cape Island WMA. The entire area is a focus for the North American Waterfowl Plan. Finally the area lies within the jurisdiction of three strong state regulatory programs protecting significant concentrations of migratory birds within the coastal zone, freshwater wetlands, and the pineland reserve.

On the other hand, the New Jersey coastal zone is one of the fastest growing areas in the state. Both resident and tourist populations has grown drastically in the last decade spurring a development boon that has only recently slowien from the nationwide recession. Between 1973 and 1986, more than 30% of all available habitat was developed.

Given the sharp contrast of ecological and economic importance in the coastal area the protection of critical habitats is a source of great conflict between developers and conservation agencies. Any action taken to protect migrant passerines will be both costly and difficult.

Given these conditions, we recommend the following:

1. Incoporate the recommendations from this study into guidelines on the protection of migrant species now being developed by the Endangered and Nongame Species Program of the Division of Fish, Game and Wildlife. Much of the area is the same and will increase justification for acquisition or regulatory protection.

2. Develop detailed mapping of the 0.9 mi coastal band and the lower 10 km area of the peninsula, and deveop protection guidelines for each of the three land use regulatory programs and the state master plan.

3. Review all current acquisition program plans and readjust acquisition boundaries to include the 0.9 mi band and lower 10 km area. Greatest priority will be given to undeveloped barrier island habitats and upland and freshwater wetland habitats adjacent to both the Atlantic and Delaware Bay marshes.

4. Initiate educational programs aimed at landowners to improve their understanding of the need of migratory passerines. This would include landscape recommendations based on minimizing impacts to natural habitats and improving habitat condition for feeding,

resting, and roosting migratory birds.

5. Develop guidelines for the management of public lands to provide diversity of habitats beneficial to passerine migrants without conflicting with the need fof other migrants and breedin populations of rare and endangered species.

6. Initiate surveys to determine the relative improtance of Delaware Bay and Atlantic coastal areas outside of the study area.

VIRGINIA

Neotropical migratory songbirds have been recognized as a vital natural resource for the Commonwealth of Virginia as illustrated by this statement released in October 1991 to the press by the Secretary of Natural Resources, Elizabeth H. Haskell:

> Virginia is taking the lead in this conservation issue of international importance... Virginia's Eastern Shore is thought to be one of the most important migratory songbird concentration [stopover] areas in North America. This 15 month study will be the first attempt to document the importance of the mid-Atlantic coastal corridor to scores of bird species. The commitment of nearly 100 Virginia citizen volunteers, whose help has made this study possible, is an inspirational illustration of local action toward global solutions.

With this high level of commitment to migratory bird conservation, integration of the migrant concentration zone and habitat requirements as established by the NMSCC study into state and local policy should proceed in a timely fashion. In addition to the recommendations outlined for the four-state region, we place added emphasis on local and non-governmental protection mechanisms.

The following tools may be appropriate vehicles for migratory bird and habitat conservation:

1. Overlay zoning for the 0.9 mi migrant concentration area requiring creation/maintenance of open space and preservation of native vegetation. Such policy is justified by aesthetic values, pollution abatement, migratory bird conservation, and eco-tourism potential.
2. Adjust the definition of Chesapeake Bay Preservation Act resource protection buffers (NWI lines) to include native vegetation rather than exotic grasses.
3. Amend sub-division ordinances to maximize connectiveness of habitat

patches.

RECOMMENDATIONS FOR FURTHER RESEARCH

The Neotropical Migratory Songbird Coastal Corridor Study has taken the first step towards defining the distributions of southward migrating songbirds stopping-over on the Cape May and Delmarva peninsulas. It was, however, designed to address broad-scale patterns. Many fine-scale issues remain for investigation. If concentrations of migrants exist at peninsula tips, our sampling design was unable to detect them. Alternative methodology (including more intensive coverage of the tip areas) that might examine peninsular effects on a different scale are recommended.

Details of species-habitat associations and habitat utilization will be critical to our understanding of the relative importance of habitat types. Current research at Cape May, NJ indicates that habitat utilization and association patterns vary within a single day, as well as over longer periods of time (Niles, *in prep.*; Kerlinger *in prep.*).

The relative importance of habitat may also vary according to the overall landscape (i.e., degree of patch isolation, relative abundance of particular habitat types, etc.). Additionally, riparian corridors and inland estuaries are significant landscape features on both the Cape May and Delmarva peninsulas. Migrant use of these coastal extensions should be examined. Local land use planning and migratory songbird protection efforts will benefit from studies of migrant-landscape associations.

BIBLIOGRAPHY

Askins, R.A., J.F. Lynch, and R. Greenberg. 1990. Population declines in migratory birds in eastern North America. Current Ornithology 7: 1-57

Baird, J., and I.C.T. Nisbet. 1960. Northward fall migration on the Atlantic coast and its relation to offshore drift. *Auk* 77: 119-149.

Clancy, K. 1992. Delaware exemplary natural habitats. Delaware Natural Heritage Inventory, Department of Natural Resources and Environmental Control. Dover, DE.

Drury, W.H., Jr. 1960. Radar and bird migration - a second glance. *Mass. Aud.* 44: 173-178.

_____, and J.A. Keith. 1962. Radar studies of songbird migration in coastal New England. *Ibis* 104: 449-489.

_____, and I.C.T. Nisbet. 1964. Radar studies of orientation of songbird migrants in southeastern New England. *Bird-banding* 35:69-119.

Dunne, P., R. Kane, and P. Kerlinger. 1989. *New Jersey at the Crossroads of Migration*. New Jersey Audubon Society.

Emlen, S.T. 1975. Migration: Orientation and Navigation. pp. 129-219 *in* Avian Biology, Vol. V. D.S. Farner and J.R. King, eds. Academic Press, Inc.

Greenberg, R. 1990a. "Southern Mexico: Crossroads of Migratory Birds." Smithsonian Institution Press. Washington, DC.

_____. 1990b. "Birds Over Troubled Forests." Smithsonian Institution Press. Washington, DC.

Hagan, J. and D. Johnston, eds. 1992. *The Ecology and Conservation of Neotropical Migrant Landbirds*. Smithsonian Institution Press. Washington, DC.

Keast, A. and E.S. Morton. 1980. *Migrant Birds in the Neotropics: Ecology, Behavior, Distribution, and Conservation*. Smithsonian Institution Press. Washington, DC.

Kerlinger, P. 1989. Flight stratagies of migratory hawks. University of Chicago Press, Chicago, IL.

Lovejoy, T.E. 1983. Tropical Deforestation and North American Migrant Birds. pp. 126-128 *in* Bird Conservation, S.A. Temple, ed. University of Wisconsin Press. Madison, WI.

Maryland Natural Heritage Program (MDNHP). 1992. Exemplary natural habitats of Maryland's coastal corridor study. Department of Natural Resources. Annapolis, MD.

Moore, F. and P. Kerlinger. 1987. Stopover and fat deposition by North American wood-warblers (Parulinae) following spring migration over the Gulf of Mexico. *Oecologia* 74:47-54.

_____ and T.R. Simons. 1992. Habitat Suitability and the Stopover Ecology of Neotropical Passerine Migrants *in* The Ecology and Conservation of Neotropical Migrant Landbirds, J. Hagan and D. Johnston, eds., Smithsonian Institution Press. Washington, DC.

Morse, D.H. 1989. *American Warblers: An Ecological and Behavioral Perspective*. Cambridge: Harvard University Press.

Robbins, C.S., J.R. Sauer, R.S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. *Proc. Natl. Acad. Sci. USA*. 86: 7658-7662.

Terborgh, J. 1989. *Where Have All the Birds Gone?* Princeton Universit Press. Princeton, NJ.

U.S. Fish and Wildlife Service. 1984. Final environmental assessment: proposal to protect migratory bird habitat, Northampton County, Virginia. Unpubl. MS.

Virginia Natural Heritage Program (VNHP). 1988. Report on the bayside and Kiptopeke Beach, Northampton County, Virginia. Tech. Publ. Series No. 1: 28 pp.

Wiedner, D.S., P. Kerlinger, D. Sibley, P. Holt, J. Hough, and R. Crossley. 1992. Visible morning flight of neotropical migrants at Cape May, NJ. *Auk*. In press.

Windisch, A.G. 1992. Best remaining natural community and rare species sites of New Jersey's Cape May Peninsula and vicinity. NOAA Grant #NA90AA-H-CZ839. New Jersey Natural Heritage Program. Trenton, NJ.

Zebryk, T. and T.J. Rawinski. 1992 A preliminary survey of natural heritage resource sites in Northampton and Accomack Counties, Virginia. Natural Heritage Technical Report 92-22, Virginia Department of Conservation and Recreation, Division of Natural Heritage. Richmond, VA. 43pp.

APPENDIX A

STUDY PARTICIPANTS

Lloyd Alexander - Policy Advisor
Delaware Division of Fish & Wildlife

Charles Bartlett - DE Coordinator
Delaware Natural Heritage Inventory

Thomas Breden - Ecologist/ NJ Project Manager
New Jersey Natural Heritage Program

Keith Clancey - Ecologist
Delaware Natural Heritage Program

Sarah Cooksey - Policy Advisor
Coastal Management Program
Delaware Department of Natural Resources and Environment

Samual Droege - Science Advisor
Patuxent Wildlife Research Center
U. S. Fish & Wildlife Service

Lisa Gelvin-Innvaer - Science/Policy Advisor
Delaware Division of Fish & Wildlife
Nongame & Endangered Species Program

Ernest Hahn - Policy Advisor
New Jersey Environmental Regulation
Land Use Regulation Program

Paul Kerlinger - Science/Policy Advisor
Cape May Bird Observatory
New Jersey Audubon Society

Susan Laporte - Policy Advisor
Delaware Department of Natural Resources and Environmental Control
Division of Parks and Recreation

Thomas Litwin - Science Advisor
Clark Science Center
Smith College

Laura McKay Lower - Grant Coordinator/Policy Advisor
Coastal Resources Program
Virginia Council on the Environment

Sarah E. Mabey - VA Coordinator
Virginia Department of Conservation and Recreation
Divsion of Natural Heritage

Lawrence Master - Project Coordinator
Eastern Regional Office
The Nature Conservancy

James McCann - MD Coordinator
Nongame & Urban Wildlife Program
Maryland Forest, Park & Wildlife Service

Kathy McCarthy - Ecologist
Inventory and Protection
Maryland Natural Heritage Program

Janet McKegg - Ecologist
Maryland Natural Heritage Program

Shepard Moon - Policy Advisor
Virginia Council on the Environment

Lawrence Niles - NJ Coordinator
New Jersey Division of Fish, Game & Wildlife
Endangered & Nongame Species Program

Christopher Pague - Science/Policy Advisor
Colorado Natural Heritage Program

Charles Pattison - Policy Advisor
Virginia Coast Reserve
The Nature Conservancy

Steven Patton - Science Advisor
Devil's Den Preserve
The Nature Conservancy

Diane Pence - Science Advisor
U. S. Fish & Wildlife Service

Thomas Rawinski - Ecologist
Virginia Division of Natural Heritage

Chandler S. Robbins - Science/Policy Advisor
Patuxent Wildlife Research Center
U. S. Fish & Wildlife Service

Thomas L. Smith - VA Project Manager
Virginia Division of Natural Heritage

Glenn Therres - MD Project Manager
Nongame & Urban Wildlife Program

Lawrence Torok - Policy Advisor
New Jersey Environmental Regulation
Land Use Regulation Program

Leslie Trew - DE Project Manager
Delaware Natural Heritage Inventory

Barry Truit - Science Advisor
Virginia Coast Reserve
The Nature Conservancy

Robert Unnasch - Science Advisor
Science Department
The Nature Conservancy

David Wilcove - Science Advisor
Environmental Defense Fund
Washington, DC

Steven Whitney - Policy Advisor
New Jersey Environmental Regulation
Regulatory Policy Program

Tad Zebryk - Ecologist
Virginia Department of Conservation and Recreation
Divsion of Natural Heritage

APPENDIX B.

BIRD SPECIES INCLUDED IN NMSCC STUDY

Common Name	Latin Name	Total Study Count
Black-billed Cuckoo	*Coccyzus erythropthalmus*	19
Yellow-billed Cuckoo	*Coccyzus americanus*	222
Ruby-throated Hummingbird	*Archilochus colubris*	322
Yellow-bellied Sapsucker	*Sphyrapicus varius*	122
Olive-sided Flycatcher	*Contopus borealis*	7
Eastern Wood-Pewee	*Contopus virens*	238
Yellow-bellied Flycatcher	*Empidonax flaviventris*	21
Acadian Flycatcher	*Empidonax virescens*	27
Alder Flycatcher	*Empidonax alnorum*	1
Willow Flycatcher	*Empidonax traileii*	1
Least Flycatcher	*Empidonax minimus*	11
Eastern Phoebe	*Sayornis phoebe*	139
Eastern Kingbird	*Tyrannus tyrannus*	168
Great Crested Flycatcher	*Myiarchus crinitus*	243
House Wren	*Troglodytes aedon*	206
Ruby-crowned Kinglet	*Regulus calendula*	880
Blue-gray Gnatcatcher	*Polioptila caerulea*	241
Veery	*Catharus fuscescens*	247
Gray-cheeked Thrush	*Catharus minimus*	30
Swainson's Thrush	*Catharus ustulatus*	79
Hermit Thrush	*Catharus guttatus*	195
Wood Thrush	*Hylocichla mustelina*	170
Gray Catbird	*Dumetella carolinensis*	1365
Brown Thrasher	*Toxostoma rufum*	150
White-eyed Vireo	*Vireo griseus*	546
Solitary Vireo	*Vireo solitarius*	207
Yellow-throated Vireo	*Vireo flavifrons*	93
Warbling Vireo	*Vireo gilvus*	52
Philadelphia Vireo	*Vireo philadelphicus*	91
Red-eyed Vireo	*Vireo olivaceus*	3181
Blue-winged Warbler	*Vermivora pinus*	99
Golden-winged Warbler	*Vermivora chrysoptera*	5

Tennessee Warbler	*Vermivora peregrina*	29
Orange-crowned Warbler	*Vermivora celata*	9
Nashville Warbler	*Vermivora ruficapilla*	36
Prothonotary Warbler	*Protonotaria citrea*	42
Northern Parula	*Parula americana*	532
Yellow Warbler	*Dendroica petechia*	93
Chestnut-sided Warbler	*Dendroica pensylvanica*	385
Magnolia Warbler	*Dendroica magnolia*	358
Cape May Warbler	*Dendroica tigrina*	108
Black-throated-Blue Warbler	*Dendroica caerulescens*	845
Yellow-rumped Warbler	*Dendroica coronata*	9617
Black-throated Green Warbler	*Dendroica virens*	177
Blackburnian Warbler	*Dendroica fusca*	62
Yellow-throated Warbler	*Dendroica dominica*	77
Pine Warbler	*Dendroica pinus*	1411
Prairie Warbler	*Dendroica discolor*	525
Palm Warbler	*Dendroica palmarum*	83
Bay-breasted Warbler	*Dendroica castanea*	65
Blackpoll Warbler	*Dendroica striata*	63
Cerulean Warbler	*Dendroica cerulea*	9
Black-and-White Warbler	*Mniotilta varia*	2546
American Redstart	*Setophaga ruticilla*	3540
Worm-eating Warbler	*Helmitheros vermivorus*	74
Swainson's Warbler	*Limnothlypis swaisonii*	8
Ovenbird	*Seirus aurocapillus*	410
Northern Waterthrush	*Seirus noveboracensis*	41
Louisiana Waterthrush	*Seirus motacilla*	7
Kentucky Warbler	*Oporornis formosus*	28
Connecticut Warbler	*Oporornis agilis*	12
Mourning Warbler	*Oporornis philadelphia*	14
Common Yellowthroat	*Geothlypis trichas*	539
Hooded Warbler	*Wilsonia citrina*	24
Wilson's Warbler	*Wilsonia pusilla*	12
Canada Warbler	*Wilsonia canadensis*	55
Yellow-breasted Chat	*Icteria virens*	43
Summer Tanager	*Piranga rubra*	103

Scarlet Tanager	*Piranga olivacea*	157
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	47
Blue Grosbeak	*Guiraca caerulea*	44
Indigo Bunting	*Passerina cyanea*	72
Dickcissel	*Spiza americana*	2
Chipping Sparrow	*Spizella passerina*	38
Vesper Sparrow	*Pooecetes gramineus*	3
Grasshopper Sparrow	*Ammodramus savannarum*	9
Lincoln's Sparrow	*Melospiza lincolnii*	0
Bobolink	*Dolichonyx oryzivorus*	16
Orchard Oriole	*Icterus spurius*	35
Northern Oriole	*Icterus galbula*	657
Osprey	*Pandion haliaetus*	70
Bald Eagle	*Haliaeetus leucocephalus*	5
Northern Harrier	*Circus cyaneus*	25
Sharp-shinned Hawk	*Accipiter striatus*	200
Cooper's Hawk	*Accipiter cooperii*	40
Red-shouldered Hawk	*Buteo lineatus*	10
Broad-winged Hawk	*Buteo platypterus*	34
Red-tailed Hawk	*Buteo jamaicensis*	60
American Kestrel	*Falco sparverius*	59
Merlin	*Falco columbarius*	17
Peregrine Falcon	*Falco peregrinus*	14
Prairie Falcon	*Falco mexicanus*	0

APPENDIX C.

VEGETATION COMMUNITY TYPES IDENTIFIED WITHIN STUDY AREA

Community 1: Dry Oak Forest - Deciduous Variant
Diagnostic features: well-drained sandy soils; less than 60% of tree cover coniferous; several oaks, including *Quercus stellata, Q. coccinea, Q. falcata, Q. velutina, Q. phellos, Q. prinus* and *Q. alba*; other typical trees and tall shrubs are *Acer rubrum, Carya* spp. *Diospyros virginiana, Cornus florida, Sassafras albidum, Liquidambar styraciflua, Prunus serotina,* and *Vaccinium corymbosum; Pinus virginiana* and *Pinus taeda* usually present, except in parts of New Jersey where *Pinus rigida* appears; low ericads such as *Vaccinium pallidum, V. stamineum, Gaylussacia baccata* usually abundant; *Carex pennsylvanica* and other drought tolerant herbs usually present.

Community 2: Mesic Mixed Hardwood/Sweet Pepperbush Forest - Deciduous Variant
Diagnostic features: mesic to wet-mesic sites; organic matter on soil surface tends to be thick, except on some richer soils; less than 60% of tree cover coniferous; *Quercus alba, Pinus taeda, Ilex opaca, Acer rubrum, Nyssa sylvatica, Liriodendron tulipifera, Liquidambar styraciflua, Rhododendron* spp., *Gaylussacia frondosa, Clethra alnifolia* and *Magnolia virginiana* typically present; *Smilax rotundifolia* sometimes abundant; herbaceous layer is usually sparse, with species such as *Monotropa uniflora, Tipularia discolor, Chasmanthium laxum,* and *Mitchella repens* being characteristic; richer soils support an abundance of *Liriodendron* and herbs such as *Podophyllum peltatum;* Northamptom County, VA occurrences frequently support *Persea borbonia.*

Community 3: Mesic Beech/Holly Forest
Diagnostic features: similar to no. 2, but with an abundance of *Fagus grandifolia* and *Ilex opaca; frequently occurs on steep* slopes, less frequently on wet-mesic flats.

Community 4: Red Maple/Sweet Gum Swamp
Diagnostic features: seasonally wet sites; an early succession deciduous swamp forest community dominated by *Acer rubrum* and *Liquidambar styraciflua;* additional species include *Nyssa sylvatica, Quercus phellos, Q. nigra* and *Pinus taeda.*

Community 5: Black Gum Swamp
Diagnostic features: perennially wet sites; rather mature deciduous swamp community with an abundance of water tolerant herbs such as *Saururus cernuus, Osmunda cinnamomea, Anchistea virginica, Cinna arundinacea,* and *Carex* spp.; *Nyssa sylvatica* is dominant.

Community 6: Cape May Lowland Forest
Diagnostic features: a wet-mesic flatwoods similar to no. 4 but characterized by *Quercus michauxii, Q. phellos, Populus heterophylla,* and other hardwoods.

Community 7: Black Willow/Alder Swamp
Diagnostic features: a community of seasonally flooded, mucky stream bottoms encountered very rarely (in VA); characterized by *Salix nigra* and *Alnus serrulata.*

Community 8: Atlantic White Cedar Swamp
Diagnostic features: a community of peaty, oligotrophic lowlands;

encountered very rarely (in NJ); characterized by *Chamaecyparis thyoides*, tall ericads, and *Magnolia virginiana*.

Community 9: Pine Plantation Forest
Diagnostic features: obviously planted; usually dominated by *Pinus taeda*; can occur on several different soil types.

Community 10: Old Field Forest
Diagnostic features: a young, early-successional, post-agriculture forest characterized by mixed pines and hardwoods, and a weedy understory, e.g. with much *Loncera japonica, Ailanthus altissima, Toxicodendron radicans, Aralia spinosa*; old fences, rusting farm equipment, and junked cars can be diagnostic.

Community 11: Old Field Scrub
Diagnostic features: an early successional post-agricultural shrub community with plants such as *Juniperus virginiana, Rhus copallinum, Prunus serotina, Tidens flavus* and *Andropogon virginicus, Rubus* spp. and *Lonicera japonica*.

Community 12: Coastal Dune Woodland
Diagnostic features: woodlands situated near the coast and influenced by salt spray; trees usually with gnarled growth forms; *Celtia occidentalis, Sassafras albidum, Pinus taeda* (or *P. rigida* in NJ), *Juniperus virginiana*, and *Prunus serotina* are characteristic; understory usually thick with *Smilax rotundifolia, Toxicodendron radicans, Parthenocissus quinquefolia*, and *Myrica* spp.

Community 13: Salt Marsh Fringe Woodland
Diagnostic features: occurs primarily on the mainland as a narrow fringe bordering salt marshes; characteristic trees are *Pinus taeda, (P. rigida* in NJ), *Juniperus virginiana, Magnolia virginiana, Diospyros virginiana, Ilex opaca, Quercus falcata, Nyssa sylvatica, Liquidambar*, and *Acer rubrum*; frequent in the scrubby understory are *Baccharis halimifolia, Myrica cerifera, Toxicodendron radicans, Panicum virgatum, Poa compressa, Phragmites australis*, etc.

Community 14: Young Pine Scrub
Diagnostic features: usually this community is a young pine plantation occurring with a post-logging coppice of sprout hardwoods; herbs such as *Eupatoriaum capillifolium* and *Androprogon virginicus* usually abundant.

Community 15: Coastal Dune Scrub
Diagnostic features: typical species include *Myrica pensylvancica, Prunus maritima, Diospyros virginiana, Juniperus virginiana, Toxicodendron radicans, Ammophila breviligulata, Rubus spp., Hudsonia tomentosa, Panicum amarulum*, and *Opuntia humifusa*.

Community 16: Dry Oak Forest - Coniferous Variant
Diagnostic features: similar to no. 1, but with greater than 60% of the tree cover coniferous.

Community 17: Mesic Mixed Hardwoods/Sweet Pepperbush Forest - Coniferous Variant
Diangnostic features: similar to no. 2, but with greater than 60% of tree cover coniferous.

Bird abundance, species richness, and frequency distribution by state for 17 vegetation community types.

Community Type	Mean[1] Bird Abundance	Mean Species Richness	Frequency Distribution by State[2]			
			Delaware	Maryland	New Jersey	Virginia
1 (n = 1631)	2.58 ± 7.68	1.51 ± 1.93	32	8	37	23
2 (n = 2964)	2.58 ± 5.15	1.58 ± 1.90	27	37	9	27
3* (n = 178)	4.04 ± 6.41	1.96 ± 2.13	29	0	0	71
4 (n = 644)	2.63 ± 8.50	1.32 ± 1.83	3	14	52	31
5* (n = 233)	3.79 ± 10.56	1.32 ± 1.73	0	0	0	100
6* (n = 22)	0.86 ± 1.88	0.68 ± 0.99	0	0	100	0
7* (n = 23)	4.00 ± 4.06	2.61 ± 2.19	0	0	0	100
8						
9 (n = 411)	3.28 ± 6.37	1.59 ± 1.61	0	67	0	33
10 (n = 1817)	3.67 ± 8.38	1.61 ± 1.87	26	6	5	62
11 (n = 653)	3.72 ± 7.64	1.98 ± 2.02	0	10	90	0
12* (n = 24)	6.42 ± 6.89	3.04 ± 2.27	100	0	0	0
13 (n = 656)	3.40 ± 6.10	1.78 ± 1.84	18	67	15	0
14 (n = 636)	2.09 ± 4.33	1.16 ± 1.38	0	12	12	76
15 (n = 580)	7.18 ± 20.12	2.10 ± 1.89	4	48	44	4
16 (n = 383)	2.88 ± 5.86	1.49 ± 1.75	46	15	0	39
17 (n = 633)	2.05 ± 3.28	1.24 ± 1.65	19	58	0	23

[1]Mean ± standard deviation
[2]Percent of community in each state
*Note low sample size and highly skewed distribution

APPENDIX D.

ANNOTATED RESOURCE LIST

1. Neotropical Migratory Bird Facts

* Neotropical migrants are those species that breed in North American and winter in the tropical and sub-tropical Americas. They include some of our most beautiful breedin birds: hummingbirds, warblers, swallows, nighthawks, orioles, tanagers, flycatchers, vireos, thrushes, sparrows, and cuckoos.

* 190-200 species of North American breeding birds are considered neotropical migrants. (This is greater than one half of all bird species breeding in North America and accounts for 65-80% of all individual birds in the eastern U.S.)

* During the non-breeding season (our winter), neotropical migrants constitute more than one half of all individual birds in parts of Mexico, Cuba, Jamaica, and Hispaniola. They comprise 20-40% of the birds in the tropical forests of Guatamala and Belize.

* The breedin range for the majority of neotropical migrants consists of over 15 million square miles while the primary wintering grounds are only 2.3 million square miles.

* The average life span of neotropical migratory songbirds (that survive the firs critical year) is five years.

* An average warbler pair removes caterpillars from more than a million leaves during the nesting season, reducing the caterpillar numbers by as much as one half. Swallows and Purple Martins feed mosquitoes to their voracious families.

* A migratory songbird can double its mass in preparation for its fall migration. The fat acquired can be burned off with the estimated fuel efficiency of 720,000 miles/gallon.

* A Blackpoll Warbler can fly from New England to Venezuela in 60-80 hours. (A human running six-minute miles for the same amount of time would only make it from Maine to Virginia.) Most migrants, however, take a leisurely 4-8 weeks for their trip south with different peaks of movement for different species.

* Migratory songbirds lead versatile lives. Some species, such as Eastern Kingbirds and White-eyed Vireos rely heavily on fruit for thier winter diet, a significant change from their otherwise insectivorous ways. White-eyed Vireos are largely responsible for the dispersal of seeds from the Chacah tree (*Bursera simaruba*) in Mexico. Tennessee Warblers and orioles join the ranks of important tropical pollinators. The ecology, behavior, and population biology of these birds during migration is very poorly documented.

* Although some species of neotropical migrants join flocks in the winter, many are territorial throughout the year, even during their migratory movements. Thus every individual bird has specific spatial requirements.

* In the states of VA, MD, DE, and NJ population declines of 47-74% for neotropical migrant species were observed during the

period 1978-1987 (based on analyses of Breeding Bird Survey data). Some speices have declined in abundance by as much as 16% per year between 1978 and 1987. At a long-term study site near Washington, D.C., 65-80% of all birds were neotropical migrants in 1940. Today the number is closer to 20 percent. In that area, Red-eyed Vireos have declined by more than 60% and Hooded Warblers have disappeared.

* Tropical forests, winter home of most neotropical migrants, are being lost at an estimated 1-3% a year. In some countries this rate is greatly accelerated. In North America, the fragmentation of our forests exposes neotropical migrants to an abundance of predators that thrive in the human altered landscape. These include raccoons, blue jays, grackles, dogs, cats, and the insidious nest parasite, the Brown-headed Cowbird.

* Hundreds of thousands of Americans enjoy birding as a hobby. Studies have shown that the economic value of birds can be substantial in some communities. An estimated $5.5 million/year is spent by birders in Cape May, NJ, and about $1.7 million U.S./year at Point Pelee, Ontario.

2. Comprehensive Plan: Northampton County, Virginia

While striving for a balance between resource conservation and sustainable economic growth, Northampton County has recognized that there is a potential for conservation to feed economic growth. The first planning goal and objective listed in this 1990 comprehensive plan is to: "Conserve the County's Natural Resources." In outlining the "natural conditions" of the county, the comp plan specifically addresses the importance of migratory birds in a proactive voice.

> Northampton County has one of the great ecological and biological phenomena of the entire east coast of the United States. A peculiarity of geography has caused semi-annual pile-ups of some millions of birds (passerines) in the lower section of the County. Here they pause for rest, cover, and forage in trees and scrub growth along the edge of the Chesapeake Bay... Loss of natural habitat will cause serious declines in the number of birds, and of course eventual elimination. Suitable land use planning and management can preserve this valuable and unique natural asset which if handled correctly can be of great benefit not only to the migrating birds but to the County as a scientific and educational entity. Economic returns would also accrue from the influx of interested scientists and those who enjoy ornithology as an avocation.

3. Borough of Cape May Point Ordinance No. 291-90

This ordinance requires that a Landscaping and Vegetation Plan be submitted the zoning officer for approval if a permit is being sought to increase existing lot coverage by more than 15 %; to construct or convert apartment buildings; or in cases where land use will disrupt or remove more than 50 % of the existing vegetation in less than a five year period. The ordinance provides specific guidelines for retaining trees and replanting if

trees are removed. Replanting guidelines are based on the pamphlet: "Backyard Habitat for Birds: A Guide for Landowners and Communities in New Jersey" by P. Sutton, Cape May Bird Observatory/New Jersey Audubon Society. 1989.

4. The Economics of Birding at Cape May, New Jersey. Kerlinger, P. and D. Wiedner. in

Kerlinger and Wiedner present a study of the economic value of birding in the Cape May Peninsula. The results of their surveys indicate that an excess of $5.5 million enters the local economy directly from birders. This estimate does not include any multipliers. The authors use this information to argue that there is an economic benefit in maintaining open land and a clean environment.

5. Nearctic Avian Migrants in the Neotropics. Rappole, J.H., E.S. Morton, T.E. Lovejoy, III, and J.L. Ruos. U.S. Department of Interior Fish and Wildlife Service. July 1983.

This reference document provides the most thorough bibliography of literature on neotropical migrants, despite the fact that it is somewhat out-of-date.

6. "Birds over troubled forests." Greenberg, R. Smithsonian Migratory Bird Center. Smithsonian Inst. Press. 1990.

The Smithsonian Migratory Bird Center has created this and other educational materials for a lay audience. Not only do these pamphlets provide a clear and interesting description of migrants and their conservation problems, they offer recommendations for actions easily undertaken by citizens and local governments.

Table 1. Comparison of bird abundance and species richness between near-coast and inland sites.

	Near-coast (n = 5858)	Inland (n = 4126)	SL[a]
Mean Total Birds/Survey	3.13 ± 8.62	2.61 ± 8.62	*
Mean Species Richness	1.58 ± 1.87	1.45 ± 1.79	**
Red-eyed Vireo	0.28 ± 0.87	0.87 ± 0.87	
Black-and-white Warbler	0.24 ± 0.75	0.21 ± 0.81	
Pine Warbler	0.13 ± 0.73	0.09 ± 0.49	*
American Redstart	0.28 ± 0.93	0.31 ± 1.04	
Yellow-rumped Warbler	0.81 ± 7.04	0.50 ± 3.53	*
Gray Catbird	0.11 ± 0.57	0.06 ± 0.39	*
Ruby-crowned Kinglet	0.09 ± 0.61	0.05 ± 0.37	*

[a] SL = statistical significance level, based on ANOVA.
* $P < 0.05$, ** $P < 0.01$.

Table 2. Comparison of bird abundance and species richness between bayside, oceanside, and interior sites.

	Bayside (n = 5273)	Seaside (n = 4711)	Interior (n = 720)	SL[a]
Mean Total Birds/Survey	3.29 ± 8.56	2.49 ± 6.71	2.30 ± 7.44	**
Mean Species Richness	1.72 ± 1.99	1.31 ± 1.64	1.54 ± 1.86	**
Red-eyed Vireo	0.29 ± 0.89	0.27 ± 0.85	0.13 ± 0.61	
Black-and-white Warbler	0.28 ± 0.88	0.17 ± 0.63	0.12 ± 0.56	**
Pine Warbler	0.12 ± 0.57	0.11 ± 0.71	0.19 ± 0.66	
American Redstart	0.37 ± 1.17	0.20 ± 0.70	0.25 ± 0.79	**
Yellow-rumped Warbler	0.66 ± 6.53	0.71 ± 4.99	0.26 ± 1.60	
Gray Catbird	0.11 ± 0.54	0.08 ± 0.47	0.06 ± 0.27	*
Ruby-crowned Kinglet	0.12 ± 0.67	0.03 ± 0.26	0.10 ± 0.46	**

[a] SL = statistical significance level, based on ANOVA. * $P < 0.05$, ** $P < 0.01$.

Table 3. Regional comparison of bird abundance and species richness between sites that were 0-10 km (0-6.2 miles), 10-30 km (6.2-18.6 miles), and 30-50 km (18.6-31.1 miles) from the tips of the Delmarva and Cape May peninsulas.

	0-10 km (n = 617)	10-30 km (n = 1442)	30-50 km (n = 3391)	SL[a]
Mean Total Birds/Survey	3.29 ± 8.56	2.49 ± 6.71	2.30 ± 7.44	**
Mean Species Richness	1.72 ± 1.99	1.31 ± 1.64	1.54 ± 1.86	**
Red-eyed Vireo	0.17 ± 0.56	0.29 ± 0.92	0.19 ± 0.70	**
Black-and-white Warbler	0.26 ± 0.80	0.22 ± 0.80	0.20 ± 0.77	**
Pine Warbler	0.63 ± 0.48	0.06 ± 0.36	0.15 ± 0.79	**
American Redstart	0.34 ± 1.14	0.35 ± 1.04	0.24 ± 0.88	**
Yellow-rumped Warbler	1.58 ± 16.88	1.03 ± 6.21	0.83 ± 5.09	
Gray Catbird	0.15 ± 0.62	0.15 ± 0.73	0.07 ± 0.41	
Ruby-crowned Kinglet	0.06 ± 0.51	0.03 ± 0.21	0.04 ± 0.31	

[a] SL = statistical significance level, based on ANOVA. * $P < 0.05$, ** $P < 0.01$.

Table 4. Comparison by state of bird abundance and species richness between sites that were 0-10 km (0-6.2 miles), 10-30 km (6.2-18.6 miles), and 30-50 km (18.6-31.1 miles) from the tips of the Delmarva and Cape May peninsulas.

	Cape May Peninsula			
	0-10 km (n = 617)	10-30 km (n = 1442)	30-50 km (n = 3391)	SL[a]
Mean Total Birds/Survey				
Mean Species Richness	to be added			
Red-eyed Vireo	0.13 ± 0.54	0.10 ± 0.53	0.03 ± 0.19	**
Black-and-white Warbler	0.18 ± 0.70	0.07 ± 0.50	0.11 ± 0.62	*
Pine Warbler	0.05 ± 0.53	0.02 ± 0.28	0.18 ± 1.35	**
American Redstart	0.22 ± 0.97	0.14 ± 0.58	0.14 ± 0.61	
Yellow-rumped Warbler	1.99 ± 22.08	1.07 ± 5.70	1.05 ± 4.56	**
Gray Catbird	0.27 ± 0.80	0.29 ± 1.02	0.23 ± 0.78	
Ruby-crowned Kinglet	0.10 ± 0.68	0.02 ± 1.93	0.06 ± 0.35	

		Delmarva Peninsula		
	(n = 280)	(n = 736)	(n = 2706)	
Mean Total Birds/Survey				
Mean Species Richness	to be added			
Red-eyed Vireo	0.21 ± 0.59	0.47 ± 1.16	0.24 ± 0.77	**
Black-and-white Warbler	0.35 ± 0.89	0.36 ± 0.99	0.22 ± 0.81	**
Pine Warbler	0.08 ± 0.42	0.08 ± 0.41	0.14 ± 0.57	**
American Redstart	0.48 ± 1.30	0.55 ± 1.31	0.26 ± 0.94	**
Yellow-rumped Warbler	1.08 ± 6.47	1.00 ± 6.66	0.77 ± 5.21	
Gray Catbird	0.01 ± 0.19	0.02 ± 0.41	0.03 ± 0.22	
Ruby-crowned Kinglet	0.01 ± 0.51	0.03 ± 0.21	0.04 ± 0.31	

[a] SL = statistical significance level, based on ANOVA. * $P < 0.05$, ** $P < 0.01$.

Table 5. Comparison of bird abundance and species richness between barrier islands and the adjacent coastal mainland.

	Barrier Islands (n = 939)	Mainland Coast (n = 2717)	SL[a]
Mean Total Birds/Survey	6.16 ± 9.46	2.75 ± 7.34	**
Mean Species Richness	2.15 ± 1.92	1.41 ± 1.74	**
Red-eyed Vireo	0.23 ± 1.35	0.21 ± 0.65	
Black-and-white Warbler	0.15 ± 0.59	0.17 ± 0.64	
Pine Warbler	0.12 ± 0.56	0.10 ± 0.78	
American Redstart	0.33 ± 0.97	0.25 ± 0.88	*
Yellow-rumped Warbler	3.34 ± 8.99	0.71 ± 4.71	**
Gray Catbird	0.55 ± 1.07	0.11 ± 0.59	**
Ruby-crowned Kinglet	0.07 ± 0.43	0.04 ± 0.29	**

[a] SL = statistical significance level, based on ANOVA.
* $P < 0.05$, ** $P < 0.01$.

Table 6. Comparison of species abundance among four general habitat types.

	Coniferous Forest (n = 838)	Deciduous Forest (n = 3194)	Mixed Forest (n = 5023)	Scrub-shrub (n = 1357)	SL[a]
Mean Total Birds/Survey	2.82 ± 5.66	2.76 ± 6.38	2.82 ± 6.94	3.61 ± 13.26	*
Mean Species Richness	1.50 ± 1.74	1.61 ± 1.95	1.45 ± 1.79	1.73 ± 1.88	**
Red-eyed Vireo	0.22 ± 0.62	0.36 ± 1.00	0.30 ± 0.98	0.06 ± 0.37	**
Black-and-white Warbler	0.27 ± 0.85	0.22 ± 0.72	0.27 ± 0.89	0.08 ± 0.60	**
Pine Warbler	0.04 ± 1.34	0.07 ± 0.71	0.17 ± 0.65	0.07 ± 0.51	**
American Redstart	0.27 ± 0.94	0.36 ± 1.15	0.33 ± 1.04	1.12 ± 0.73	**
Yellow-rumped Warbler	0.60 ± 2.62	0.49 ± 4.05	0.65 ± 4.60	1.82 ± 13.01	**
Gray Catbird	0.10 ± 0.41	0.08 ± 0.44	0.05 ± 0.32	0.31 ± 0.96	**
Ruby-crowned Kinglet	0.07 ± 0.28	0.07 ± 0.45	0.06 ± 0.45	0.07 ± 0.43	

[a] SL = statistical significance level, based on ANOVA. * $P < 0.05$, ** $P < 0.01$.

FIGURE 1

SAMPLING AREA FOR NEOTROPICAL MIGRATORY SONGBIRD COASTAL CORRIDOR STUDY

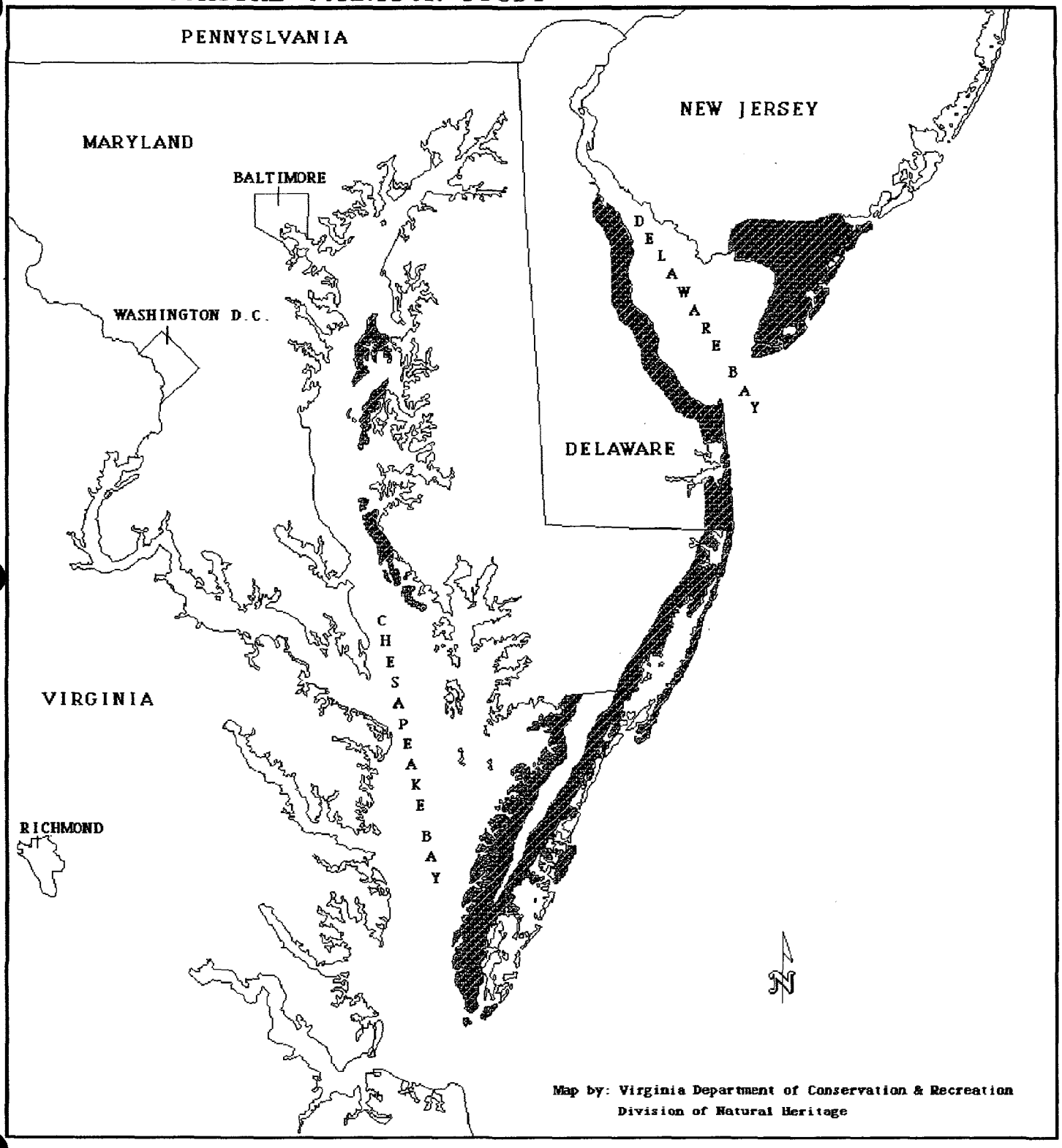


FIGURE 2

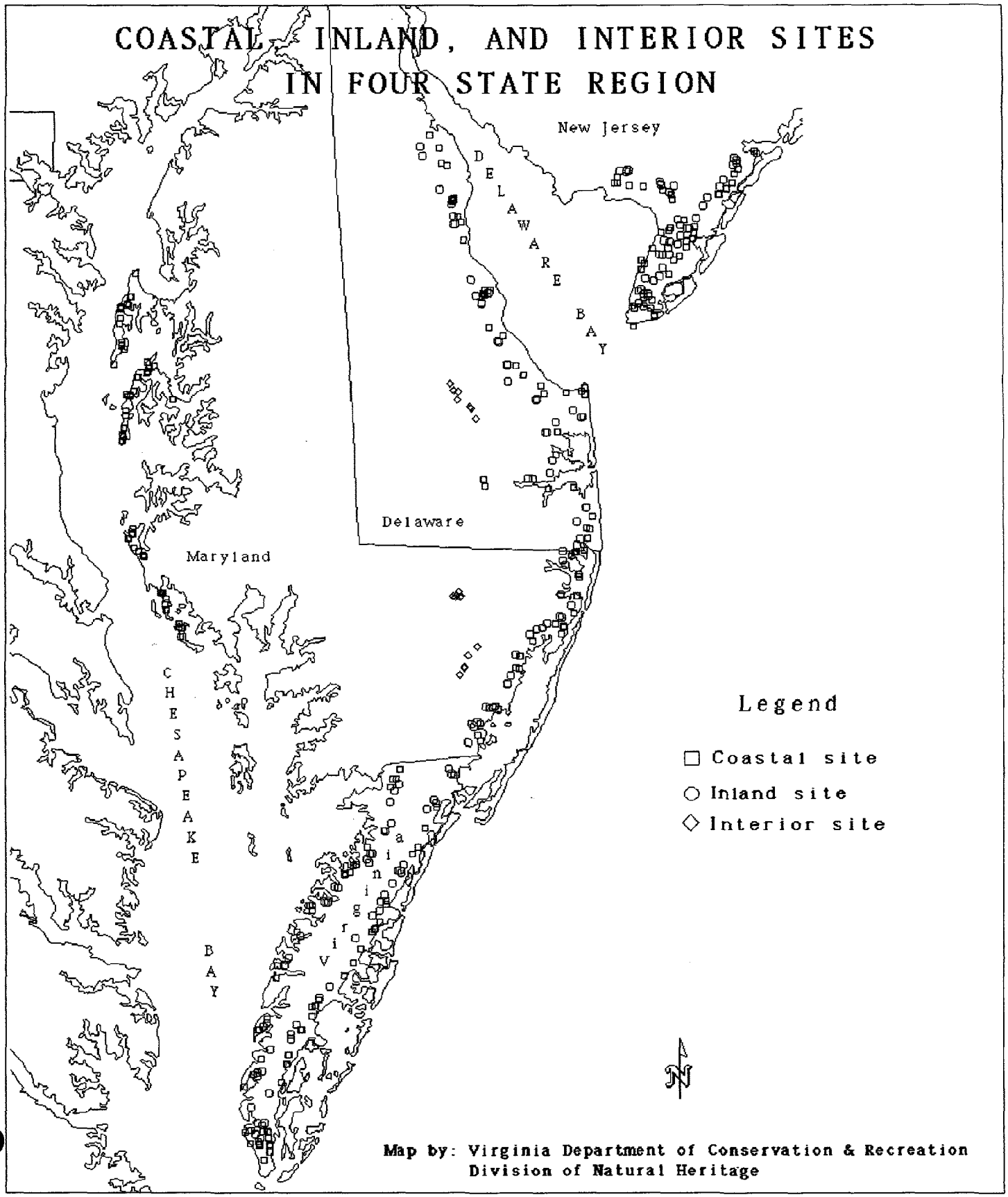

COASTAL, INLAND, AND INTERIOR SITES
IN FOUR STATE REGION
New Jersey
DELAWARE BAY
Delaware
Maryland
CHESAPEAKE BAY
Virginia
Legend
Coastal site
Inland site
Interior site
N
Map by: Virginia Department of Conservation & Recreation
Division of Natural Heritage

FIGURE 3

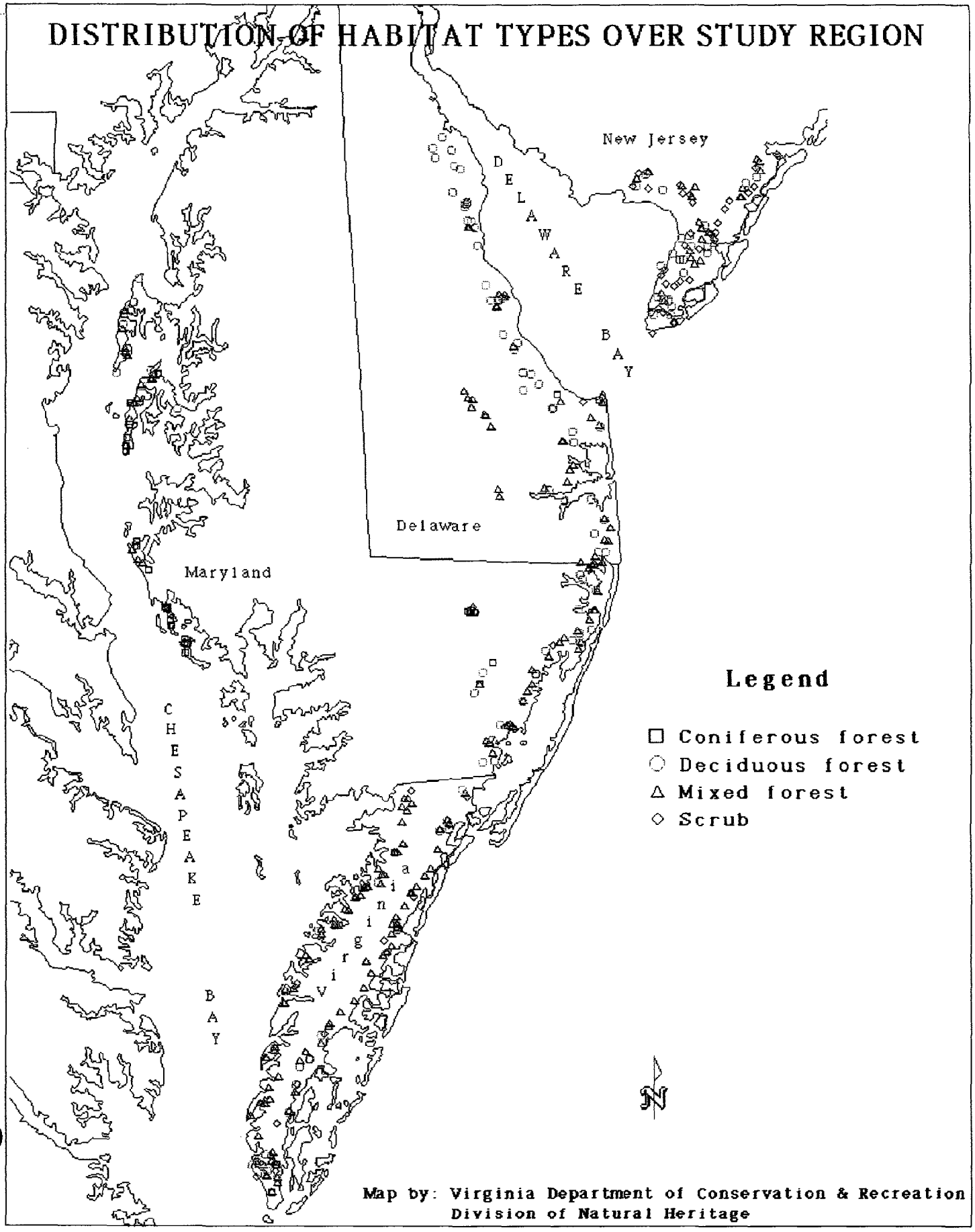

DISTRIBUTION OF HABITAT TYPES OVER STUDY REGION
New Jersey
DELAWARE BAY
Delaware
Maryland
CHESAPEAKE BAY
Virginia
Legend
Coniferous forest
Deciduous forest
Mixed forest
Scrub
N
Map by: Virginia Department of Conservation & Recreation
Division of Natural Heritage

FIGURE 4

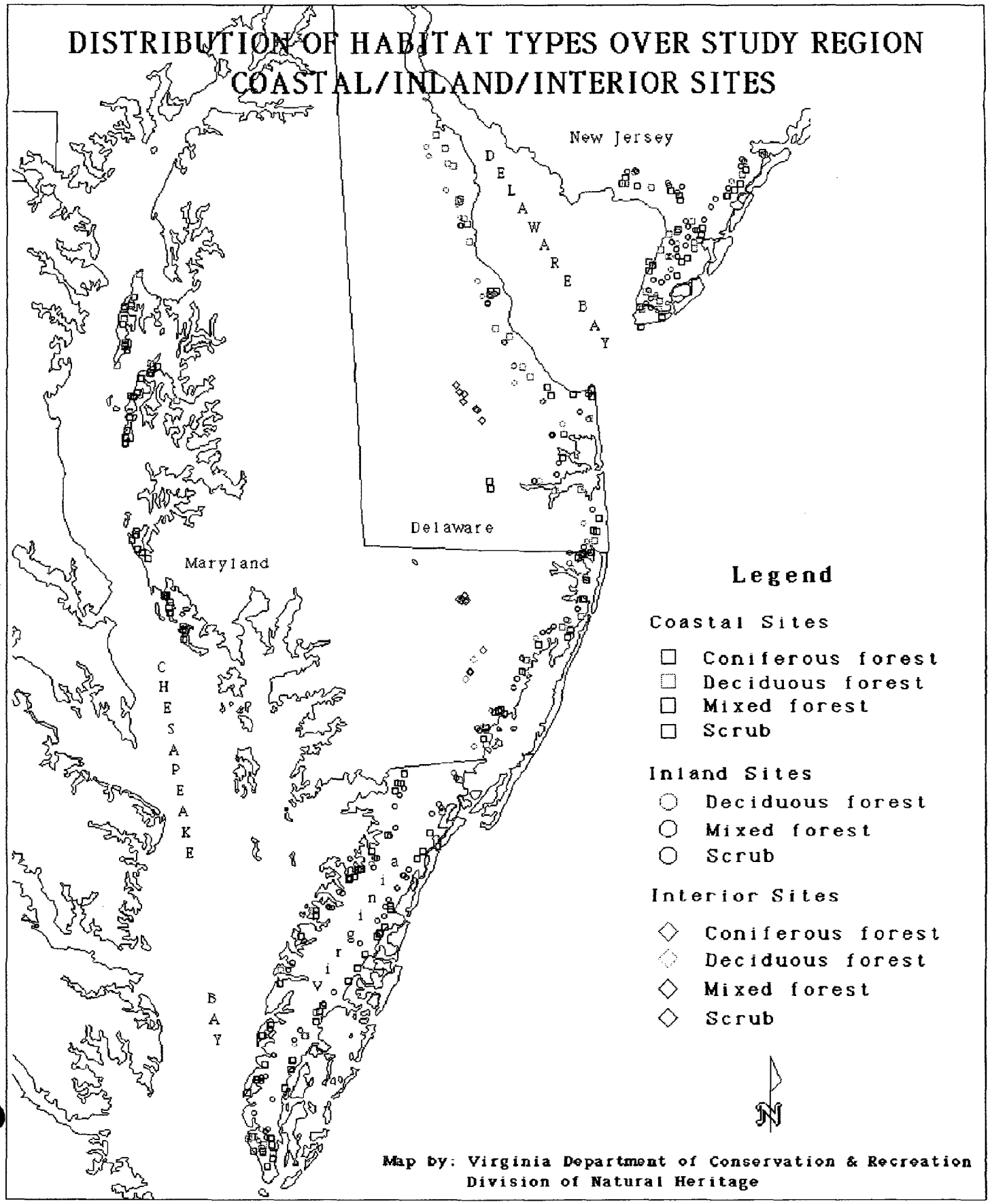

DISTRIBUTION OF HABITAT TYPES OVER STUDY REGION
COASTAL/INLAND/INTERIOR SITES
New Jersey
DELAWARE BAY
Delaware
Maryland
CHESAPEAKE BAY
Virginia
Legend
Coastal Sites
Coniferous forest
Deciduous forest
Mixed forest
Scrub
Inland Sites
Deciduous forest
Mixed forest
Scrub
Interior Sites
Coniferous forest
Deciduous forest
Mixed forest
Scrub
N
Map by: Virginia Department of Conservation & Recreation
Division of Natural Heritage

FIGURE 5

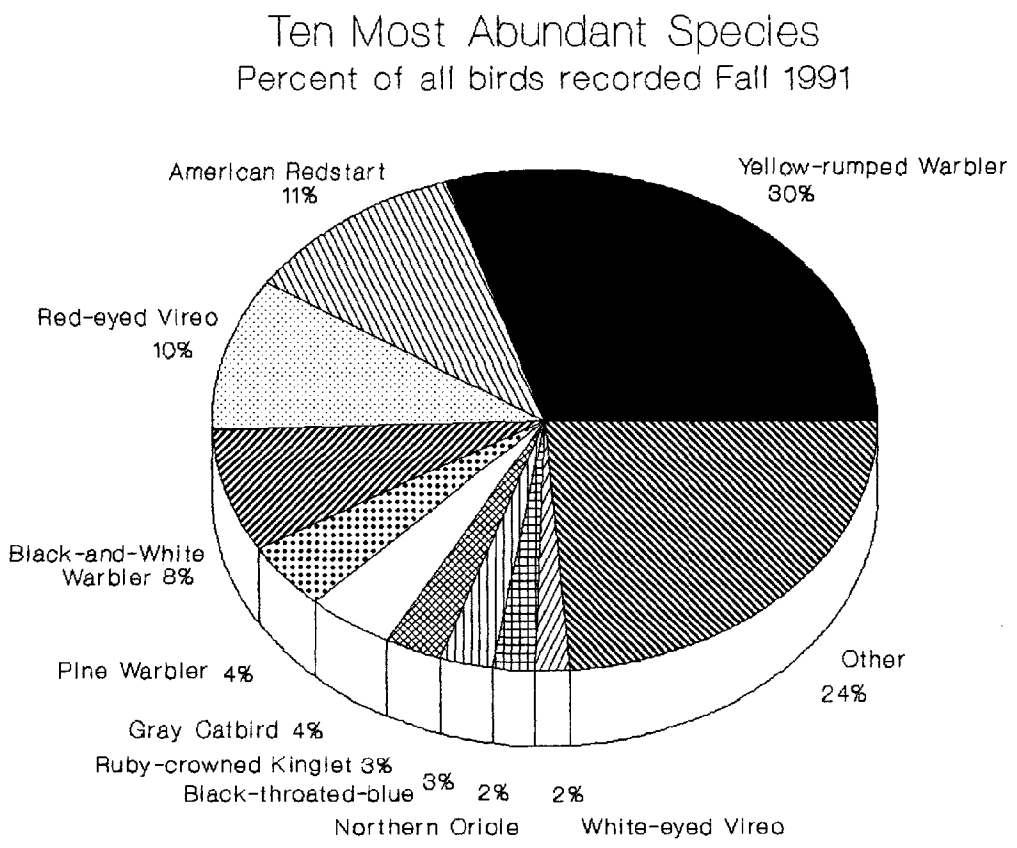
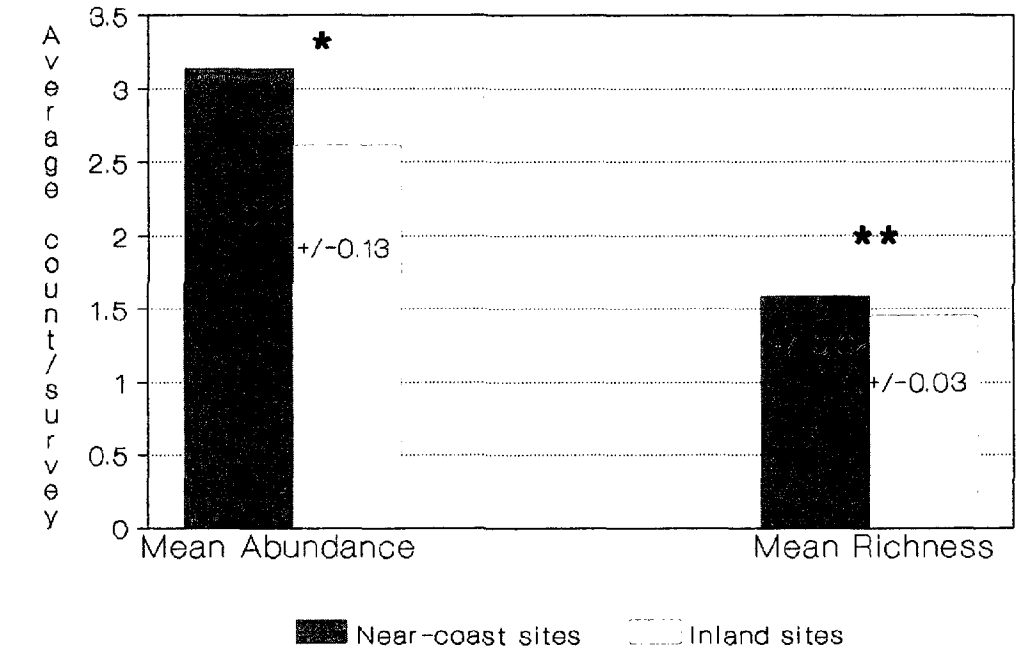

Ten Most Abundant Species
Percent of all birds recorded Fall 1991
American Redstart 11%
Yellow-rumped Warbler 30%
Red-eyed Vireo 10%
Black-and-White Warbler 8%
Pine Warbler 4%
Other 24%
Gray Catbird 4%
Ruby-crowned Kinglet 3%
Black-throated-blue 3%
2%
2%
Northern Oriole
White-eyed Vireo

FIGURE 6

Comparison of Migrant Abundance and Species Richness Between Near-coast and Inland Sites



* p< 0.05
** p< 0.01

FIGURE 7

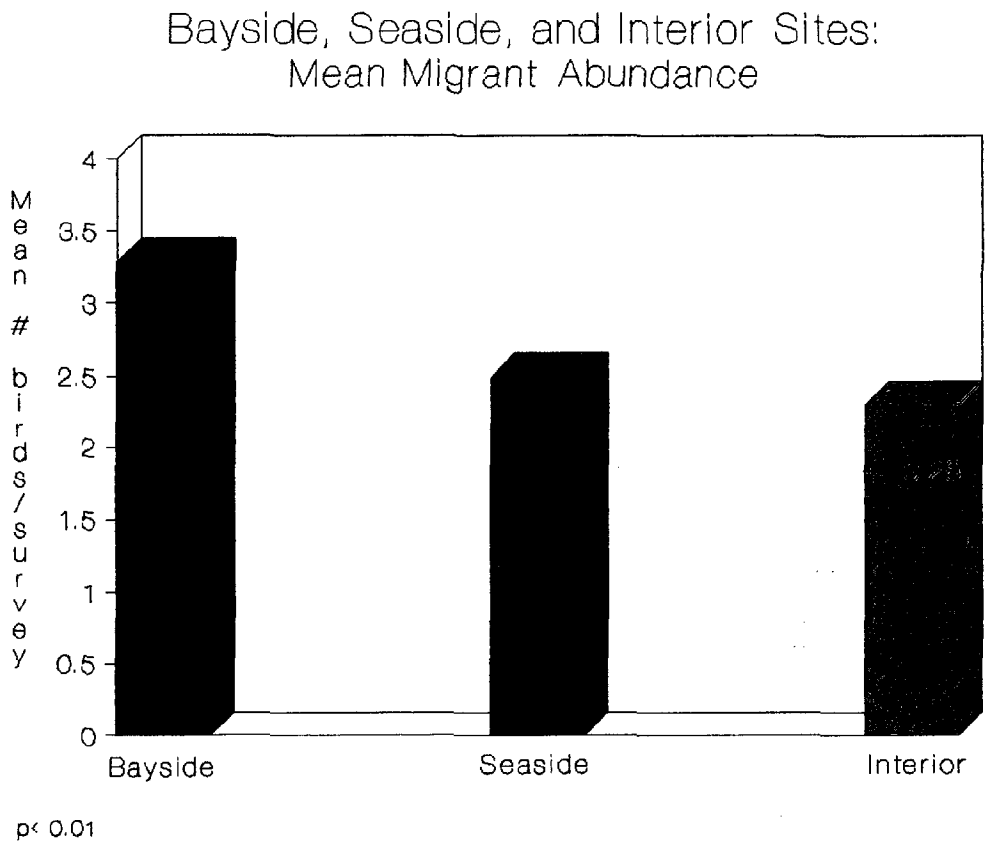
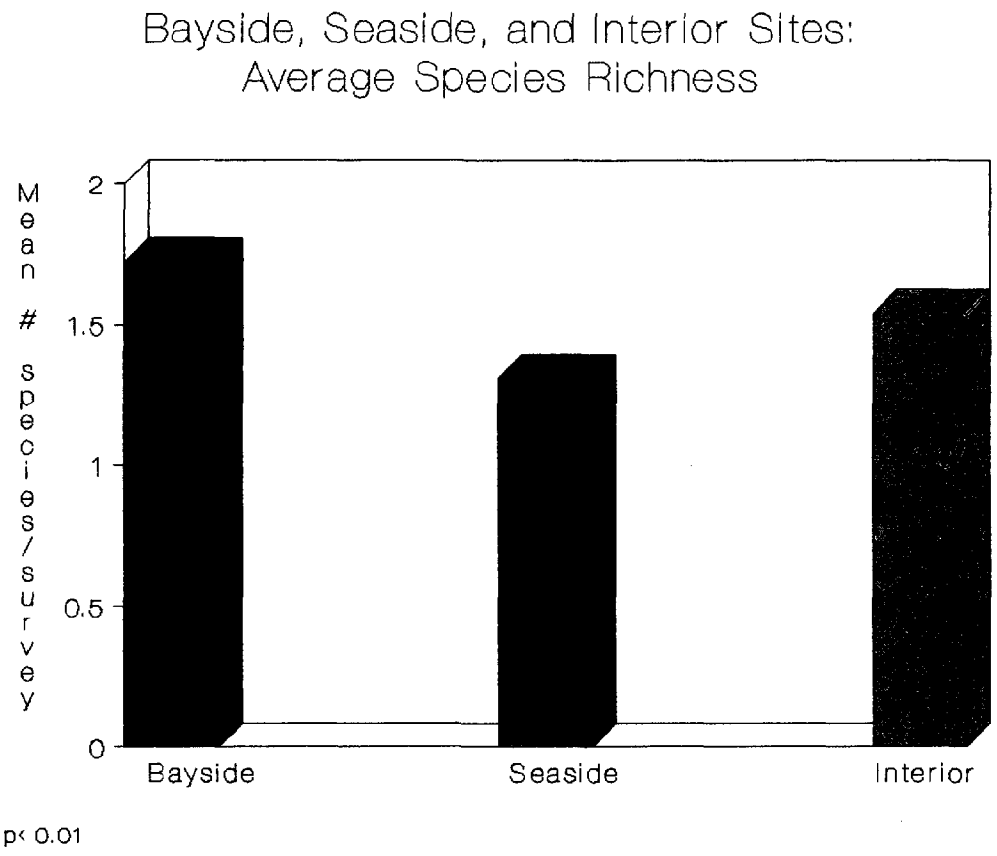

Bayside, Seaside, and Interior Sites:
Mean Migrant Abundance
Mean # birds/survey
4
3.5
3
2.5
2
1.5
1
0.5
0
Bayside
Seaside
Interior
p< 0.01

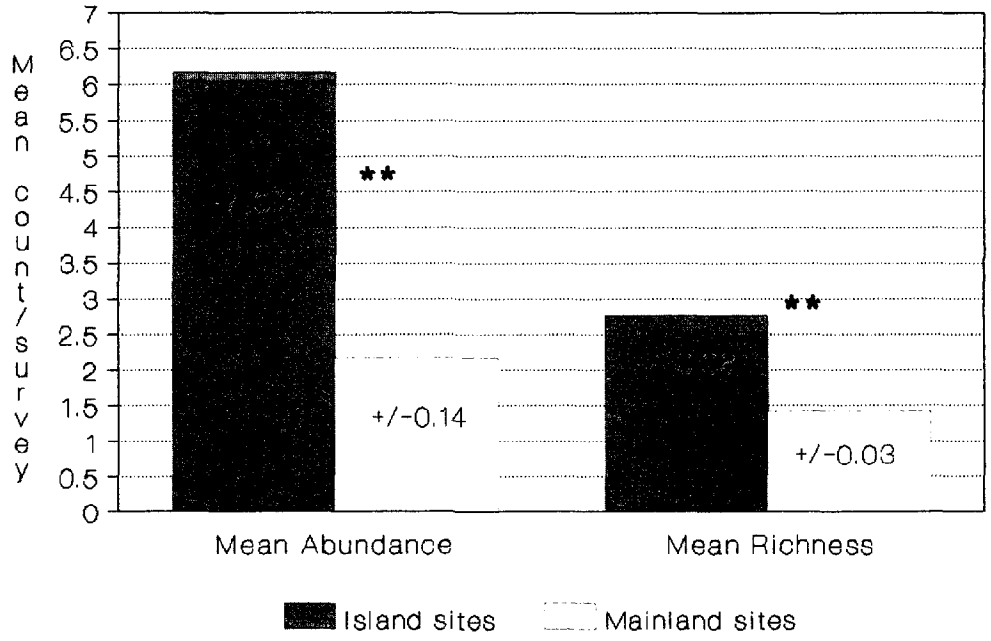
FIGURE 8



p< 0.01

FIGURE 9

Comparison of Barrier Island and Adjacent Mainland Sites:
Mean Migrant Abundance and Species Richness



** $p < 0.01$

FIGURE 10

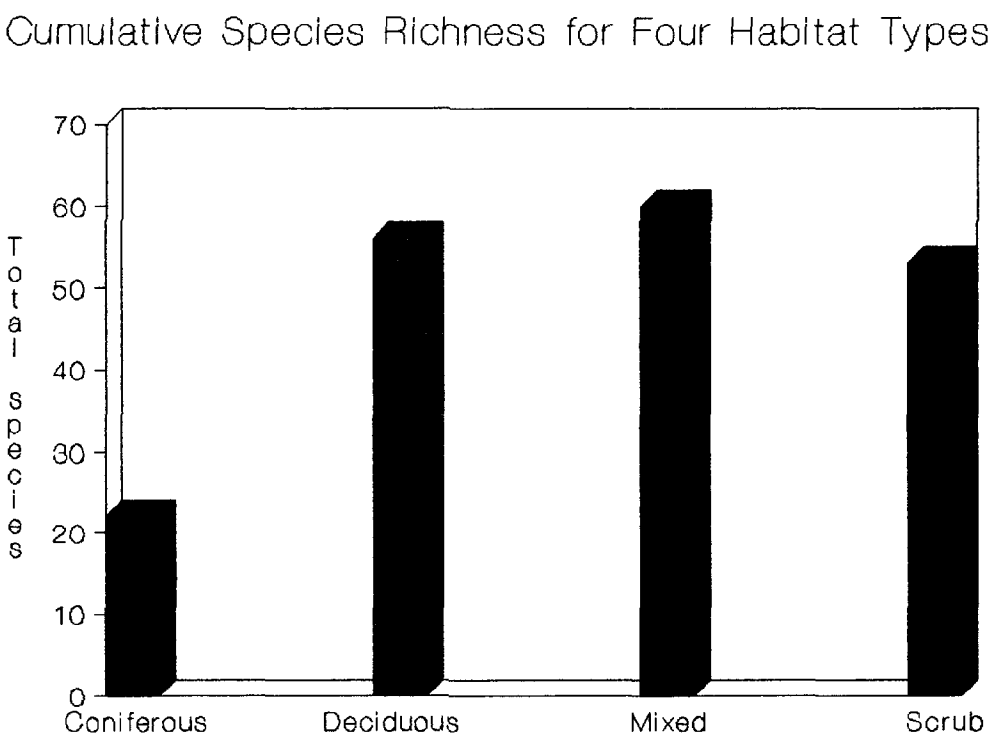

Cumulative Species Richness for Four Habitat Types
Total species
70
60
50
40
30
20
10
0
Coniferous
Deciduous
Mixed
Scrub

FIGURE 11

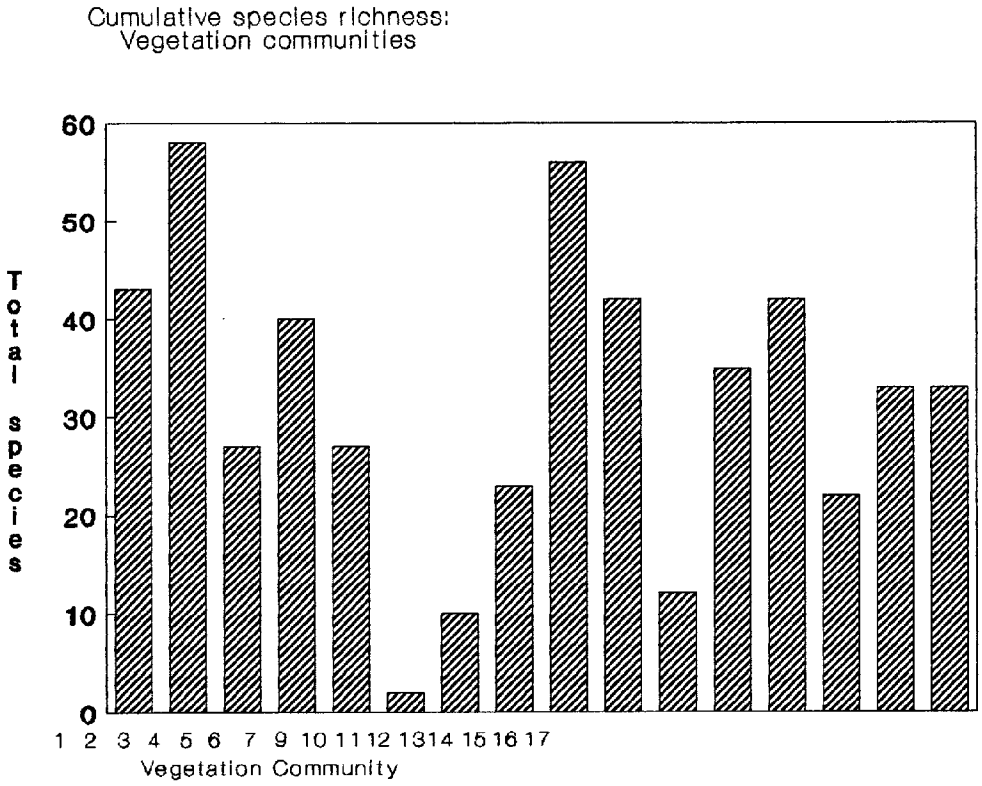

Cumulative species richness:
Vegetation communities
Total species
60
50
40
30
20
10
0
1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17
Vegetation Community

FIGURE 12

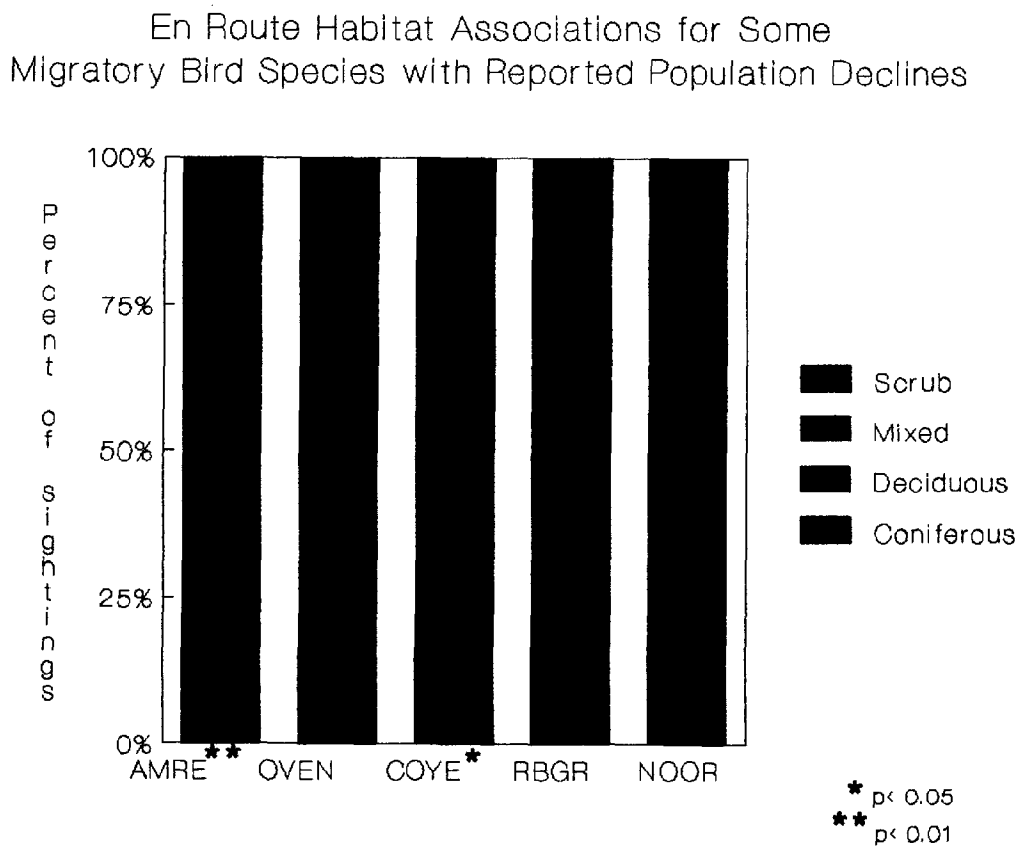
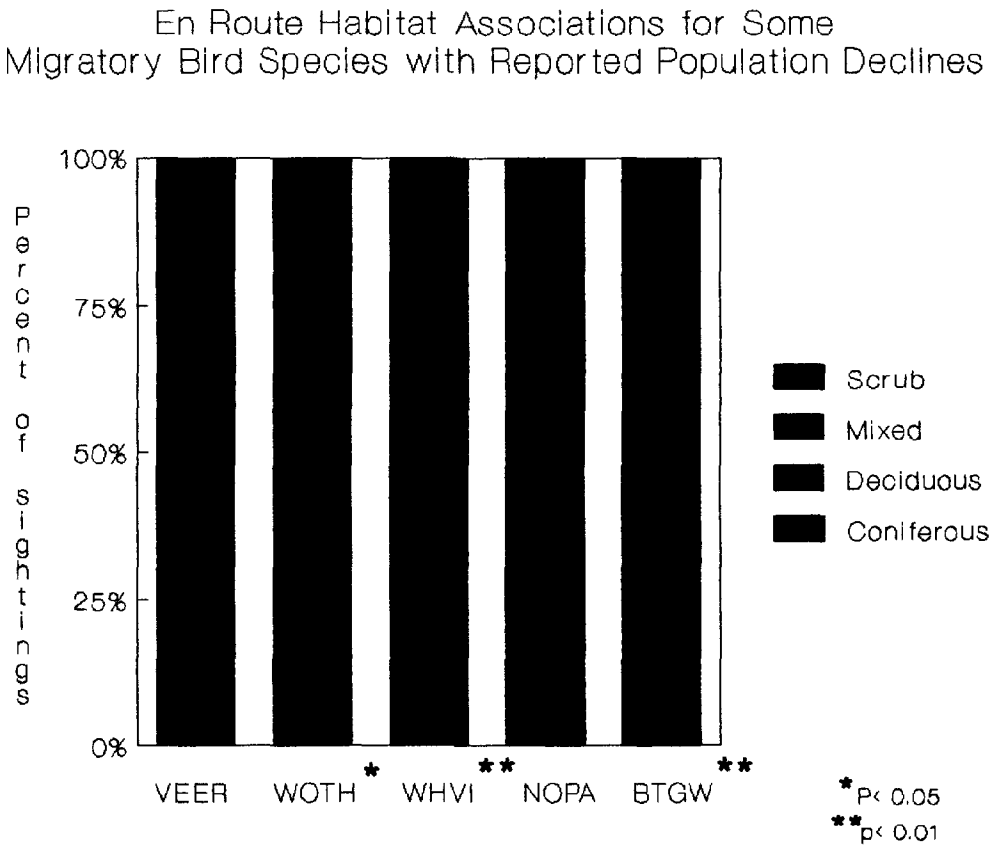

En Route Habitat Associations for Some
Migratory Bird Species with Reported Population Declines
Percent of sightings
100%
75%
50%
25%
0%
AMRE**
OVEN
COYE*
RBGR
NOOR
Scrub
Mixed
Deciduous
Coniferous
* p< 0.05
** p< 0.01

FIGURE 13


En Route Habitat Associations for Some
Migratory Bird Species with Reported Population Declines
Percent of sightings
100%
75%
50%
25%
0%
VEER
WOTH
WHVI
NOPA
BTGW
*
**
**
Scrub
Mixed
Deciduous
Coniferous
*P< 0.05
**p< 0.01