ABSTRACT

Klimstra, David Jon. Using banding data to assess the use of 100-meter-wide habitat corridors by breeding landbirds, in an intensively managed pine landscape. (Under the direction of Richard A. Lancia.)

Six-years of banding data were analyzed from an intensively managed pine plantation in the Lower Coastal Plain of South Carolina on land owned by Mead Westvaco. The focus of the six-year study was to determine if the installed corridors were providing habitat throughout the overall landscape that would be beneficial to breeding landbirds. To address this question, avian productivity and abundance were monitored using nest searching, point counts, territory mapping, and mist netting. The objectives of my study, based on banding data, were to see how birds were using the corridors versus the adjacent stands. There were 4 sites in the control (Ashley) and 3 in the experimental (Edisto). Sites had a corridor and adjacent stand. Corridors were not "installed" in the control, however in the experimental corridor "installation" began in 1993 as part of MeadWestvacos' Multiple-Use Ecosystem-Based Management Plan. Planned and installed corridors made up approximately 25% of the MeadWestvaco land base. In both districts stands were predominantly loblolly pine (*Pinus taeda*) with interspersed hardwood stands and gum ponds. Adjacent stands were managed on a 20-25 year rotation while corridor rotation time was double that of the adjacent stand.

Birds were captured in mist nets and banded from 1995 through 2000. Banding was conducted from early April till mid-July all six years. Sampling followed a standard mist netting protocol. Vegetation data were collected for all stands in 1999.

Based on cluster analysis and Detrended Correspondence Analysis (DCA) for vegetation and bird assemblages, most of the experimental sites grouped together as did

the control sites. Sycamore corridor (experimental) and Sandy Hill hardwood (control) were distinctly different from other stands. Both stands were older (50(+) and 32 years, respectively) and both had a large hardwood component.

Avian abundance was higher in the corridors for the experimental district ($p < 0.0001$). Control and experimental districts showed no significant differences between corridors and no significant differences between adjacent stands. Experimental corridors had a higher Shannon-Weaver (H') index than did any of the other stands, while control adjacent stands had the highest evenness value of all stands. While not statistically significant, corridors had higher catches of Hatch Year birds for the Carolina Wren, Hooded Warbler, and Common Yellowthroat.

Relative abundance for the top ten species was calculated. Many of the ten most abundant species occurred in both the adjacent and corridor stands in both the control and experimental districts. Species with the highest relative abundance in the experimental corridors were more early-successional species whereas species with high relative abundance in the control were more mid-successional species.

Finally, apparent annual survival for six species was estimated: Acadian Flycatcher, Hooded Warbler, White-eyed Vireo, Common Yellowthroat, Northern Cardinal, and Carolina Wren. Apparent survival was estimated using program MARK with the Cormack-Jolly-Seber (CJS) model. Apparent survival ranged from 0.30 for the Acadian Flycatcher to 0.54 for the Northern Cardinal. Models for the Acadian Flycatcher, Hooded Warbler, and Carolina Wren all had small confidence intervals indicating a more precise estimate than those of the Cardinal and Common Yellowthroat.

Migrants and residents had similar survival rates and were within ranges reported in the literature.

Abundance and species diversity was higher in corridors along with catches of HY birds. Based on relative abundance corridors in the experimental had early-successional species while corridors in the control had mid-successional species. Apparent survival rates for four Neotropical migrants and two residents indicate that estimates are within ranges reported in the literature.

Using banding data to assess the use of 100-meter-wide habitat corridors by breeding landbirds, in an intensively managed pine landscape

by

Jon David Klimstra

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Raleigh, North Carolina

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Approved by:

Dr. Phil Doerr	Dr. Ken Pollock
Dr. Ted Simons	Dr. Dick Lancia Chair of Committee

DEDICATION

This thesis is dedicated to the memory of my Grandfather, Dr. Willard Klimstra, and to my parents. There is nothing more that I would have liked than for my grandfather to see me follow in his footsteps. I realize that those footsteps are probably bigger than I can ever hope to fill but I would like to think that I am doing a good job in perfecting the "Klimstra Technique".

To my parents, I couldn't have asked for better people to support me in my endeavors. Every time I had trouble, they had advice for me. Mom and Dad I love you.

BIOGRAPHY

Jon David Klimstra was born in Hendersonville, North Carolina on June 22, 1978, the son of Gene and Ann Klimstra. He attended East Henderson High School where he graduated in 1996. That fall he began his quest for knowledge at Catawba College in Salisbury, North Carolina. After four years he earned a BA in Environmental Science. However, what Jon would be remembered for was his running, while at Catawba he ran cross country and ended his career with two of the schools top-10-times. Realizing that he would never run at the professional level and it paid peanuts, he decided to continue his education and was accepted into a masters program at North Carolina State University.

Jon grew up in the mountains of North Carolina. While most kids were playing Nintendo, Jon was outside catching insects and building forts in the woods. The seed that was planted early in Jon was a love of the outdoors. Much time was spent battling with Mom and not understanding why he couldn't be outside all the time. Only when Dad insisted on some type of chore did being outside no longer seem fun. At the age of 14 Jon went to spend the summer with his Grandparents in Illinois. This summer is what changed Jon forever and would lead him down the path to a career in wildlife.

The first real job Jon ever had was working for his dad in the apple orchards. While it wasn't wildlife it was outside all day, and there were cool things in orchards and packing houses. During high school summers were spent working for a small appliance installer and umpiring or refereeing various sports. The first two summers home from college were spent working in an entomology lab counting insects in apple orchards and tomato fields. After taking ornithology his junior year at Catawba, birds seemed to be pretty cool and Jon took a liking to them. A chance meeting with his future advisor in graduate school would land him his first field job studying birds in an intensively managed pine landscape on the Coastal plane of South Carolina. Here Jon could watch birds all summer. He also enjoyed catching all forms of Herpetofauna as it was very abundant in this region. After graduation Jon decided he wanted to study birds at the graduate level. Dr. Dick Lancia accepted him as a graduate student and soon began the long tutelage that has produced the thesis you are about to read.

Assuming that all things work out, Jon has inquired about a possible Ph.D. with Dr. Drew Lanham of Clemson University. While no project has been set in stone, something with the theme of nest predation on avifauna by Black Rat Snakes will be proposed.

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I would first and foremost like to thank my advisor Dr. Richard Lancia. Without him accepting me as a graduate student none of this would have been possible. His advice and guidance have helped me to focus on my goals and to see the big picture. I am sure that I was in his office with questions more than any of his other students, but he was always patient and had time for my thoughts. I would like to thank my other committee members as well, for their ideas and advice: Drs. Phillip Doerr, Ted Simons, and Ken Pollock. I would also like to thank John Gerwin from the North Carolina Museum for Natural Sciences for lots of advice about all those swweeett little birds. Thanks also go to all the field technicians who collected data over the six-years of this project. I know it was not an easy task as I was a field technician for two summers, and know how miserable it can be in a pine-stand in the Low Country of South Carolina in mid-July.

Special thanks goes to the department of Biological Sciences for granting me a teaching assistantship for two years. Without their support I would have been eating Ramen noodles. I would also like to thank Dr. Tom Wentworth of the Botany department. He provided me with a program to analyze my vegetation data and took the time out of his busy schedule to show me how to run it.

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INTRODUCTION

Traditionally land use in the South has been either agricultural or forest management. With rising timber prices, where conducive, land use has been dominated by intensively managed timber production in the Southeast (Wear 2002). Approximately 20% of forested commercial land in the Southeast is industrial forest land (Lancia et al. 2000). In an intensively managed landscape there are concerns about the effects of even-aged management and clearcutting practices on avian species in these landscapes (Duguay et al. 2001). In particular clearcutting creates edges and potentially fragments habitats. As compared to forest edges, agricultural edges are more abrupt. Studies have shown nest predation rates to be higher along more abrupt agricultural/forest edges (Walters 1998). Forest edge effects and reduced nesting success in agricultural landscapes has been well documented in mid-western states, but is poorly understood in a predominantly forested landscape (Manolis et al. 2002).

The typical silvicultural system in the Southeast is even-aged management with harvesting by clearcutting, which has an effect on the structure of the avian community. Conner et al. (1979) found that a thirty-year-old clearcut stand, the oldest in the study, had the highest breeding bird species diversity and number of species. However, the total number of birds was lower there than in the younger stands (age= 3yrs). In pine-oak clearcuts breeding bird diversity and species richness increased with age of the stand (Conner et al. 1979). As a pine-oak stand matures, breeding bird species composition changes. Early successional species become less abundant as vegetative changes occur and soon late successional species become dominate (Conner et al. 1979). Overall numbers of birds are higher in older stands but numbers drop in the breeding season and become higher in younger stands (Conner et al. 1979). Childers et al. (1986) found the same to be true, i.e. there were a larger number of birds in younger plantations (<8 years) vs. older plantations. However, the high numbers could be attributed to a high number of juvenile birds left over from the spring hatch because many adults bred in these same plantations (Childers et al. 1986). The fact that there was a good supply of food, such as seeds and insects in the younger stands, could have also attracted adults and juveniles from other areas solely for the purpose of feeding (Childers et al. 1986).

In the Southeast industrial forests make up about 20% of forestlands and thus present researchers with concerns of fragmentation. Songbird population declines from fragmentation have led researchers to investigate populations of breeding birds in recent years in the Southeast. However, based on BBS data from South Carolina from 1980-2000 there are only 12 of 67 total species with significant negative declines (Sauer et al. 2002). However when species suffering significant and non-significant declines are combined 32 of the 67 species found in this region are declining. To contrast this there were only 5 species with significant positive trends. For species that have had significant declines reasons for the decline include: (1) brood parasitism by the Brown-headed Cowbird (*Molothrus ater*), (2) loss of winter habitat in the wintering grounds, (3) low rate of colonization and high rate of extinction in small woodlots, (4) lack of critical microhabitats, (5) loss of stopover habitats during migration, and (6) high rates of nest predation in areas with lots of edge created by harvesting relative to a more contiguous forest (Duguay et al. 2001). The last factor, nest predation, has been cited as a primary reason for these population declines, with some of the best evidence coming from breeding sites in eastern North America.

Most declining bird species are forest interior or interior-edge specialist, and forest fragmentation is believed to play a role in their decline (Thompson et al. 1992). Short rotation (e.g. 20 years), even-aged forest management, has an effect on the carrying capacity for forest interior birds because a large percentage of the forest – 5% per year for a fully area regulated forest – will be in regenerating clearcuts. Therefore forest interior birds, many of which like older growth stands, might not have the opportunity to breed (Thompson et al. 1992). In addition fragmentation creates areas of "edge" exposing nests to predators, and has been identified as one of the leading causes of nest failure, thus affecting productivity rates. Survival rates of birds nesting in habitats that are highly fragmented might also be reduced. Farnsworth and Simons (2000) hypothesize that rates of predation are higher for fragmented landscapes than for contiguous forests. One example of this is the Wood Thrush (*Hylocichla mustelina*) in which populations have experienced consistent declines (Farnsworth et al. 2000). However, many of these declines are in a landscape that is fragmented by agriculture more so than a landscape fragmented by forestry practices (Walters 1998).

Vegetation is a key driving force in determining what species are present in a given habitat and how those species respond to habitat changes. Holmes et al. (2001) looked at thirty-year population trends in temperate deciduous forest and found temporal change in forest vegetation structure at a local scale to be one of the most important factors in affecting bird abundance. In a managed pine landscape the majority of the landscape is managed in even-aged silviculture. This management greatly influences vegetation structure at all levels, which can potentially affect avian species in these systems (Repenning 1985, Yahner 1987). In an intensively managed landscape site preparation is typical and frequent intermediate treatments including prescribed burning, fertilizing, and thinning are common. All of these not only influence the trees being grown but also mid and understory components. In pine forests, especially in the Southeast, the nature of the understory is what largely determines avian composition (Johnston 1956). Major differences in vegetation in my study could help explain bird assemblages in a particular stand, thus helping explain avian diversity, abundance, and distribution.

The MeadWestvaco Corporation, formerly Westvaco, as a part of its Multiple-Use Ecosystem-Based Management Plan, began installing a system of forested corridors across its managed landbase in 1993. The corridors made up 25% of the landbase and were 100-meter-wide strips of forest that were left unharvested for double the rotation stand age of 20-25 years (Amacher 2002). The purpose of the corridors is to protect and preserve water quality, wildlife habitat, visual quality, and biodiversity (Lancia 2000). Corridors were defined as 100-meter-wide linear strips of habitat rather than in the traditional sense of a corridor that provides overall connectivity in the landscape. Even though these linear habitat strips are not defined in the traditional sense they will be referred to as corridors throughout the paper. In cooperation with MeadWestvaco, NCSU undertook a six-year project from 1995-2000 to study the impacts of an intensively managed pine landscape on landbirds. The focus of the six-year study was to determine if the corridors were providing habitat throughout the overall landscape that would be beneficial to Neotropical migrants, short distant migrants, and resident birds. Study units were composed of Loblolly pine (*Pinus taeda*) with interspersed hardwood stands.

In order to address this question of benefits researchers set up four major sampling protocols: nest searching, point counts, territory mapping, and mist netting. In addition vegetation sampling was conducted in all stands. The focus of my thesis will be on the mist-netting data that were collected from 1995 through 2000. Mist netting sampled a sub-suite of species that are actually present in the stand, i.e., those species that use the lowest vertical layers of the forest vegetation.

STUDY AREA

Study Area

The study area was located in the Lower Coastal Plain of South Carolina south of Charleston, South Carolina, on land owned by MeadWestvaco (Map 1). MeadWestvaco owns approximately 200,000 hectares in this region with one-half of the region in managed loblolly pine (*Pinus taeda*) plantations (Amacher 2002). Hardwood stands, which range from small gumponds to larger contiguous forests, make up another component of their land holdings. Loblolly pine plantations are managed on a 20-25 year rotation for fiber production. The major land use in the region is private forestry and because of this the landscape can be seen as a shifting mosaic of managed loblolly pine stands. There were two districts in the study region: Experimental (Edisto 83,000 ha) and the Control (Ashley 33,200 ha). Both districts were sampled from 1995 through 2000. Sites within each district had a specific sampling history (Table 1). For a complete description of these stands see Amacher (2002).

In both the control and experimental districts the corridor was placed in an area that was generally slightly lower than the surrounding stands, which meant that it had a wetter hydrology and somewhat different vegetation community than the adjacent stand. Corridors were 100-meter-wide strips of forest that were left unharvested for double the rotation stand age of 20-25 years (Amacher 2002).

Study Sites

<u>Experimental (Edisto) District</u>

There were three sites in the Experimental district: Horseshoe (HS), Sycamore (SY), and Jacksonboro (JB) (Map 2). Each site had an adjacent and corridor stand, where the adjacent stand abutted one end of a corridor stand. The corridor was 100-meters-wide, ran for an undetermined length, and was linear in shape. In 1993 corridor "installation" began in Sycamore and Jacksonboro and was completed in two years. Installation began in Horseshoe in 1994 lasted through 1996 (Table 2). Stands surrounding the experimental corridors had either been harvested or were in early re-generation (1-2 yrs) making the corridor a very distinct entity in the landscape. Corridors in the experimental district had two "nodes" which were adjacent stands, on either end of the corridor, while control corridors had stands surrounding the corridor on all sides (Figure 1). Ten nets were placed in both the adjacent and corridor stands for both experimental and control.

Adjacent and corridor stands in the experimental district were relatively similar in most respects with some notable differences (Table 3). The largest stand was Horseshoe corridor at 33 hectares and the smallest was Sycamore adjacent at 12 hectares. Thus, Horseshoe corridor had the largest perimeter and total area. Horseshoe corridor and adjacent had a site index (base 50) of 83 and 95 respectively. Pine basal area (PBA) ranged from 202 to 108 ft^2/acre with Sycamore corridor having a PBA of zero. Jacksonboro had the most pine trees per acre at 277 with Sycamore corridor having the lowest at 150. Because Sycamore corridor was described as a pine/wet flat hardwood site it had the highest hardwood basal area (hba), 140 ft^2/acre, and the most hardwood trees per acre, 400. All sites were prescribed burned sometime during the history of the respective stand. All stands received some type of site preparation, which consisted of bedding alone or bedding and piling. Finally, all stands except Jacksonboro adjacent received fertilizer treatment once during their respective histories.

Control (Ashley) District

There were four sites in the Control district: Sandy Hill (SH), Greenwood (GW), Beech Hill (BH), and Sandywood (SW) (Map 3). These sites consisted of a corridor and adjacent stand as in the experimental district; however, corridors were not "installed" in the control sites. Control sites were more rectangular in shape as compared to experimental sites, and the corridor was not a distinct entity in the landscape; rather it had been delineated on a map. As in the experimental sites, the adjacent stand in the control sites abutted the corridor stand. Stands surrounding the corridors in the control sites had not been harvested and ranged in age from 18 years to 21 years. Beech Hill was harvested in 1998, and because of this, Sandywood was added so that there would still be three stands in each district.

Stands in the control district were relatively similar but with some differences (Table 4). Sandy Hill corridor was 53-years old, and was the oldest control site. All stands in the control district were managed pine stands except for Sandy Hill corridor, which was a managed hardwood stand. Stands varied in their size with Sandywood adjacent the largest at 39 hectares and Greenwood corridor the smallest at 5 hectares. Site index ranged from 68 to 79 with Sandywood corridor having the highest and Beech Hill adjacent having the lowest. Sandywood corridor had the highest pine basal area of 201 and Sandy Hill adjacent had the lowest with 103. Both Greenwood corridor and Beech Hill corridor had very high pine trees per acre with 466 and 442 respectively. The only stand having a significantly high hardwood basal area and hardwood trees per acre was Sandy Hill with 114 and 342. All sites except Sandy Hill corridor, because it was a hardwood stand, received prescribed burning some time during the history of the stands.

All sites except for Sandy Hill corridor received some site preparation, which included some combination of bedding, pilling, shearing, and raking. Finally, all stands except Sandy Hill corridor received fertilizer treatment once during the stand history.

Comparison of Control and Experimental Stands

Compared with the control district, sites were generally older in the experimental district by about 10 years. Sites between the two districts were generally the same size with some of the control sites being a little larger. The experimental sites generally had a higher site index value than did the control sites.

Basal area is a measure of the cross-section area of a tree and is usually correlated to canopy cover (Barbour 1987). Along with basal area, trees per acre is another indication of stocking rate. Pine basal area (PBA) and pine trees per acre were both tested against the null hypothesis of no difference between the control and experimental districts. A simple one-way ANOVA test was used to test PBA and pine trees per acre ($p = 0.05$). The ANOVA test failed to reject the null hypothesis of any difference between districts based on PBA ($p = 0.88$). However, the null hypothesis assuming no difference between districts based on pine trees per acre was rejected ($p = 0.0445$). Thus, the two districts are similar in PBA but are different in the number of pine trees per acre. Because basal area is a function of both trees per acre and tree diameter, the control district has younger trees of smaller diameter but with more trees per acre, and thus has the same basal area as the experimental units. In the experimental district there are fewer trees per acre but they are older and larger in size.

METHODS

Mist Netting

Birds were captured in mist nets and banded from 1995 through 2000. Banding was conducted from early April till mid-July in each of the six years. Nets were approximately 12-meters wide and 2.6-meters tall with a 30-mm mesh. Ten nets were placed in the corridor and 10 in an adjacent stand at one end of the corridor. In both the corridor and adjacent stand nets were placed as close to the interior of the stand as possible without nets overlapping one another. Nets were set up approximately 50 to 100 meters from one another. The same net lanes were used for each netting event, except when logging in neighboring stands necessitated a change. Nets were placed in a horseshoe pattern to facilitate checking by banders.

Nets were opened at sunrise and left open for approximately six hours if weather conditions permitted. Time when nets were opened and closed was recorded. Weather conditions (temperature, cloud cover, and humidity) were recorded when nets were opened and closed. Nets were checked every hour or less. Once captured and extracted from the net, birds were taken back to the banding station in small cloth bags for processing. Processing the bird included: identifying to species; banding the bird with an individually numbered United States Fish and Wildlife Service band and possibly a color band for some species; aging the bird based on plumage and possibly breeding conditions; sexing the bird based on presence/absence of a cloacal protuberance or brood patch and possibly plumage; recording weight, skulling, and measuring the wing. Sex was recorded as a U for Unidentified, M for Male or F for Female. Age was recorded as either U for Unidentified, HY for Hatch Year, AHY for After Hatch Year, SY for Second

Year, ASY for After Second Year, and L for nestling if banded at the nest. The study unit, date, time, whether adjacent or corridor stand, and net number were all recorded as well. Finally, notes about the bird, such as unusual molt or injury, and the bander's initials were recorded. Birds were released where captured. Nets were closed in the event of rain.

Seven sites were sampled: the control district consisted of Sandywood, Greenwood, Beech Hill, and Sandy Hill, whereas the experimental district consisted of Horseshoe, Sycamore, and Jacksonboro. Beech Hill was sampled until 1998, after which it was cut in 1999. A new site Sandywood was created to replace Beech Hill and was sampled in 1999 and 2000 (Table 1). Six-sites were sampled in each year, because of this there was a six-day cycle from the first site sampled to the last site. Banding alternated between a site in the control district and a site in the experimental district. After six days banding, two days rest were taken and then banding resumed with the first site. In 1995 and 1996 banding occurred for two consecutive days in each site. For this reason only three sites were banded per six-day cycle before two days rest were taken. In 1997 the regime changed to banding in each site only once before moving to the next site.

At each mist netting site the number of net hours was calculated by summing the number of hours each net was open. Because net hours in each site were different, effort was standardized so that all sites could be compared. This was done by dividing the captures for each site by the net hours for that particular site and then multiplying by 100. Thus captures are compared as captures per 100 net hours. For Hatch Year birds, captures were calculated as the number of total captures for that species divided by total net hours then multiplied by 1,000. Thus captures were compared as captures per 1,000 net hours. Species with high Hatch Year (HY) captures were: Carolina Wren, Hooded Warbler, and Common Yellow-throat.

Vegetation Sampling

Vegetation data were collected at each net site in 1999 for a total of 120 vegetation plots: 10 in corridors and 10 in adjacent stands in each of 6 sites. The center of each vegetation plot was designated as the approximate center of a net. Plots were 50 meters in diameter. The following variables were measured: canopy cover (%), pine, hardwood and snag basal area (ft^2/acre); pine, hardwood and snag diameter at breast height (DBH, in cm); canopy and subcanopy height (m); scaled measures of vine and cane in the understory (scaled 1-5, 1=high coverage, 5=no or little coverage); and shrub cover (%). A convex densiometer was used to measure canopy cover with the 4 cardinal directions being averaged. A BAF-10 prism was used to measure basal area for pines, hardwoods, and snags. DBH of all trees in the prism plot were measured with a metric DBH-tape. A clinometer was used to measure overstory height (loblolly pine) and midstory height (hardwood). The shrub-layer was sampled using a cover board, 2.5-m high by 10-cm wide, subdivided into 5 equal sections. From plot center the board was placed 11.5-m in each cardinal direction, and the observer at the center visually estimated the percentage of five board sections that were covered by leafy vegetation. All five values for each cardinal direction were averaged to obtain a single number for each individual plot.

PC-ORD is a program used to do multivariate analysis of ecological data. It takes multi-dimensional data and reduces them into a two dimensional plane. Sites were compared at the adjacent and corridor level based on vegetation occurrence and birds caught in mist nets per unit effort. Sandywood corridor and adjacent were left out of the analysis because they were only sampled for two years. Beech Hill was also left out of the analysis because it was cut in 1998, and vegetation data were collected in 1999.

PC-ORD uses cluster analysis (CA) and detrended correspondence analysis (DCA) to analyze data. Cluster analysis classifies data whether they are sites, species or variables (Tongeren 1995). Cluster analysis was used to show relationships between stands based on vegetation data and bird assemblages. A dendrogram is a graphical representation generated by cluster analysis showing the associations of stands. Sites are grouped based on the amount of information left from the beginning of the analysis to the end. The less information remaining indicates a weaker association between sites. Ordination is defined as a multivariate technique for arranging sites along axes based on data from species composition (Braak 1995). Because species exhibit a bell shaped curve against some environmental gradients, these ecological data can be analyzed using ordination. Detrended correspondence analysis (DCA) was developed to correct two problems with correspondence analysis (CA): (1) the ends of the axes are often compressed relative to the axes middle and (2) the second axis frequently shows a systematic, often quadratic relation with the first axis (Braak 1995).

Because of the problems mentioned above, I also used DCA to help show relationships between vegetation and bird communities. This analysis is an eigenanalysis ordination technique (McCune et al. 1999). It is based on reciprocal averaging or correspondence analysis and is geared towards ecological data. DCA takes both species (birds) and samples (vegetation) and ordinates them simultaneously in a two-dimensional plane (McCune et al. 1999). The final product is a plane showing lines varying in length, which represent vegetation and species ordinating around these lines. Where bird species are in relation to each line (vegetation variable) is a representation of how strong the relationship between vegetation variables and bird species.

A correlation matrix was computed to determine if any of the vegetation variables showed high positive or negative (+ or – 75%) correlation with one another. When two variables were highly correlated, then the characteristic(s) that made the most sense biologically was retained. This reduced the data set down to eight vegetation characteristics (Table 5).

Bird Assemblages

Captures for the nine most abundant bird species were used to create a dendrogram for bird assemblages by corridor and adjacent stands for of all six sites. The nine species of birds were: Acadian Flycatcher, Carolina Wren, Common Yellowthroat, Hooded Warbler, Northern Cardinal, Red-eyed Vireo, Summer Tanager, White-eyed Vireo, and Yellow-breasted Chat. Of these nine species, seven were classified as Neotropical migrants: Acadian Flycatcher, Common Yellowthroat, Hooded Warbler, Summer Tanager, Yellow-breasted Chat, White-eyed Vireo, and Red-eyed Vireo (Alsop 2001). The last two species, Carolina Wren and Northern Cardinal, were residents (Alsop 2001).

Captures and Species Diversity

A Split-Plot design was used to analyze data (personal communication Dr. Helen Zhang, and Lavanya Ramanan, Statistics Department NCSU). Years served as replications rather than as a treatment effect. Whole plot, which was site, was treated as random effect. Forest management, nets, and interaction between type of forest management and nets were treated as fixed effects. Analyses were preformed in SAS©.

Captures were tested statistically between the control and experimental (a1 vs. a2), between the corridor and adjacent in the experimental (b1 vs. b2 in a2), between the corridors and adjacent in the control (b1 vs. b2 in a1), between the adjacents in experimental and control (a1 vs. a2 in b2) and between corridors in experimental and control (a1 vs a2 in b2). All hypotheses were tested at a significance level of $p < 0.05$.

A coefficient of variation (CV) was calculated based on the average of captures over the six years. A CV was calculated for all sites. Captures were then pooled across all years. From these data three diversity indices were calculated: species richness (S), Shannon-Weaver (H'), and evenness value (J').

<u>Relative Abundance</u>

Relative abundance was calculated for the top ten species in the control adjacent/corridor and experimental adjacent/corridor (total captures for a species/total captures of all species). In addition a successional value was generated for where each species occurred following Hamel et al. (1982). To classify habitat preferences by habitat type and successional stage, I used the mixed pine-hardwood vegetation category, where pine is represented by loblolly pine or shortleaf pine (*Pinus echinata*) and the hardwood component is mostly made up of oak (*Quercus* spp.) species (Hamel et al. 1982). The four successional stages were: grass-forb stage = 0, shrub-seedling stage = 1, sapling-poletimber stage = 2, and sawtimber stage =3. Using this ranking system, a successional stage was assigned to each species, and if a species occurred in more than one stage then the average stage value was used (Mitchell et al. 2001). A successional stage index was calculated by multiplying relative abundance by the successional stage for a particular species. The lower the index, the earlier the successional stage preferred by a given species. Then these index values for all species in a particular stand were averaged to obtain an average index for a stand.

Estimation of Survival

Program MARK, a Windows based program was used to estimate apparent survival and capture probabilities. (White et al. 1999). Because of small sample sizes all six years of data were combined from both Ashley and Edisto districts, across all sites, and for all females and males. The Cormack-Jolly-Seber (CJS) model was used with and without time variation for survival and capture probabilities.

There two parameters of concern are: survival represented by *phi* and capture probability represented by *p*. Survival and capture probability can be held constant or can vary with time: *phi(.) p(.)* no time variation, *phi(t) p(.)* time variation for survival but not captures, *phi(.) p(t)* time variation for captures but not survival, and *phi(t) p(t)* time variation for both survival and captures. When time varies the estimate for the parameters is for i=1,. . .K-2 for survival, and i=2,. . . K-1 for capture probability, with K being the number of sampling periods. For example, if one of the parameters varies over time, then for six years of data MARK will return five time intervals. In this case the 5^{th} time interval is estimated as the products of the last two encounter occasions (White et al. 1999). This generally leads to problems with the standard error for this estimate and because of this model *phi(t) p(t)* does not fit well.

The Cormack-Jolly-Seber (CJS) requires six assumptions (Williams et al. 2002).

1. Every marked animal present in the population at sampling period *i* has the same probability p_i of being recaptured or resighted.
2. Every marked animal present in the population immediately following the sampling in period *i* has the same probability *phi* of survival until sampling period *i*+1.
3. Marks are neither lost nor overlooked, and are recorded correctly.
4. Sampling periods are instantaneous (in reality they are very short periods) and recaptured animals are released immediately.
5. All emigration from the sampled area is permanent.
6. The fate of each animal with respect to capture and survival probability is independent of the fate of any other animal.

Apparent survival was used rather than true survival based on the assumption of emigration. If true survival were used then we would assume emigration to be 0 (S=1-mortality), however this is probably not the case. Because of this we use apparent survival, which takes into account emigration from a particular site (phi=1-mortality-emigration).

Model Selection

Model selection involves trying to find the most parsimonious model available. A model that is closer to reality has more parameters and lower bias, but is more complex and harder to interpret. Models that are too simplistic have few parameters and small standard error, but are further from reality. A trade off between reality and simplicity (low bias and high precision) can be used to select the best model. The Akaike Information Criteria (AIC) was developed to help make model selection easier. AIC ranks models by taking into account the trade off between increasing parameters (closer to reality) and decreasing parameters (better precision) (Burnham et al. 1995). It is computed as follows: -2 log L + 2(# pars) where L is the likelihood function from Maximum Likelihood and # pars is the number of parameters. The second part is a penalty for over parameterization, which is twice the number of parameters. In model selection the model with the lowest AIC value is generally selected (Burnham et al. 1995). For some species the model with the lowest AIC value was not selected which is acceptable as long as the AIC value is no more than + or – 2 places from the lowest AIC value. AIC values are specific to a given model and cannot be compared to one another or subjected to statistical testing.

RESULTS

Cluster Analysis

Vegetation

Four adjacent stands and three corridor stands grouped together in the dendrogram showing a close association (Figure 2). The sites were: Greenwood adjacent and corridor, Horseshoe adjacent and corridor, Jacksonboro adjacent, Sycamore adjacent, and Sandy Hill corridor. One of the three corridors was from the experimental unit (Horseshoe corridor), while the other two corridors were from the control unit (Greenwood and Sandy Hill corridor). Three of the adjacent stands were experimental stands (Horseshoe, Jacksonboro, and Sycamore adjacent) while the fourth (Greenwood adjacent) was from the control unit. Jacksonboro corridor and Sandy Hill hardwood showed the closest association to one another but were not closely associated to any other stand. Sycamore corridor showed no association to any other stand.

Bird Assemblage

Four adjacent stands and three corridor stands grouped together (Figure 3). With a little more than 75% of the information left in the analysis, these seven stands were closely associated to one another. Two of the adjacent stands were from the control district (Greenwood adjacent and Sand Hill hardwood), while the other two were from the experimental district (Horseshoe adjacent and Jacksonboro adjacent). Two of the three corridor stands were from the control district (Greenwood and Sand Hill corridor) and the third one was from the experimental district (Horseshoe corridor). Jacksonboro corridor was similar to Sycamore adjacent but was not similar to any of the other stands. Sycamore corridor was not similar to any of the stands in analysis.

When compared to the vegetation dendrogram, the dendrogram for bird assemblages was similar. The stands that were similar (at 75% level) in the vegetation dendrogram were the same in the dendrogram for bird assemblages. The exception was the vegetation dendrogram that showed Sandy Hill hardwood being very dissimilar to any of the other stands, and Sycamore adjacent being similar to the majority of the other stands. In the dendrogram for bird assemblages, Sandy Hill was similar to most of the other stands, whereas Sycamore adjacent was much different from the other stands.

Detrended Correspondence Analysis (DCA)

The same eight vegetation characteristics and nine bird species used in the cluster analysis were used for the DCA analysis. Sites were broken down into corridor and adjacent stands. The length and direction of the line for a particular vegetation variable indicates how strongly correlated it is with a site or a group of sites.

Vegetation

Vegetation data were overlaid on the sites to see which vegetative characteristics showed strong correlations with each site (Figure 4). Sandy Hill hardwood showed the highest correlation with canopy cover. All of the experimental corridors and adjacent stands were highly correlated with mid-story height with Horseshoe corridor and Sycamore adjacent having the highest correlation. Sycamore corridor and Sandy Hill hardwood were the two stands with the highest correlation with pine DBH. Sandy Hill hardwood showed the highest correlation for hardwood DBH. Horseshoe corridor and adjacent showed the strongest correlation with absolute number of snags. Horseshoe corridor and adjacent, Jacksonboro corridor and adjacent, Sycamore adjacent, and Greenwood adjacent all showed high correlation with vine density. The control sites showed a slightly higher correlation with cane than did any of the experimental sites. Jacksonboro corridor had a slight correlation with average vertical density. Sycamore corridor showed the highest correlation for average vertical density.

Bird Assemblage

The top nine bird species were analyzed using DCA analysis (Figure 5). The same nine species used in the dendrogram were used in the DCA analysis. Except for Sycamore corridor the Acadian Flycatcher (AFCL) had strong correlations only with the experimental sites. The Carolina Wren (CARW) also showed strong correlation with all the experimental sites. The Common Yellowthroat (COYE) only showed a strong correlation with Sycamore corridor. The Hooded Warbler (HOWA) showed a strong correlation with Greenwood adjacent and corridor and Sandy Hill hardwood all of which were in the control district. The Northern Cardinal (NOCA) showed a strong correlation with two sites in the experimental district, Jacksonboro corridor and Sycamore corridor, and one site in the control district, Sandy Hill hardwood. The Red-eyed Vireo (REVI) showed a strong correlation with Sycamore corridor and Horseshoe adjacent in the experimental district, and only a slight correlation in Jacksonboro corridor and other adjacent stands also in the experimental district. The only site in the control district to show a strong correlation with the REVI was Sandy Hill hardwood. All of the sites in the experimental district with exception of Sycamore corridor showed a strong correlation with the Summer Tanager (SUTA). No sites in the control district were correlated with the SUTA. The only site to be strongly correlated with the White-eyed Vireo was Sycamore corridor. Three sites in the experimental district, Sycamore adjacent and corridor and Jacksonboro corridor were correlated with the Yellow-breasted Chat.

Captures and Species Diversity

Captures in the control district (Ashley) were higher in the corridor in all years except for 1999 (Figure 6). Captures in the experimental district (Edisto) were higher in the corridor in all years (Figure 7). In all two-way comparisons in all cases except for one, hypothesis testing failed to reject the null hypothesis (H_a) (Table 6). The only difference was between the adjacent and corridor in the experimental district. Thus, corridors in the experimental district were significantly different than the adjacent stand. However, while not significantly different, corridors in the control had more captures than did the adjacent stands in all years but one.

For the three species (Carolina Wren, Hooded Warbler, and Common Yellow-throat) with highest HY captures, the experimental corridor had the highest number of captures (Table 8); however, differences were not significant (p value = 0.05, chi-square value =3.84, and df = 1).

Six of the seven adjacent stands had a higher CV than did the corridors. Jacksonboro corridor was the only corridor to have a higher CV than it's respective adjacent stand. This indicates that the adjacent stands fluctuated more in captures across the six-year period than did the corridors (Table 8).

Species richness was higher in the corridors than in the adjacent stands (Figure 9). Experimental corridors had the highest species richness. Shannon-Weaver index (H') within the control district adjacent stands had a larger value than did the corridors because sample sizes were too small for the remaining species to be of value (Figure 10). In the experimental district, H' values were higher in the corridors than the adjacent stands. Removing Sycamore corridor did not change the relationships very much.

Control adjacents had the highest evenness value than any other stands (Figure 9). The remaining adjacent and corridor stands were all relatively similar to one another.

Relative Abundance

Control

Relative abundance for species with 30 captures or more was calculated for all stands. However, only the top ten species in each corridor and adjacent were used for comparison (Table 9). Based on relative abundance the Hooded Warbler, Carolina Wren, and Northern Cardinal were the top species in both the control corridor and adjacent stands. Eight of the 10 species in the corridor and adjacent stands were the same.

Experimental

In the experimental adjacent stands, the Acadian Flycatcher had the highest relative abundance, whereas in the corridor the Common Yellowthroat had the highest relative abundance. The Carolina Wren was the only resident mid-successional species that was among the top species in the adjacent and corridor. The remaining top species were migratory early successional species: Common Yellowthroat, Yellow-breasted Chat, and White-eyed Vireo. The Summer Tanager was present with these early-successional species but is a woodland mid-successional species. Six of the 10 top species in the control and adjacent stands were similar.

The experimental corridors had a lower average successional index than did any other stands (Table 10), indicating that the species in the experimental corridors were predominately early-successional species.

Estimation of Apparent Survival

Apparent survival and capture estimates were calculated for four Neotropical migrants and two resident species: Acadian Flycatcher, Hooded Warbler, White-eyed Vireo, Common Yellowthroat, Northern Cardinal, and Carolina Wren. For all species except for the Common Yellowthroat the simplest model (phi (.) p(.)) with no time variation for either parameter was selected. For the Common Yellowthroat model phi(.) p(t), with time variation for re-capture probability, was selected. Apparent survival estimates ranged from 0.30 in the Acadian Flycatcher to 0.54 in the Northern Cardinal (Table 11).

DISCUSSION

Cluster analysis

Based on dendrograms for vegetation and bird assemblages there were some differences between stands. Sycamore corridor in both dendrograms was not associated with any other stands, thus vegetation differences found in Sycamore corridor were probably also driving the differences in bird assemblages. This substantiates a strong relationship between vegetation and species present (Morrison et al. 1998). In most cases stands from their respective unit (Experimental or Control) were found grouping together. In the vegetation dendrogram Sandy Hill corridor, which is a control site, was found with four other experimental sites. Also because Sandy Hill hardwood (a control site) was so different, it grouped away from other sites and near Sycamore corridor (an experimental site). Both Sycamore and Sandy Hill hardwood had greater volume of hardwood species than they did pine which is the primary reason that they were not associated with any of the other stands. Sycamore is also different because it was approximately 32-years old, while other experimental stands were approximately 30-years old, and stands in the control district were 10 years or more younger.

Detrended Correspondence Analysis

Of the nine species in the DCA analysis, five of them are classified as successional scrub species (NOCA, CARW, COYE, WEVI, and YBCH) (http://www.purc.usgs.gov). All five of these species showed strong correlations with three experimental sites (Sycamore adjacent, Jacksonboro and Sycamore corridors). All three of these sites are in the experimental district meaning that the corridors have been "installed." This has the potential to create an edge that is shrubbier and in an early successional stage than a more contiguous stand. Also, because the corridors have been cut around the edges this allows increased amounts of light to penetrate the center of the stand, thus providing light for undertsory shrubs, which in turn provide suitable habitat for these five species. This is supported by the fact that vine mass was more associated with the experimental sites. Further, greater average vertical density was highly correlated with Sycamore corridor and Jacksonboro corridor. All five of these species (NOCA, CARW, COYE, WEVI, and YBCH) nest in thick early successional habitat with high vertical density near the ground.

Four of the nine species were classified as woodland species (ACFL, HOWA, REVI, and SUTA) (http://www.purc.usgs.gov). The Hooded Warbler was strongly correlated with two sites in the control district (Greenwood adjacent and Sandy Hill hardwood). Three of the control sites were highly associated with cane, thus possibly explaining the correlation between the control sites and the Hooded Warbler. The Hooded warbler uses cane as a primary nesting material in this region (Dunn et al. 1997).

The Acadian Flycatcher, Red-eyed Vireo, and Summer Tanager were all highly correlated with one or more sites in the experimental district. All three of these species are woodland species, which generally occupy the canopy of the forest interior. Experimental sites were highly correlated with midstory vegetation, which possibly explains why the Acadian Flycatcher, Red-eyed Vireo, and Summer Tanager were all highly correlated with sites in the experimental district. It is also possible that these species were associated with the experimental sites because at a larger spatial scale the landscape matrix of pine and hardwood provided enough of a hardwood component for these species. Experimental sites had a significant midstory and many of the sites had a developed hardwood component due to older stand ages. Turner et al. (2002) looked at hardwood area and adjacency in this same system and found that Neotropical forest interior species tended to spill over from hardwood dominated stands into surrounding pine stands. This is potentially what is happening in the experimental sites explaining why these species were not correlated with any control sites.

In summarizing, the cluster analysis appears to show that there are some differences and similarities in vegetation between sites of the experimental and control units at the site level. These differences are very large for Sycamore corridor based on both vegetation and bird assemblages (Figure 2 and 3). DCA analysis also shows some large differences between sites based on vegetation at the local scale. However when bird species are analyzed using DCA certain species show strong affinity for either control sites or experimental sites, perhaps because of large, landscape habitat patterns (Figure 5).

Captures and Species Diversity

For both the experimental and control district the corridors had higher captures in every year (except for 1999 in the control) than did the adjacent stands. Furthermore, significantly more birds were caught in the corridors, in the experimental district, than in the adjacent stands ($p < 0.05$). Even though it wasn't supported statistically, corridors in the control appear to be different than the adjacent stand based on the fact that there were more captures in all years but one. There are several possible explanations for these differences. The inherent shape of the corridors would tend to funnel birds into them. A stand that was 100-meters-wide with no other timber on either side presents tempting habitat to birds with no other alternatives. However, in the control district where corridors had not been “installed,” meaning that stands on either side had not been harvested, there were higher captures in the corridors compared to the adjacent stands. This potentially questions the funneling explanation. The fact that corridors in both the control and experimental districts were placed in lower wetter areas suggests that they were naturally better habitat for birds. Differences between control and experimental corridors could potentially be explained by management practices, specifically experimental corridors had been installed and control corridors had not.

However, it must also be recognized that the number of captures is a function of both the number of birds present and the capture rate. Therefore, a high number of captures could be due to high numbers of birds or to a high capture rate or both. If corridors are funneling birds into them and capture rates are higher because of decreased visibility of nets in corridors, then higher capture rates would potentially be explained by a higher number of birds present and an increased capture rate.

Corridors can support numbers of birds. Coburn (1998) found higher bird richness and abundance in riparian buffer zones within a fragmented, managed, landscape in east Texas. Another study looking at the value of buffer strip width in a pre- and postharvest study found that buffer strips greater than 100-meters-wide post harvest had no negative impacts on Ovenbird abundance and territory size (Lambert et al. 2000). Corridors also had higher species richness than did adjacent stands. In my study corridors were older in age, and studies have found that mature pine forests support peak bird densities (Conner et al. 1979, Turner et al. 2002). A study of the Barrens Grouse Habitat Management Area (HAM) found higher species richness on 100-meter-wide corridors in a managed pine landscape versus a contiguous forest sector (Yahner 1997).

Based on cluster analysis corridors grouped as being distinctly different based on both vegetation and bird assemblages indicating that they are valuable habitat for bird species.

High numbers of hatch year birds of these species: Carolina Wren, Hooded Warbler, and Common Yellowthroat were captured in the corridors. What is not clear is whether these birds fledged from the corridors where caught or if they are merely using them for travel, foraging, or cover. What these captures do indicate is that hatch year birds were using these corridors and that reproduction was occurring in the corridors or in nearby stands.

The fact that six of the seven adjacent stands had higher capture CV values than did their respective corridor indicates more variation in captures for adjacent stands compared to corridors. One explanation is that birds are moving around more in the adjacent stand, which is not as linear, thus birds are not as confined to the habitat as they would be in a corridor, making captures more variable in the adjacent stands. One study looking at thirty-year bird population trends in an unfragmented landscape found high CV values from year to year for species with low mean abundance (Holmes et al. 2001). This appears to be the same situation in the adjacent stands where there was low abundance but high variation.

Relative Abundance

Control

The top three species in both the adjacent and corridor stands in the control district were the: Hooded Warbler, Carolina Wren, and Northern Cardinal respectively. Cane showed slightly more correlation with the control sites than it did with any experimental sites. Because the Hooded Warbler nests in cane in this region, it is likely that higher cane abundance in the control sites provided better habitat for the Hooded Warbler. The corridors in the control had not been "installed" as in the experimental sites, which meant that the forest was more contiguous. The Hooded Warbler is associated with the forest interior and it has been shown that this species does well in riparian buffer strips with a mature pine matrix surrounding these areas (Sargent et al. 1997).

There were only two species unique to the control adjacent stands: the Yellow-billed Cuckoo and Yellow Breasted Chat. The Yellow-billed Cuckoo is associated with the forest interior, which would make sense in it being present in the control adjacent stands (Alsop 2001). However, the Yellow-breasted Chat is more associated with edge habitat than interior stands. Tuner et al. (2002) found that species associated with hardwood or mix-hardwood in this same system spilled over into neighboring pine stands. This could explain why these two species are present in the control adjacent stands.

Experimental

In the experimental district the Acadian Flycatcher had the highest abundance in the adjacent stands. This is supported by research from two prior graduate students working on this project who both found higher abundance and nesting success in experimental sites (Hazler 1999, Amacher 2002). The Common Yellowthroat, which is defined as an edge habitat species, had the highest relative abundance in the experimental corridors. Because the corridors had been "installed" there was a large amount of early successional edge habitat, which is prime habitat for the Common Yellowthroat. Mitchell et al. (2001) found that this particular species selected habitat on a fine scale.

Because it is selecting habitat on a fine scale, it is possibly restricting its self to experimental corridors where there is increased early-successional edge. Other species with high abundance in the corridors were also suited to early successional edge habitat: Yellow-breasted Chat, White-eyed Vireo, and Indigo Bunting.

Furthermore, the experimental corridor had a low successional index indicating that there were more early-successional species in the experimental corridors (Table 5). Even though these stands were older and had more mature timber, the edge around experimental corridors provided early-successional habitat. Also as noted earlier because stands had been harvested on either side of the corridor, light could penetrate into the center of the stand, thus giving the shrub understory favorable growing conditions. These favorable growing conditions could also potentially lead to better micro-habitat and increased insect abundance.

Estimation of Survival

Neotropical Migrants

It is widely believed that Neotropical migrant land birds are suffering declines with these trends showing up in analysis of Breeding Bird Survey (BBS) data (Peterjohn 1995, James et al. 1996). Many of these declines have been attributed to fragmentation of habitat, with one example being forest fragmentation (King et al. 1997). Many of these species are forest interior species (Thompson et al. 1992). Most studies researching declines have investigated small woodlots in agricultural areas rather than managed forests (Thompson 1992, Bayne et al. 2002). Species abundance and return rates have traditionally been used to measure declines experienced by Neotropical migrants (Powell et al. 2000, Cilimburg et al. 2002).

To really understand why certain species are declining and at what scale, demographic parameters must be estimated (Powell et al. 2000). Those parameters are: fecundity, dispersal probability (emigration and immigration), and survival (Cilimburg et al. 2002). Unfortunately those parameters are difficult to estimate. Many earlier studies have estimated apparent or true survival as the return rate of these birds to a particular site (Cilimburg et al. 2002). For this reason researchers need to be careful how they interpret survival rates and realize that they are only the apparent survival and not true survival.

The MeadWestvaco landscape is a managed industrial forest that is highly fragmented by clearcutting. I estimated apparent survival for three Neotropical migrants: the Acadian Flycatcher, White-eyed Vireo, and Hooded Warbler to be 0.30, 0.33, and 0.34 respectively (Table 11). The Common Yellow-throat had a survival estimate of approximately 0.51. Two different studies reported survival rates for Ovenbirds (*Seiurus aurocapillus*) to be as high as 0.50 and 0.62 (Porneluzi et al. 1999, Bayne et al. 2002). Both of these studies looked at survival rates for Ovenbirds in fragmented and unfragmented forests. Ovenbirds appeared to have higher apparent survival in forest fragments versus agricultural landscapes but survival in forest fragments was still lower than survival of birds in contiguous forests (Bayne et al. 2002). However, another study found that male Ovenbirds in fragmented sites did not have a significantly lower survival rate than males in unfragmented sites (Porneluzi et al. 1999).

The Common Yellowthroat is an early successional species (successional index 0.50) that likes thick undergrowth that is potentially created by thinning, burning, or clearcutting. In a system that is highly fragmented by clearcutting and other silvicultural practices, it would be plausible that the Common Yellowthroat would have high survival rates, while the other three species would not do as well. Because data were pooled across districts, sites, years and sex, these survival estimates can only be interpreted very generally. The Black-throated blue Warbler (*Dendroica caerulescens*) was found to have a high apparent survival rate of about 0.51 for males and 0.40 for females in the Hubbard Brook experimental Forest in New Hampshire (Sillett et al. 2002). However, the survival estimates for the Acadian Flycatcher, Hooded Warbler, and Common Yellowthroat might be lower than for other species.

Permanent Residents

The Northern Cardinal and Carolina Wren had survival estimates of approximately 0.54 and 0.30 respectively with recapture probabilities of 0.22 and 0.46 respectively. One might expect survival rates of residents to be lower than Neotropical migrants because the life history of Neotropical migrants has evolved as a means of increasing their survival chances by migrating. A study conducted on winter woodlots investigated four resident species: Carolina Chickadee (*Parus carolinensis*), Tufted Titmouse (*Parus bicolor*), White-breasted Nuthatch (*Sitta carolinensis*), and Downy Woodpecker (*Picoides pubescens*) and estimated apparent survival to be 0.43, 0.33, 0.26, and 0.26, respectively (Doherty et al. 2002). While the Doherty et al. (2002) study was conducted in winter, which is a different time of the year than when my study took place, it showed estimates for permanent resident species are similar to those of the Cardinal and Wren in our study (Doherty et al. 2002).

Possible Assumption Violations

The first assumption made by the CJS model is that every marked animal in the population at sampling period i has the same probability of being re-captured or re-sighted. This assumption is easily violated because of the inherent nature and mobility of birds causes both survival and re-capture probabilities to be biased low. Assuming equal survival probability of all marked animals could possibly be violated if certain individuals or a particular species was more susceptible to predation. For example, nest predation would affect females more than males, and because data were pooled over sex, this could violate the assumption. Assumption 3 assumes that all marks are neither lost, overlooked, and are recorded correctly. There are several situations where assumptions could be violated. First if bands are being lost, then survival would be biased low. Secondly a researcher could misidentify color bands and incorrectly resight an individual. The fourth assumption of an instantaneous sample could also be violated based on when birds are captured. A bird that is captured first thing in the morning has a longer time to survive than does the bird that is captured just before netting ends for that day. This potentially has a negative bias on survival. The fifth assumption of permanent emigration from the study area is probably the assumption most susceptible to violation. This assumes that once a bird leaves the area that it is dead because the model cannot separate death from emigration. To the model, a bird that leaves to go to another stand or district is dead thus having a negative bias on survival. The final assumption assumes that fates of animals are independent. This assumption is largely influenced by behavioral characteristics of the birds. Birds that are more solitary will be less likely to influence one another in their trap response. However, birds that travel together such as parents and fledgling have the potential to influence one another in being caught in a net.

CONCLUSIONS

Two questions can be asked when summarizing the overall findings. The first question is; are these birds using the corridors? The answer to this is yes. In the experimental district birds are using the corridors significantly more than adjacent stands ($p < .0001$) (Table 6). While not statistically significant abundance was numerically higher in all but one year in the corridors for the control district. This is also supported by the fact that corridors had higher species richness and Shannon-Weaver index than adjacent stands (Figure 8 and 9). We can also infer reproduction is occurring in the landscape because three species (Hooded Warbler, Carolina Wren, and Common Yellowthroat) had relatively high captures of Hatch Year (HY) birds. Catches of HY birds were numerically higher in the corridors than in adjacent stands but not statistically significant. This tells us that HY birds are using the corridor stands but why they are using them is still unclear. They could be traveling, foraging, or using them for cover. The possible explanation for differences in both experimental and control corridors is vegetation. Based on the cluster analysis and DCA it was shown that corridors tended to be different from adjacent stands based on vegetation characteristics.

Based on relative abundance experimental corridors had more early-successional species than other stands (Table 9). Nevertheless most species occurred in both corridor and adjacent stands in both the control and experimental districts, so all the sites were relatively similar. In the experimental corridor the top species were two early successional species (Common Yellowthroat and Yellow-breasted Chat) (Table 9). While the top species in the experimental adjacent, control adjacent, and control corridor were more mid-successional forest interior species. Regardless of their successional stages, many species of birds are doing well in the corridors, whether it is in the experimental or control district.

The second question that can be asked is; are these birds surviving in this landscape? The answer to this question is yes. Based on the survival estimates for six species, these birds are surviving in a managed forested landscape, where the alternative is obtaining an apparent survival estimate of 0. (Table 11). Because data were pooled, survival rates for my study apply across the entire landscape and not to any particular type of stand (ex. corridor vs. adjacent). What we don't know is whether the corridors are promoting survival or are they forming an ecological trap. It has been shown that corridors not only support high avian abundance and richness but also in some cases increased predator abundance (Coburn 1998). This has the potential to adversely affect survival of birds nesting in corridors.

Management Recommendations

Corridors are providing habitat for birds in both the control and experimental districts. The fact that these stands are left as habitat zones is beneficial to not only avifauna but also to other species as well. Additionally, corridors can provide connectivity throughout the overall landscape by providing a means of moving from one patch to another. Because areas designated as corridors are usually wetter in hydrology, thus making them harder to harvest, it makes sense to allow them a longer rotation time thus providing habitat.

It appears that by managing a system of corridors generally left for double the normal rotation time this landscape can provide suitable habitat for both generalists and specialists. Even though most stands are managed on an even-aged rotation, corridors with their diverse mid and under-stories provide a suitable mix of habitat for avifauna. Based on the findings from my project and other findings from this same study, if financially feasible, corridors make sense as an alternative to harvesting the entire landscape on a 20-25 year interval.

FUTURE RESEARCH NEEDS

It has been recognized that fragmentation and problems generally affecting avian species in an agricultural landscape are not as well understood in an intensively managed forested landscape. Research needs to be focused on answering this question. Understanding how avian species respond to an intensively managed landscape is important to providing habitat for birds in areas other than reserves. In my study corridors were an important habitat for birds. Why were these particular areas able to attract and hold birds? Possibly these linear habitat strips were creating funnels where birds were naturally funneled into them rather than being good habitat for them. Another question that will need to be addressed is how over time will corridors affect avian species composition, abundance, and survival? Because this system is dynamic and changing over both time and the landscape, long-term studies are needed to address these questions.

It was shown in my study that the way corridors are managed affected to some degree what species (i.e. early or mid-successional) were present in the corridor. It is unclear whether corridors in the control once "installed" will support the same types of species found in corridors in the experimental district.

Additionally it was shown that corridors had a higher abundance than did adjacent stands in both the control and experimental districts. Again it is unclear if this will remain the case over time, or was higher abundance the product of some other effect such as shape, size, or again possibly funneling.

Finally, I estimated apparent survival for six species. Because of sample size, these apparent survival rates can only be applied to the entire landscape rather than to control or experimental district or corridor or adjacent stands. In addition the problem of confounding estimates because of mortality and emigration lead to possible negatively biased estimates. More studies are needed to discern where birds are surviving the best or if survival is equal across the entire landscape. Because of the inherent shape and nature of experimental corridors, one could hypothesize that these areas of habitat are creating more opportunity for birds to be predated or parasitized on the nest. Nest predation studies alone are not enough to provide an answer of how these birds are surviving. They need to be coupled with mark re-capture in order to give researchers a better idea of how well birds are doing in this landscape.

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Table 1 Sampling history of sites for the six-year project 1995 through 2000 Charleston, SC. An X indicates that a site was sampled in that particular year.

	1995	1996	1997	1998	1999	2000
Control						
Sandy Hill	x	x	x	x	x	x
Beech Hill	x	x	x	cut	cut	cut
Greenwood	x	x	x	x	x	x
Sandywood					x	x
Experimental						
Horseshoe	x	x	x	x	x	x
Sycamore	x	x	x	x	x	x
Jacksonboro	x	x	x	x	x	x

Table 2 Corridor installation for the experimental corridors. Installation began in 1993 and ended in 1996. Stands cut surrounded the existing corridor, thus reducing it to a 100-meter-wide corridor.

Experimental Corridors		
Horseshoe	Sycamore	Jacksonboro
Cut '94-'96	Cut '93-'95	Cut '93-'95

Table 3 Site characteristics of experimental district sites for years 1995-2000 Charleston. PBA= pine basal area, PTPA= pine trees per acre, HBA= hardwood trees per acre, and HTPA= hardwood trees per acre.

							Experimental (Edisto)				
		Horseshoe				Sycamore				Jacksonboro	
	Adjacent		Corridor		Adjacent		Corridor		Adjacent		Corridor
Year Planted	1971		1971		1969		1969		1972		1972
Stand age	30		30		32		32		29		29
Program	Pine Plt		Pine Plt		Pine Plt		Pine Plt/ Wet flat hardwood mixed in		Pine Plt		Pine Plt
Acres	49		84		30		42		36		51
Hectares	19.796		33.936		12.12		16.968		14.544		20.604
Site Index	95		83		75		75		76		75
PBA	171		190		202		0		108		150
PTPA	173		222		230		150		118		205
HBA	5.6		0.22		3		140		19		5
HTPA	13.8		1.1		8		400		81		27
Prescribed Burn	'90, '92,'00		'90, '92, '96		94		90		93		'89, '93
Site Prep	Bed		Bed		Bed&Pile		Bed&Pile		Bed&Pile		Bed&Pile
Fertilizer	P		P		P		P		XXXXXXXX		P

Table 4 Site characteristics of control district sites for years 1995-2000 Charleston. PBA= pine basal area, PTPA= pine trees per acre, HBA= hardwood trees per acre, and HTPA= hardwood trees per acre.

							Control (Ashley)				
		Greenwood				Sandywood				Beech Hill	
	Adjacent		Corridor		Adjacent		Corridor		Adjacent		Corridor
Year Planted	1980		1980		1981		1981		1977		1977
Stand age	21		21		20		20		21		21
Program	Pine Plt		Pine Plt		Pine Plt		Pine Plt		Pine Plt		Pine Plt
Acres	82.7		14		98		20		65		25.2
Hectares	33.4108		5.656		39.592		8.08		26.26		10.1808
Site Index	74		71		77		79		68		72
PBA	144		163		111		201		149		172
PTPA	381		466		276		375		384		442
HBA	0.9		5		0		1		0		0
HTPA	0.8		68		0		15		0		0
Prescribed Burn	1996		1996		'93,'94,'95		'93, '94,'95		1993		1993
Site Prep	XXX		XXX		Sheared, Raked, Bedded		Sheared, Raked, Bedded		Bed		Bed
Fertilizer	P		P		P		P		P		P

Table 4. Continued

Sandy Hill	Adjacent		Corridor
Year Planted	1978		1950
Stand age	23		53
Program	Pine Plt		Hardwood
Acres	20.7		17.3
Hectares	8.3628		6.9892
Site Index	76		N/A
PBA	103.8		10
PTPA	247.2		10.5
HBA	0		114.3
HTPA	0		342.2
Prescribed Burn	'95&'98		No
Site Prep	Sheared, raked, bedded		No
Fert	P		No

Table 5. Vegetation characteristics of control and experimental sites Charleston, SC. Data were collected in 1999. Sandywood and Beech Hill sites were not used in analysis because of lack of data. Vines and cane were ranked on a scale of 1-5 with 1 = high coverage and 5 = to no to little coverage.

		Control	Sites				Experimental		Sites		
	Greenwood Adjacent	Greenwood Corridor	Sandy Hill Corridor	Sandy Hill Hardwood		Horseshoe Adjacent	Horseshoe Corridor	Sycamore Adjacent	Sycamore corridor	Jacksonboro Adjacent	Jacksonboro Adjacent
Canopy Cover(%)	83.38	83.25	79.90	89.70		80.00	78.20	78.80	82.07	79.13	82.20
Midstory (m)	9.61	8.01	11.08	12.41		13.59	15.12	15.23	12.70	11.31	12.10
Pine DBH	22.15	23.10	28.32	41.43		34.41	32.51	31.94	42.38	34.09	28.25
Hardwood DBH	7.69	10.50	11.21	26.32		5.90	6.50	9.81	17.87	10.62	10.69
Snag DBH	0.30	1.90	2.70	0.60		10.10	10.20	3.80	0.20	4.40	0.60
Vines (1-5)	4.10	3.60	2.70	2.50		4.80	5.00	4.50	3.10	4.40	3.80
Cane (1-5)	5.00	4.80	4.80	3.60		5.00	5.00	4.00	4.90	4.00	4.30
Avg Vertical Density (%)	13.74	13.28	16.05	22.89		6.43	13.58	18.42	58.17	15.21	31.73

Table 6. Test between control and experimental (a1 vs. a2), between corridor and adjacent in the experimental (b1 vs. b2 in a2), between corridor and adjacent in the control (b1 vs b2 in a1), between corridors in experimental and control districts (a1 vs. a2 in b1), and between adjacents in experimental and control districts (a1 vs a2 in b2). Tested at the .05 significance level indicating a difference given p value < .05. Testing is based on captures per 100-net hours from both the control and experimental sites for all years 1995-2000.

Label	Pr > |t|
a1 vs a2	0.2402
b1 vs b2 in a2	<.0001
b1 vs b2 in a1	0.6374
a1 vs a2 in b1	0.0778
a1 vs a2 in b2	0.7654

Table 7. Hatch Year captures per 1000 net hours for Carolina wren (CARW), Hooded Warbler (HOWA), and Common Yellowthroat (COYE). Captures are for control adjacent and corridor and experimental adjacent and corridor from 1995-2000.

	Control A	Control C	Exp. A	Exp. C
CARW	12.11	23.60	23.11	36.31
HOWA	9.22	12.11	7.70	14.67
COYE	2.30	5.77	7.70	55.62

Table 8. Coefficient of Variation for sites based on captures per 100-net hours for entire six years of the project 1995-2000.

				Coefficient of Variation			
		Control				Experimental	
	Sandy Hill	Greenwood	Beech Hill	Sandywood	Horseshoe	Sycamore	Jacksonboro
Adjacent	0.50	0.42	0.74	0.09	0.26	0.25	0.18
Corridor	0.25	0.13	0.50	0.04	0.19	0.21	0.29

Table 9. Relative abundance for top ten species in the corridor and adjacent for control and experimental district. Species in same color occur in both the corridor and adjacent for their respective district. Species were sampled from 1995-2000.

		Control						**Exper.**		
	A		C				A			C
HOWA	0.25		**HOWA**	0.22		**ACFL**	0.18		**COYE**	0.20
CARW	0.10		**CARW**	0.12		**CARW**	0.16		YBCH	0.10
NOCA	0.07		**NOCA**	0.08		**HOWA**	0.12		**CARW**	0.09
ACFL	0.05		**WEVI**	0.06		**COYE**	0.07		WEVI	0.08
YBCU	0.05		**ACFL**	0.05		SUTA	0.06		**ACFL**	0.06
YBCH	0.05		**WEWA**	0.05		REVI	0.05		**HOWA**	0.05
WOTH	0.05		**OVEN**	0.05		**NOCA**	0.04		**NOCA**	0.04
OVEN	0.05		COYE	0.04		**KEWA**	0.04		**KEWA**	0.04
WEWA	0.05		**WOTH**	0.04		TUTI	0.03		INBU	0.03
WEVI	0.05		KEWA	0.04		WOTH	0.03		GRCA	0.03

Table 10. Abundance value, successional value for each species, and average weighted successional stage value for each stand. Derived from Hamel et al (1982). If a species was found in more than one successional stage then average value was assigned. Relative abundance for species based on captures for entire six-year period 1995-2000.

*** Successional values for White-eyed Vireo were used from the Oak-Hickory vegetation type as this was the only type that indicated this species breed in.**

Species	Abbreviation	Abundance value	Successional stage	(Abundance value) X (Successional stage value)
Control A				
Hooded Warbler	**HOWA**	0.25	2.50	0.64
Carolina Wren	**CARW**	0.10	2.00	0.19
Northern Cardinal	**NOCA**	0.07	2.00	0.13
Acadian Flycatcher	**ACFL**	0.05	2.00	0.11
Yellow-billed Cuckoo	YBCU	0.05	2.00	0.11
Yellow-breasted Chat	YBCH	0.05	0.50	0.03
Wood Thrush	**WOTH**	0.05	2.00	0.11
Ovenbird	**OVEN**	0.05	2.00	0.10
Worm-eating Warbler	WEWA	0.05	2.00	0.10
*__White-eyed Vireo__	**WEVI**	0.05	1.00	0.05
Avg. Stage value				**0.16**
Control C				
Hooded Warbler	HOWA	0.22	2.50	0.54
Carolina Wren	CARW	0.12	2.00	0.24
Northern Cardinal	NOCA	0.08	2.00	0.16
*__White-eyed Vireo__	WEVI	0.06	1.00	0.06
Acadian Flycatcher	ACFL	0.05	2.00	0.11
Worm-eating Warbler	WEWA	0.05	2.00	0.10
Ovenbird	OVEN	0.05	2.00	0.09
Common Yellowthroat	COYE	0.04	0.50	0.02
Wood Thrush	WOTH	0.04	2.00	0.08
Kentucky Warbler	KEWA	0.04	3.00	0.12
Avg. Stage value				**0.15**

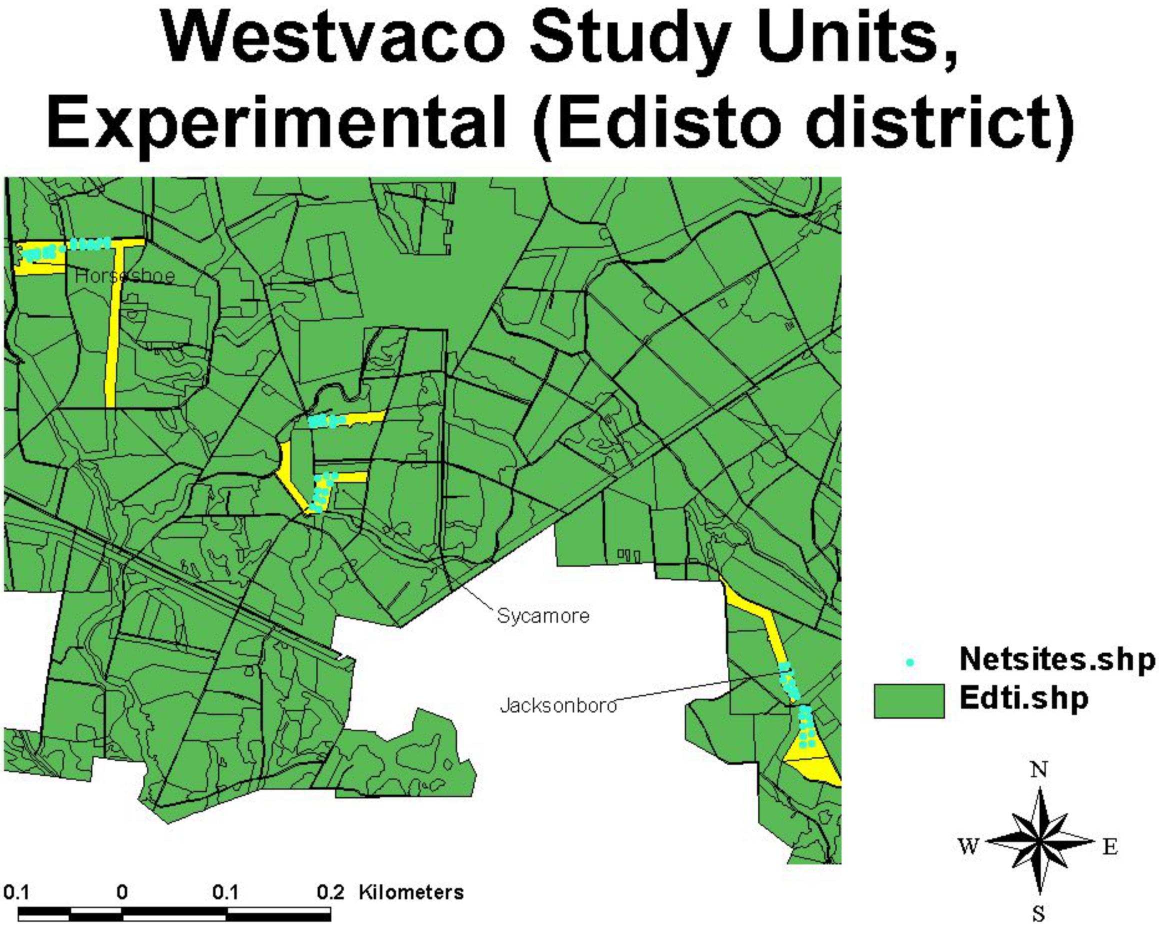
Table 10. continued.

Species	Abbreviation	Abundance value	Successional stage	(Abundance value) X (Successional stage value)
Experimental A				
Acadian Flycatcher	**ACFL**	0.18	2.00	0.36
Carolina Wren	**CARW**	0.16	2.00	0.31
Hooded Warbler	**HOWA**	0.12	2.50	0.31
Common Yellowthroat	**COYE**	0.07	0.50	0.04
Summer Tanager	SUTA	0.06	2.50	0.16
Red-eyed Vireo	REVI	0.05	2.50	0.13
Northern Cardinal	**NOCA**	0.04	2.00	0.08
Kentucky Warbler	**KEWA**	0.04	3.00	0.11
Tufted Titmouse	TUTI	0.03	2.50	0.08
Wood Thrush	WOTH	0.03	2.00	0.06
Avg. Stage value				**0.16**
Experimental C				
Common Yellowthroat	**COYE**	0.20	0.50	0.10
Yellow-breasted Chat	YBCH	0.10	0.50	0.05
Carolina Wren	**CARW**	0.09	2.00	0.19
*__White-eyed Vireo__	WEVI	0.08	1.00	0.08
Acadian Flycatcher	**ACFL**	0.06	2.00	0.13
Hooded Warbler	**HOWA**	0.05	2.50	0.13
Northern Cardinal	**NOCA**	0.04	2.00	0.08
Kentucky Warbler	**KEWA**	0.04	3.00	0.11
Indigo Bunting	INBU	0.03	1.50	0.04
Gray Catbird	GRCA	0.03	3.00	0.08
Avg. Stage value				**0.10**

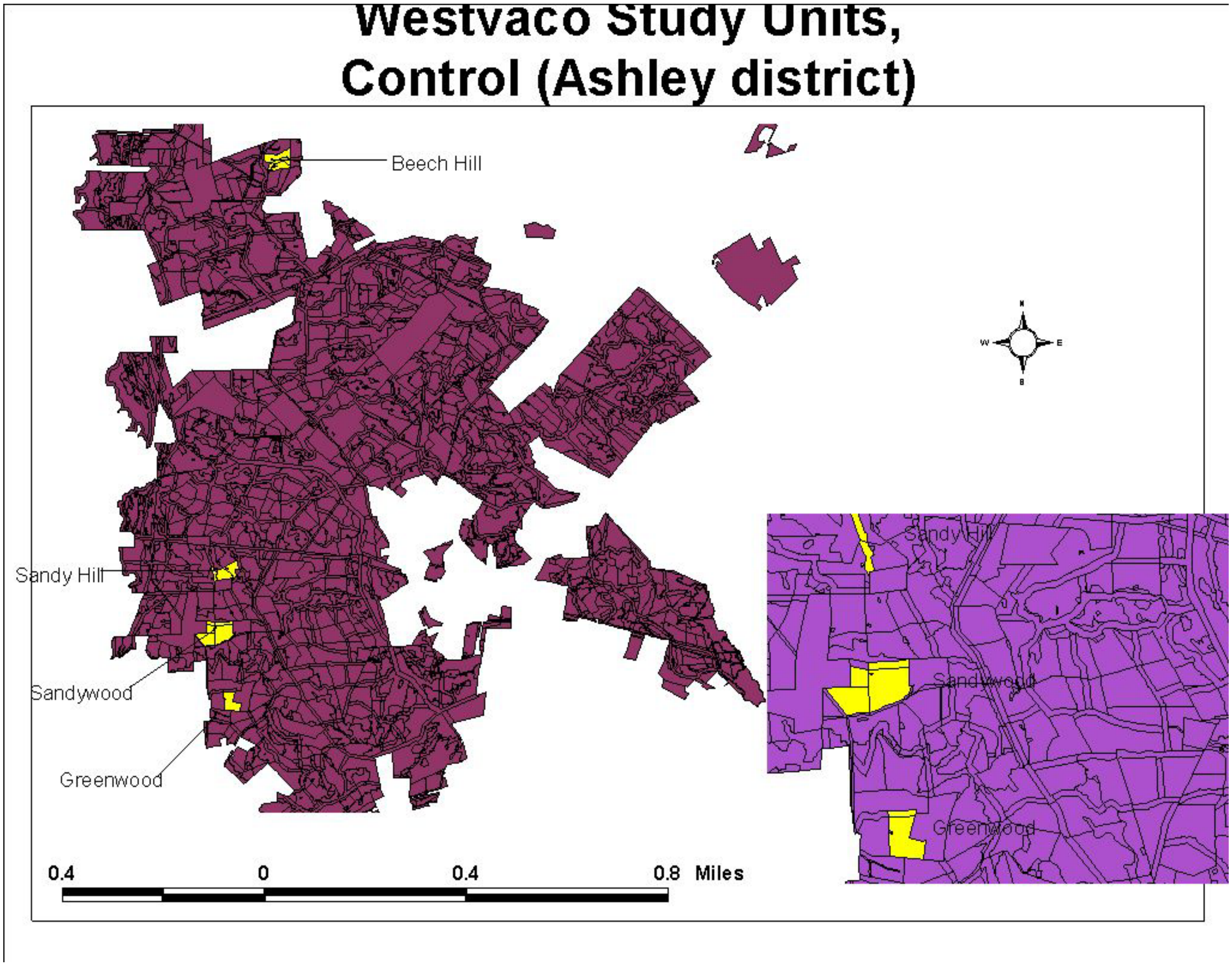
Table 11. Number of marked individuals, model selected, survival, probability of recapture, lower and upper confidence interval, and AIC values. Survival estimates were based on combining all adult captures from all sites, across both districts, and across all years 1995-2000. Phi = survival estimate and p = recapture probability.

Species	No. Marked Individuals	Model Selected	Survival	Probability of capture in following year	Lower CI	Upper CI	AIC
ACFL	298	phi(.) p(.)	0.30	0.50	0.21	0.40	315.8
HOWA	332	phi(.) p(.)	0.34	0.55	0.26	0.44	402.7
WEVI	156	phi(.) p(.)	0.33	0.52	0.19	0.50	157.6
COYE	415	phi(.) p(t)	0.51	0.57	0.26	0.75	225.2
NOCA	179	phi(.) p(.)	0.54	0.18	0.37	0.70	222.4
CARW	278	phi(.) p(.)	0.51	0.15	0.20	0.41	293.5

Map 1. Map of Lower Coastal Plain of South Carolina.



Map 2. Map of Experimental district (Edisto) adjacent and corridor stands. Blue dots in stands represent where a net was placed. Stands were sampled for six years from 1995-2000.



Map 3. Map of control sites. Inset of map is a close up of sites. Sandy Hill and Greenwood were sampled from 1995-2000. Beech Hill was sampled from 1995-1998 and Sandywood was sampled from 1999-2000.

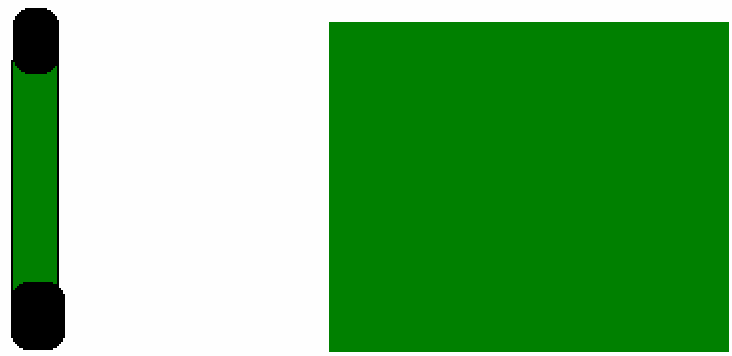


Figure 1 Diagram of installed corridor from experimental district on left and uninstalled corridor from control district on right. Installation began in experimental district in 1993 and ran for approximately two to three years. Corridors located south of Charleston, South Carolina.

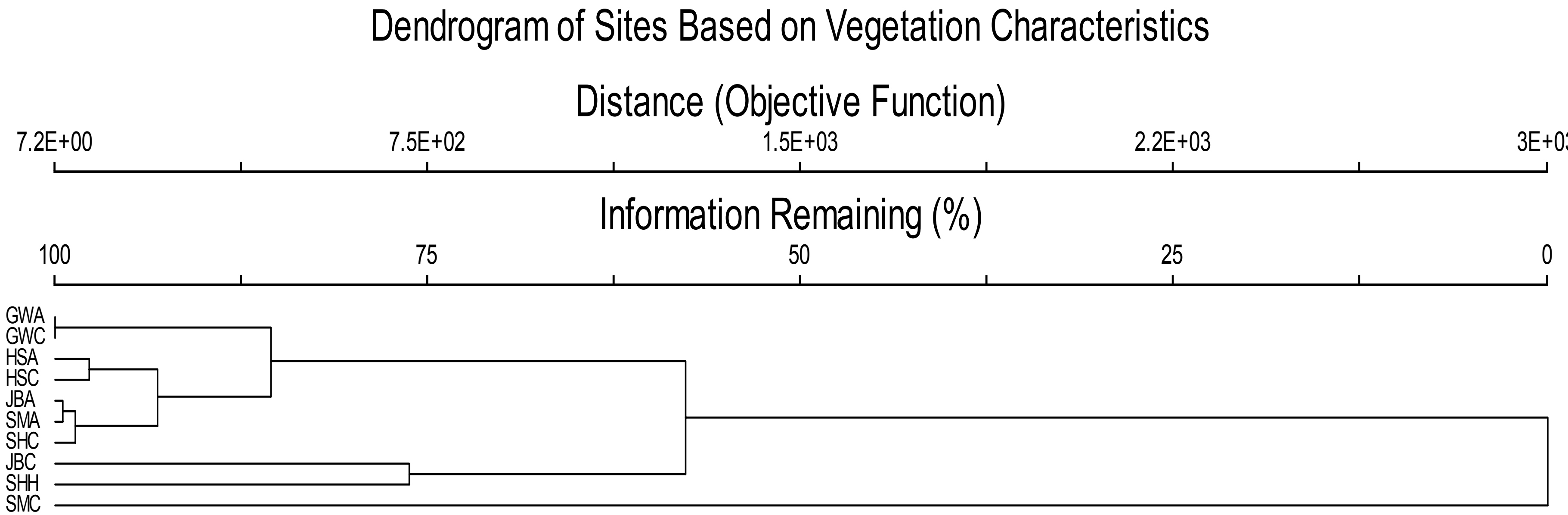


Figure 2. Dendrogram of sites based on vegetation characteristics. Eight vegetation characteristics were used as computed from a correlation matrix. Vegetation data were collected in 1999.

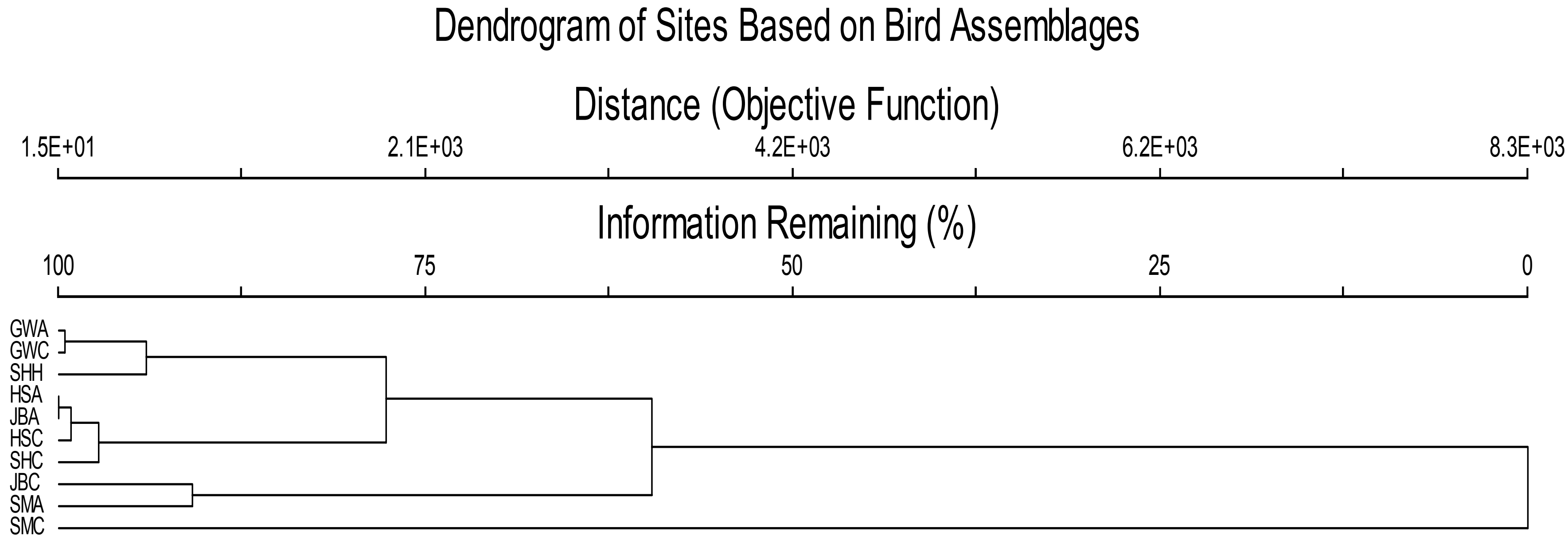


Figure 3. Dendrogram of sites based on bird assemblages. Dendrogram is based on captures per 100-net-hours from nine most abundant species from 1995 through 2000.

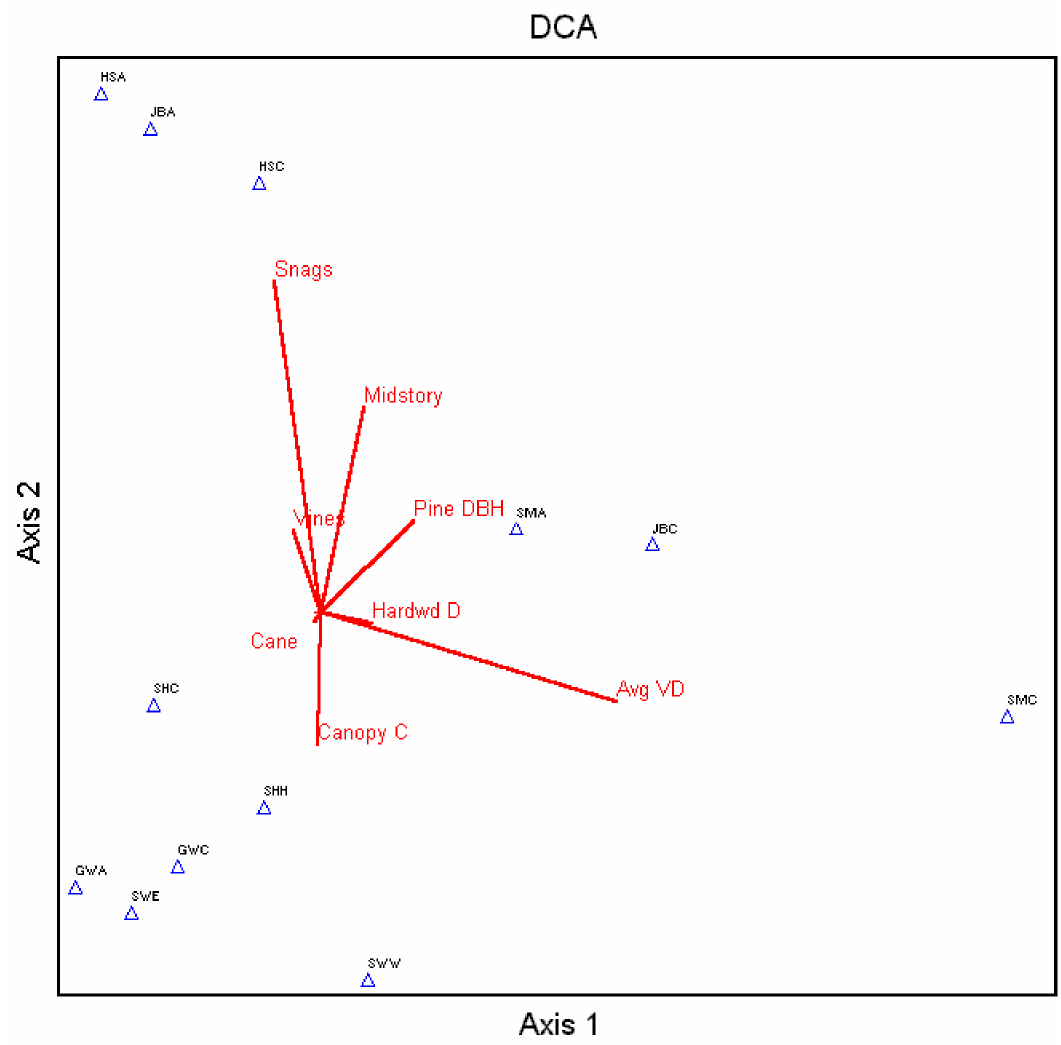


Figure 4. Graph of Detrended Correspondence Analysis correlating sites with vegetation characteristics. Sites included both control and experimental districts and were sampled from 1995-2000.

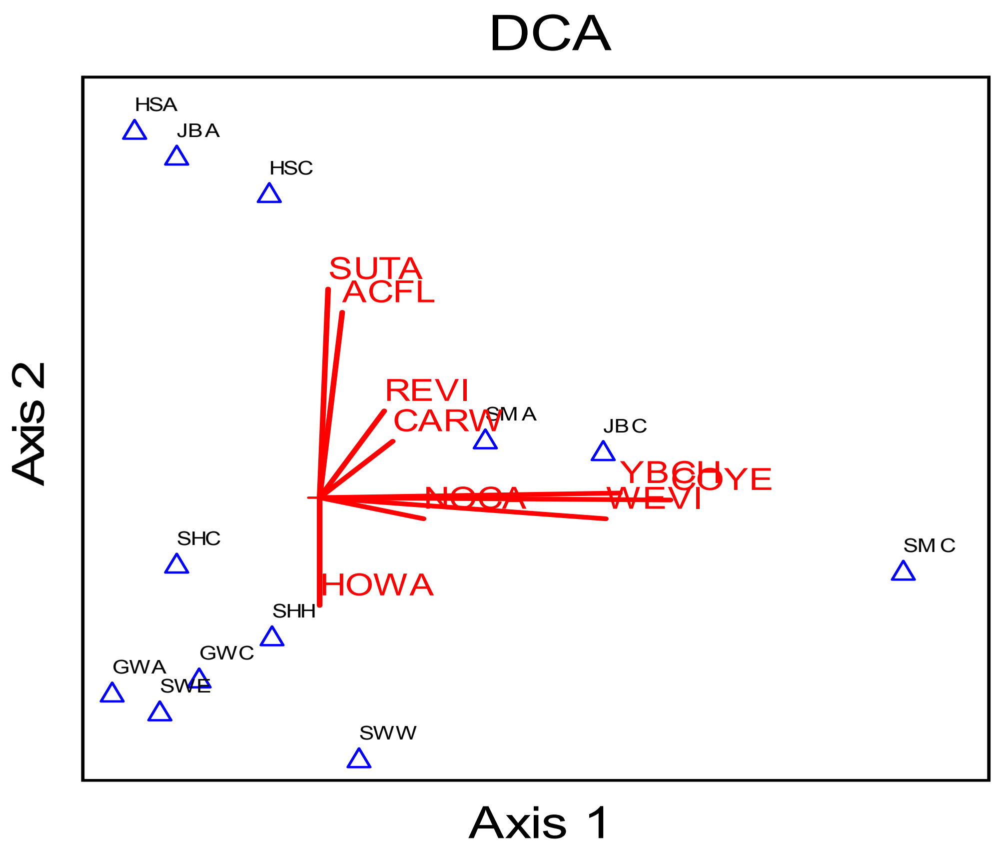


Figure 5. Graph of Detrended Correspondence Analysis correlating sites with bird assemblages. Nine most abundant species from 1995-2000 were used.

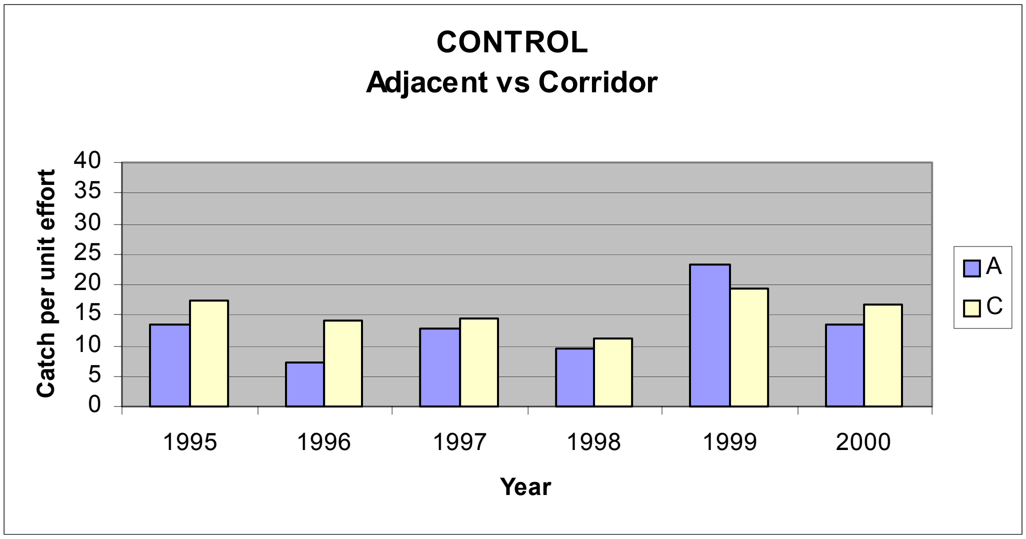


Figure 6. Catch per 100-net hours in the control district (Ashley) for all adult species from 1995-2000.

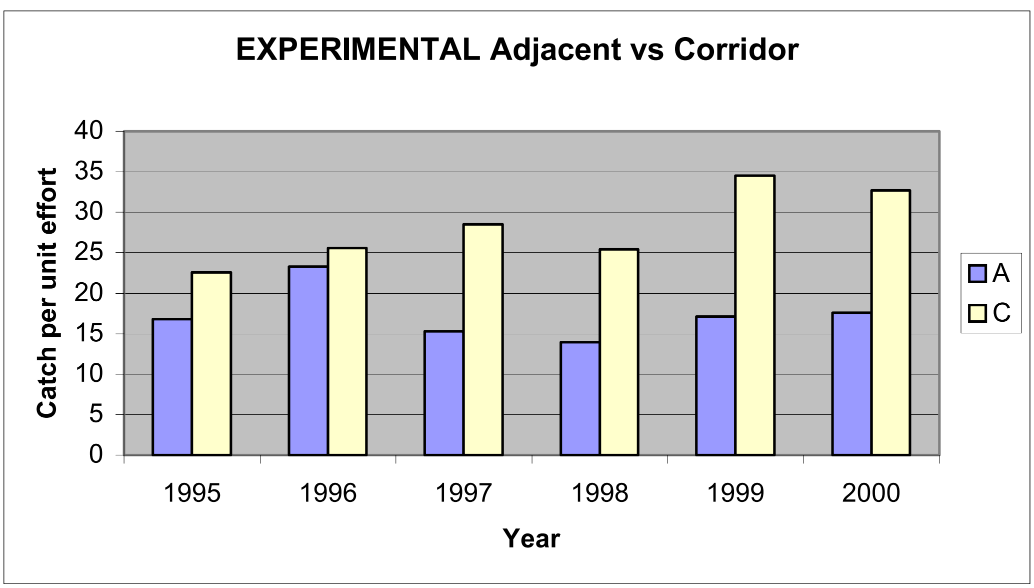


Figure 7. Catch per 100-net hours in the experimental district (Edisto) for all adult species from 1995-2000.

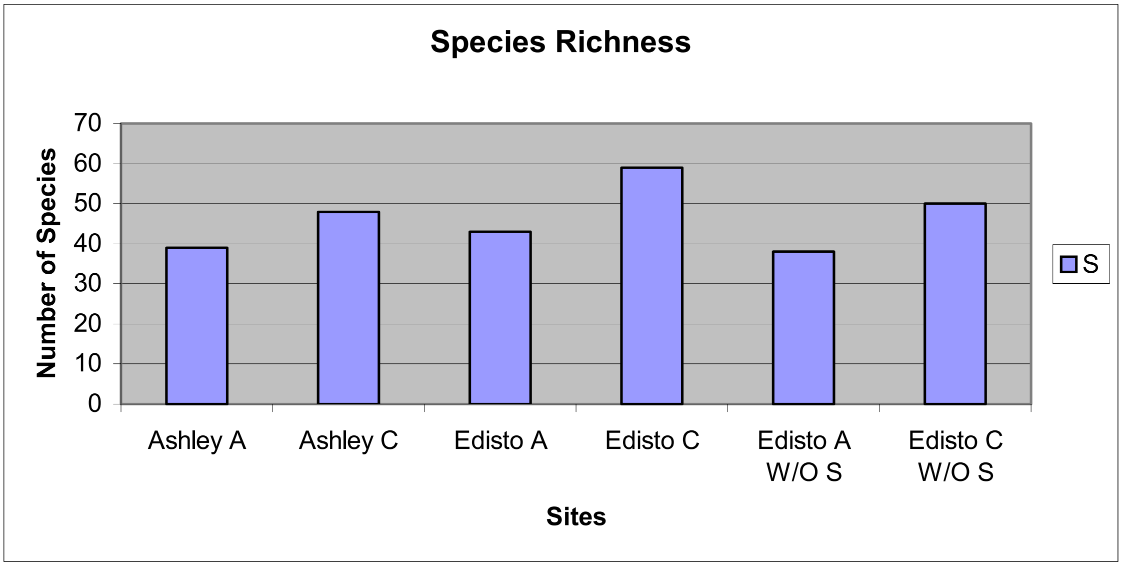


Figure 8. Species richness for control (Ashley) corridor/adjacent and experimental (Edisto) corridor/adjacent. Sycamore adjacent corridor were removed from experimental (Edisto) sites to see if it made a significant difference. Species abundance is from entire six-year period 1995-2000.

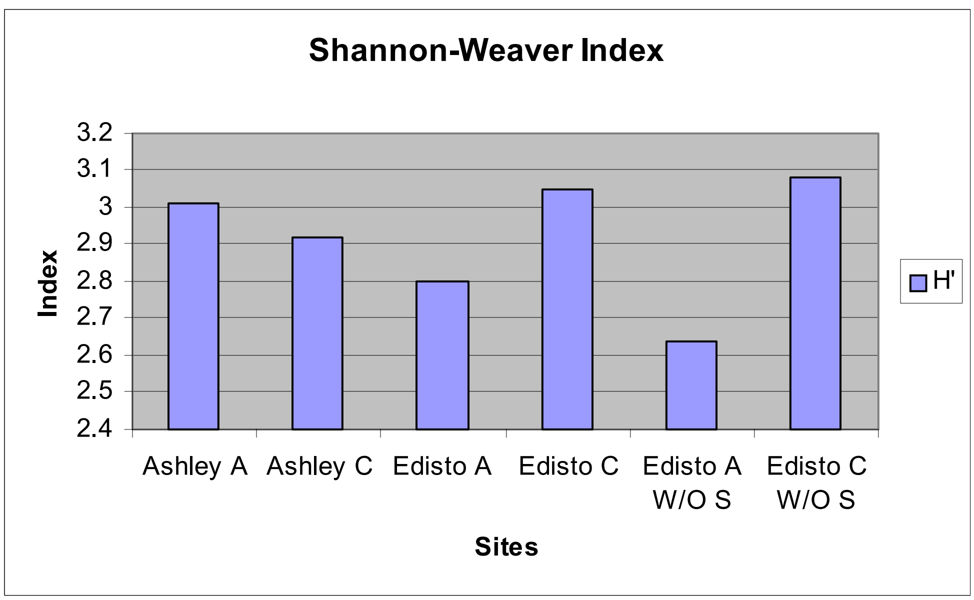


Figure 9. Shannon-Weaver index (H') for control (Ashley) corridor/adjacent and experimental (Edisto) corridor/adjacent. Edisto adjacent and corridor are shown without Sycamore captures. H' values are based on all captures from 1995-2000.

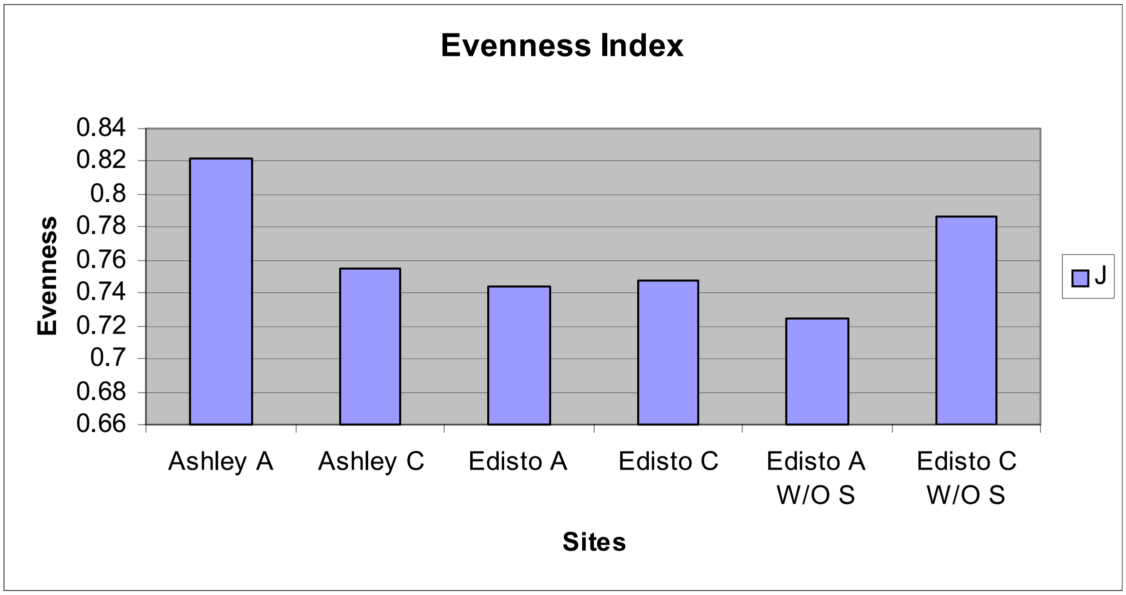


Figure 10. Evenness index for Ashley corridor/adjacent and Edisto corridor/adjacent. Edisto adjacent and corridor are shown without Sycamore captures. Evenness index is based on all captures from 1995-2000.

Appendix – Table 1. Avian species codes (American Ornithologists Union codes), common names, and scientific names.

AOU Code	Common Name	Scientific Name
ACFL	Acadian Flycatcher	*Empidonax virescens*
BACS	Bachmans Sparrow	*Aimophila aestivalis*
BAWW	Black-and-White Warbler	*Mniotilta varia*
BGGN	Blue-gray Gnatcatcher	*Polioptila caerulea*
BHCO	Brown-headed Cowbird	*Molothrus ater*
BHNU	Brown-headed Nuthatch	*Sitta pusilla*
BLGR	Blue Grosbeak	*Guiraca caerulea*
BLJA	Blue Jay	*Cyanocitta cristata*
BRTH	Brown Thrasher	*Toxostoma rufum*
BTBW	Black-throated Blue Warbler	*Dendroica caerulescens*
CACH	Carolina Chickadee	*Parus carolinensis*
CARW	Carolina Wren	*Thryothorus ludovicianus*
COGR	Common Grackle	*Quiscalus quiscula*
COYE	Common Yellow-throat	*Geothlypis trichas*
DOWO	Downy Woodpecker	*Picoides pubescens*
EABL	Eastern Bluebird	*Sialia sialis*
EATO	Eastern Towhee	*Pipilo erythrophthalmus*
EAWP	Eastern Wood-Pewee	*Contopus virens*
GCFL	Great Creasted Flycatcher	*Myiarchus crinitus*
GCTH	Gray-cheeked Thrush	*Catharus minimus*
GRCA	Gray Catbird	*Dumetella carolinensis*
HAWO	Hariy Woodpecker	*Picoides villosus*
HETH	Hermit Thrush	*Catharus guttatus*
HOWA	Hooded Warbler	*Wilsonia citrina*
HOWR	House Wren	*Troglodytes aedon*
INBU	Indigo Bunting	*Passerina cyanea*
KEWA	Kentucky Warbler	*Oporornis formosus*
LBHE	Little Blue Heron	*Florida caerulea*
LOWA	Louisiana Waterthrush	*Seiurus motacilla*
NOBO	Northern Bobwhite	*Colinus virginianus*
NOCA	Northern Cardinal	*Cardinalis cardinalis*
NOPA	Northern Parula	*Parula americana*
NOWA	Northern Waterthrush	*Seiurus noveboracensis*
OROR	Orchard Oriole	*Icterus spurius*
OVEN	Oven Bird	*Seiurus aurocapillus*
PABU	Painted Bunting	*Passerina ciris*
PIWA	Pine Warbler	*Dendroica pinus*
PIWO	Pileated Woodpecker	*Dryocopus pileatus*
PRAW	Prarie Warbler	*Dendroica discolor*
PROW	Prothonotary Warbler	*Protonotaria citrea*
RBWO	Red-bellied Woodpecker	*Melanerpes carolinus*
RCKI	Ruby-crowned Kinglet	*Regulus calendula*

Appendix – Table 1. Continued from previous page.

REVI	Red-eyed Vireo	*Vireo olivaceus*
RHWO	Red-headed Woodpecker	*Melanerpes erythrocephalus*
RTHU	Ruby-throated Hummingbird	*Archilochus colubris*
SUTA	Summer Tanager	*Piranga rubra*
SWSP	Swamp Sparrow	*Melospiza georgiana*
SWTH	Swainson's Thrush	*Catharus ustulatus*
SWWA	Swainson's Warbler	*Limnothlypis swainsonii*
ETTI	Eastern Tufted Titmouse	*Parus bicolor*
VEER	Veery	*Catharus fuscescens*
WBNU	White-breasted Nuthatch	*Sitta carolinensis*
WEVI	White-eyed Vireo	*Vireo griseus*
WEWA	Worm-eating Warbler	*Helmitheros vermivorus*
WOTH	Wood Thrush	*Hylocichla mustelina*
WPWA	Western Palm Warbler	*Dendroica palmarum palmarum*
WTSP	White-throated Sparrow	*Zonotrichia albicollis*
YBCH	Yellow-breasted Chat	*Icteria virens*
YBCU	Yellow-billed Cuckoo	*Coccyzus americanus*
YPWA	Yellow Palm Warbler	*Dendroica palmarum hypochrysea*
YRWA	Yellow-rumped Warlber	*Dendroica coronata*
YSFL	Yellow-shafted Flicker	*Colaptes auratus*
YTVI	Yellow-throated Vireo	*Vireo flavifrons*