AVIAN COMMUNITIES AND VEGETATION COMPOSITION IN LONGLEAF PINE (*PINUS PALUSTRIS*) RESTORATION STANDS IN THE UPPER COASTAL PLAIN OF GEORGIA

by

BRIAN JAMAAL GATES

(Under the Direction of John P. Carroll and Robert J. Cooper)

ABSTRACT

I determined baseline bird communities and vegetation composition in newly established longleaf pine (*Pinus palustris*) Conservation Priority Area and Bobwhite Quail Initiative (BQI) stands in the Upper Coastal Plain of Georgia in late spring/early summer 2001-2002. I used distance sampling to estimate bird density and occupancy models to estimate bird presence-absence and species richness. I also measured vegetation characteristics including vegetation height, % cover, and plant species present in the longleaf pine stands. Finally, I investigated the effects of vegetation characteristics and BQI management on bird densities and occupancy. I found that birds associated with grassland and shrub/scrub habitat were present in these stands, but were generally low at densities. Additionally, BQI management did not seem to positively affect bird abundance and occupancy. Relative bird species richness was generally high and increased the second year. These results suggest that CPA and BQI lands provide bird habitat, but management efforts need to be modified to maximize benefits of the CPA and BQI.

INDEX WORDS: Bobwhite Quail Initiative, Conservation Priority Area, Conservation Reserve Program, crop fields, density, early succession, Georgia, grassland birds, longleaf pine, Longleaf Pine Initiative, occupancy, *Pinus palustris*, shrub/scrub birds, Upper Coastal Plain

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DEDICATION

This thesis is dedicated to my parents, Donna and Paul, my brother Brandon, and my grandparents, Charlene, Lee, and Johnnie Grace. And to the rest of my family who supported me and encouraged me to achieve.

And most of all, to my wife, Shantoyia, without whom, I would not have been able to complete this thesis.

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CHAPTER 1

INTRODUCTION, LITERATURE REVIEW, AND STUDY OVERVIEW

INTRODUCTION

Early succession bird species are associated with open habitats, such as grasslands, old fields (abandoned farmland), bogs, floodplains, open old-growth oak forests, and old-growth longleaf pine (*Pinus palustris*) savannas (Hunter et al. 2001). Many of the bird species associated with early succession have undergone long-term population declines during the last 50 years in eastern North America (Askins 2000). Loss of early succession pine-grassland habitats may have contributed to the widespread declines in some of these bird species. In response to these documented population declines, wildlife management plans need to be implemented to increase or at least sustain bird populations, particularly in the southeastern U.S.A.

In this chapter, I discuss the history of the longleaf pine ecosystem and the wildlife, specifically birds, typically associated with the ecosystem at varying stages of succession. I also describe specific federal and state government initiatives aimed, in part, at restoring wildlife habitat in the U.S.A. In subsequent chapters, I discuss in detail the bird populations that I observed in newly restored longleaf pine stands in Georgia. I also discuss vegetation habitat characteristics and how they might affect those bird populations.

LITERATURE REVIEW

Longleaf Pine Ecosystem

Longleaf pine occurs naturally from the Atlantic and Gulf Coastal Plains, to southeastern Virginia, west to Texas, south to northern Florida, extending into the Piedmont and mountains of northern Alabama and northwest Georgia. This species can occur on various sites, including wet to poorly drained coastal flatwoods to dry, rocky mountain ridges (Boyer 1990). It can live potentially beyond 500 years; however, longleaf pine forests are susceptible to natural disasters such as tropical storms, wild fires, and frequent lightning strikes. Because of these events, longleaf pine probably lives shorter lives (Landers et al. 1995, Barnett 1999).

Longleaf pine grows slowly and is difficult to regenerate (Landers et at. 1995). It is an extremely intolerant pioneer species, poor seed producer, and its large seeds have little dispersal range (Landers et at. 1995). When in competition with more aggressive species, longleaf pine does not successfully invade open land (Landers et at. 1995). Once successfully established, regeneration depends on two factors: first year survival and the length of time spent in the grass stage after planting (Lauer 1987). If there is vigorous competition, it may remain in the stem-less grass stage for many years (Landers et at. 1995).

According to Noss (1989), the longleaf pine ecosystem is actually comprised of many plant associations, including longleaf pine and wiregrass (*Aristida* spp.), a perennial, bunched or tufted grass (Miller and Miller 1999). Together, longleaf pine and wiregrass are keystone species that facilitate fire (Platt et al. 1988, Noss 1989). Living and dead wiregrass, combined with fallen longleaf pine needles, result in an accumulation of highly flammable plant material (Parrot 1967, Outcalt et al. 1999). Thus, wiregrass is important in fueling frequent and evenly burning surface fires that regulate plant composition and favor fire adapted species (Outcalt et al. 1999). Fire is important in controlling the establishment of competitive but less fire-tolerant species, especially hardwoods, in this ecosystem (Clewell 1989).

Decline of the Longleaf Pine Ecosystem

In the southeastern U.S., frequent fire disturbance historically maintained the longleaf pine-wiregrass ecosystem (hereafter, longleaf pine ecosystem), which covered approximately 37.2 million ha before European settlement (Landers et al. 1995, Hill 1998). The majority of the wildlife species that occupied this ecosystem are fire dependent. When Europeans colonized North America, they affected the natural landscape by hindering the natural disturbance regime of fire, felling groves of longleaf pines, and draining and cutting wetlands (Jackson 1988).

Europeans heavily exploited longleaf pines for construction and to clear land to plant crops (Croker 1979, Landers et al. 1995). Waterways were the major form of transportation in the 19th century. Therefore, settlers cut timber that was near water to move lumber on rivers (Lander et al. 1995). The beginning of railroad logging in the late 19th century, which provided access to the remaining longleaf pine forest, increased detrimental effects on the longleaf pine ecosystem (Landers et al. 1995). Logging proceeded from the Atlantic coastal states west through the Gulf Coast region, and on to Texas with increasing intensity. It was not until > 70 million m^3 of lumber had been cut, that longleaf pine harvest slowed (Wahlenberg 1946).

During the past 30 years, much of the reduction of longleaf pine forests has been caused by continued cutting and conversion of longleaf pine to short-rotation slash pine (*P. elliottii*) or loblolly pine (*P. taeda*) stands or dense mixed pine hardwood forests (Croker 1987, Jackson 1988, Landers et al. 1995). These changes had negative effects on many wildlife species endemic to the longleaf pine ecosystem (Jackson 1988), including the ivory-billed woodpecker (*Campephilus principalis*), which is now thought to be extinct (Hill 1998). Today many other wildlife species associated with longleaf pine are declining, threatened, or endangered including the red-cockaded woodpeckers (*Picoides borealis*), gopher tortoises (*Gopherus polyphemus*), and southern fox squirrels (*Sciurus niger*) (Landers et al. 1995).

Birds and the Longleaf Pine Ecosystem

More than 68 species of birds use the longleaf pine ecosystem (Rounsaville 1989) and many of those species have undergone population declines (Askins 2000). The loss of natural and human-induced disturbance regimes, along with habitat degradation, is resulting in substantial declines for many species, possibly leading to local extirpations and eventually global extinctions (Litviatis 1993, Litviatis et al. 1999, Askins 2000). Several disturbance-dependent species are already extirpated, threatened, or endangered (Hunter et al. 2001), although others are still common and widespread (Sauer et al. 2007).

The bird community in a regenerated pine stand is determined by the age of the stand and the methods used for its site preparation. As an example, in slash pine plantations, overall avian diversity and species richness tend to increase with age. Diversity may decline during the late sapling to early pole stage (Johnson and Landers 1982, Dickson et al. 1993), but increases as the stand approaches saw timber size (Darden et al. 1990). Typically, bird species richness increases with age of the stand until canopy closure, and then declines through the early pole stage (Darden et al. 1990, Dickson et al. 1993).

Bird species assemblages are closely linked to succession stage in longleaf pine ecosystems. Grassland and early succession bird species such as eastern meadowlark (*Sturnella magna*), eastern bluebird (*Sialia sialis*), Bachman's sparrow (*Aimophila aestivalis*), northern bobwhite (*Colinus virginianus*), and mourning dove (*Zenaida macroura*) are the most abundant species during establishment period (Dickson et al. 1993). As the stand develops, herbaceous understory plants are replaced by shrubby species, and height and structural complexity increase (Heard et al. 2000). These vegetation changes are accompanied by corresponding changes in the avian community (Johnson and Landers 1982, Dickson et al. 1993). Grassland and early succession bird species experience population declines, while shrub-succession species such as indigo bunting (*Passerina cyanea*), yellow-breasted chat (*Icteria virens*), common yellowthroat (*Geothlypis trichas*), and prairie warbler (*Dendroica discolor*) populations increase, peaking 3 to 10 years after stand establishment. Continued aging of the stand results in grassland bird disappearance and shrub-succession bird decline, while forest birds begin to occupy the site (Johnson and Landers 1982, Dickson et al. 1993). Therefore, although total bird species diversity increases with the age of the pine stands, species diversity and abundance decreases for early successional bird species (Heard et al. 2000).

Management on Federal and State Government Levels

According to Heard et al. (2000) > 364 million hectares of the privately owned land in the U.S. is managed as agricultural fields, pasture, or rangeland. The passage of the Farm Bill in 1985 by Congress recognized the importance of private land conservation with the inclusion of the conservation title. Given the loss of vital wildlife habitat such as longleaf pine and wetland ecosystems, the federal government implemented a number of programs that will aid in conservation of these ecosystems. Included among these programs are the Wetlands Reserve Program, Wildlife Habitat Incentives Program, Environmental Quality Incentives Program and the Conservation Reserve Program (CRP).

The CRP is administered by the Natural Resource Conservation Service (NRCS) and is the oldest, largest, and most expensive conservation program in the Farm Bill (Heard et al. 2000). As of 2001, the government allowed only 14.7 million ha to be enrolled in CRP at one time; however, new enrollments can replace terminated or expired contracts with private landowners (United States Department of Agriculture 2007). Eligible lands for the CRP include agricultural fields that have been planted, were prevented from being planted, or considered planted to an agricultural commodity, field margins such as turn rows, field borders, and center pivot corners, and land that is physically and legally capable of being planted in a normal manner to an agricultural commodity (United States Department of Agriculture 2001). One of the goals of the CRP is to encourage private landowners to convert unproductive and environmentally sensitive agricultural fields to non-invasive, native grasses, wildlife plantings, trees, filter strips, or riparian buffers (United States Department of Agriculture 2001). However, initially the CRP did not address restoring and conserving non-agricultural lands such as longleaf pine stands.

In the southeastern U.S., 67% of the 1.1 million hectares of CRP land is planted in stands of mostly loblolly pine. Because of its rapid growth rate, loblolly pine is the leading commercial timber species in the southeastern U.S. (Brender et al. 1981, Baker and Langdon 1990). However, it is often planted in even-aged pine plantations, which limits its wildlife value (Heard et al. 2000). Longleaf pine possibly provides better habitat for wildlife than loblolly pine because it takes longer to mature, grows in a more open setting, and lives much longer (Landers et al. 1995, Barnett 1999).

To address the problem of disappearing longleaf pine in its native range, further conservation legislation was established in 1998 with the approval of the National Longleaf Pine Conservation Priority Area (CPA), now called the Longleaf Pine Initiative, as part of the CRP (Figure 1.1). According to the United States Department of Agriculture's CRP Manual (2001), the overall goal of the Longleaf Pine Initiative is to re-establish up to 250,000 acres of longleaf pine forests in the CPA by converting old agricultural fields (old fields) to longleaf pine stands. Longleaf Pine Initiative regulations allows landowners to plant longleaf pine seedlings in old fields, but, unlike other non-longleaf pine CPA's, fields enrolled in the CPA are not automatically eligible for the CRP. These fields must have been planted with crops during 2 of the last 5 years, the stands must have a density of no more than 500 trees per acre, and at least 51% of the land must be located within CPA. Also, the land must be suitable for longleaf pine and planted to or already established as longleaf pine. Furthermore, prescribed burning must be used as deemed necessary by the applicable technical agency.

The Longleaf Pine CPA includes nearly three-fourths of the counties in the state of Georgia. In some of the same counties another important wildlife habitat management initiative had been implemented by the Wildlife Resources Division of the Georgia Department of Natural Resources. The Bobwhite Quail Initiative (BQI) was a pilot program designed to restore habitat for bobwhite quail, songbirds, and other farm wildlife on private lands in 17 counties in Georgia (Thackston 2007). The primary focus of the BQI is to provide nesting and brood rearing habitat, the 2 most common limiting factors affecting northern bobwhite populations in Georgia. These practices also hope to improve habitats for other early succession bird species whose populations are in serious decline, and also reduce soil erosion and improve water quality (Thackston 2007).

BQI was expanded during the sign-up period in November 1999 to include longleaf pine CPA lands. The primary assumption behind this expansion was that benefits for bobwhite quail would be best realized in the long-term as plant succession moved most of these sites to nesting cover and escape cover. Rotationally winter disked areas enrolled in BQI would provide enhanced brood range by encouraging heavy-seeded annual plants such as ragweed (*Ambrosia artemisiifolia*), beggarweed (*Desmodium* spp.), and partridge pea (*Chamechrista* spp.), all important fall and winter food sources for northern bobwhite (R. Thackston, pers. comm.). Because management of long leaf CPA stands requires planting trees at lower densities than typically found with other pine species, it provided opportunities for management of early succession bird species such as northern bobwhite during the life of the CRP contract.

STUDY OVERVIEW

I documented baseline bird population and vegetation composition in the early succession stage of newly established longleaf pine stands in the Upper Coastal Plain of Georgia. To accomplish this, I estimated the abundance of birds representing 3 habitat guilds (grassland, shrub/scrub, and all other bird species not associated with early succession habitat) using distance sampling methods. Additionally, I estimated density of several early succession bird species that I made > 20 observations. I also estimated the proportion of area occupied (occupancy) in my study area by select grassland and shrub/scrub species that I observed. I hypothesized that habitat characteristics in the newly planted longleaf pine stands would affect bird species composition. Therefore, I investigated relationships between birds and several vegetation characteristics including vegetative height, percent cover, and species composition. Finally, I investigated the effect of BQI enrollment on bird communities (density and occupancy) in the longleaf pine stands.

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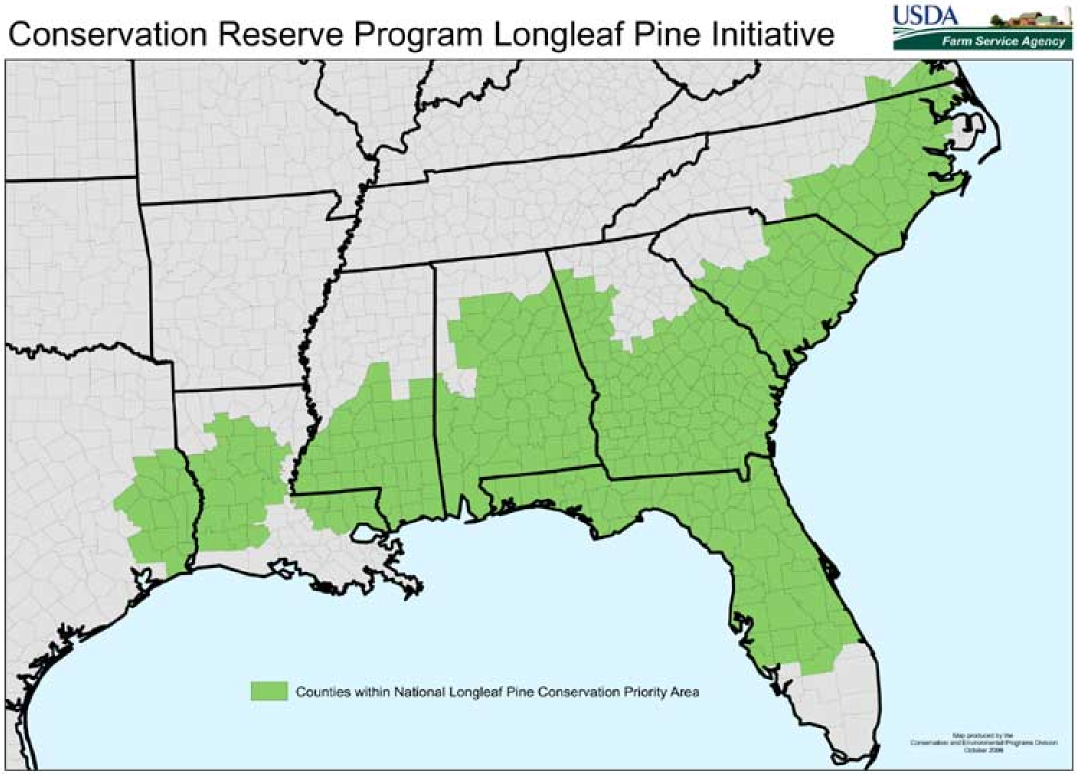

Figure 1.1. Map of the counties in the U.S. within the National Longleaf Pine Conservation Priority Area, courtesy of the United States Department of Agriculture.

CHAPTER 2

AVIAN DENSITIES AND VEGETATION COMPOSITION IN RESTORED EARLY SUCCESSION LONGLEAF PINE (*PINUS PALUSTRIS*) STANDS IN THE UPPER COASTAL PLAIN OF GEORGIA[1]

[1] Gates, B.J, R.J. Cooper, and J.P. Carroll. To be submitted to *Southeastern Naturalist*.

ABSTRACT

The National Longleaf Pine (*Pinus palustris*) Conservation Priority Area (CPA) and Georgia's Bobwhite Quail Initiative (BQI) are programs aimed, in part, at restoring habitat for wildlife and grassland and shrub/scrub birds. We measured baseline breeding season bird densities and vegetation composition in 41 newly established (0-3 years of age) CPA stands in the Upper Coastal Plain of Georgia from 2001-2002. Fourteen stands were in BQI. We found that grassland bird guild densities were significantly lower (95% CI) than shrub/scrub and non-early succession birds. None of the 6 bird species we analyzed individually, blue grosbeaks (*Guiraca caerulea*), eastern kingbirds (*Tyrannus tyrannus*), field sparrows (*Spizella pusilla*), indigo buntings (*Passerina cyanea*), mourning doves (*Zenaida macroura*), and northern bobwhites (*Colinus virginianus*), showed significant differences (95% CI) in densities within species between management practices (BQI/non-BQ) in either year. Grass covered 19% of the habitat while forbs covered 30%. We found bare ground present in 100% of the stands and accounted for 34% of the habitat structure. Litter was also present in 100% of stands and covered 16% of the habitat structure. Wildlife-beneficial plant species such as broomsedge (*Andropogon virginicus*) and ragweed (*Ambrosia artemisiifolia*) were uncommon in CPA stands (in 7 and 17% of stands respectively). Conversely, invasive, agricultural pests such as sicklepod (*Senna obtusifolia*) and bermudagrass (*Cynodon dactlya*) were common in these stands (in 39 and 54% of stands respectively). We found 33 forb species (2 exotic), 16 grass species (7 exotic), 13 woody-stemmed species (1 exotic), and 8 volunteer crops in 41 longleaf pine restoration stands in 2002. We conclude that CPA

and BQI provide habitat for birds, but control of invasive and exotic plants is needed to improve habitat quality, which may increase bird abundance.

INTRODUCTION

Early succession bird species associate with open habitats, such as grasslands, abandoned farmland, bogs, open old-growth oak forests, and old-growth longleaf pine (*Pinus palustris*) savannas (Hunter et al. 2001). Many of these species have had declining trends during the last 50 years in eastern North America (Askins 2000). In Georgia, grassland bird species, such as grasshopper sparrows (scientific names in Table 2.1) and eastern meadowlarks, have declined by >80% during 1966-2006 (Sauer 2007). Other species associated with early succession habitat in Georgia, such as northern bobwhites, field sparrows, and eastern towhees have also undergone significant declines (Sauer et al. 2007). Loss of early succession pine-grassland habitats has contributed possibly to the widespread declines of these bird species (Heard et al. 2000).

Because of declining bird population trends, wildlife management plans needed to be implemented to increase or at least sustain populations, particularly in the southeastern U.S. Congress approved the Longleaf Pine Conservation Priority Area (CPA) in 1998 to restore longleaf pine to its native range, particularly on privately-owned, unproductive crop fields. An indirect benefit of the program has been restoration of wildlife habitat (Heard et al. 2001). Similarly, Georgia legislation approved the Bobwhite Quail Initiative (BQI) to create nesting and brood rearing habitat for bobwhite quail (northern bobwhites), which in turn may benefit other wildlife (including other breeding birds) as well as having positive effects on the environment. A key component of the BQI is that private landowners disk their fields and field borders in the winter to promote desirable weeds, grasses, and woody plants (Thackston 2007). Nearly three-fourths of the counties in Georgia are within the longleaf pine CPA and all of the BQI counties are within the CPA. In November 1999, longleaf pine CPA properties became eligible to enroll in the BQI, with the idea that the programs would be mutually beneficial to wildlife (R. Thackston, pers. comm.).

The objective of this study was to assess baseline bird populations and vegetation composition and structure in the early succession stage of the newly established longleaf pine stands in the CPA in the Upper Coastal Plain of Georgia. We were particularly interested in bird species that have undergone significant population declines. Using distance sampling methods, we estimated abundance of three bird habitat guilds and several select individual bird species.

METHODS

Study Area

We located study sites in the Upper Coastal Plain of Georgia in Dodge, Emanuel, Laurens, and Sumter counties. These counties are in the CPA and BQI Focus Area (Figure 2.1). We used Natural Resource Conservation Service and Georgia Department of Natural Resources data and aerial photographs to identify 41 privately-owned longleaf pine stands enrolled in CPA and BQI programs. All 41 stands were enrolled in CPA, but only 14 of those stands were enrolled in BQI. Therefore, we classified the other 27 stands as non-BQI. Six stands were in Dodge county (4 BQI, 2 non-BQI), 16 stands were in Emanuel county (0 BQI, 16 non-BQI), 14 stands were in Laurens county (5 BQI, 9 non-BQI), and five stands were in Sumter county (5 BQI, 0 non-BQI). The stands ranged from 6.4 to 53.9 ha and averaged 16.2 ha in area. Each stand was previously planted in row crops or pasture. Stands were planted with longleaf pines of approximate even age ranging from 0 months to 3 years depending on the site. In 2001, 35 stands had already been planted with longleaf pines and 4 more were planted prior to our surveys in 2002. The other 2 stands were planted the following fall or winter after our surveys. We recorded additional details about each stand such as age and land use history such as previous crop or pasture grass type (See Appendix I).

Bird Counts

We conducted bird counts within each stand three times between 4 June to 14 July in 2001 and three times from 13 May to 10 June in 2002. We began counts at sunrise and continued for up to 3 hours. Before each count, we recorded temperature, weather conditions, and approximate wind speed. We did not conduct bird counts in adverse weather conditions (Robbins 1981). To reduce observer bias, we ensured that field technicians had strong bird identification skills. Our preliminary DISTANCE analysis (see Data Analysis) indicated that observer bias had no influence on detectability.

We used the line transect method described by Burnham et al. (1980) to sample birds. We randomly oriented a 250 m line in each stand at least 50 m from the edge of the field. We walked the line, flushed birds in the early successional habitat, and recorded species. Observers started at one transect line endpoint and walked the line at 1.5 km/hr pace toward the second point. To account for variation at either start point, we alternated start points for every other survey. We also alternated stands between counts so that each observer surveyed every stand at least once.

We recorded bird species and perpendicular distance to the bird from the observer for birds detected either aurally or visually. We only counted birds that actively used the stands. Birds that flew over the stands were recorded, but not used in analysis. We recorded unidentifiable native sparrows thought to be in family Emberizidae as "unknown sparrows." Occasionally birds we flushed "unknown birds" that could not be identified to species or family.

For analysis purposes, we grouped bird species into three functional "guilds" based on the habitats with which they are most associated. Habitat guilds were grassland species, shrub/scrub species, and all other species not associated with grassland and shrub/scrub habitat (non-early succession species) (Table 2.1). We assumed that "unknown sparrows" were associated with shrub/scrub habitat based on where they were observed. We grouped "unknown birds" in the non-early succession guild.

Vegetation Surveys

We conducted vegetation surveys usually on the same day as bird counts for each respective stand and measured vegetation three times in 2001 and 2002. We placed five 1–m^2 plots alternately along the surveying transect at 25, 75, 125, 175, and 225 m from the starting point. We placed each plot 5 m from the line center. We used a Robel pole to measure vegetation height (Robel et al. 1970). One observer held a pole divided in 0.5 dm increments in the center of the plot while another observer kneeled from 4 m away, and read height from the north, west, south, and east. We determined height by the topmost increment that was obstructed by vegetation and calculated mean height.

We also assessed vegetation structure by visually estimating the percent coverage of grasses, forbs, litter, bare ground, and woody plant species within the plot. For this study, grasses are generally defined as plant species of the family Poaceae; forbs are broadleaf, herbaceous plants; litter is fallen leaves, twigs, and other unclassified matter; bare ground is exposed soil and rocks; and woody species are saplings, shrubs, or other woody-stemmed plants. We calculated mean percent cover of each structure category for each stand to the nearest tenth. To eliminate bias, the same observer estimated all Robel pole and percent cover measurements.

We identified key plant species and groups within each plot in 2001. These included bermudagrass (plant scientific names in Table 2.2), bahia grass, crab grass, broomsedge, partridge pea, beggarweed, sicklepod, ragweed, and blackberry. We chose these species because they are common in agricultural fields and/or early succession habitats and range from being highly beneficial to having little benefit to early succession bird species and wildlife (Miller and Miller 1999). In addition to target plant species, we recorded any other grasses, forbs, or legumes present within the plot in a respective "miscellaneous" category. We also recorded presence of litter and bare ground in each plot. We calculated the percentage of stands in which these species or habitat characteristics occurred.

We expanded our plant composition list in 2002 to include all species within the plots. Additionally, we recorded each species that intersected the line transect, but did not necessarily fall within the plot. In BQI stands, we randomly placed an additional plot in 2 locations within the established field border and recorded every species present within the plot.

Data Analysis

Bird abundance – We used the distance sampling analysis program DISTANCE to estimate bird densities for variable distance line transect counts (Thomas et al. 2006) and analyzed each year and BQI and non-BQI stands separately. Although most bird species were detected as individuals (n = 1), we analyzed the birds as "clusters" because some species were detected in pairs or flocks (n > 1). We used the mean of observed clusters to estimate abundance. Also, because DISTANCE recommends relatively large sample sizes ($n \geq 70$) to calculate reliable density estimates, we were unable to estimate densities for every bird species observed in this study. However, we believed that in the open landscapes of our study area, we could estimate densities of individual species observed at $n \geq 20$. To account for populations that declined and were detected in low numbers, we grouped species into three habitat association guilds: grassland species, shrub/scrub species, and non-early succession species (Table 2.1). We estimated density for each guild.

All of the individual species that we estimated density for (where $n \geq 20$) were in the shrub/scrub guild: blue grosbeak, eastern kingbird, field sparrow, indigo bunting, mourning dove and northern bobwhite. These species were also included in the shrub/scrub guild analysis. We used non-overlapping 95% confidence intervals (95% CI) to detect significant differences in our density estimates.

RESULTS

Bird Analysis

Observations Overview – We observed 44 bird species during two field seasons, from 837 observations in 2001 and 939 observations in 2002 (Table 2.1). We found five grassland bird species: grasshopper sparrow (both years), eastern meadowlarks (both years), horned larks (2001), bobolinks (2002), and savannah sparrows (2001). We detected 10 shrub/scrub species in 2001, 14 in 2002, and 15 species total over both years. We found blue grosbeaks, common ground-doves, eastern bluebirds, eastern kingbirds, field sparrows, indigo buntings, mourning doves, northern bobwhites, and northern cardinals in both years. We found painted buntings in 2001 only. We detected American goldfinches, common yellowthroats, eastern towhees, loggerheaded shrikes, and yellow-breasted chats, only during 2002. We detected 10 non-early succession bird species in

2001 including chimney swifts, brown-headed cowbirds, red-winged blackbirds, and common grackles. We found 20 non-early succession species in 2002 including barn swallows, blue jays, brown thrashers, northern mockingbirds, and yellow-billed cuckoos.

Habitat Guild Densities – Grassland birds had the lowest overall density in both years and ranged from 0.04/ha to 0.12/ha between years (Table 2.5). In BQI stands, grassland bird density was low at 0.004/ha to 0.01/ha between years (Table 2.6). Grassland bird density was also low in non-BQI stands and ranged from 0.009/ha to 0.03/ha between years (Table 2.7). Shrub/scrub bird density was highest of all habitat guilds in both years, 1.61/ha and 1.69/ha respectively (Table 2.5). In BQI stands, shrub/scrub bird density ranged from 0.14/ha to 0.19/ha between years (Table 2.6). Shrub/scrub density ranged from 0.22/ha to 0.15/ha between years in non-BQI stands (Table 2.7). Non-early succession bird species density ranged from 0.94/ha to 1.33/ha in all longleaf pine stands between years (Table 2.5). In BQI stands, non-early succession species was highest of all guilds when analyzed separately in BQI and non-BQI stands (Tables 2.6 and 2.7). We did not find significant differences in density estimates among habitat guilds between management practices (BQI vs. non-BQI) or years.

Individual Species Densities – Density of individual species also varied between years. When we analyzed species in 41 longleaf pine stands combined, density was higher for each species in 2002 except for morning doves (Table 2.8). However, density of these select individual species was generally low when analyzed in BQI and non-BQI stands separately (Tables 2.9 and 2.10).

Mourning doves had the highest overall density (both years combined) among species we analyzed (Table 2.8). We found them generally in greater abundance in non-

BQI stands, but the differences between management practices were not significant in either year (Tables 2.9 and 2.10). Northern bobwhites, another shrub/scrub game species, were the least abundant species we analyzed (Table 2.8). We found them in greater abundance in BQI stands in 2001 (0.035/ha) and non-BQI stands in 2002 (0.040/ha), although the differences were not statistically significant (Tables 2.9 and 2.10).

Blue grosbeaks had the highest overall density in combined stands among non-game songbirds (Table 2.8). We found them in greater abundance in non-BQI stands in both years, but the differences were not significant (Tables 2.9 and 2.10). We found that field sparrow density was significantly higher in non-BQI stands in 2001, but was similar in 2002 between management practices (Tables 2.9 and 2.10). We found that eastern kingbird density was not significantly different between management practices in either year.

Vegetation Analysis

Vegetation Height and Percent Cover – Vegetation was of an early succession stage and consisted generally of native and exotic broad-leaf herbaceous plants, invasive pasture grasses, native grasses, standing volunteer crops, longleaf pine saplings, and a few hardwood trees, pine trees, and shrubs. Mean vegetative height ranged from 1.01 to 3.50 dm in BQI stands and 0.94 to 2.62 dm in non-BQI stands between years (Table 2.3). Grass cover ranged from 19 to 16% in BQI stands and 22 to 25% in non-BQI stands between years (Table 2.3). Forb cover ranged from 30 to 34% in BQI stands and 31 to 26 % in non-BQI stands. Woody cover averaged 1% across management practices and between years. Litter cover ranged from 16 to 20% in BQI and 24 to 33% in non-BQI.

Bare ground cover ranged from 34 to 29% in BQI and 21 to 16% in non-BQI stands between years.

Vegetation Composition – We found a least one grass species in every stand in 2001 (Table 2.4). We found broomsedge in 7.3%, bermudagrass in 39.0%, bahia grass in 12.2%, and crab grass in 26.8% of stands in 2001 (Table 2.3). We found 16 grass species in 2002, 10 of which were native (Table 2.2). We also found bermudagrass and crab grass in BQI field borders (Table 2.2). We found crop grasses in field interiors including oat, rye, thistle, wheat, and Johnson grass in 2002 (Table 2.2).

We found ragweed in 17.1% and sicklepod 53.7% of stands in 2001 (Table 2.4). We did not find beggarweed and partridge pea in 2001. We observed 33 forb species in 2002 (Table 2.2). Of these species, we found 17 in BQI field borders, including partridge pea and ragweed. We also observed collards and watermelon, both volunteer agricultural crops. Other beneficial wildlife forb species we observed in either field borders or interiors were butterfly pea, Japanese clover, and poke berry.

We found woody plant species in 85.3% of stands in 2001 (Table 2.4), most of which was longleaf pine saplings. Longleaf pine height ranged from 0-70 dm and averaged 27.0 dm (Table 2.3). We found 13 woody species in 2002 including black cherry, blackberry, cat briar, greenbriar, palmetto, pecan, persimmon, slash pine, and wild plum (Table 2.2).

DISCUSSION

Birds associated with grassland habitat have undergone significant decline in recent decades (Askins 2000, Brennan and Kuvlesky 2005, Knick et al. 2003, and Peterjohn and Sauer 1999). We found grassland birds in low abundance in both BQI and non-BQI stands and found only two species in great enough abundance to perform DISTANCE analysis: grasshopper sparrows and eastern meadowlarks. These species have shown significant declines in Georgia (Sauer et al. 2007). Our results suggest that some restored longleaf pine stands we surveyed are suitable habitat for these two species. They prefer vegetation of intermediate height (Wiens 1969 and Vickery 1996) and our mean vegetation height in 2001 was low to intermediate in our estimation (Table 2.4). Grasshopper sparrows prefer relatively short and clumped grasses for nesting (Smith 1963) and we found them in stands with dense concentrations of bermudagrass. We detected eastern meadowlarks in low abundance as well, but always detected them in stands with high percent cover of pasture grass, especially bahia grass. This was not surprising because meadowlarks are found often in and around pastures (Lanyon 1995).

Based on our analysis using guilds, the BQI did not have a positive impact on grassland bird abundance. However, BQI practices do encourage proliferation of plants that provide valuable food sources for songbirds (Thackston 2007). A study investigating songbird use of BQI stands would provide more insight on effectiveness of BQI in providing habitat for songbirds, which could increase grassland bird abundance.

We detected 11 of the 17 significantly declining successional-scrub bird species in the U.S. (Table 2.1, Sauer et al. 2007). Actual bird species densities varied between management practices, but differences were not significant. We expected to find blue grosbeaks, eastern kingbirds, field sparrows, indigo buntings, and mourning doves in early succession habitat (Dickson et al. 1993). These species were likely present because several plants we observed in stands provide food for these species including croton, butterfly pea, Japanese clover, Johnson grass, lespedeza, partridge pea, and ragweed (Miller and Miller 1999).

The purpose of the BQI is to achieve greater northern bobwhite populations (Thackston 2007), but our results did not indicate a large degree of success. We found bobwhites in low abundance in all the stands we surveyed. On average, bobwhite density was greater in non-BQI stands (though not significantly), which indicates that BQI may not be effective. Their density decreased sharply in BQI stands in 2002 from 0.035/ha to 0.009/ha. In 2001, they have been actively using field borders for brooding habitat in BQI stands. In 2002, we observed several important plants for bobwhites, such as ragweed and partridge pea, in field borders and interiors of BQI stands. We also found bare ground percent cover at 30% in 100% of the stands we measured. Bare ground is important for many grassland and shrub-successional birds (Bollinger 1995). We believe it is unlikely that bobwhite density decreased. We suspect that the decrease was caused by failure to detect birds when present or that bobwhites used stands, but were not at the sites during surveys. It is also possible that some landowners did not disk field interiors or borders in the winter to encourage beneficial plant species as prescribed in the BQI program.

Many of the longleaf pine stands we surveyed contained agricultural pests such as sicklepod or monocultures of pasture grass, with less important native forbs. Although required as part of CPA, little to no management was conducted on non-BQI stands with the exception of an unsuccessful prescribed burn at one site in 2002 and 1 mowing at another site, also in 2002. All of the sites were previously planted in row crops, but after the sites were taken out of the crop rotation, some landowners converted to pastures.

This inconsistency in application creates significant challenges in wildlife management. Pasture grasses, such as bermudagrass, tend to be invasive and difficult or expensive to control. Furthermore, the grasses could impede the growth of longleaf pine trees and other potentially beneficial grasses and forbs (D'Antonio and Vitousek 1992). Research on the effects of invasive grass encroachment on wildlife populations is limited, but anecdotal evidence suggests that invasive species such as bermudagrass slow bobwhite quail chick mobility, exposing them to predators (Burkhart and Carroll, unpublished data).

MANAGEMENT IMPLICATIONS

Loss of habitat and alterations in habitat structure are generally the main causes of bird population declines. Our results suggest that CPA and BQI stands are providing habitat for birds, but the full effects of habitat restoration on bird use of the newly established habitat are yet to be fully researched. The longleaf pine CPA can provide quality habitat for wildlife, including birds, as long as specific wildlife management plans are implemented at the stand level. Our vegetation analysis yielded inconsistent results, probably because of the variable nature of the fields. For example, land histories of many of the longleaf pine stands varied considerably. Landowners will likely need to work with wildlife biologists and government officials to develop effective wildlife management plans specifically for their property. In the short-term, we recommend controlling exotic grasses to encourage a broader variety of forbs and native grasses. Spot mowing may be important for meadowlarks because it would open up dense vegetation and potentially increase meadowlark use of CRP fields (Patterson and Best 1995).

Pine-grassland restoration efforts have been beneficial to quail (e.g. Brennan 1991, Cram et al. 2002). The BQI created a systematic approach to wildlife management in agricultural and longleaf CPA fields. Although the BQI did not seem to positively affect the most critical bird species—grassland birds—the prescribed management, if done correctly, may yield food sources for birds including many songbirds and game species such as quail (Thackston 2007).

Although we observed that grassland birds with declining trends seemed to be more likely to be detected in young longleaf pine stands with high concentrations of pasture grass, we do not recommend that pasture grass be planted as a management practice because of its invasive nature. Some pasture grasses do provide food sources, seeds, leaves, and insects, or habitat for birds, but the benefits of a "longleaf pine-pasture grass" habitat to a wide variety of wildlife species are likely less than those of a more diverse ground cover. There may be short-term benefits for birds such as eastern meadowlarks prior to succession, but once longleaf pine trees mature or reach a certain height, meadowlarks will eventually move out. Furthermore, the benefit and potential use of such a habitat to endangered bird species such as red cockaded woodpeckers (*Picoides borealis*) may not occur for many decades.

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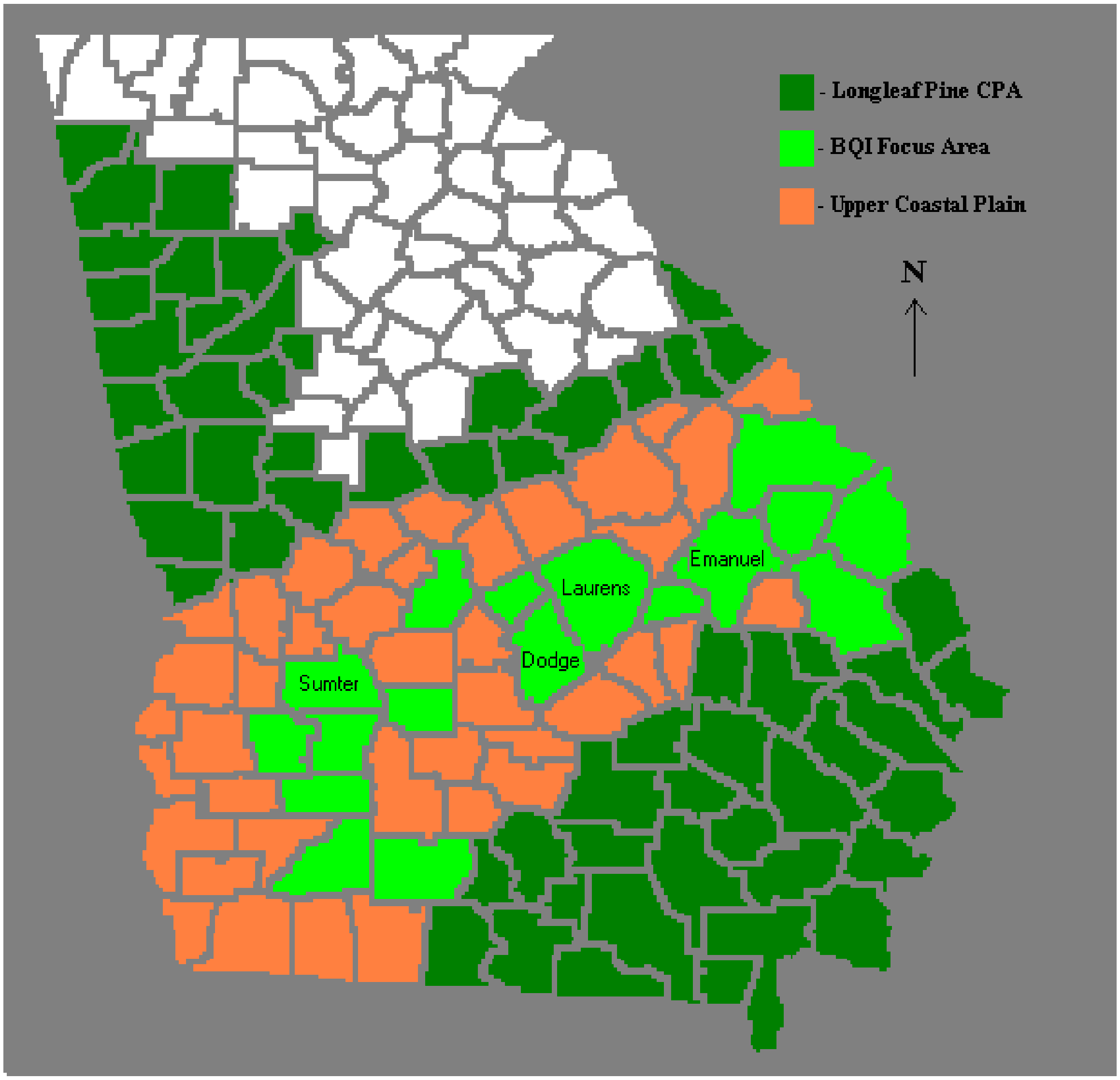

Figure 2.1. Study area within Dodge, Emanuel, Laurens, and Sumter counties in the Longleaf Pine CPA and BQI Focus Area in the Upper Coastal Plain of Georgia, 2001-2002.

Table 2.1. Bird species detected in line transect counts in 41 longleaf pine CPA stands in the Upper Coastal Plain of Georgia during late spring/early summer 2001-2002. Also included is bird habitat guilds and Breeding Bird Survey population status. An asterisk (*) indicates significant population trend according to Sauer et al 2007.

Common Name	**Scientific Name**	**Habitat Guild**	**Year(s) Detected**	**Pop. Trend**
Eastern Meadowlark	*Sturnella magna*	Grassland	2001, 2002	Declining*
Grasshopper Sparrow	*Ammodramus savannarum*	Grassland	2001, 2002	Declining*
Bobolink	*Dolichonyx oryzivorus*	Grassland	2002	Declining*
Horned Lark	*Eremophila alpestris*	Grassland	2001	Declining*
Savannah Sparrow	*Passerculus sandwichensis*	Grassland	2002	Declining*
American Goldfinch	*Carduelis tristis*	Shrub/scrub	2002	Declining*
Blue Grosbeak	*Guiraca caerulea*	Shrub/scrub	2001, 2002	Increasing*
Common Ground-Dove	*Columbina passerine*	Shrub/scrub	2001, 2002	Declining
Common Yellowthroat	*Geothlypis trichas*	Shrub/scrub	2002	Declining*
Eastern Bluebird	*Sialia sialis*	Shrub/scrub	2001, 2002	Increasing*
Eastern Kingbird	*Tyrannus tyrannus*	Shrub/scrub	2001, 2002	Declining*
Eastern Towhee	*Pipilo erythrophthalmus*	Shrub/scrub	2002	Declining*
Field Sparrow	*Spizella pusilla*	Shrub/scrub	2001, 2002	Declining*
Indigo Bunting	*Passerina cyanea*	Shrub/scrub	2001, 2002	Declining
Loggerhead Shrike	*Lanius ludovicianus*	Shrub/scrub	2002	Declining*

Table 2.1 continued.

Common Name	Scientific Name	Habitat Guild	Year(s) Detected	Pop. Trend
Mourning Dove	*Zenaida macroura*	Shrub/scrub	2001, 2002	Increasing
Northern Bobwhite	*Colinus virginianus*	Shrub/scrub	2001, 2002	Declining*
Northern Cardinal	*Cardinalis cardinalis*	Shrub/scrub	2001, 2002	Declining
Painted Bunting	*Passerina ciris*	Shrub/scrub	2001	Declining*
Yellow-breasted Chat	*Icteria virens*	Shrub/scrub	2002	Increasing
American Crow	*Corvus brachyehynchos*	Non-early succession	2002	Increasing*
Barn Swallow	*Hirundo rustica*	Non-early succession	2002	Declining*
Blue Jay	*Cyanocitta cristata*	Non-early succession	2002	Declining*
Brown Thrasher	*Taxostoma rufum*	Non-early succession	2002	Declining*
Brown-headed Cowbird	*Molothrus ater*	Non-early succession	2001, 2002	Declining*
Cattle Egret	*Bubulcus ibis*	Non-early succession	2001, 2002	Increasing
Chimney Swift	*Chaetura pelagica*	Non-early succession	2001, 2002	Declining*
Chipping Sparrow	*Spizella passerine*	Non-early succession	2001	Increasing
Common Grackle	*Quiscalus quiscula*	Non-early succession	2001, 2002	Declining*
Cooper's Hawk	*Ipiter cooperi*	Non-early succession	2002	Increasing*
Eastern Phoebe	*Sayornis phoebe*	Non-early succession	2002	Increasing*
Great Egret	*Ardea alba*	Non-early succession	2002	Increasing*
Great-crested Flycatcher	*Myiarchus crinitus*	Non-early succession	2001, 2002	Increasing

Table 2.1 continued.

Common Name	**Scientific Name**	**Habitat Guild**	**Year(s) Detected**	**Pop. Trend**
House Finch	*Carpodacus mexicanus*	Non-early succession	2002	Increasing
Northern Mockingbird	*Mimus polyglottos*	Non-early succession	2002	Declining*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Non-early succession	2002	Increasing
Orchard Oriole	*Icterus spurious*	Non-early succession	2001, 2002	Declining
Purple Martin	*Progne submis*	Non-early succession	2001, 2002	Declining
Red-bellied Woodpecker	*Melanerpes carolinus*	Non-early succession	2002	Increasing*
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Non-early succession	2002	Increasing*
Red-winged Blackbird	*Agelaius phoeniceus*	Non-early succession	2001/2002	Declining*
Ruby-throated Hummingbird	*Archilochus colubris*	Non-early succession	2001	Increasing*
Summer Tanager	*Piranga rubra*	Non-early succession	2002	Declining
Yellow-billed Cuckoo	*Coccyzus americanus*	Non-early succession	2002	Declining*
Unknown Bird[1]	-	Non-early succession	2001, 2002	-
Unknown Sparrow	-	Shrub/scrub	2001, 2002	-

[1] We were unsuccessful in identifying 32 birds and 4 sparrows in 2001 and 16 birds in 2002.

Table 2.2. Plant species observed in 41 longleaf pine CPA stands and field borders in the Upper Coastal Plain of Georgia, 2002. Plant type and origin are also included.

Common Name	**Scientific Name**	**Interior**	**Border**	**Type**	**Origin**
Collards	*Brassica oleracea*	x		Crop	Domesticated
Corn	*Zea mays*	x		Crop	Domesticated
Oat	*Avena sativa*	x		Crop	Domesticated
Pearl millet	*Pennisetum glaucum*	x		Crop	Domesticated
Rye	*Secale cereale*	x		Crop	Domesticated
Watermelon	*Citrullus lanatus*	x		Crop	Domesticated
Wheat	*Triticum aestivum*	x		Crop	Domesticated
Unknown aster	*Aster* spp.	x		Forb	Native
Baccharis	*Baccharis* spp.	x		Forb	Native
Bitter weed	*Helenium amarum*		x	Forb	Native
Butterfly pea	*Clitoria mariana*	x	x	Forb	Native
Camphor weed	*Heterotheca subaxillaris*	x	x	Forb	Native
Croton	*Croton capitatus*	x	x	Forb	Native
Dandelion	*Taraxacum officinale*	x		Forb	Native
Dogfennel	*Eupatorium capillifolium*	x		Forb	Native
Flea bane	*Erigeron* spp.	x		Forb	Native

Table 2.2 continued

Common Name	Scientific Name	Interior	Border	Type	Origin
Florida pussley	*Richardia scabra*	x	x	Forb	Native
Golden rod	*Solidago* spp.	x		Forb	Native
Horseweed	*Conyza canadensis*	x	x	Forb	Native
Ironweed	*Vernonia* spp.	x		Forb	Native
Japanese clover	*Kummerowia striata*	x	x	Forb	Exotic
Lamb's quarters	*Chenopodium album*	x	x	Forb	Native
Maypop	*Passiflora incarnata*	x		Forb	Native
Morning glory	*Ipomoea coccinea*	x	x	Forb	Native
Nightshade	*Solanum carolinense*	x	x	Forb	Native
Partridge pea	*Chamechrista* spp.	x	x	Forb	Native
Pigweed	*Amaranthus* spp.	x		Forb	Native
Pine weed	*Hypericum gentianoides*	x		Forb	Native
Poke berry	*Phytolacca americana*	x		Forb	Native
Primrose	*Oenothera* spp.	x	x	Forb	Native
Rabbit tobacco	*Gamocheata purpurea*	x	x	Forb	Native
Ragweed	*Ambrosia artemisiifolia*	x	x	Forb	Native
Rustweed	*Polypremum procumbens*	x	x	Forb	Native
Sicklepod	*Senna obtusifolia*	x	x	Forb	Exotic

Table 2.2 continued

Common Name	Scientific Name	Interior	Border	Type	Origin
Smartweed	*Polyganum* spp.	x		Forb	Native
Verbena	*Verbena brasiliensis*	x		Forb	Native
Virginia creeper	*Parthenocissus quinquefolia*	x		Forb	Native
Wild lettuce	*Lactuca canadensis*	x		Forb	Native
Wild sorrel	*Rumex* spp.	x		Forb	Native
Yellow wood sorrel	*Oxalis stricta*	x	x	Forb	Native
Bahia grass	*Paspalum notatum*	x		Grass	Exotic
Bermudagrass	*Cynodon dactlya*	x	x	Grass	Exotic
Broomsedge	*Andropogon virginicus*	x		Grass	Native
Crab grass	*Digitaria* spp.	x	x	Grass	Exotic
Dallis grass	*Paspalum dilatatum*	x		Grass	Exotic
Johnson grass	*Sorghum halepense*	x		Grass	Exotic
Love grass	*Eragrostis* spp.	x	x	Grass	Native
Misc. native grass	-	x	x	Grass	Native
Nut grass	*Scleria* spp.	x	x	Grass	Native
Oat grass	*Danthonia* spp.	x		Grass	Native
Panic grass	*Dichanthelium* spp.	x	x	Grass	Native
Unknown rush	-	x	x	Grass	Native

Table 2.2 continued

Common Name	Scientific Name	Interior	Border	Type	Origin
Rye grass	*Lolium* spp.	x	x	Grass	Exotic
Sandbur grass	*Cenchrus echinatus*	x	x	Grass	Native
Unknown sedge	-	x		Grass	Native
Thistle	*Cirsium lecontei*	x		Grass	Native
Vasey grass	*Paspalum urvillei*	x		Grass	Exotic
Black cherry	*Prunus serotina*	x		Woody	Native
Blackberry	*Rubus* spp.	x		Woody	Native
Cat briar	*Smilax bona-nox*	x		Woody	Native
China berry	*Melia azedarach*	x		Woody	Exotic
Greenbriar	*Smilax rotundifolia*	x		Woody	Native
Hawthorn	*Crataegus* spp.	x		Woody	Native
Longleaf pine	*Pinus palustris*	x		Woody	Native
Palmetto	*Sabal* spp.	x		Woody	Native
Pecan	*Carya illinoinensis*	x		Woody	Native
Persimmon	*Diospyros virginiana*	x		Woody	Native
Slash pine	*Pinus elliottii*		x	Woody	Native
Wild plum	*Prunus* spp.	x		Woody	Native
Winged sumac	*Rhus copallinum*	x		Woody	Native

Table 2.3. Mean values (±SE) for vegetative characteristics measured on 41 longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001, , 2002.

	2001		2002	
Variable	**BQI**	**non-BQI**	**BQI**	**non-BQI**
Vegetation height (dm)	1.01 ± 0.33	0.94 ± 0.27	3.50 ± 0.98	2.62 ± 0.73
Pine height (dm)	26.93 ± 7.09	31.04 ± 4.70	41.85 ± 10.82	60.10 ± 10.98
Grass cover (%)	19 ± 7	22 ± 5	16 ± 6	25 ± 6
Forb cover (%)	30 ± 6	31 ± 4	34 ± 7	26 ± 4
Woody cover (%)	1 ± 1	1 ± 1	1 ± 1	2 ± 1
Litter cover (%)	16 ± 4	24 ± 4	20 ± 5	33 ± 4
Bare ground (%)	34 ± 7	21 ± 4	29 ± 6	16 ± 3

Table 2.4. Percent occurrence of target plant species or groups in longleaf pine CPA restoration stands (N=41) in the Upper Coastal Plain of Georgia, 2001.

Plant Species or Group	**% Occurrence**	**Origin**
Broomsedge	7.3	Native
Bermuda grass	39.0	Exotic
Bahia grass	12.2	Exotic
Crab grass	26.8	Exotic
Miscellaneous grass	100	Mixture
Ragweed	17.1	Native
Beggarweed	0.0	Native
Partridge pea	0.0	Native
Sicklepod	53.7	Exotic
Miscellaneous legume	7.3	Native
Miscellaneous forb	100	Native
Rubus spp.	7.3	Native
Woody species	85.3	Mixture
Litter	100	-
Bare ground	100	-

Table 2.5. Mean density (birds/ha)[a] of bird habitat guilds detected during summer counts in all 41 longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001- 2002.

	2001				2002			
Habitat Guild	**Density**	**LCL** [b]	**UCL** [b]	**CV** [c]	**Density**	**LCL** [b]	**UCL** [b]	**CV** [c]
Grassland	0.036	0.016	0.082	0.437	0.123	0.077	0.196	0.240
Shrub/Scrub	1.607	1.370	1.885	0.081	1.687	1.461	1.947	0.073
Non-Early Succession	0.941	0.717	1.236	0.139	1.333	1.043	1.705	0.125

[a] Mean density of individuals from 3 bird counts in each of 41 longleaf pine stands from 4 June to 14 July in 2001 and 13 May to 10 June 2002.

[b] Density of individuals analytic lower (95% LCL) and upper (95% UCL) confidence limits.

[c] Density of individuals analytic coefficient of variance.

Table 2.6. Mean density (birds/ha)[a] of bird habitat guilds detected during summer counts in BQI longleaf pine restoration stands (N=14) in the Upper Coastal Plain of Georgia, 2001- 2002.

	2001				2002			
Habitat Guild	**Density**	**LCL**[b]	**UCL**[b]	**CV**[c]	**Density**	**LCL**[b]	**UCL**[b]	**CV**[c]
Grassland	0.004	0.001	0.015	0.742	0.010	0.004	0.024	0.461
Shrub/Scrub	0.144	0.086	0.241	0.266	0.186	0.127	0.273	0.194
Non-Early Succession	0.263	0.175	0.395	0.208	0.367	0.237	0.568	0.224

[a] Mean density of individuals from 3 bird counts in each of 14 longleaf pine stands from 4 June to 14 July in 2001 and 13 May to 10 June 2002.

[b] Density of individuals analytic lower (95% LCL) and upper (95% UCL) confidence limits.

[c] Density of individuals analytic coefficient of variance.

Table 2.7. Mean density (birds/ha)[a] of bird habitat guilds detected during summer counts in non-BQI longleaf pine restoration stands (N=27) in the Upper Coastal Plain of Georgia, 2001- 2002.

	2001				2002			
Habitat Guild	**Density**	**LCL**[b]	**UCL**[b]	**CV**[c]	**Density**	**LCL**[b]	**UCL**[b]	**CV**[c]
Grassland	0.009	0.004	0.021	0.446	0.030	0.018	0.051	0.274
Shrub/Scrub	0.220	0.161	0.300	0.159	0.154	0.116	0.203	0.142
Non-Early Succession	0.614	0.451	0.834	0.157	0.394	0.299	0.519	0.141

[a] Mean density of individuals from 3 bird counts in each of 27 longleaf pine stands from 4 June to 14 July in 2001 and 13 May to 10 June 2002.

[b] Density of individuals analytic lower (95% LCL) and upper (95% UCL) confidence limits.

[c] Density of individuals analytic coefficient of variance.

Table 2.8. Mean density (birds/ha)[a] of select clusters of bird species detected during summer counts in all 41 longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001- 2002.

	2001				**2002**			
Species	**Density**	**LCL**[b]	**UCL**[b]	**CV**[c]	**Density**	**LCL**[b]	**UCL**[b]	**CV**[c]
Blue Grosbeak	0.245	0.169	0.353	0.188	0.437	0.353	0.541	0.108
Eastern Kingbird	0.090	0.058	0.140	0.225	0.097	0.065	0.146	0.206
Field Sparrow	0.248	0.157	0.391	0.234	0.398	0.296	0.534	0.150
Indigo Bunting	0.068	0.044	0.103	0.217	0.114	0.072	0.181	0.236
Mourning Dove	0.618	0.406	0.940	0.215	0.261	0.127	0.537	0.378
Northern Bobwhite	0.080	0.045	0.142	0.298	0.105	0.069	0.159	0.214

[a] Mean density of individuals from 3 bird counts in each of 41 longleaf pine stands from 4 June to 14 July in 2001 and 13 May to 10 June 2002.

[b] Density of individuals analytic lower (95% LCL) and upper (95% UCL) confidence limits.

[c] Density of individuals analytic coefficient of variance.

Table 2.9. Mean density (birds/ha)[a] of select clusters of bird species detected during summer counts in BQI longleaf pine restoration stands (N=14) in the Upper Coastal Plain of Georgia, 2001- 2002.

	2001				2002			
Species	**Density**	**LCL**[b]	**UCL**[b]	**CV**[c]	**Density**	**LCL**[b]	**UCL**[b]	**CV**[c]
Blue Grosbeak	0.047	0.027	0.079	0.271	0.100	0.063	0.158	0.236
Eastern Kingbird	0.023	0.010	0.056	0.461	0.014	0.006	0.036	0.474
Field Sparrow	0.011	0.005	0.024	0.421	0.091	0.052	0.158	0.288
Indigo Bunting	0.006	0.003	0.013	0.387	0.028	0.016	0.051	0.300
Mourning Dove	0.098	0.033	0.286	0.578	0.014	0.004	0.056	0.742
Northern Bobwhite	0.035	0.014	0.089	0.494	0.009	0.004	0.019	0.419

[a] Mean density of individuals from 3 bird counts in each of 14 longleaf pine stands from 4 June to 14 July in 2001 and 13 May to 10 June 2002.

[b] Density of individuals analytic lower (95% LCL) and upper (95% UCL) confidence limits.

[c] Density of individuals analytic coefficient of variance.

Table 2.10. Mean density (birds/ha)[a] of select clusters of bird species detected during summer counts in longleaf pine restoration stands not entered in the BQI (N=27) in the Upper Coastal Plain of Georgia, 2001- 2002.

	2001				2002			
Species	**Density**	**LCL [b]**	**UCL [b]**	**CV [c]**	**Density**	**LCL [b]**	**UCL [b]**	**CV [c]**
Blue Grosbeak	0.055	0.038	0.080	0.189	0.072	0.052	0.099	0.166
Eastern Kingbird	0.023	0.011	0.047	0.377	0.017	0.011	0.028	0.244
Field Sparrow	0.078	0.050	0.120	0.224	0.069	0.045	0.104	0.213
Indigo Bunting	0.019	0.012	0.030	0.233	0.013	0.008	0.021	0.266
Mourning Dove	0.185	0.104	0.331	0.301	0.063	0.028	0.140	0.422
Northern Bobwhite	0.014	0.006	0.033	0.461	0.040	0.021	0.078	0.342

[a] Mean density of individuals from 3 bird counts in each of 27 longleaf pine stands from 4 June to 14 July in 2001 and 13 May to 10 June 2002.

[b] Density of individuals analytic lower (95% LCL) and upper (95% UCL) confidence limits.

[c] Density of individuals analytic coefficient of variance.

CHAPTER 3

AVIAN OCCUPANY AND SPECIES RICHNESS IN RESTORED EARLY SUCCESSION LONGLEAF PINE (*PINUS PALUSTRIS*) STANDS IN THE UPPER COASTAL PLAIN OF GEORGIA[3]

[3] Gates, B.J., R.J. Cooper, and J.P. Carroll. To be submitted to *Wilson Bulletin*.

ABSTRACT

The National Longleaf Pine (*Pinus palustris*) Conservation Priority Area (CPA) and Georgia's Bobwhite Quail Initiative (BQI) are programs aimed, in part, at restoring habitat for wildlife and grassland and shrub/scrub birds. We measured baseline breeding season bird occupancy (presence-absence) and relative species richness in 41 newly established (0-3 years of age) CPA stands in the Upper Coastal Plain of Georgia from 2001-2002. Fourteen stands were in BQI. Habitat association guild occupancy almost always increased between years. Grassland bird occupancy increased from 0.189 to 0.383 in all stands, but was generally higher when analyzed separately in non-BQI stands. Shrub/scrub species occupancy was high, regardless of stand-type. Individual species analysis yielded blue grosbeaks (*Guiraca caerulea*) displaying the highest occupancy rates in 2001 (0.9095) and 2002 (0.9795) overall while eastern meadowlarks (*Sturnella magna*) and grasshopper sparrows (*Ammodramus savannarum*) had the lowest occupancy rates overall (0.2747 and 0.2470 in 2002, respectively). No single habitat variable (covariate) had the greatest affect on bird occupancy, although vegetation height, percent cover of grass, forbs, litter, and bare ground seemed to have more effect than BQI management. We calculated relative species richness using occupancy models. We observed 44 bird species and species richness increased from 0.75 to 0.92 between years. The longleaf pine CPA in Georgia is providing habitat for a wide variety of bird species, but BQI management did not seem to have a positive affect on bird occupancy.

INTRODUCTION

Early succession bird species associate with open habitats, such as grasslands, abandoned farmland, bogs, open old-growth oak forests, and old-growth longleaf pine

(*Pinus palustris*) savannas (Hunter et al. 2001). Many of these species have had declining trends during the last 50 years in eastern North America (Askins 2000). In Georgia, grassland bird species, such as grasshopper sparrows (scientific names in Table 2.1) and eastern meadowlarks, have declined by >80% during 1966-2006 (Sauer 2007). Other species associated with early succession habitat in Georgia, such as northern bobwhites, field sparrows, and eastern towhees have also undergone significant declines (Sauer et al. 2007). Loss of early succession pine-grassland habitats has contributed possibly to the widespread declines of these bird species (Heard et al. 2000).

Because of declining bird population trends, wildlife management plans needed to be implemented to increase or at least sustain populations, particularly in the southeastern U.S. Congress approved the Longleaf Pine Conservation Priority Area (CPA) in 1998 to restore longleaf pine to its native range, particularly on privately-owned, unproductive crop fields. An indirect benefit of the program has been restoration of wildlife habitat (Heard et al. 2001). Similarly, Georgia legislation approved the Bobwhite Quail Initiative (BQI) to create nesting and brood rearing habitat for bobwhite quail (northern bobwhites), which in turn may benefit to other wildlife (including other breeding birds) as well as having positive effects on the environment. A key component of the BQI is that private landowners disk their fields and field borders in the winter to promote desirable weeds, grasses, and woody plants (Thackston 2007). Nearly three-fourths of the counties in Georgia are within the longleaf pine CPA and all of the BQI counties are within the CPA. In November 1999, longleaf pine CPA properties became eligible to enroll in the BQI, with the idea that the programs would be mutually beneficial to wildlife (R. Thackston, pers. comm.).

The objective of this study was to assess baseline bird occupancy and relative species richness in the early succession stage of newly established longleaf pine stands within the CPA in the Upper Coastal Plain of Georgia. We were particularly interested in bird species that have undergone significant declines. For conservation purposes, occupancy analysis may provide some important insight on bird species found in longleaf pine CPA lands, including those stands within the BQI focus area.

METHODS

Study Area

We located study sites in the Upper Coastal Plain of Georgia in Dodge, Emanuel, Laurens, and Sumter counties. These counties are in the CPA and BQI Focus Area (Figure 2.1). We used Natural Resource Conservation Service and Georgia Department of Natural Resources data and aerial photographs to identify 41 privately-owned longleaf pine stands enrolled in CPA and BQI programs. All 41 stands were enrolled in CPA, but only 14 of those stands were enrolled in BQI. Therefore, we classified the other 27 stands as non-BQI. Six stands were in Dodge county (4 BQI, 2 non-BQI), 16 stands were in Emanuel county (0 BQI, 16 non-BQI), 14 stands were in Laurens county (5 BQI, 9 non-BQI), and five stands were in Sumter county (5 BQI, 0 non-BQI). The stands ranged from 6.4 to 53.9 ha and averaged 16.2 ha in area. Each stand was previously planted in row crops or pasture. Stands were planted with longleaf pines of approximate even age ranging from 0 months to 3 years depending on the site. In 2001, 35 stands had already been planted with longleaf pines and 4 more were planted prior to our surveys in 2002. The other 2 stands were planted the following fall or winter after our surveys. We recorded additional details about each stand such as age and land use history such as previous crop or pasture grass type (See Appendix I).

Bird Counts

We conducted bird counts within each stand three times between 4 June to 14 July in 2001 and three times from 13 May to 10 June in 2002. We began counts at sunrise and continued for up to 3 hours. Before each count, we recorded temperature, weather conditions, and approximate wind speed. We did not conduct bird counts in adverse weather conditions (Robbins 1981). To reduce observer bias, we ensured that field technicians had strong bird identification skills. Our preliminary DISTANCE analysis (see Data Analysis) indicated that observer bias had no influence on detectability.

We used the line transect method described by Burnham et al. (1980) to sample birds. We randomly oriented a 250 m line in each stand at least 50 m from the edge of the field. We walked the line, flushed birds in the early successional habitat, and recorded species. Observers started at one transect line endpoint and walked the line at 1.5 km/hr pace toward the second point. To account for variation at either start point, we alternated start points for every other survey. We also alternated stands between counts so that each observer surveyed every stand at least once.

We recorded bird species and perpendicular distance to the bird from the observer for birds detected either aurally or visually. We only counted birds that actively used the stands. Birds that flew over the stands were recorded, but not used in analysis. We recorded unidentifiable native sparrows thought to be in family Emberizidae as "unknown sparrows." Occasionally birds we flushed "unknown birds" that could not be identified to species or family.

For analysis purposes, we grouped bird species into three functional "guilds" based on the habitats with which they are most associated. Habitat guilds were grassland species, shrub/scrub species, and all other species not associated with grassland and shrub/scrub habitat (non-early succession species) (Table 2.1). We assumed that "unknown sparrows" were associated with shrub/scrub habitat based on where they were observed. We grouped "unknown birds" in the non-early succession guild.

Vegetation Surveys

We conducted vegetation surveys usually on the same day as bird counts for each respective stand and measured vegetation three times in 2001 and 2002. We placed five 1–m^2 plots alternately along the surveying transect at 25, 75, 125, 175, and 225 m from the starting point. We placed each plot 5 m from the line center. We used a Robel pole to measure vegetation height (Robel et al. 1970). One observer held a pole divided in 0.5 dm increments in the center of the plot while another observer kneeled from 4 m away, and read height from the north, west, south, and east. We determined height by the topmost increment that was obstructed by vegetation and calculated mean height.

We also assessed vegetation structure by visually estimating the percent coverage of grasses, forbs, litter, bare ground, and woody plant species within the plot. For this study, grasses are generally defined as plant species of the family Poaceae; forbs are broadleaf, herbaceous plants; litter is fallen leaves, twigs, and other unclassified matter; bare ground is exposed soil and rocks; and woody species are saplings, shrubs, or other woody-stemmed plants. We calculated mean percent cover of each structure category for each stand to the nearest tenth. To eliminate bias, the same observer estimated all Robel pole and percent cover measurements.

Data Analysis

Bird Occupancy and Detection Probability – We estimated proportion of the area occupied (occupancy) and detection probability for select individual grassland and shrub/scrub bird species and habitat association guilds in single seasons using the model described by MacKenzie et al. (2002). The single-season model is useful in situations where a species is not guaranteed to be detected even when present at a site. Occupancy estimates could typically be calculated using the formula:

(# sites where species detected) / (total # sites surveyed)

For example, if we observed blue grosbeaks at 22 of the 41 longleaf pine stands we surveyed, then the occupancy rate for that species would be 22/41 or 0.537. However, that would underestimate the true occupancy for that species, yielding what is termed a naïve estimate. To calculate true occupancy we considered a site occupied if ≥ 1 birds were present at a specified time; probability of occupancy is ψ. Birds were detected if they were both present at a site and detected in at least 1 of k samples. The probability of detection is:

$$d = 1 - (1 - p)^k$$

where p is the detection probability on each of the samples. Therefore, the probability that a bird was both present and detected ("1") is:

$$\psi \times d$$

Birds were not detected ("0") if they were either not present, or were present, but not detected in at least 1 sample. The probability of this happening is:

$$(1 - \psi) + \psi(1 - d)$$

We used program PRESENCE to estimate global occupancy with constant detection rates for habitat association guilds and select grassland and shrub/scrub bird species.

We analyzed occupancy for each habitat guild. Although we collected data on all bird species observed, we limited occupancy analyses to habitat guilds and select grassland and shrub/scrub species because our goal was to assess bird species that are associated with early successional habitat. We detected enough eastern meadowlarks and grasshopper sparrows—both grassland birds—in 2002 for individual analysis. We analyzed six shrub/scrub song birds in both years: blue grosbeaks, common ground-doves, eastern kingbirds, field sparrows, and indigo buntings. Additionally, we analyzed two shrub/scrub game bird species: mourning doves and northern bobwhites.

Bird Occupancy with Habitat Covariates – Within PRESENCE, we used the logistic model to investigate relationships between bird occupancy (habitat guilds and select individuals) and several covariates. The logistic model ensures that bird occupancies stay between 0 and 1 (or absent-present). The logistic model is generally defined as:

$$\log_e(y/(1-y)) = X\beta$$

The value y is the probability of the bird species occupying the site and X represents a row vector containing the covariate values. The value β is a column vector of coefficient values that are to be estimated. Large positive values for $X\beta$ make y move towards to 1, while large negative $X\beta$ values make y move towards to 0 (McKenzie et al. 2002).

The site-specific covariate, BQI management (mgmt), is constant for each site. We also investigated the effects of sampling-occasion covariates that may change with each survey of a site: vegetation height (veght) and percent cover of grass (cvrgrass), forbs (cvrforbs), woody plants (cvrwdy), litter (cvrlitter), and bare ground (cvrbare). For comparison, we ran pre-defined models within PRESENCE that included 1 group and either a constant detection probability (p) or survey-specific detection probability. Groups refer to the number of unknown groups in the population of occupied sites with different detection probabilities (MacKenzie et al. 2002).

PRESENCE ranked the models using Akaike's Information Criterion (AIC) (Burnham and Anderson 1998); however, we did not correct for small sample sizes (AIC_c). For most species, we only report the top two best-fitting models to show that there was usually a strong contrast between the best-fitting model and the second best-fitting model. However, we reported every model for the bobwhite quail because the species is the primary bird of interest to the BQI program.

Bird Species Richness – We estimated relative bird community richness using occupancy models following MacKenzie et al. (2006) in program PRESENCE, which has the desirable feature of estimating and accounting for detection probability. We ran three models: constant detection probability, detection probability varying by survey, and with habitat association (grassland, shrub-scrub, or non-early succession) of each species as a covariate. Using this method, ψ from our occupancy models represents our estimate of the relative proportion of species found on our sites during a particular season. PRESENCE used AIC to determine the likelihood of the model being chosen.

RESULTS

Bird Analysis

Observations Overview – We observed 44 bird species during two field seasons, from 837 observations in 2001 and 939 observations in 2002 (Table 3.1). We found five grassland bird species: grasshopper sparrow (both years), eastern meadowlarks (both years), horned larks (2001), bobolinks (2002), and savannah sparrows (2001). We detected 10 shrub/scrub species in 2001, 14 in 2002, and 15 species total over both years. We found blue grosbeaks, common ground-doves, eastern kingbirds, field sparrows, indigo buntings, mourning doves, and northern bobwhites in both years. We found painted buntings in 2001 only. We detected American goldfinches, common yellowthroats, eastern towhees, loggerheaded shrikes, and yellow-breasted chats, only during 2002. We detected 10 non-early succession bird species in 2001 including chimney swifts, brown-headed cowbirds, red-winged blackbirds, and common grackles. We found 20 non-early succession species in 2002 including barn swallows, blue jays, brown thrashers, northern mockingbirds, and yellow-billed cuckoos.

Bird Occupancy and Detection Rate

Grassland bird species occupancy and detection rates were generally low, but increased between years in all stands and for both BQI and non-BQI stands separately (Table 3.2). However, grassland bird occupancy and detection probability was always greatest in non-BQI stands. Shrub/scrub species occupied nearly 100% of all stands combined in both years and was also near 100% in BQI and non-BQI stands (Table 3.2). Occupancy for shrub/scrub species decreased in BQI stands, yet detection probability was high and quite variable (0.96±0.06). Shrub/scrub species were more detectable in non-BQI stands in 2001 and in BQI stands in 2002.

In 2002, eastern meadowlarks and grasshopper sparrows had the lowest overall occupancy rates in all stands combined (Table 3.3). Blue grosbeaks had highest occupancy rates over all stands in both years (Table 3.3) and increased in both BQI and non-BQI stands between years (Tables 3.4 and 3.5). Detection probability also increased each year for all stands and in BQI stands, but decreased in non-BQI stands. Eastern kingbirds, field sparrows, and indigo buntings had occupancy rates ranging from 0.370 to 0.910 in 2001 and 0.448 to 0.980 in 2002. Common ground-dove occupancy was at 0.47 in 2001 for all stands combined with a low detection probability (0.27 ± 0.09, Table 3.3). In 2001, ground-dove occupancy was 0.56 in BQI stands (Table 3.4) and 0.57 in non-BQI stands (Table 3.5). We did not observe enough ground-doves in 2002 to estimate occupancy.

Northern bobwhite occupancy increased in both BQI and non-BQI stands between years, but had the lowest occupancy of all analyzed species in 2001 (Table 3.3). Also, bobwhites had its highest occupancy and greatest increase between years in those stands not entered in the BQI program (Table 3.4). Mourning doves had a high occupancy rate (0.73) in all stands combined in 2001 (Table 3.3), but decreased sharply in 2002 (0.53). Likewise, initially in non-BQI stands, mourning dove occupancy was high (0.74), but dropped sharply in 2002 (0.56). In BQI stands, mourning dove occupancy was high in 2001 (0.71), but we did not detect enough individuals in 2002 to estimate reliable actual occupancy.

Vegetation Analysis

Mean vegetative height ranged from 1.01 to 3.50 dm in BQI stands and 0.94 to 2.62 dm in non-BQI stands between years (Table 2.3). Grass cover ranged from 19 to 16% in BQI stands and 22 to 25% in non-BQI stands between years (Table 2.3). Forb cover ranged from 30 to 34% in BQI stands and 31 to 26 % in non-BQI stands. Woody cover averaged 1% across management practices and between years. Litter cover ranged from 16 to 20% in BQI and 24 to 33% in non-BQI. Bare ground cover ranged from 34 to 29% in BQI and 21 to 16% in non-BQI stands between years.

Bird Occupancy and Habitat Covariates

BQI management affected grassland bird guild occupancy the most, although in 2001, the model with constant detection rate was the better fit based on AIC (Table 3.7). Other vegetation measurements such as height and percent cover did not seem to affect occupancy of the grassland bird habitat association guild (Table 3.7). For shrub/scrub bird species, the best-fitting model in both years was with constant detection probability (Table 3.8). Habitat and management variables had little effect on shrub/scrub bird occupancy.

Of the grassland bird species we analyzed, eastern meadowlark occupancy was affected the most by management. Grasshopper sparrows were most affected by vegetation height, percent cover of litter, and management respectively (Table 3.9).

Blue grosbeak occupancy was most affected by forb cover in 2001, but the models with constant and variable detection rates ranked highest in 2002 (Table 3.10). Common ground-doves were most affected by bare ground percent cover in 2001 and management in 2002 (Table 3.10). Habitat variables had no effect on eastern kingbird occupancy (Table 3.10). Field sparrow occupancy was affected most by forb percent cover in 2001 and litter percent cover and vegetation height in 2002 (Table 3.10). Habitat variables did not affect indigo bunting occupancy in 2001, but bare ground and litter percent cover had the greatest affects in 2002 (Table 3.10).

Mourning dove occupancy did not seem to be affected by habitat covariates in 2001, but vegetation height and management had the greatest affects in 2002, respectively (Table 3.11). Management (BQI) had the greatest affect on bobwhite quail in 2001. Yet grass and bare ground percent cover also had affects in 2001. In 2002, however, litter percent cover had the greatest affect, while BQI management had less of an affect than it did in 2001.

Relative Bird Species Richness

We observed 44 bird species during the entire study with 23 species observed in 2001 and 39 species observed in 2002. The model with 1 group and constant detection probability was the best-fitting model in both years and represents the model from which we derived our estimate of relative species richness, ψ (Table 3.12). The model with a habitat association covariate ranked 3rd in 2001 and 2nd in 2002. From the best fitting model, we estimated relative species richness of 0.752 $\pm$ 0.067 in 2001, which was close to our naïve estimate of 0.744 (Table 3.13). In 2002 richness increased significantly to 0.925 ± 0.461, slightly higher than our naïve richness estimate of 0.907 (Table 3.13).

DISCUSSION

Grassland Bird Occupancy

We found grassland bird occupancy low in both BQI and non-BQI stands. This was not surprising because birds associated with grassland habitat have undergone significant declines in recent decades (Askins 2000, Brennan and Kuvlesky 2005, Knick et al. 2003, and Peterjohn and Sauer 1999), including the 5 we observed in this study: bobolinks, grasshopper sparrows, eastern meadowlarks, horned larks, and savannah sparrows (Sauer et al. 2007). The model with management affected the grassland bird guild the most in both years indicating that BQI might have had a negative affect on grassland bird occupancy. Management also possibly negatively affected eastern meadowlarks most in 2002. Conversely, vegetation height affected grasshopper sparrow occupancy in 2002.

Our results suggest that these birds are occupying some restored longleaf pine stands in the CPA in the Upper Coastal Plain in Georgia, but BQI management did not show a large degree of success in creating adequate habitat for grassland birds. One explanation for low grasshopper sparrow occupancy is that vegetation height was too high (Table 3.6) because they prefer relatively short and clumped grasses for nesting (Smith 1963). We found eastern meadowlarks only in stands with high concentrations of pasture grass. They are found commonly in this habitat type (Lanyon 1995).

Shrub/scrub Bird Occupancy

Shrub/scrub guild occupancy was high in BQI and non-BQI stands and in combined stands. Blue grosbeaks, common in early succession fields, occupied the greatest proportion of the stands in all treatments and have displayed increasing trends in the southeastern U.S. and Georgia (Sauer et al. 2007). Eastern kingbirds, common ground-doves, field sparrows, and indigo buntings were also found in relatively high proportions of stands in all treatments. Management and habitat covariates did not affect shrub/scrub guild occupancy in either year and there were no consistent trends of covariate effects on individual shrub/scrub species occupancy. Blue grosbeak occupancy was not affected by management type. We expected to find these species in early succession habitat (Dickson et al. 1993).

Mourning doves are increasing throughout their range (Sauer et al. 2007) and we found them in relatively high occupancy in both BQI and non-BQI stands in 2001. However, they decreased in combined and non-BQI stands. We are not clear as to what caused this decline; it may be caused by sampling error. Habitat covariates did not affect morning dove occupancy in 2001, but vegetation height and management had the greatest effects in 2002.

Our results suggest that the BQI did provide habitat for bobwhites although they occurred more in non-BQI stands. Many of the BQI management regimes were either not fully realized or being neglected to some extent. Future studies investigating songbird and game bird use of BQI stands after management has been well established—both in stand borders and interiors—need to be completed to fully examine the effects of BQI. Bobwhites are an important game species in Georgia, but to what extent they were hunted on these privately-owned stands is also unknown. Bird occupancy should also be measured in the fall season, especially for bobwhite quail.

Relative Bird Species Richness

Our richness estimates included grassland, shrub/scrub, and non-early succession species. Relative species richness increased significantly from 0.75 to 0.92 between years. This increase may be attributed to natural succession of bird species as habitat changed, but it is also likely that observer bird identification skills improved in 2002. The increase in species richness between years is consistent with other studies (e.g. Darden et al. 1990, Dickson et al. 1993). We observed more non-early succession bird species in longleaf pine restoration stands than grassland and shrub/scrub species combined and many of these non-early succession species, such as common grackles, brown-headed cowbirds, and red-winged blackbirds are generalists (Lowther 1993, Peer et al. 1997, and Yasukawa and Searcy 1995). High overall bird species richness suggests that longleaf pine CPA and BQI stands are providing habitat for a wide variety of bird species.

MANAGEMENT IMPLICATIONS

Our results suggest that CPA and BQI stands are providing habitat for birds, BQI management did not greatly affect bird occupancy. We believe that if management practices are enforced more stringently in CPA stands and if BQI stands are allowed time to establish wildlife-beneficial plants with winter disking, occupancy of bird species of concern (grassland and shrub/scrub) may increase. Current management practices are encouraging a wide variety of bird species, but most are non-early succession.

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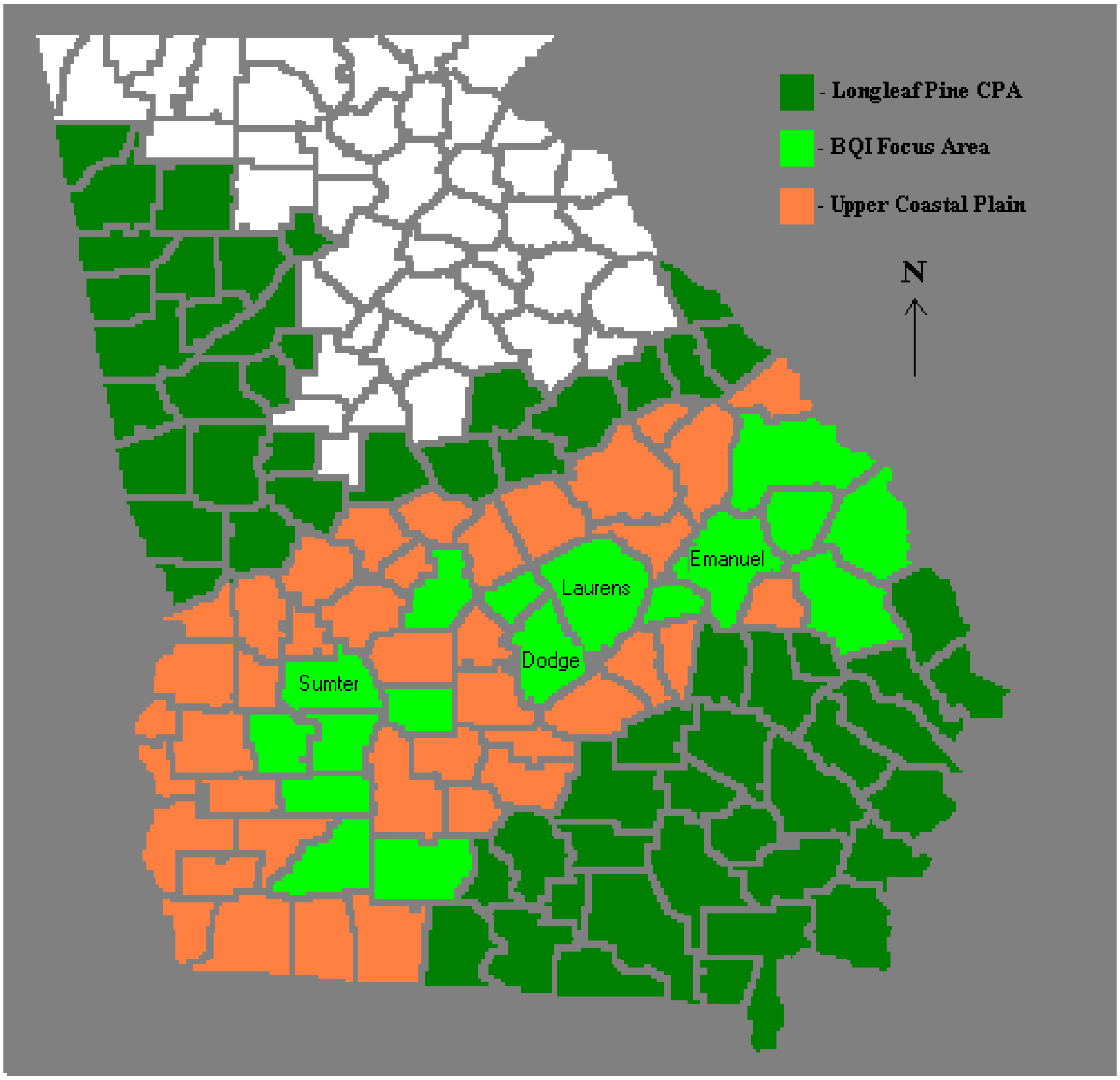

Figure 3.1. Study area within Dodge, Emanuel, Laurens, and Sumter counties in the Longleaf Pine CPA and BQI Focus Area in the Upper Coastal Plain of Georgia, 2001-2002.

Table 3.1. Bird species detected in line transect counts in 41 longleaf pine CPA stands in the Upper Coastal Plain of Georgia during late spring/early summer 2001-2002. Also included is bird habitat guilds and Breeding Bird Survey population status. An asterisk (*) indicates significant population status trend according to Sauer et al. 2007.

Common Name	**Scientific Name**	**Habitat Guild**	**Year(s) Detected**	**Pop. Status**
Eastern Meadowlark	*Sturnella magna*	Grassland	2001, 2002	Declining*
Grasshopper Sparrow	*Ammodramus savannarum*	Grassland	2001, 2002	Declining*
Bobolink	*Dolichonyx oryzivorus*	Grassland	2002	Declining*
Horned Lark	*Eremophila alpestris*	Grassland	2001	Declining*
Savannah Sparrow	*Passerculus sandwichensis*	Grassland	2002	Declining*
American Goldfinch	*Carduelis tristis*	Shrub/scrub	2002	Declining*
Blue Grosbeak	*Guiraca caerulea*	Shrub/scrub	2001, 2002	Increasing*
Common Ground-Dove	*Columbina passerine*	Shrub/scrub	2001, 2002	Declining
Common Yellowthroat	*Geothlypis trichas*	Shrub/scrub	2002	Declining*
Eastern Bluebird	*Sialia sialis*	Shrub/scrub	2001, 2002	Increasing*
Eastern Kingbird	*Tyrannus tyrannus*	Shrub/scrub	2001, 2002	Declining*
Eastern Towhee	*Pipilo erythrophthalmus*	Shrub/scrub	2002	Declining*
Field Sparrow	*Spizella pusilla*	Shrub/scrub	2001, 2002	Declining*
Indigo Bunting	*Passerina cyanea*	Shrub/scrub	2001, 2002	Declining
Loggerhead Shrike	*Lanius ludovicianus*	Shrub/scrub	2002	Declining*

Table 3.1 continued.

Common Name	Scientific Name	Habitat Guild	Year(s) Detected	Pop. Status
Mourning Dove	*Zenaida macroura*	Shrub/scrub	2001, 2002	Declining*
Northern Bobwhite	*Colinus virginianus*	Shrub/scrub	2001, 2002	Declining*
Northern Cardinal	*Cardinalis cardinalis*	Shrub/scrub	2001, 2002	Declining
Painted Bunting	*Passerina ciris*	Shrub/scrub	2001	Declining*
Yellow-breasted Chat	*Icteria virens*	Shrub/scrub	2002	Increasing
American Crow	*Corvus brachyehynchos*	Non-early succession	2002	Increasing*
Barn Swallow	*Hirundo rustica*	Non-early succession	2002	Declining*
Blue Jay	*Cyanocitta cristata*	Non-early succession	2002	Declining*
Brown Thrasher	*Taxostoma rufum*	Non-early succession	2002	Declining*
Brown-headed Cowbird	*Molothrus ater*	Non-early succession	2001, 2002	Declining*
Cattle Egret	*Bubulcus ibis*	Non-early succession	2001, 2002	Increasing
Chimney Swift	*Chaetura pelagica*	Non-early succession	2001, 2002	Declining*
Chipping Sparrow	*Spizella passerine*	Non-early succession	2001	Increasing
Common Grackle	*Quiscalus quiscula*	Non-early succession	2001, 2002	Declining*
Cooper's Hawk	*Ipiter cooperi*	Non-early succession	2002	Increasing*
Eastern Phoebe	*Sayornis phoebe*	Non-early succession	2002	Increasing*
Great Egret	*Ardea alba*	Non-early succession	2002	Increasing*
Great-crested Flycatcher	*Myiarchus crinitus*	Non-early succession	2001, 2002	Increasing

Table 3.1 continued.

Common Name	Scientific Name	Habitat Guild	Year(s) Detected	Pop. Status
House Finch	*Carpodacus mexicanus*	Non-early succession	2002	Increasing
Northern Mockingbird	*Mimus polyglottos*	Non-early succession	2002	Declining*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Non-early succession	2002	Increasing
Orchard Oriole	*Icterus spurious*	Non-early succession	2001, 2002	Declining
Purple Martin	*Progne submis*	Non-early succession	2001, 2002	Declining
Red-bellied Woodpecker	*Melanerpes carolinus*	Non-early succession	2002	Increasing*
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Non-early succession	2002	Increasing*
Red-winged Blackbird	*Agelaius phoeniceus*	Non-early succession	2001/2002	Declining*
Ruby-throated Hummingbird	*Archilochus colubris*	Non-early succession	2001	Increasing*
Summer Tanager	*Piranga rubra*	Non-early succession	2002	Declining
Yellow-billed Cuckoo	*Coccyzus americanus*	Non-early succession	2002	Declining*
Unknown Bird[1]	-	Non-early succession	2001, 2002	-
Unknown Sparrow	-	Shrub/scrub	2001, 2002	-

[1] We were unsuccessful in identifying 32 birds and 4 sparrows in 2001 and 16 birds in 2002.

Table 3.2. True and naïve occupancy estimates of habitat guilds, AIC values, and detection probabilities (±SE) in combined (N=41), BQI managed (N=14), and non-BQI managed (N=27) longleaf pine restoration stands, 2001-2002.

Species	Year	Management	Occupancy Rate	Naïve Estimate	AIC	Detection Rate/Survey	SE
Grassland	2001	Combined	0.189	0.146	60.894	0.389	0.867
	2002	Combined	0.383	0.366	116.077	0.542	0.087
	2001	BQI	0.076	0.071	14.946	0.605	0.701
	2002	BQI	0.251	0.214	30.210	0.475	0.156
	2001	non-BQI	0.265	0.185	48.225	0.327	0.095
	2002	non-BQI	0.490	0.444	87.484	0.572	0.150
Shrub/scrub	2001	Combined	0.995	1.000	87.932	0.913	0.062
	2002	Combined	1.000	1.000	52.813	0.931	1.524
	2001	BQI	0.974	1.000	43.164	0.786	1.080
	2002	BQI	0.829	1.000	31.448	0.955	0.066
	2001	non-BQI	0.935	1.000	60.440	0.985	0.088
	2002	non-BQI	0.996	1.000	40.894	0.850	0.046

Table 3.3. True and naïve occupancy estimates of select individual bird species, AIC values, and detection probabilities (±SE) in all longleaf pine restoration stands (N=41), 2001-2002.

Species	**Year**	**Occupancy Rate**	**Naïve Estimate**	**AIC**	**Detection Rate/Survey**	**SE**
Grasshopper Sparrow	2002	0.247	0.146	65.006	0.348	0.092
Eastern Meadowlark	2002	0.275	0.220	81.700	0.414	0.075
Blue grosbeak	2001	0.910	0.805	171.927	0.558	0.202
	2002	0.980	0.927	168.350	0.623	0.031
Common ground-dove	2001	0.473	0.293	96.232	0.275	0.085
	2002	-	-	-	-	-
Eastern kingbird	2001	0.783	0.488	132.548	0.281	0.203
	2002	0.836	0.585	148.290	0.331	0.041
Mourning dove	2001	0.732	0.634	159.012	0.489	0.048
	2002	0.530	0.341	107.033	0.291	0.074
Northern bobwhite	2001	0.370	0.293	94.050	0.356	0.042
	2002	0.549	0.439	129.315	0.414	0.051
Field sparrow	2001	0.537	0.488	137.936	0.574	0.123
	2002	0.530	0.512	127.033	0.861	0.071
Indigo bunting	2001	0.828	0.561	144.319	0.314	0.046
	2002	0.474	0.415	125.800	0.502	0.078

Table 3.4. True and naïve occupancy estimates of select individual bird species, AIC values, and detection probabilities (±SE) in longleaf pine restoration stands entered in the BQI (N=14), 2001-2002.

Species	Year	Occupancy Rate	Naïve Estimate	AIC	Detection Rate/Survey	SE
Blue grosbeak	2001	0.785	0.714	60.109	0.687	0.884
	2002	0.985	0.929	58.795	0.692	0.684
Common ground-dove	2001	0.561	0.429	45.876	0.382	0.076
	2002	-	-	-	-	-
Eastern kingbird	2001	0.704	0.500	49.380	0.338	0.073
	2002	0.851	0.500	47.662	0.271	0.716
Mourning dove	2001	0.708	0.643	57.221	0.521	0.207
	2002	-	-	-	-	-
Northern bobwhite	2001	0.426	0.357	41.574	0.446	0.102
	2002	0.521	0.357	40.597	0.320	0.103
Field sparrow	2001	0.374	0.286	35.921	0.382	0.092
	2002	0.583	0.571	49.842	0.740	0.101
Indigo bunting	2001	0.468	0.429	41.847	0.167	0.319
	2002	0.539	0.500	50.369	0.566	0.101

Table 3.5. True and naïve occupancy estimates of select individual bird species, AIC values, and detection probabilities (±SE) in longleaf pine restoration stands not entered in the BQI (N=27), 2001-2002.

Species	**Year**	**Occupancy Rate**	**Naïve Estimate**	**AIC**	**Detection Rate/Survey**	**SE**
Blue grosbeak	2001	0.809	0.852	119.489	0.672	0.044
	2002	0.990	0.926	113.470	0.599	0.041
Common ground-dove	2001	0.575	0.222	51.312	0.150	0.164
	2002	-	-	-	-	-
Eastern kingbird	2001	0.816	0.481	86.933	0.257	0.078
	2002	0.741	0.630	103.988	0.412	0.277
Mourning dove	2001	0.744	0.630	105.596	0.465	0.057
	2002	0.557	0.407	81.675	0.354	0.047
Northern bobwhite	2001	0.433	0.259	59.119	0.242	0.242
	2002	0.609	0.481	91.776	0.429	0.140
Field sparrow	2001	0.635	0.593	101.202	0.606	0.053
	2002	0.485	0.481	77.944	0.815	0.815
Indigo bunting	2001	0.741	0.630	103.988	0.412	0.277
	2002	0.449	0.370	78.239	0.443	0.072

Table 3.6. Mean values (±SE) for vegetative characteristics measured on 41 longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001 - 2002.

	2001		**2002**	
Variable	**BQI**	**non-BQI**	**BQI**	**non-BQI**
Vegetation height (dm)	1.01 ± 0.33	0.94 ± 0.27	3.50 ± 0.98	2.62 ± 0.73
Pine height (dm)	26.93 ± 7.09	31.04 ± 4.70	41.85 ± 10.82	60.10 ± 10.98
Grass cover (%)	19 ± 7	22 ± 5	16 ± 6	25 ± 6
Forb cover (%)	30 ± 6	31 ± 4	34 ± 7	26 ± 4
Woody cover (%)	1 ± 1	1 ± 1	1 ± 1	2 ± 1
Litter cover (%)	16 ± 4	24 ± 4	20 ± 5	33 ± 4
Bare ground (%)	34 ± 7	21 ± 4	29 ± 6	16 ± 3

Table 3.7. Model summaries of grassland bird habitat association guild occupancy (ψ) with vegetation structure measurements as covariates, AIC values, Δ AIC values, AIC weight, model likelihood, number of parameters, and -2*log likelihood in longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001-2002. Models are indicated by the variable in parentheses, with (.) indicating constant detection probability (p) across groups.

Habitat Guild	Year	Model	AIC	ΔAIC	AIC wgt	Model Likelihood	no.Par.	-2*LogLike
Grassland	2001	1 group, constant p	60.89	0.00	0.4271	1.0000	2	56.89
		ψ(mgmt),p(.)	61.97	1.08	0.2489	0.5827	2	57.97
		ψ(veght),p(.)	64.29	3.40	0.0780	0.1827	2	60.29
		ψ(cvrlitter),p(.)	64.37	3.48	0.0750	0.1755	2	60.37
		ψ(cvrforbs),p(.)	64.38	3.49	0.0746	0.1746	2	60.38
		ψ(cvrwdy),p(.)	64.38	3.49	0.0746	0.1746	2	60.38
		1 group, survey-specific p	66.83	5.94	0.0219	0.0513	4	58.83
		ψ(cvrgrass),p(.)	1181.45	1120.56	0.0000	0.0000	2	1177.45
		ψ(cvrbare),p(.)	1240.98	1180.09	0.0000	0.0000	2	1236.98
Grassland	2002	ψ(mgmt),p(.)	118.31	0.00	0.4443	1.0000	2	114.31
		ψ(cvrlitter),p(.)	120.90	2.59	0.1217	0.2739	2	116.90
		1 group, constant p	121.09	2.78	0.1107	0.2491	2	117.09
		ψ(veght),p(.)	121.25	2.94	0.1022	0.2299	2	117.25
		ψ(cvrwdy),p(.)	121.49	3.18	0.0906	0.2039	2	117.49
		ψ(cvrforbs),p(.)	121.49	3.18	0.0906	0.2039	2	117.49
		1 group, survey-specific p	123.13	4.82	0.0399	0.0898	4	115.13
		ψ(cvrgrass),p(.)	1216.76	1098.45	0.0000	0.0000	2	1212.76
		ψ(cvrbare),p(.)	1276	1157.69	0.0000	0.0000	2	1272.00

Table 3.8. Model summaries of shrub/scrub bird habitat association guild occupancy (ψ) with habitat structure measurements as covariates, AIC values, Δ AIC values, AIC weight, model likelihood, number of parameters, and -2*log likelihood in longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001-2002. Models are indicated by the variable in parentheses, with (.) indicating constant detection probability (p) across groups.

Habitat Guild	**Year**	**Model**	**AIC**	**ΔAIC**	**AIC wgt**	**Model Likelihood**	**no.Par.**	**-2*LogLike**
		1 group, constant p	60.89	0.00	0.4271	1.0000	2	56.89
		1 group, survey-specific p	61.97	1.08	0.2489	0.5827	2	57.97
		ψ(veght),p(.)	64.29	3.40	0.0780	0.1827	2	60.29
		ψ(cvrlitter),p(.)	64.37	3.48	0.0750	0.1755	2	60.37
Grassland	2001	ψ(mgmt),p(.)	64.38	3.49	0.0746	0.1746	2	60.38
		ψ(cvrwdy),p(.)	64.38	3.49	0.0746	0.1746	2	60.38
		ψ(cvrforbs),p(.)	66.83	5.94	0.0219	0.0513	4	58.83
		ψ(cvrgrass),p(.)	1181.45	1120.56	0.0000	0.0000	2	1177.45
		ψ(cvrbare),p(.)	1240.98	1180.09	0.0000	0.0000	2	1236.98
		1 group, constant p	118.31	0.00	0.4443	1.0000	2	114.31
		1 group, survey-specific p	120.90	2.59	0.1217	0.2739	2	116.90
		ψ(veght),p(.)	121.09	2.78	0.1107	0.2491	2	117.09
		ψ(cvrlitter),p(.)	121.25	2.94	0.1022	0.2299	2	117.25
Grassland	2002	ψ(mgmt),p(.)	121.49	3.18	0.0906	0.2039	2	117.49
		ψ(cvrgrass),p(.)	121.49	3.18	0.0906	0.2039	2	117.49
		ψ(cvrbare),p(.)	123.13	4.82	0.0399	0.0898	4	115.13
		ψ(cvrforbs),p(.)	1216.76	1098.45	0.0000	0.0000	2	1212.76
		ψ(cvrwdy),p(.)	1276	1157.69	0.0000	0.0000	2	1272.00

Table 3.9. Model summaries of select individual grassland bird species occupancy (ψ) with habitat structure measurements as covariates, AIC values, Δ AIC values, AIC weight, model likelihood, number of parameters, and -2*log likelihood in longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001-2002. Models are indicated by the variable in parentheses, with (.) indicating constant detection probability (p) across groups.

Species	**Year**	**Model**	**AIC**	**ΔAIC**	**AIC Wgt**	**Model Likelihood**	**No.Par.**	**-2*LogLike**
Eastern meadowlark	2002	ψ(mgmt),p(.)	79.36	0.00	0.4623	1.0000	2	75.36
		1 group, constant p	81.7	2.34	0.1435	0.3104	2	77.699702
Grasshopper sparrow	2002	ψ(veght),p(.)	66.33	0.00	0.4309	1.0000	2	62.33
		ψ(cvrlitter),p(.)	67.55	1.22	0.2341	0.5434	2	63.55
		ψ(mgmt),p(.)	67.64	1.31	0.2238	0.5194	2	63.64

Table 3.10. Model summaries of select individual shrub/scrub bird species occupancy (ψ) with habitat structure measurements as covariates, AIC values, Δ AIC values, AIC weight, model likelihood, number of parameters, and -2*log likelihood in longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001-2002. Models are indicated by the variable in parentheses, with (.) indicating constant detection probability (p) across groups.

Species	Year	Model	AIC	ΔAIC	AIC Wgt	Model Likelihood	No.Par.	-2*LogLike
Blue grosbeak	2001	ψ(cvrforbs),p(.)	171.72	0.00	0.4885	1.0000	2	76.51
		1 group, constant p	171.93	0.21	0.4398	0.9003	2	78.64
	2002	1 group, constant p	168.35	0.00	0.7941	1.0000	2	80.07
		1 group, survey-specific p	171.05	2.70	0.2059	0.2592	4	80.45
Common ground-dove	2001	ψ(cvrbare),p(.)	95.18	0.00	0.4489	1.0000	2	111.40
		1 group, constant p	96.23	1.05	0.2655	0.5916	2	111.58
	2002	ψ(mgmt),p(.)	80.51	0.00	0.4357	1.0000	2	128.55
		1 group, constant p	82.64	2.13	0.1502	0.3447	2	128.32
Eastern kingbird	2001	1 group, constant p	132.55	0.00	0.6114	1.0000	2	119.02
		1 group, survey-specific p	136.32	3.77	0.0928	0.1518	4	119.37
	2002	1 group, constant p	148.29	0.00	0.4188	1.0000	2	140.32
		ψ(cvrbare),p(.)	149.75	1.46	0.2018	0.4819	2	139.30
Field sparrow	2001	ψ(cvrforbs),p(.)	130.97	0.00	0.6953	1.0000	2	119.77
		ψ(cvrbare),p(.)	134.56	3.59	0.1155	0.1661	2	121.32
	2002	ψ(cvrlitter),p(.)	123.02	0.00	0.2431	1.0000	2	76.51
		ψ(veght),p(.)	123.37	0.35	0.2040	0.8395	2	78.64
Indigo bunting	2001	1 group, constant p	144.32	0.00	0.6036	1.0000	2	80.07
		1 group, survey-specific p	147.3	2.98	0.1360	0.2254	4	80.45
	2002	ψ(cvrbare),p(.)	123.77	0.00	0.2833	1.0000	2	111.40
		ψ(cvrlitter),p(.)	125.32	1.55	0.1305	0.4607	2	111.58

Table 3.11. Model summaries of game bird species occupancy (ψ) with habitat structure measurements as covariates, AIC values, Δ AIC values, AIC weight, model likelihood, number of parameters, and -2*log likelihood in longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001-2002. Models are indicated by the variable in parentheses, with (.) indicating constant occupancy or detection probability (p) across groups.

Species	Year	Model	AIC	ΔAIC	AIC Wgt	Model Likelihood	No.Par.	-2*LogLike
Mourning dove	2001	1 group, survey-specific p	158.81	0.00	0.4217	1.0000	4	150.81
		1 group, constant p	159.01	0.20	0.3815	0.9048	2	155.01
	2002	ψ(veght),p(.)	105.50	0.00	0.2128	1.0000	2	101.50
		ψ(mgmt),p(.)	105.96	0.46	0.1691	0.7945	2	101.96
Northern bobwhite	2001	ψ(cvrgrass),p(.)	97.81	0.00	0.2889	1.0000	2	93.81
		1 group, constant p	98.05	0.24	0.2562	0.8869	2	94.05
		ψ(cvrbare),p(.)	99.32	1.51	0.1358	0.4700	2	95.32
		ψ(cvrlitter),p(.)	99.67	1.86	0.1140	0.3946	2	95.67
		ψ(veght),p(.)	100.00	2.19	0.0966	0.3345	2	96.00
		1 group, survey-specific p	100.63	2.82	0.0705	0.2441	4	92.63
		ψ(cvrforbs),p(.)	103.11	5.30	0.0204	0.0707	2	99.11
		ψ(mgmt),p(.)	**103.40**	**5.59**	**0.0177**	**0.0611**	**2**	**99.40**
		ψ(cvrwdy),p(.)	1242.19	1144.38	0.0000	0.0000	2	1238.19
Northern bobwhite	2002	ψΨ(cvrlitter),p(.)	125.63	0.00	0.4890	1.0000	2	121.63
		ψΨ(veght),p(.)	128.32	2.69	0.1274	0.2605	2	124.32
		ψΨ(cvrbare),p(.)	129.28	3.65	0.0788	0.1612	2	125.28
		1 group, constant p	129.31	3.68	0.0777	0.1588	2	125.31
		ψ(mgmt),p(.)	**129.34**	**3.71**	**0.0765**	**0.1565**	**2**	**125.34**
		ψ(cvrforbs),p(.)	129.51	3.88	0.0703	0.1437	2	125.51
		ψ(cvrgrass),p(.)	129.51	3.88	0.0703	0.1437	2	125.51
		1 group, survey-specific p	133.40	7.77	0.0100	0.0205	4	125.40
		ψ(cvrwdy),p(.)	1245.83	1120.20	0.0000	0.0000	2	1241.83

Table 3.12. Model summaries of bird community richness using occupancy models with AIC values, Δ AIC values, AIC weight, model likelihood, number of parameters, and -2*log likelihood in longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001-2002. Models are indicated by the variable in parentheses, with (.) indicating constant detection probability (p) across groups.

Year	Model	AIC	ΔAIC	AIC Wgt	Model Likelihood	No.Par.	-2*LogLike
	1 group, constant p[a]	150.54	0.00	0.5503	0.3028	2	146.54
2001	1 group, survey-specific p[b]	152.14	1.60	0.2473	0.1361	4	144.14
	ψ(.),p(habitat)[c]	152.54	2.00	0.2024	0.1114	3	146.54
	1 group, constant p	162.38	0.00	0.6391	1.00	2	158.38
2002	ψ(.),p(habitat)	164.38	2.00	0.2351	0.37	3	158.38
	1 group, survey-specific p	165.63	3.25	0.1258	0.20	4	157.63

[a] Model "1 group, constant p" represents species at all surveys/samples detected with a single probability, p.

[b] Model "1 group, survey-specific p" represents detection probability at all surveys.

[c] Model "ψ(.),p(habitat)" represents the occupancy model parameter (ψ) and detection probability, p, with habitat as a covariate.

Table 3.13. Number of bird species detected, estimates of bird community richness (±SE), naïve species richness, and detection rate (±SE) using occupancy models in the longleaf pine restoration stands in the Upper Coastal Plain of Georgia, 2001-2002.

Year	No. Species	Richness	SE	Naïve Richness	Detection Rate	SE
2001	23	0.7518	0.067385	0.744186	0.78365	0.044349
2002	39	0.9254	0.046142	0.906977	0.728749	0.04451

CHAPTER 4

CONCLUSION

I assessed baseline bird communities and vegetation composition in newly established longleaf pine (*Pinus palustris*) Conservation Priority Area (CPA) and Bobwhite Quail Initiative (BQI) stands in the Upper Coastal Plain of Georgia. I used distance sampling to estimate density. Distance analysis indicated that birds generally were more abundant in stands not in the BQI program. However, I did detect some bird species of concern in both BQI and non-BQI stands including, bobolinks (*Dolichonyx oryzivorus*), grasshopper sparrows (*Ammodramus savannarum*), eastern meadowlarks (*Sturnella magna*), horned lark (*Eremophila alpestris*), savannah sparrows (*Passerculus sandwichensis*), loggerhead shrikes (*Lanius ludovicianus*), and painted buntings (*Passerina ciris*). These grassland and shrub/scrub species have undergone significant declines throughout their ranges according to the Breeding Bird Survey. I detected so few of these species; however, that I could not estimate their densities in distance analysis. Contrary to my hypothesis, northern bobwhites (*Colinus virginianus*) were not more abundant in BQI stands.

Vegetation structure (% cover) varied considerably between BQI and non-BQI stands. Forb and bare ground % cover represented the greatest overall structure in the stands we surveyed. Non-BQI stands generally had more grass cover (particularly exotic pasture grass), while BQI stands consisted of more forb and bare ground cover. There were not significant differences in vegetative cover in BQI and non-BQI stands. I observed over 30 forb species in 2002, including 17 in BQI field borders. These forbs included native and exotic weeds and volunteer crops. Grass species, mostly exotic pasture grasses, occupied the greatest proportion of stands (60%), while more desirable species such as native legumes, broomsedge (*Andropogon virginicus*), and ragweed (*Ambrosia artemisiifolia*) were in < 5% of the stands.

I used occupancy models to estimate bird occupancy (presence-absence), detection probability and bird community species richness. All of the bird habitat guilds and most of the individual bird species we analyzed occupied non-BQI stands more readily. As with our abundance analysis, occupancy was generally low for grassland birds, the lowest of the three guilds I investigated. Two individual grassland species I analyzed, grasshopper sparrows and eastern meadowlarks, also had low occupancy rates in all stands combined. Shrub/scrub species occupancy varied depending on the species. Blue grosbeaks (*Guiraca caerulea*), a species of less conservation concern, had the highest overall occupancy rate. However, species of greater concern either for conservation (declining population) or recreation (hunting) had lower occupancy rates.

My bird community species richness analysis was different from the usual Shannon-Weiner Index calculation. We constructed 3 occupancy models, 1 with constant detection rate, 1 with variable detection rate, and 1 with bird habitat association as a covariate. My results suggest that habitat did not have much of an affect on richness as I would have suspected. The model with constant detection probability ranked the highest. Bird community species richness was generally high and increased between years. Increased observer identification skills and sampling period (I began samples one month earlier in 2002) may have contributed to the increase. However, the relatively high richness estimates in 2001 and 2002 suggest that while I did not detect individual species in great numbers, the longleaf pine CPA and BQI does provide habitat for a wide variety of bird species.

APPENDIX I

Longleaf Pine Conservation Priority Area and Bobwhite Quail Initiative (BQI) Stand Histories

Landowner	County	Size (ha)	Stand #	Management	Date Planted	Old Crop	Comments
GM1	Laurens	9.6	1	non-BQI	unknown	unknown	
MM	Laurens	17.6	1	non-BQI	Dec-00/Jan-01	rye	
		18.8	2	non-BQI	Dec-00/Jan-01	rye	
		28	3	non-BQI	Dec-00/Jan-01	rye	
		7.9	4	non-BQI	Dec-00/Jan-01	rye	
		38.3	5	non-BQI	Dec-00/Jan-01	rye	
		15.9	6	non-BQI	Dec-00/Jan-01	rye	
GF	Laurens	15.7	1	non-BQI	Oct-00	pasture	
		19.5	2	non-BQI	Oct-00	pasture	
RC	Laurens	14	1	BQI	Oct-01	soy bean	
		12.7	2	BQI	Oct-01	soy bean	
ML	Laurens	24.9	1	BQI	Jan & Feb-01	soy bean	
		6.4	2	BQI	Oct-99	cotton/peanuts	Roundup Ready Cotton
		53.9	3	BQI	Oct-99	cotton/peanuts	Roundup Ready Cotton
LS	Emanuel	9.2	1	non-BQI	Dec-00	grain/pasture	
		10.7	2	non-BQI	Dec-00	grain/pasture	
		9	3	non-BQI	Dec-00	grain/pasture	
		9.1	4	non-BQI	Dec-00	grain/pasture	

APPENDIX I continued.

FS	Emanuel	18.2	1	non-BQI	Dec-00	pasture	Replanted 2001
		23	2	non-BQI	Dec-00	pasture	Replanted 2001
		30.2	3	non-BQI	Dec-00	pearl millet	Replanted 2001
		6.7	4	non-BQI	Dec-00	millet/corn	Replanted 2001
		10	5	non-BQI	Dec-00	millet/corn	Replanted 2001
		10	6	non-BQI	Dec-00	millet/corn	Replanted 2001
AM	Emanuel	10.3	1	non-BQI	Feb-01	cotton/wheat	
		12	2	non-BQI	Feb-01	cotton/wheat	
CO	Emanuel	11.3	1	non-BQI	Jan-01	cotton,soy,oats	
		10.5	2	non-BQI	Jan-01	cotton,soy,oats	
GM2	Emanuel	6.8	1	non-BQI	unknown	unknown	
BG	Emanuel	13.5	1	non-BQI	Dec-98/Jan-99	cotton	Replanted Dec-00/Jan-01
PH	Dodge	20.9	1	BQI	Dec-00	peanuts,cotton	
		17.8	2	BQI	Dec-00	peanuts,cotton	
		14.4	3	BQI	Dec-00	peanuts,cotton	
DP	Dodge	10.3	1	BQI	Feb-01	soy bean	
LH1	Dodge	19.6	1	non-BQI	unknown	unknown	
		7	2	non-BQI	unknown	unknown	
RW	Sumter	10.4	1	BQI	Fall 2001	unknown	
KS	Sumter	18.1	3	BQI	Dec-99	Cotton	Replanted Dec-00
		6.8	4	BQI	Dec-99	Cotton	Replanted Dec-00
LH2	Sumter	44	1	BQI	Nov-01	cotton/peanuts	
		9.4	2	BQI	Nov-01	cotton/peanuts	

Stand Size Totals	**Hectares**	662.4
	Mean	16.2
	Range	6.4 - 53.9