EFFECTS OF INTENSIVE PINE PLANTATION MANAGEMENT ON WINTERING AND BREEDING AVIAN COMMUNITIES IN SOUTHERN MISSISSIPPI

By

Phillip Hanberry

A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Wildlife and Fisheries Science
in the Department of Wildlife and Fisheries

Mississippi State, Mississippi

May 2005

Federal Aid in Wildlife Restoration Funds

Project W-48, Study 57

EFFECTS OF INTENSIVE PINE PLANTATION MANAGEMENT

ON WINTERING AND BREEDING AVIAN COMMUNITIES

IN SOUTHERN MISSISSIPPI

By

Phillip Hanberry

Approved:

Stephen Demarais
Professor of Wildlife and Fisheries
(Co-Major Professor)

Jeanne C. Jones
Associate Professor of Wildlife and Fisheries
(Co-Major Professor)

Andrew W. Ezell
Professor of Forestry
(Committee Member)

Eric T. Linder
Assistant Professor of Biological Sciences
(Committee Member)

Bruce D. Leopold
Professor and Head of the
Department of Wildlife and Fisheries

Bob L. Karr
Interim Dean of the College of
Forest Resources

Name: Phillip Hanberry

Date of Degree: May 7, 2005

Institution: Mississippi State University

Major Field: Wildlife and Fisheries Science

Major Professors: Dr. Stephen Demarais and Dr. Jeanne Jones

Title of Study: EFFECTS OF INTENSIVE PINE PLANTATION MANAGEMENT ON WINTERING AND BREEDING AVIAN COMMUNITIES IN SOUTHERN MISSISSIPPI

Pages in Study: 75

Candidate for Degree of Master of Science

The growth of intensive pine plantation management requires consideration of how management activities affect native biological diversity. I evaluated the effects of 5 pine plantation establishment regimes varying from low to high intensity on abundance of wintering birds during years 1, 2, and 3 post-treatment, and breeding birds during years 1 and 2 post-treatment on 4 timber industry stands in southern Mississippi. Also, I tested models comprised of 6 habitat variables to identify the most influential variables on abundance of species of concern. Bird abundance generally decreased with increasing treatment intensity. Also, species richness and species of concern were associated negatively with treatment intensity. Snag density appeared to be the most influential variable related to abundance of species of concern. Knowledge of habitat conditions that affect bird abundance on intensively managed pine plantations can aid managers interested in attaining forestry objectives, while providing habitat for avian communities.

ACKNOWLEDGEMENTS

I would like to thank my major advisors, Dr. Steve Demarais and Dr. Jeanne Jones, for their support, encouragement, and manuscript edits. I am grateful for the suggestions and reviews of my committee members, Dr. Andy Ezell and Dr. Eric Linder.

I am indebted to all the graduate students who were there to supply continual assistance and support, especially Scott Edwards, without whom I could not have made it through this project. I would also like to thank Brice Bond and Russell Singleton for their birding help and expertise, Jarrod Fogarty, Joshua Stafford, and Bronson Strickland for all the statistical help, and Lee Woodall and Houston Havens for their encouragement throughout the program. Most of all though, I would like to thank my parents for more things than I am able to list.

I am appreciative for all the timber industry foresters who managed the stands: Phil Brown and Deland Miller with Molpus Timberlands, Angela Holland with Plum Creek Timber Company, and Tina Knoll, Bobby Armstrong, and Mark Perry with Weyerhaeuser Company. Study sites and treatment installation were provided by Molpus Timberlands, Plum Creek Timber Company, and Weyerhaeuser Company. Funding for this study was provided by the Mississippi Department of Wildlife, Fisheries, and Parks, the National Council of Air and Stream Improvement, Inc., Federal Aid in Wildlife Restoration, Weyerhaeuser Company, International Paper Company, MeadWestvaco Corporation, and Boise Cascade Corporation.

TABLE OF CONTENTS

CHAPTER Page

LIST OF TABLES

TABLE Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Area in pine plantations in the South is predicted to increase from 12.0 to 22.0 million hectares between 1999 and 2040 (Conner and Hartsell 2002, Prestemon and Abt 2002). Three main factors contributing to increasing use of intensive management in these plantations are the increasing costs of accessing old-growth forests, technology that has increased productivity and yields of short rotation timber plantations, and social pressure to protect old-growth forests (Sedjo and Botkin 1997). Silvicultural tools common in intensive timber management include planting improved stock, using herbicides to control competing vegetation, fertilizing, and thinning (Yin and Sedjo 2001). If management intensity is too great then the plantations may be dominated by fast growing pines, and potentially be unsuitable for some species of birds.

The growth of intensive pine plantation management requires consideration of how management activities affect native biological diversity. Managing biodiversity includes more than providing for threatened and endangered species; it means maintaining the integrity of ecological processes and the continuation of all species over time (Pregitzer et al. 2001). Research is needed to quantify how the increase in management intensity will affect the ecology of the plantations (Yin and Sedjo 2001). Proactive approaches integrating sustainable forest commodity production and

conservation of native biological diversity can prevent rare species from becoming threatened or endangered (Hunter 1990).

Most avian species associated with early successional habitat, consisting of grasslands and shrublands, are decreasing (Askins 2001, Hunter et al. 2001). Hunter et al. (2001) found declines in 27 of 37 grassland bird species and 27 of 40 shrubland bird species in eastern North America. Suppression of disturbance, mainly fire, has reduced the amount of early successional habitat (Askins 2000). Clearcuts, powerlines, and old fields are now essential sources of shrubland (Hunter et al. 2001). Clearcuts can provide necessary habitat for many disturbance-dependent birds (Thompson and DeGraaf 2001).

Managers should consider species of concern and their habitat associations when deciding how tree harvests affect bird populations. Past studies have focused on effects of clearcutting on abundance and distribution of avian communities (Yahner 1997, Sallabanks et al. 2000). Small (<1 ha) clearcuts seem to have no local long-term effects upon most breeding and wintering forest birds (Yahner 1993). In widely forested areas, clearcuts increase abundance of some bird species and decrease others compared to unharvested areas. However, clearcutting in these areas may be compatible with sustaining neotropical migrant bird populations (Thompson et al.1992). Merrill et al. (1998) found that residual patches in clearcuts benefited several species of regional concern in Minnesota, and could increase bird populations at larger scales.

Herbicides may influence breeding bird diversity by changing vegetative structure and composition (Cone et al. 1993, Brooks et al. 1994). Herbicides may affect density and behavior of songbirds by altering vegetative structure (Morrison and Meslow 1984). When herbicides increase floral community complexity, songbird populations may

increase (Schultz et al. 1992). The opposite is also true, songbird populations may decrease when herbicides reduce floral community complexity (Santillo et al. 1989).

The effects of intensive pine plantation management were monitored on 4 forest industry stands in southern Mississippi. Management regimes (i.e., treatments) were selected to represent a range of operational intensities in forest industry site preparation and release techniques. Five treatments were created increasing from a "low" for treatment 1 to "high" for treatment 5. I will quantify the effects of these 5 pine plantation establishment regimes on wintering and breeding avian communities (Chapter II) and determine relationships among the plant communities, standing snags or dead wood, and the associated breeding avian community (Chapter III). I hypothesize that as treatment intensity increases, bird numbers will be negatively impacted. This study will provide managers with information regarding initial effects of intensive pine plantation management alternatives on avian communities, and will allow them to make more informed decisions when planning intensive forest management regimes.

LITERATURE CITED

Askins, R. A. 2000. North America's birds: lessons from landscape ecology. Yale University Press, New Haven, Connecticut, USA.

Askins, R. A. 2001. Sustaining biological diversity in early successional communities: the challenge of managing unpopular habitats. Wildlife Society Bulletin 29:407-412.

Brooks, J. J., J. L. Rodrigue, M. A. Cone, K. V. Miller, B. R. Chapman, and A.S. Johnson. 1994. Small mammal and avian communities on chemically-prepared sites in the Georgia Sandhills. Proceedings of the Biennial Southern Silvicultural Research Conference 8:21-23.

Cone, M. A., J. J. Brooks, B. R. Chapman, and K.V. Miller. 1993. Effects of chemical site preparation on songbird use of clearcuts in Georgia. Proceedings of the Southern Weed Science Society 46:175.

Conner, R. C., and A. J. Hartsell. 2002. Forest area and conditions. Pages 357-402 *in* Wear, D. N., and J. G. Greis, editors. Southern forest resource assessment. USDA, Southern Research Station, Asheville, North Carolina, USA.

Hunter, M. L. 1990. Wildlife, forests, and forestry, principles of managing forests for biological diversity. Prentice Hall, Englewood, New Jersey, USA.

Hunter, W. C., D. A. Buehler, R. A. Canterbury, J. L. Confer, and P. B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin 29:440-455.

Morrison, M. L., and E.C. Meslow. 1984. Response of avian communities to herbicide-induced vegetation changes. Journal of Wildlife Management 48:14-22.

Pregitzer, K. S., P. C. Goebel, and T. B. Wigley. 2001. Evaluating forestland classification schemes as tools for maintaining biodiversity. Journal of Forestry 99(2):33-40.

Prestemon, J. P., and R. C. Abt. 2002. Timber products supply and demand. Pages 299-325 *in* Wear, D. N., and J. G. Greis, editors. Southern forest resource assessment. USDA, Southern Research Station, Asheville, North Carolina, USA.

Sallabanks R., E. B. Arnett, and J.M. Marzluff. 2000. An evaluation of research on the effects of timber harvest on bird populations. Wildlife Society Bulletin 28:1144-1155.

Santillo, D. J., P. W. Brown, and D. M Leslie, Jr. 1989. Response of songbirds to gyphosate-induced habitat changes on clearcuts. Journal of Wildlife Management 53:64-71.

Schulz, C. A., D. M. Leslie Jr., R. L. Lochmiller, and D. E. Engle. 1992. Herbicide effects on cross timbers breeding birds. Journal of Range Management 45:407-411.

Sedjo, R. A., and D. Botkin. 1997. Using forest plantations to spare natural forests. Environment 39(10):14-30.

Thompson, F. R., III, and R. M. DeGraaf. 2001. Conservation approaches for woody, early successional communities in the eastern United States. Wildlife Society Bulletin 29:483-494.

Thompson, F. R., W. D. Dijak, T. G. Kulowiec, and D. A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. Journal of Wildlife Management 56:23-30.

Yahner, R. H. 1993. Effects of long-term forest clear-cutting on wintering and breeding birds. Wilson Bulletin 105:239-255.

Yahner, R. H. 1997. Long-term dynamics of bird communities in a managed forested landscape. Wilson Bulletin 109:595-613.

Yin, R., and R. A. Sedjo. 2001. Is this the age of intensive management: A study of loblolly pine of Georgia's Piedmont. Journal of Forestry 99(12):10-17.

CHAPTER II

THE EFFECTS OF INTENSIVE PINE PLANTATION MANAGEMENT ON WINTERING AND BREEDING BIRDS IN SOUTH MISSISSIPPI

ABSTRACT

The amount of land in intensive pine plantation management continues to increase in the southeastern United States. Silvicultural methods used in this type of forest management may negatively impact biological diversity. I evaluated the effects of 5 pine plantation site preparation and release treatments on wintering birds during years 1, 2, and 3 post-treatment and breeding birds during years 1 and 2 post-treatment. Bird abundance, species richness, species of concern, and total bird numbers generally decreased as treatment intensity increased. Bird community measurements were usually greatest in the herbicide-only treatment, which exhibited the greatest density of residual snags (80 snags/ha). These bird community responses to site preparation and release treatments can be used to integrate pine forest regeneration and management with bird conservation on private and public land bases.

Key words: breeding birds, intensive pine plantation management, release, residual snags, site preparation, wintering birds

INTRODUCTION

In 1987, there were roughly 8.5 million ha of pine plantations in the Southeastern U.S. (Martin and Boyce 1993). In 1996, this region included 15 million ha of commercial forests, consisting of 50% hardwoods, 34% pines, and 16% mixed pine-hardwoods (Allen et al. 1996). The region is projected to receive twice as much disturbance from harvest as any other region in the U.S. while contributing 79 % to future increases in softwood production (Haynes 2002).

Most investigations of the effects of herbicides have reported negative consequences to the bird community (Lautenschlager 1993). Herbicides may affect density and behavior of songbirds by altering vegetation structure (Morrison and Meslow 1984). Brooks et al. (1994) described significant conversion of summer avian communities in an herbicide comparison, with greater abundance of birds that used both forest interior and edge on imazapyr-treated areas (attributed to snag retention), and greater abundance of edge and shrubland bird species on hexazinone-treated areas (attributed to greater shrub cover).

Few studies have investigated the effects of chemical versus mechanical site preparation on bird abundance or species richness. O'Connell and Miller (1994) compared hexazinone-treated (controls a broad spectrum of annual grasses, forbs, and hardwoods) areas and mechanically-prepared (shear/root raking) sites in South Carolina, and documented slight increases in bird diversity due to snag presence, although the change did not endure 5 years post-treatment. Darden (1980) compared herbicide applications (2,4,5-T mist-blown and 2,4-D injections – in combination control shrubs and trees) to mechanical site preparation treatments (shearing, root-raking, and bedding).

After 2 years, herbicide- treated areas had greater species richness and numbers due to snag retention and understory vegetative structure.

The goal of my study was to determine effects of intensive pine plantation management alternatives on avian communities, so that managers can make informed decisions when planning intensive forest management regimes. I documented the effects of 5 site preparation and release treatment intensities on wintering and breeding birds in southern Mississippi. I addressed how these treatments affect mean species abundance and richness, total conservation score, species of concern scores, and total bird presence. I hypothesized that as treatment intensity increases, reducing vegetation structure, bird abundance will decrease.

STUDY AREAS AND TREATMENTS

I monitored the effects of intensive pine plantation management on areas managed by forest industry in southern Mississippi ($n = 4$) with vegetation and soil characteristics of the Mississippi Lower Coastal Plain (LCP) (Pettry 1977). Study sites were proposed by cooperating forest management companies and selected based on timber harvest and regeneration schedule, size (> 40.5 ha), edaphic similarity, and hydrological conditions.

Soil associations were similar in terms of soil texture among the study sites. The McLaurin-Heidel-Prentiss association was common to 2 stands and was comprised of gently sloping, moderately well-drained, sandy and loamy soils. The McLaurin-Savannah-Susquehenna association, comprised of somewhat poorly drained, nearly level

upland soils, occurred on 1 stand. The Prentiss-Rossella-Benndale association occurred on 2 stands and was characterized by loamy and fine sandy loam soils.

Management regimes (i.e., treatments) represented a range of operational intensities in forest industry site preparation and release techniques reflecting a gradient in vegetation management intensity and consequent potential wildlife habitat quality and pine growth response. Treatments were arranged in a randomized complete block design where each of 5 treatments was assigned randomly to a > 8-ha area within each stand (n = 4). Management intensity increased from "low" for treatment 1 to "high" for treatment 5.

Treatment 1, hereafter referred to as Mech+Band, consisted of mechanical site preparation using a combination plow to subsoil, disk, and bed, pulled behind a bulldozer with a V-blade attached to the front to clear debris. In year 1, a banded herbaceous control using 11.8 kg/ha of Oustar® was applied.

Treatment 2, hereafter referred to as Chem+Band, consisted of chemical site preparation using a mixture of 2.4 L/ha Chopper®, 5.3 L/ha Accord®, 5.3 L/ha Garlon 4, and 1% volume to volume (v/v) ratio of Timberland 90 surfactant (T90) in a total spray solution of 93.6 L/ha. In year 1, a banded herbaceous control using 11.8 kg/ha of Oustar® was applied. No mechanical preparation (i.e., bedding) occurred in Treatment 2.

Treatment 3, hereafter referred to as Combo+Band, consisted of the same mechanical site preparation as Mech+Band and the same chemical site preparation as Chem+Band. In year 1, a banded herbaceous control using 11.8 kg/ha of Oustar® was applied.

Treatment 4, hereafter referred to as Combo+Broad, consisted of the same mechanical site preparation as Mech+Band and the same chemical site preparation as

Chem+Band. In year 1, a broadcast herbaceous control using 11.8 kg/ha of Oustar® was applied.

Treatment 5, hereafter referred to as Combo+2Broad, consisted of the same mechanical site preparation as Mech+Band and the same chemical site preparation as Chem+Band. In years 1 and 2, a broadcast herbaceous control using 11.8 kg/ha of Oustar® was applied.

Chemical site preparation was applied during July–August 2001, and mechanical site preparation occurred September–December 2001. Year 1 herbaceous control was applied March–April 2002 and year 2 herbaceous treatments occurred March–May 2003.

Additional details were agreed upon by all forest industry cooperators to standardize stand management. Stands were planted during December 2001–January 2002. Pine tree seedlings were planted on a 3.0-m x 2.1-m spacing (i.e., 3.0 m between rows and 2.1 m between trees), totaling 1,551 trees/ha. Banded herbaceous control treatments were applied with a band width of 1.5 m, and broadcasted herbicide applications were aerially applied via helicopter. A broadcast fertilizer application of DAP at 280 kg/ha was applied during April 2002. Two stands were machine planted to facilitate banding application by tractor. Two other stands were hand planted due to greater debris loads remaining post-harvest. Banding applications were conducted using backpack sprayers on these 2 sites.

METHODS

Winter Bird Sampling

Winter bird species richness and abundance were quantified during February 2002, and January and February of 2003 and 2004. I assumed there was no temporal variation in bird community response during the time intervals. Linear belt (i.e., fixed width) transects were used to estimate the density of bird populations. Permanent transects with a minimum length of 150 m and width of 60 m were established in each treatment. Transects were subdivided into 3 distance categories, 0-10 m, 10-20 m, and 20-30 m. Lines were terminated at least 50 m from treatment boundaries to reduce influence of edge effect (Wakeley 1987).

Treatments were surveyed between sunrise and 9:30 a.m. during optimal weather conditions (i.e., < 40% cloud cover and calm wind conditions). Transects were sampled 3 times in 2002 and 6 times in 2003 and 2004. Surveyors identified and recorded all species heard or observed and estimated distance to the birds. To increase distance estimation accuracy, surveyors used a laser range finder (Verner 1985). Habitat conditions at the point where the bird was recorded were noted (i.e., herbaceous cover, brush pile, standing snag, downed woody debris). Density estimates were developed using Program Distance (Thomas et al. 1998).

Breeding Bird Sampling

Breeding bird surveys were conducted from late April through early June in 2002 and 2003. I assumed there was no temporal variation in bird community response during the time intervals. I used a 10-minute, variable-radius point count. The observer

identified each bird to species and recorded its distance from the center point (Buckland et al. 1993). Three subplots were permanently marked in each treatment for the point counts.

Point counts were sampled 3 times in 2002 and 6 times in 2003. Treatments were surveyed from sunrise until 9:30 a.m. during optimal weather conditions (i.e., < 40% cloud cover and calm wind conditions). Surveyors used laser range finders to increase distance estimation accuracy (Verner 1985).

Partners in Flight Concern Scores

Partners in Flight created a system to assess the conservation status of North American bird species (Panjabi 2001). Seven vulnerability categories are scored from "1" for low vulnerability to "5" for high vulnerability. The 6 vulnerability factors are: relative abundance, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, and population trend. The seventh factor, area importance, incorporates regional abundance depending on season. Summation of the scores generates priority species pools for physiographic regions, and a national watch list for species scoring greater than or equal to 19. Additionally, a score of 19 must be in combination with a population trend of at least 5, and 20 must match a population trend of at least 3.

I calculated the conservation score by multiplying the mean abundance of each species by its Partners in Flight score and summing all scores across the entire treatment. The species of concern score was similar, however, only the priority species were summed within a treatment.

Experimental Design and Analysis

I used a repeated-measures, mixed model analysis of variance to test for year effects, treatment effects and year X treatment interactions for bird species richness, total conservation score, total bird numbers, and individual species means for all sampling periods. Means were compared among treatments ($n = 5$) and years ($n = 3$ for winter, $n = 2$ for spring) in SAS Proc MIXED (SAS Institute 2000). Stands (i.e., blocks, $n = 4$) were treated as the random effect, year as the repeated effect, and the subject was stand X treatment. A first-order autoregressive covariance structure (Littell et al. 1996) was chosen for the models, because there were equal time intervals between sampling periods. A $P < 0.05$ was considered significant and protected Fisher's least significant difference was used for mean separation when a treatment effect or a treatment X year interaction was found, using the LSMEANS PDIFF option (Littell et al. 1996).

Normality and equal variance assumptions were tested prior to analysis. Variables with non-equal variances were log-transformed when transformation improved the variance structure (Zar 1999). Original means are presented in tables, although analysis was conducted on transformed data.

Species richness was standardized using rarefaction due to unequal repetitions between the first year and subsequent years. The computer program EstimateS was used to calculate the adjusted species richness (Colwell 2004).

I used Program Distance to determine abundance and density within treatments across all stands (Thomas et al. 1998). Global layers were composed of the stand level and total area for the stand. The stratum layer was treatment area. The sample layer was either the line transect and its total length or the point within a treatment and the number

of repetitions. Finally, the observation layer contained the distances of individual sightings. Analyses were performed on all model types available in the program and the best model was chosen by Akaike's Information Criterion (AIC) (See Appendices C.1-C.2 for site results by treatment).

RESULTS

Winter Bird Communities

I detected 37 species over the entire study area during the 3-year study period, 2002 through 2004 (Table 2.1). Abundance of these species generally declined as the intensity of treatment increased. Of the 37 species, 2 species exhibited a year and treatment effect, 1 species exhibited a treatment effect, 4 species exhibited a year X treatment interaction, and 9 species exhibited year effects.

Year and treatment effects were observed for Carolina wren (See Appendix B.1 for list of winter bird scientific names) ($F_{2,42} = 7.50$, $P = 0.002$; $F_{4,42} = 2.90$, $P = 0.033$) and northern cardinal ($F_{2,42} = 7.09$, $P = 0.002$; $F_{4,42} = 5.47$, $P = 0.001$). Both species had the greatest abundance in Chem+Band, and increased in abundance from year 1 to year 2. The type of site preparation and release treatment influenced abundance of red-bellied woodpecker ($F_{4,42} = 4.31$, $P = 0.005$) with the greatest numbers in Chem+Band. Abundance of American robin ($F_{8,42} = 2.36$, $P = 0.034$), common yellowthroat ($F_{8,42} = 3.05$, $P = 0.009$), eastern towhee ($F_{8,42} = 3.45$, $P = 0.009$), and song sparrow ($F_{8,42} = 4.13$, $P = 0.001$) exhibited differences between treatment types and study years. Abundance of common yellowthroat, eastern towhee, and song sparrow was greatest in the 2 lowest

intensity treatments, whereas American robin had the greatest abundance in the highest intensity treatment.

Several bird species were influenced by stand age rather than treatment type. For example, dark-eyed junco ($F_{2,42} = 3.40$, $P = 0.043$), eastern phoebe ($F_{2,42} = 3.80$, $P = 0.031$), and yellow-rumped warbler ($F_{2,42} = 12.34$, $P < 0.001$) decreased in abundance as stand age increased. In contrast, field sparrow ($F_{2,42} = 10.51$, $P < 0.001$), northern bobwhite ($F_{2,42} = 3.36$, $P = 0.044$), northern mockingbird ($F_{2,42} = 5.28$, $P = 0.009$), and sedge wren ($F_{2,42} = 3.40$, $P < 0.001$) increased in abundance over time.

During year 1, bird species with a year X treatment interaction had no differences among treatment types. However, by years 2 and 3 post-treatment, a total of 4 species exhibited differences in abundance among treatment types. Additionally, all species that exhibited differences were more abundant in the 2 lowest intensity treatments. In general, the greatest numbers of birds were detected in Chem+Band. The exception to this statement was the American robin, which exhibited the greatest abundance in Combo+2Broad during year 2 post-treatment. Of the 3 bird species that exhibited differences in abundance levels among treatments over the combined 3-year period, all species had the greatest mean abundance in Chem+Band.

Species richness ($F_{2,42} = 3.79$, $P < 0.001$; $F_{4,42} = 8.08$, $P < 0.001$), species of concern ($F_{2,42} = 16.26$, $P < 0.001$; $F_{4,42} = 4.89$, $P = 0.003$), and total birds recorded ($F_{2,42} = 20.32$, $P < 0.001$; $F_{4,42} = 6.98$, $P < 0.001$) differed by year and treatment, while total conservation score ($F_{8,42} = 2.20$, $P = 0.047$) had a year X treatment interaction (Table 2.2). Species richness, species of concern, and total birds recorded had the greatest means in

Chem+Band. During 2003 and 2004, total conservation score was greatest in Chem+Band.

Breeding Bird Communities

I recorded 38 species using point count surveys during April – June 2002 and 2003 (Table 2.3). Abundance of these species typically declined as treatment intensity increased. Of the 38 species, 2 species exhibited a year and treatment effect, 5 species exhibited a treatment effect, 8 species exhibited a year X treatment interaction, and 5 species exhibited year effects.

Year and treatment effects were observed for numbers of indigo bunting ($F_{1,27}$ = 89.91, $P < 0.001$; $F_{4,27} = 4.35$, $P = 0.008$) and prairie warbler ($F_{1,27} = 15.84$, $P < 0.001$; $F_{4,27} = 5.63$, $P = 0.002$). Both species exhibited greater abundance levels in the 3 lowest intensity treatments, and numbers of each species increased from year 1 to year 2 post-treatment. The type of site preparation and release treatment influenced abundance of blue jay (See Appendix B.2 for list of breeding bird scientific names) ($F_{4,27} = 3.12$, P = 0.031), brown thrasher ($F_{4,27} = 9.12$, $P < 0.001$), chipping sparrow ($F_{4,27} = 3.51$, P = 0.020), great crested flycatcher ($F_{4,27} = 3.39$, $P = 0.023$), and northern cardinal ($F_{4,27}$ = 2.81, $P = 0.045$) with the greatest abundance of these species being recorded in Chem+Band. Abundance of common yellowthroat ($F_{4,27} = 5.85$, $P = 0.002$), eastern towhee ($F_{4,27} = 5.22$, $P = 0.003$), field sparrow ($F_{4,27} = 10.86$, $P < 0.001$), mourning dove ($F_{4,27} = 2.78$, $P = 0.047$), orchard oriole ($F_{4,27} = 3.61$, $P = 0.018$), red-bellied woodpecker ($F_{4,27} = 3.51$, $P = 0.020$), red-headed woodpecker ($F_{4,27} = 25.00$, $P < 0.001$), and yellow-breasted chat ($F_{4,27} = 3.05$, $P = 0.034$) exhibited differences due to treatment type and

year interactions. Each of these species had their greatest numbers in the 2 lowest intensity treatments, with the greatest abundance generally found in Chem+Band. Some species were influenced by stand age rather than treatment type during the study period. For example, blue grosbeak ($F_{1,27} = 24.65$, $P < 0.001$), Carolina wren ($F_{1,27} = 9.57$, $P = 0.005$), eastern kingbird ($F_{1,27} = 9.12$, $P = 0.006$), and northern bobwhite ($F_{1,27} = 5.56$, $P = 0.026$) increased in abundance as stand age increased with greatest numbers of these species being detected during year 2 of the study. During years 1 and 2 post-treatment, 8 species differed in abundance among treatment types. Additionally, all species that exhibited differences in abundance among treatment types were found in greater numbers in the 3 lowest intensity treatments, with the most birds detected in Chem+Band. Of the 7 bird species that exhibited differences in abundance levels between treatments over the 2-year period, all had a greater mean abundance in Chem+Band.

Species richness ($F_{4,27} = 6.74$, $P < 0.001$), total conservation score ($F_{4,27} = 6.55$, $P < 0.001$), species of concern ($F_{4,27} = 6.37$, $P = 0.001$), and total birds recorded ($F_{4,27} = 5.98$, $P = 0.001$) all exhibited year X treatment interactions (Table 2.4), with no differences between treatments being detected during 2002. In 2003, species richness was greatest in sites receiving Chem+Band. Total conservation score, species of concern score, and total bird numbers were greater in the 3 lowest intensity treatments, but was still greatest in Chem+Band.

DISCUSSION

Winter Bird Communities

Few studies have documented the effects of site preparation and release treatments on wintering bird abundance and diversity. Darden (1980) found that herbicide site preparation resulted in greater avian numbers and diversity during the stand initiation stage than did raked, sheared, or bedded areas. Brooks et al. (1994) found no differences for winter avian abundance between sites prepared with different herbicide regimes. In my study, Chem+Band generally had the greatest mean number of total birds and greatest mean abundance of 6 bird species. In addition to supporting greater bird abundance, sites treated with herbicide-only provided habitat for species of concern (eastern towhee and red-bellied woodpecker). Bird community composition that includes declining species may be more important than overall abundance of common species in assessing management impacts in bird conservation programs.

Habitat structure variation likely caused differences of bird abundance among the treatments. Site disturbance treatments such as shearing typically removed or relocated woody debris and standing snags; whereas, sites treated with Chem+Band exhibited dispersed woody debris and deadened hardwoods which produced standing snags over time. The retention of standing snags combined with herbaceous and shrub presence (Edwards 2004) in Chem+Band likely contributed to the greater mean abundance of common yellowthroat, song sparrow, eastern towhee, Carolina wren, northern cardinal, and red-bellied woodpecker. Common yellowthroat, song sparrow, eastern towhee, and Carolina wren often are found in habitats typified by dense, low growing vegetation (Haggerty and Morton 1995, Greenlaw 1996, Guzy and Ritchison 1999, Arcese et al.

2002), whereas, red-bellied woodpeckers forage on snags (Shackelford et al. 2000) which were found in Chem+Band. In contrast, Brooks et al. (1994) found no differences between chemical treatments with high and low snag abundance in the winter.

The Chem+Band sites also supported bird communities with greater species of concern values resulting from a greater abundance of eastern towhee, field sparrow, and sedge wren. Sedge wren typically inhabit marshy habitat (Hamel 1992), but may occur in meadows and grasslands with medium shrub cover (Herkert et al. 2001). Eastern towhees are often found in edge habitat or understory thickets (Greenlaw 1996). Field sparrows use open or grassy fields, as well as thickets and edge habitats (Carey et al. 1994).

The lone exception to the greater abundance in the lower intensity treatments was the American robin. During year 2, flocks of robins were seen only in Combo+2Broad, which received the greatest intensity of herbicide applications. Habitat conditions in these sites were typified by less total ground cover and more soil exposure than other treatments. These habitat characteristics may have influenced use by American robin, which tend to use short grassy areas for foraging for animal matter (e.g., worms and insects) (Hamel 1992).

Breeding Bird Communities

The greater total bird abundance within the 3 lowest intensity treatments, particularly the Chem+Band, was similar to Darden's (1980) results showing areas treated with mist-blown and injected herbicides had greater abundance than 2 types of mechanical treatments. In contrast, O'Connell and Miller (1994) found no difference in

total avian abundance between chemical (broadcast application of hexazinone) and mechanical-prepared (root raking and shearing) sites. The greater number of species and species of concern I detected on Chem+Band agrees with Darden (1980), who found a greater diversity of avifauna in herbicide-treated areas than the mechanical-treated or burned areas. However, these species-specific findings differed from those of O'Connell and Miller (1994). They found significant differences for only 5 avian species when comparing chemical and mechanical site preparations. In their study, mechanical treatments had 1 species more abundant at 2 years post-treatment and 2 species at 3 years post-treatment. For the herbicide treatment, 3 species were more abundant at 2 years post-treatment and 1 species at 3 years post-treatment (O'Connell and Miller 1994).

The importance of release treatments to bird communities was evidenced by a greater abundance of 4 species found in the Combo+Band when compared to Combo+2Broad. Vegetative structure effects, due to increasing release intensity, likely caused the greater abundance of common yellowthroat, field sparrow, indigo bunting, and yellow-breasted chat in Combo+Band compared to Combo+2Broad. The increasing release intensity suppressed vegetative growth and community development, as indicated by lower percent coverage of grass and grasslike, forbs, woody shrubs, trees, and vines, and total vegetation in Combo+2Broad compared to Combo+Band (Edwards 2004).

Variability of habitat conditions among different treatments likely influenced species occurrence differences. Brown thrasher, chipping sparrow, common yellowthroat, eastern towhee, field sparrow, indigo bunting, northern cardinal, prairie warbler, and yellow breasted chat are often found in dense, low growing vegetation (Payne 1992, Carey et al. 1994, Greenlaw 1996, Middleton 1998, Guzy and Ritchison

1999, Halkin and Linville 1999, Nolan 1999, Cavitt and Haas 2000, Eckerle and Thompson 2001), which is similar habitat to that found in Chem+Band. Snags in Chem+Band likely played an important role for red-bellied woodpecker and red-headed woodpecker which both nest and forage in snags (Shackelford et al. 2000, Smith et al. 2000), and eastern kingbirds which commonly nest on snags (Murphy 1996). The mixture of snags and open areas found in Chem+Band are habitats used by mourning dove and orchard oriole (Mirarchi and Baskett 1994, Scharf and Kren 1996). Other researchers have noted the importance of snags for avian communities. O'Connell and Miller (1994) stated that structural characteristics (i.e., snags) on sites treated with herbicide probably caused differences between herbicide and mechanical treatments for spring avian diversity. Darden (1980) found that residual snags on herbicide treated areas were one of the most important factors for the breeding avian community. Brooks et al. (1994) believed that greater summer abundance of forest-edge and scrubland birds on herbicide treated plots was due to the number of snags left after harvest.

CONCLUSIONS

For winter and spring bird counts, the primary habitat feature that influenced bird use was likely the presence of standing trees and snags. Snag retention may have been a more beneficial factor than the resulting vegetation community. Greater differences within Chem+Band may have resulted if all 4 sites had residual snags, yet only 3 of the 4 sites had snags during the survey period. It was not possible with this study to differentiate between the relative importance of snags and the remaining vegetation, or if there was a synergistic effect.

The results of my study support the concept that herbicide-only treatments that retain standing snags following site preparation and release provide additional niches for bird species that forage on or nest in standing deadwood. Successional changes in vegetation that yield herbaceous and woody plant cover interspersed with standing snags and downed deadwood also appear to produce habitat for forest edge and scrub species as well as cavity nesters.

LITERATURE CITED

Allen, A. W., Y. K. Bernal, and R. J. Moulton. 1996. Pine plantations and wildlife in the southeastern United States: an assessment of impacts and opportunities. United States Department of Interior, National Biological Service, Information and Technology Report 3.

Arcese, P., M. K. Sogge, A. B. Marr, and M. A. Patten. 2002. Song sparrow (*Melospiza melodia*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 704. The American Ornithologists' Union, Washington, D.C., USA.

Brooks, J. J., J. L. Rodrigue, M. A. Cone, K. V. Miller, B. R. Chapman, and A.S. Johnson. 1994. Small mammal and avian communities on chemically-prepared sites in the Georgia Sandhills. Proceedings of the Biennial Southern Silvicultural Research Conference 8:21-23.

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake. 1993. Distance sampling: Estimating abundance of biological populations. Chapman and Hall, London, England.

Carey, M., D. E. Burhans, and D. A. Nelson. 1994. Field sparrow (*Spizella pusilla*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 103. The American Ornithologists' Union, Washington, D.C., USA.

Cavitt, J. F., and C. A. Haas. 2000. Brown thrasher (*Toxostoma rufum*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 557. The American Ornithologists' Union, Washington, D.C., USA.

Colwell, R.K. 2004. EstimateS: statistical estimation of species richness and shared species from samples. Version 7. Available: http://purl.oclc.org/estimates

Darden, T. L. Jr. 1980. Bird communities in managed loblolly-shortleaf pine stands in east central Mississippi. Thesis, Mississippi State University, Mississippi State, Mississippi, USA.

Eckerle, K. P., and C. F. Thompson. 2001. Yellow-breasted chat (*Icteria virens*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 575. The American Ornithologists' Union, Washington, D.C., USA.

Edwards, S. L. 2004. Effects of intensive pine plantation management on wildlife habitat in south Mississippi. Thesis, Mississippi State University, Mississippi State, Mississippi, USA.

Greenlaw, J. S. 1996. Eastern towhee (*Pipilo erythrophthalmus*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 262. The American Ornithologists' Union, Washington, D.C., USA.

Guzy, M. J., and G. Ritchison. 1999. Common yellowthroat (*Geothlypis trichas*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 448. The American Ornithologists' Union, Washington, D.C., USA.

Haggerty, T. M., and E. S. Morton. 1995. Carolina wren (*Thryothorus ludovicianus*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 188. The American Ornithologists' Union, Washington, D.C., USA.

Halkin, S. L., and S. U. Linville. 1999. Northern cardinal (*Cardinalis cardinalis*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 440. The American Ornithologists' Union, Washington, D.C., USA.

Hamel, P. B. 1992. Land manager's guide to the birds of the South. The Nature Conservancy, Southeastern Region, Chapel Hill, North Carolina, USA.

Haynes, R. W. 2002. Forest management in the 21st century: Changing numbers, changing context. Journal of Forestry 100(2):38-43.

Herkert, J. R., D. E. Kroodsma, and J. P. Gibbs. 2001. Sedge wren (*Cistothorus platensis*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 582. The American Ornithologists' Union, Washington, D.C., USA.

Hunter, W. C., D. A. Buehler, R. A. Canterbury, J. L. Confer, and P. B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin 29:440-455.

Lautenschlager, R. A. 1993. Response of wildlife to forest herbicide applications in northern coniferous ecosystems. Canadian Journal of Forest Research 23:2286-2299.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS system for mixed models. SAS Institute, Cary, North Carolina, USA.

Martin, W. H., and S. G. Boyce. 1993. Introduction: the southeastern setting. Pages 1-46 *in* Martin, W. H., S. G. Boyce, and A. C. Echternacht. Biodiversity of the southeastern United States: lowland terrestrial communities. John Wiley & Sons, Inc., New York, New York, USA.

Middleton, A. L. A. 1998. Chipping sparrow (*Spizella passerina*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 334. The American Ornithologists' Union, Washington, D.C., USA.

Mirarchi, R. E., and T. S. Baskett. 1994. Mourning dove (*Zenaida macroura*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 117. The American Ornithologists' Union, Washington, D.C., USA.

Morrison, M. L., and E. C. Meslow. 1984. Response of avian communities to herbicide-induced vegetation changes. Journal of Wildlife Management 48:14-22.

Murphy, M. T. 1996. Eastern kingbird (*Tyrannus tyrannus*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 253. The American Ornithologists' Union, Washington, D.C., USA.

Nolan, V., Jr., E. D. Ketterson, and C. A. Buerkle. 1999. Prairie warbler (*Dendroica discolor*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 455. The American Ornithologists' Union, Washington, D.C., USA.

O'Connell, W. E., and K. V. Miller. 1994. Site preparation influences on vegetative composition and avian and small mammal communities in the South Carolina Upper Coastal Plain. Pages 321-330 *in* Proceedings of the 48th Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. Biloxi, Mississippi, October 23 – 26, 1994.

Panjabi, A. 2001. The Partners in Flight handbook on species assessment and prioritization. http://www.rmbo.org/pif

Payne, R. B. 1992. Indigo bunting (*Passerina cyanea*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 4. The American Ornithologists' Union, Washington, D.C., USA.

Pettry, D. E. 1977. Soil resource areas of Mississippi. Mississippi Agricultural and Forestry Experiment Station Information Sheet 1278.

SAS Institute. 2000. SAS/STAT User's Guide, Version 8. SAS Institute, Cary, North Carolina, USA.

Scharf, W. C., and J. Kren. 1996. Orchard oriole (*Icterus spurius*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 255. The American Ornithologists' Union, Washington, D.C., USA.

Shackelford, C. E., R. E. Brown, and R. N. Conner. 2000. Red-bellied woodpecker (*Melanerpes carolinus*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 500. The American Ornithologists' Union, Washington, D.C., USA.

Smith, K. G., J. H. Withgott, and P. G. Rodewald. 2000. Red-headed woodpecker (*Melanerpes erythrocephalus*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 518. The American Ornithologists' Union, Washington, D.C., USA.

Thomas, L., J. L. Laake, J. F. Derry, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. Strindberg, S. L. Hedley, M. L. Burt, F. F. C. Marques, J. H. Pollard, and R. M. Fewster. 1998. Distance 3.5. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. Available: http://www.ruwpa.st-and.ac.uk/distance/

Verner, J. 1985. Assessment of counting techniques. Pages 247-302 *in* R. F. Johnston, editor. Current Ornithology. Volume 2. Plenum Press, New York, New York, USA.

Wakely, J. S. 1987. Avian line-transect methods. Section 6.3.2 *in* United States Army Corps of Engineers Wildlife Resources Management Manual Technical Report EL-87-5.

Zar, J. H. 1999. Biostatistical analysis. Fourth edition. Prentiss Hall, Upper Saddle River, New Jersey, USA.

Table 2.1. Mean number of birds by species per 1000m of transects[a] for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity[b] during years 1, 2, and 3 post-treatment (February 2002, January - February 2003, and January - February 2004) in the Mississippi Lower Coastal Plain[c].

	Treatment																		P-value		
	1[de]			2[f]			3[g]			4			5								
	x̄		SE	x̄		SE	x̄		SE	x̄		SE	x̄		SE				Yr	Trt	Yr*Trt
American Goldfinch																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.166	0.125
2003	0.0		0.0	0.0		0.0	1.1		0.7	0.0		0.0	0.0		0.0				0.193	0.166	0.125
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.193	0.166	
American Robin																					
2002	0.0		0.0	0.8		0.5	0.0		0.0	0.0		0.0	0.7		0.7					0.684	0.034
2003	0.0	A	0.0	0.0	A	0.0	0.0	A	0.0	0.2	A	0.2	2.9	B	1.8				0.174	0.001	0.034
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.174	0.997	
Blue Jay																					
2002	0.0		0.0	1.2		1.2	0.0		0.0	0.0		0.0	0.0		0.0					0.418	0.450
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	0.450
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	
Brown-headed Nuthatch																					
2002	0.0		0.0	0.5		0.5	0.0		0.0	0.0		0.0	0.0		0.0					0.418	0.450
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	0.450
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	
Carolina Chickadee																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	1.3		1.3					0.103	0.422
2003	0.0		0.0	0.7		0.5	0.0		0.0	0.0		0.0	0.0		0.0				0.616	0.103	0.422
2004	0.5		0.5	1.2		0.6	0.0		0.0	0.0		0.0	0.4		0.4				0.616	0.103	
Carolina Wren																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0						
2003	1.0		0.5	3.0		1.2	1.1		0.5	0.8		0.5	0.3		0.0						
2004	0.2		0.2	1.2		0.5	0.5		0.3	0.0		0.0	0.4		0.4						
Combined	0.5	A	0.0	2.0	B	0.5	1.0	A	0.0	0.0	A	0.0	0.0	A	0.0				0.002	0.033	0.388

Table 2.1. Continued

	Treatment																		P-value		
	1[de]			2[f]			3[g]			4			5								
	x̄		SE	x̄		SE	x̄		SE	x̄		SE	x̄		SE				Yr	Trt	Yr*Trt
Chipping Sparrow																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.418	0.450
2003	0.0		0.0	0.3		0.3	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	0.450
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	
Common Ground Dove																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.456	0.380
2003	0.0		0.0	0.0		0.0	0.5		0.3	0.0		0.0	0.0		0.0				0.556	0.456	0.380
2004	0.0		0.0	0.2		0.2	0.0		0.0	0.0		0.0	0.0		0.0				0.556	0.456	
Common Snipe																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.459	0.506
2003	0.0		0.0	0.0		0.0	0.2		0.2	1.6		1.6	0.0		0.0				0.283	0.459	0.506
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.283	0.459	
Common Yellowthroat																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					1.000	0.009
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				< 0.001	1.000	0.009
2004	1.0	A	0.5	1.8	B	0.7	0.2	C	0.2	0.0	C	0.0	0.0	C	0.0				< 0.001	< 0.001	
Dark-eyed Junco																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.365	0.810
2003	2.0		1.1	5.0		4.3	4.8		2.1	1.0		1.0	0.0		0.0				0.043	0.365	0.810
2004	0.0		0.0	1.8		1.8	0.0		0.0	0.0		0.0	0.0		0.0				0.043	0.365	
Downy Woodpecker																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.250	0.099
2003	0.0		0.0	0.5		0.3	0.0		0.0	0.0		0.0	0.0		0.0				0.173	0.250	0.099
2004	0.0		0.0	1.0		0.5	0.0		0.0	0.0		0.0	0.0		0.0				0.173	0.250	
Eastern Bluebird																					
2002	4.7		2.4	6.4		3.1	0.7		0.7	1.2		1.2	1.3		1.3					0.123	0.379
2003	0.3		0.3	3.8		1.1	0.0		0.0	3.0		1.4	3.1		1.1				0.212	0.123	0.379
2004	0.0		0.0	1.8		0.8	0.7		0.5	2.4		1.4	0.3		0.3				0.212	0.123	
Eastern Phoebe																					
2002	0.7		0.5	0.0		0.0	0.0		0.0	0.0		0.0	0.7		0.7					0.532	0.685
2003	0.5		0.5	0.0		0.0	0.4		0.3	0.5		0.3	0.6		0.5				0.031	0.532	0.685
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.031	0.532	

Table 2.1. Continued

	Treatment																		P-value		
	1[de]			2[f]			3[g]			4			5								
	x̄		SE	x̄		SE	x̄		SE	x̄		SE	x̄		SE				Yr	Trt	Yr*Trt
Eastern Towhee																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					1.000	0.009
2003	0.5	A	0.4	3.9	B	1.0	0.0	A	0.0	0.0	A	0.0	0.0	A	0.0				0.016	< 0.001	0.009
2004	0.5	A	0.4	3.3	B	0.8	0.0	A	0.0	0.0	A	0.0	0.8	A	0.8				0.016	0.001	
Field Sparrow																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.449	0.394
2003	0.5		0.3	0.3		0.3	0.0		0.0	0.0		0.0	0.0		0.0				< 0.001	0.449	0.394
2004	1.0		0.6	1.9		0.9	1.1		0.6	0.8		0.5	3.5		2.4				< 0.001	0.449	
Gray Catbird																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.418	0.450
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	0.450
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.4		0.4				0.377	0.418	
Hairy Woodpecker																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.418	0.450
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	0.450
2004	0.0		0.0	0.2		0.2	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	
Loggerhead Shrike																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.525	0.744
2003	0.2		0.2	0.5		0.5	0.0		0.0	0.6		0.6	0.0		0.0				0.155	0.525	0.744
2004	0.2		0.2	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.155	0.525	
Mourning Dove																					
2002	1.3		1.3	0.0		0.0	0.0		0.0	6.6		6.6	1.3		1.3					0.570	0.515
2003	0.0		0.0	0.3		0.3	1.1		0.7	0.0		0.0	0.0		0.0				0.268	0.570	0.515
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.3		0.3				0.268	0.570	
Northern Bobwhite																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.786	0.902
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.044	0.786	0.902
2004	1.5		1.5	0.0		0.0	2.1		2.1	0.8		0.8	3.0		2.1				0.044	0.786	
Northern Cardinal																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0						
2003	0.0		0.0	1.7		0.8	0.5		0.5	1.1		0.8	0.0		0.0						
2004	0.0		0.0	1.0		0.6	0.0		0.0	0.0		0.0	0.0		0.0						
Combined	0.0	A	0.0	1.0	B	0.0	0.0	A	0.0	0.0	A	0.0	0.0	A	0.0				0.002	0.001	0.064

Table 2.1. Continued

	Treatment																		P-value		
	1[de]			2[f]			3[g]			4			5								
	x̄		SE	x̄		SE	x̄		SE	x̄		SE	x̄		SE				Yr	Trt	Yr*Trt
Northern Harrier																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.418	0.450
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.4		0.4	0.0		0.0				0.377	0.418	0.450
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	
Northern Mockingbird																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.121	0.166
2003	0.0		0.0	0.5		0.3	0.0		0.0	0.0		0.0	0.0		0.0				0.009	0.121	0.166
2004	0.2		0.2	1.7		0.7	0.2		0.2	0.5		0.3	0.0		0.0				0.009	0.121	
Palm Warbler																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.512	0.579
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.201	0.512	0.579
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.3		0.3	0.8		0.8				0.201	0.512	
Pine Warbler																					
2002	0.9		0.9	4.1		2.1	0.0		0.0	0.0		0.0	0.0		0.0					0.486	0.261
2003	0.0		0.0	0.3		0.3	0.2		0.2	0.5		0.5	2.1		1.8				0.376	0.486	0.261
2004	0.3		0.3	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.376	0.486	
Red-bellied Woodpecker																					
2002	0.0		0.0	0.8		0.8	0.0		0.0	0.0		0.0	0.0		0.0						
2003	0.0		0.0	2.0		0.6	0.0		0.0	0.0		0.0	0.0		0.0						
2004	0.0		0.0	1.5		1.0	0.0		0.0	0.0		0.0	0.0		0.0						
Combined	0.0	A	0.0	2.0	B	1.0	0.0	A	0.0	0.0	A	0.0	0.0	A	0.0				0.233	0.005	0.184
Ruby-crowned Kinglet																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.418	0.450
2003	0.0		0.0	0.0		0.0	0.2		0.2	0.0		0.0	0.0		0.0				0.377	0.418	0.450
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	
Savannah Sparrow																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.418	0.450
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	0.450
2004	0.0		0.0	0.8		0.6	0.0		0.0	0.0		0.0	0.0		0.0				0.377	0.418	
Sedge Wren																					
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0					0.098	0.074
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0				< 0.001	0.098	0.074
2004	1.8		0.7	2.6		0.7	0.7		0.5	0.7		0.5	0.0		0.0				< 0.001	0.098	

Table 2.1. Continued

	Treatment															P-value		
	1[de]			2[f]			3[g]			4			5					
	x̄		SE	x̄		SE	x̄		SE	x̄		SE	x̄		SE	Yr	Trt	Yr*Trt
Song Sparrow																		
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0		1.000	0.001
2003	15.0	A	3.0	13.0	A	2.9	6.9	B	1.2	4.6	BC	2.0	2.0	C	0.7	< 0.001	< 0.001	0.001
2004	1.0		0.5	0.6		0.4	1.6		0.9	1.1		0.8	0.9		0.9	< 0.001	0.995	
Swamp Sparrow																		
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0		0.315	0.459
2003	1.0		0.7	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.061	0.315	0.459
2004	0.7		0.4	1.5		0.9	0.0		0.0	0.0		0.0	1.4		0.7	0.061	0.315	
Turkey Vulture																		
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0		0.418	0.450
2003	0.2		0.2	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.377	0.418	0.450
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.377	0.418	
White-eyed Vireo																		
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0		0.418	0.450
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.377	0.418	0.450
2004	0.0		0.0	0.5		0.3	0.0		0.0	0.0		0.0	0.0		0.0	0.377	0.418	
Winter Wren																		
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0		0.517	0.585
2003	0.3		0.3	0.0		0.0	0.7		0.4	0.0		0.0	0.0		0.0	0.195	0.517	0.585
2004	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.195	0.517	
Yellow-rumped Warbler																		
2002	3.5		2.8	3.6		2.9	0.0		0.0	0.6		0.6	0.0		0.0		0.176	0.079
2003	1.9		1.0	8.1		3.0	0.0		0.0	3.9		1.7	2.4		1.7	0.002	0.176	0.079
2004	0.0		0.0	1.3		1.0	0.0		0.0	0.3		0.3	0.4		0.4	0.002	0.176	

[a] Transects were different lengths, but were standardized by calculating the mean number of each species per 1000m. Actual transect lengths were not greater than 300m, but were presented in this fashion for ease of interpretation.

[b] Treatment 1 = mechanical site preparation only with banded chemical control in year 1, Treatment 2 = herbicide site preparation only with banded chemical control in year 1, Treatment 3 = mechanical and chemical site preparation with banded chemical control in year 1, Treatment 4 = mechanical and chemical site preparation with broadcast chemical control in year 1, Treatment 5 = mechanical and chemical site preparation with broadcast chemical control in years 1 and 2.

Table 2.1. Continued

[c] Means within rows followed by the same letter do not differ ($P > 0.05$).

[d] Within-treatment year effect ($P < 0.001$): song sparrow

[e] Within-treatment year effect ($P < 0.01$): common yellowthroat

[f] Within-treatment year effect ($P < 0.001$): Carolina wren, common yellowthroat, eastern towhee, song sparrow

[g] Within-treatment year effect ($P < 0.05$): song sparrow

Table 2.2. Avifauna species richness[a], total conservation score[bc], species of concern score[bc], and total bird numbers[b] found on transects[d] for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity[e] during years 1, 2, and 3 post-treatment (February 2002, January - February 2003, and January - February 2004) in the Mississippi Lower Coastal Plain[f].

	Treatment																		P-value		
	1[g]			2[h]			3[i]			4			5								
	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE				Yr	Trt	Yr*Trt
Species Richness																					
2002	2.4		0.4	2.8		0.5	0.9		0.3	1.2		0.2	1.6		0.9						
2003	5.0		0.6	8.4		1.3	5.0		1.3	4.8		0.4	3.6		0.4						
2004	4.4		1.2	9.9		1.6	3.2		0.4	2.6		0.6	4.0		1.4						
Combined	4.0	A	0.5	7.0	B	1.1	3.1	A	0.8	2.9	A	0.5	3.1	A	0.6				< 0.001	< 0.001	0.079
Total Conservation Score																					
2002	18.3		9.2	28.6		11.2	1.1		1.1	12.7		9.4	7.6		7.6					0.101	0.047
2003	40.5	A	7.8	74.0	B	15.3	29.0	A	9.1	26.7	A	8.0	20.0	A	7.7				< 0.001	< 0.001	0.047
2004	17.7	A	1.1	47.3	B	9.5	14.0	A	8.6	12.5	A	5.6	25.6	A	9.1				< 0.001	0.010	
Species of Concern																					
2002	0.0		0.0	2.9		2.0	0.0		0.0	0.0		0.0	2.5		2.5						
2003	4.6		1.6	15.3		3.4	0.0		0.0	2.2		1.6	0.0		0.0						
2004	13.1		3.7	25.9		5.3	8.6		4.6	5.6		2.5	22.1		10.8						
Combined	5.9	A	1.8	14.8	B	4.2	2.9	A	2.0	2.6	A	1.0	8.1	A	4.2				< 0.001	0.003	0.262
Total Bird Numbers																					
2002	1.2		0.6	1.7		0.7	0.1		0.1	0.9		0.7	0.5		0.5						
2003	2.4		0.3	4.4		0.7	1.8		0.3	1.7		0.4	1.3		0.3						
2004	0.9		0.2	2.6		0.4	0.7		0.2	0.7		0.2	1.3		0.5						
Combined	1.5	A	0.3	2.9	B	0.5	0.9	A	0.3	1.1	A	0.3	1.0	A	0.3				< 0.001	< 0.001	0.369

[a] Species richness was standardized using rarefaction due to unequal repetitions between years. The computer program EstimateS was used to calculate the adjusted species richness (Colwell 2004).

[b] total conservation score = $\sum$ (mean abundance of all species in a treatment * Partners in Flight priority score)

species of concern score = $\sum$ (mean abundance of species with Partners in Flight score $\geq$ 19 in a treatment * Partners in Flight priority score)

total bird numbers = mean total number of birds / 100 meters of transect.

Table 2.2. Continued

[c] Partners in Flight assesses the conservation status of North American bird species. Seven factors are combined to obtain a species score: relative abundance, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, population trend, and regional abundance, each ranging from 1 (low vulnerability) to 5 (high vulnerability). Birds scoring $\geq$ 19 are considered species of concern.

[d] Transects were different lengths, but were standardized by calculating the mean number of each species per 1000m.

[e] Treatment 1 = mechanical site preparation only with banded chemical control in year 1, Treatment 2 = herbicide site preparation only with banded chemical control in year 1, Treatment 3 = mechanical and chemical site preparation with banded chemical control in year 1, Treatment 4 = mechanical and chemical site preparation with broadcast chemical control in year 1, Treatment 5 = mechanical and chemical site preparation with broadcast chemical control in years 1 and 2.

[f] Means within rows followed by the same letter do not differ ($P > 0.05$).

[g] Within-treatment year effect ($P < 0.05$): Total Conservation Score

[h] Within-treatment year effect ($P < 0.001$): Total Conservation Score

[i] Within-treatment year effect ($P < 0.01$): Total Conservation Score

Table 2.3. Mean number of each bird by species observed at permanent point count stations for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity[a] during years 1 and 2 post-treatment (April - June 2002 and April - June 2003) in the Mississippi Lower Coastal Plain[b].

	Treatment																										
	1[cd]				2[ef]				3[gh]				4				5				*P*-value		
	x̄		SE		x̄		SE		x̄		SE		x̄		SE		x̄		SE		Yr	Trt	Yr*Trt
American Crow																							
2002	0.0		0.0		0.0		0.0		0.1		0.1		0.0		0.0		0.0		0.0			0.371	0.238
2003	0.0		0.0		0.0		0.0		0.0		0.0		0.2		0.1		0.4		0.2		0.184	0.371	
Barn Swallow																							
2002	0.0		0.0		0.2		0.2		0.0		0.0		0.0		0.0		0.1		0.1			0.425	0.536
2003	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.191	0.425	
Blue Grosbeak																							
2002	0.2		0.1		0.2		0.1		0.4		0.2		0.6		0.2		0.0		0.0			0.108	0.115
2003	1.7		0.5		1.9		0.4		3.3		0.8		1.2		0.3		0.6		0.2		< 0.001	0.108	
Blue Jay																							
2002	0.3		0.2		0.5		0.3		0.0		0.0		0.0		0.0		0.1		0.1				
2003	0.1		0.1		0.5		0.3		0.0		0.0		0.0		0.0		0.0		0.0				
Combined	0.2	AB	0.2		0.5	B	0.2		0.0	A	0.0		0.0	A	0.0		0.0	A	0.0		0.415	0.031	0.832
Brown-headed Cowbird																							
2002	0.0		0.0		0.2		0.1		0.0		0.0		0.1		0.1		0.0		0.0			0.058	0.502
2003	0.0		0.0		0.8		0.3		0.0		0.0		0.1		0.1		0.0		0.0		0.363	0.058	
Brown Thrasher																							
2002	0.2		0.1		0.6		0.2		0.0		0.0		0.1		0.1		0.0		0.0				
2003	0.0		0.0		1.0		0.5		0.0		0.0		0.1		0.1		0.0		0.0				
Combined	0.1	A	0.1		0.8	B	0.3		0.0	A	0.0		0.1	A	0.1		0.0	A	0.0		0.761	< 0.001	0.838
Carolina Chickadee																							
2002	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0			0.328	0.328
2003	0.0		0.0		0.7		0.3		0.1		0.1		0.0		0.0		0.1		0.1		0.158	0.328	
Carolina Wren																							
2002	0.3		0.3		0.4		0.2		0.1		0.1		0.3		0.2		0.1		0.1			0.064	0.222
2003	1.6		0.5		1.2		0.4		1.8		0.6		0.5		0.2		0.1		0.1		0.005	0.064	

Table 2.3. Continued

	Treatment																				
	1[cd]			2[ef]			3[gh]			4			5			*P*-value		
	x̄		SE	x̄		SE	x̄		SE	x̄		SE	x̄		SE	Yr	Trt	Yr*Trt
Chipping Sparrow																		
2002	0.0		0.0	0.2		0.2	0.0		0.0	0.0		0.0	0.0		0.0			
2003	0.0		0.0	0.4		0.2	0.2		0.1	0.2		0.1	0.0		0.0			
Combined	0.0	A	0.0	0.3	B	0.2	0.1	A	0.1	0.1	A	0.1	0.0	A	0.0	0.234	0.020	0.893
Common Ground Dove																		
2002	0.0		0.0	0.0		0.0	0.1		0.1	0.0		0.0	0.0		0.0		0.536	0.334
2003	0.0		0.0	0.2		0.2	0.0		0.0	0.0		0.0	0.0		0.0	0.658	0.536	
Common Nighthawk																		
2002	0.0		0.0	0.1		0.1	0.0		0.0	0.1		0.1	0.0		0.0		0.567	0.567
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.169	0.567	
Common Yellowthroat																		
2002	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0		1.000	0.012
2003	2.4	AB	0.3	3.4	A	0.8	1.5	BC	0.5	0.2	CD	0.1	0.1	D	0.1	< 0.001	< 0.001	
Downy Woodpecker																		
2002	0.0		0.0	0.2		0.1	0.0		0.0	0.0		0.0	0.1		0.1		0.144	0.502
2003	0.0		0.0	0.5		0.2	0.0		0.0	0.0		0.0	0.1		0.1	0.363	0.144	
Eastern Bluebird																		
2002	0.4		0.3	1.5		0.7	0.2		0.2	0.8		0.4	0.7		0.3		0.248	0.507
2003	0.1		0.1	1.8		0.4	1.0		0.4	1.0		0.3	1.4		0.4	0.160	0.248	
Eastern Kingbird																		
2002	0.3		0.2	1.0		0.3	0.3		0.3	0.4		0.3	0.0		0.0		0.072	0.633
2003	1.8		0.5	2.1		0.8	1.0		0.3	0.6		0.2	0.8		0.2	0.006	0.072	
Eastern Towhee																		
2002	0.3		0.2	0.8		0.4	0.0		0.0	0.0		0.0	0.1		0.1		0.657	0.003
2003	2.0	A	0.4	3.6	B	0.7	0.8	AC	0.4	0.8	AC	0.2	0.4	C	0.2	< 0.001	< 0.001	
Field Sparrow																		
2002	0.0		0.0	0.2		0.2	0.3		0.3	0.0		0.0	0.0		0.0		0.894	< 0.001
2003	2.1	A	0.4	2.8	B	0.4	1.5	A	0.3	0.4	C	0.2	0.1	C	0.1	< 0.001	< 0.001	
Gray Catbird																		
2002	0.0		0.0	0.1		0.1	0.0		0.0	0.1		0.1	0.0		0.0		0.130	0.061
2003	0.0		0.0	0.3		0.1	0.0		0.0	0.0		0.0	0.0		0.0	0.518	0.130	

Table 2.3. Continued

	Treatment																				
	1[cd]			2[ef]			3[gh]			4			5			*P*-value		
	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE	Yr	Trt	Yr*Trt
Great Crested Flycatcher																		
2002	0.0		0.0	0.4		0.3	0.0		0.0	0.0		0.0	0.0		0.0			
2003	0.0		0.0	0.6		0.2	0.0		0.0	0.1		0.1	0.0		0.0			
Combined	0.0	A	0.0	0.5	B	0.2	0.0	A	0.0	0.0	A	0.0	0.0	A	0.0	0.490	0.023	0.926
Indigo Bunting																		
2002	0.5		0.2	1.8		0.5	1.2		0.3	0.0		0.0	0.3		0.1			
2003	4.6		0.6	4.9		0.8	4.1		0.6	2.5		0.5	1.8		0.6			
Combined	2.5	AB	0.9	3.3	A	0.8	2.6	A	0.7	1.3	BC	0.6	1.0	C	0.5	< 0.001	0.008	0.102
Killdeer																		
2002	0.0		0.0	0.0		0.0	0.1		0.1	0.0		0.0	0.0		0.0		0.567	0.314
2003	0.0		0.0	0.1		0.1	0.0		0.0	0.0		0.0	0.0		0.0	1.000	0.567	
Loggerhead Shrike																		
2002	0.0		0.0	0.0		0.0	0.3		0.2	0.0		0.0	0.3		0.3		0.425	0.560
2003	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.173	0.425	
Mourning Dove																		
2002	0.5		0.2	0.3		0.2	0.3		0.2	0.0		0.0	0.1		0.1		0.927	0.047
2003	0.1	A	0.1	2.3	B	0.8	0.0	A	0.0	0.0	A	0.0	0.1	A	0.1	0.345	0.002	
Northern Bobwhite																		
2002	0.1		0.1	0.4		0.2	0.1		0.1	0.0		0.0	0.0		0.0		0.123	0.270
2003	0.2		0.1	1.8		0.7	0.3		0.2	1.3		0.4	0.1		0.1	0.026	0.123	
Northern Cardinal																		
2002	0.5		0.2	0.6		0.2	0.2		0.1	0.1		0.1	0.0		0.0			
2003	0.0		0.0	0.5		0.3	0.0		0.0	0.0		0.0	0.1		0.1			
Combined	0.3	A	0.2	0.5	B	0.2	0.1	A	0.1	0.0	A	0.0	0.0	A	0.0	0.206	0.045	0.603
Northern Mockingbird																		
2002	1.4		0.5	2.6		0.6	1.8		0.6	2.3		0.4	1.4		0.5		0.065	0.543
2003	1.3		0.5	3.3		0.6	0.5		0.2	2.4		0.6	1.5		0.4	0.818	0.065	
Orchard Oriole																		
2002	0.2		0.1	0.2		0.1	0.0		0.0	0.0		0.0	0.0		0.0		0.995	0.018
2003	0.7	A	0.3	3.0	B	0.6	0.2	A	0.1	0.5	A	0.3	0.2	A	0.1	0.004	< 0.001	

Table 2.3. Continued

	Treatment																							
	1[cd]				2[ef]				3[gh]				4				5				*P*-value			
	x̄			SE	x̄			SE	x̄			SE	x̄			SE	x̄			SE	Yr		Trt	Yr*Trt
Pine Warbler																								
2002	0.0			0.0	0.8			0.7	0.0			0.0	0.0			0.0	0.0			0.0			0.425	0.425
2003	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.326		0.425	
Pileated Woodpecker																								
2002	0.0			0.0	0.2			0.2	0.0			0.0	0.0			0.0	0.0			0.0			0.425	0.425
2003	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.326		0.425	
Prairie Warbler																								
2002	0.2			0.1	0.6			0.3	0.0			0.0	0.0			0.0	0.0			0.0				
2003	1.8			0.6	2.3			0.3	0.8			0.3	0.2			0.1	0.3			0.3				
Combined	1.0		AB	0.5	1.5		A	0.4	0.4		BC	0.2	0.1		C	0.1	0.2		C	0.2	< 0.001		0.002	0.125
Red-bellied Woodpecker																								
2002	0.0			0.0	0.2			0.0	0.2			0.0	0.1			0.0	0.0			0.0			0.688	0.020
2003	0.1		A	0.0	0.2		B	0.1	0.0		A	0.0	0.0		A	0.1	0.0		A	0.0	0.153		< 0.001	
Red-headed Woodpecker																								
2002	0.0		A	0.0	0.6		B	0.2	0.0		A	0.0	0.0		A	0.0	0.0		A	0.0			< 0.001	< 0.001
2003	0.0			0.0	0.2			0.1	0.0			0.0	0.0			0.0	0.0			0.0	< 0.001		0.655	
Red-winged Blackbird																								
2002	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0			0.425	0.425
2003	0.0			0.0	0.1			0.1	0.0			0.0	0.0			0.0	0.0			0.0	0.326		0.425	
Red-tailed Hawk																								
2002	0.0			0.0	0.1			0.1	0.0			0.0	0.0			0.0	0.0			0.0			0.425	0.425
2003	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.326		0.425	
Ruby-throated Hummingbird																								
2002	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0			0.123	0.176
2003	0.0			0.0	0.2			0.1	0.0			0.0	0.1			0.1	0.0			0.0	0.060		0.123	
Summer Tanager																								
2002	0.0			0.0	0.1			0.1	0.0			0.0	0.1			0.1	0.0			0.0			0.425	0.425
2003	0.0			0.0	0.1			0.1	0.0			0.0	0.0			0.0	0.0			0.0	0.326		0.425	
Wild Turkey																								
2002	0.1			0.1	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0			0.425	0.425
2003	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.326		0.425	

Table 2.3. Continued

	Treatment															P-value		
	1[cd]			2[ef]			3[gh]			4			5					
	x̄		SE	x̄		SE	x̄		SE	x̄		SE	x̄		SE	Yr	Trt	Yr*Trt
Yellow-breasted Chat																		
2002	0.0		0.0	0.3		0.1	0.1		0.1	0.0		0.0	0.2		0.1		0.998	0.034
2003	5.0	A	0.5	4.4	A	0.9	2.9	AB	0.8	1.5	BC	0.6	0.3	C	0.2	< 0.001	< 0.001	

[a] Treatment 1 = mechanical site preparation only with banded chemical control in year 1, Treatment 2 = herbicide site preparation only with banded chemical control in year 1, Treatment 3 = mechanical and chemical site preparation with banded chemical control in year 1, Treatment 4 = mechanical and chemical site preparation with broadcast chemical control in year 1, Treatment 5 = mechanical and chemical site preparation with broadcast chemical control in years 1 and 2.

[b] Means within rows followed by the same letter do not differ ($P > 0.05$).

[c] Within-treatment year effect ($P < 0.01$): common yellowthroat

[d] Within-treatment year effect ($P < 0.001$): eastern towhee, field sparrow, yellow-breasted chat

[e] Within-treatment year effect ($P < 0.01$): mourning dove

[f] Within-treatment year effect ($P < 0.001$): common yellowthroat, eastern towhee, field sparrow, orchard oriole, red-bellied woodpecker, red-headed woodpecker, yellow-breasted chat

[g] Within-treatment year effect ($P < 0.05$): common yellowthroat, yellow-breasted chat

[h] Within-treatment year effect ($P < 0.001$): field sparrow

Table 2.4. Avifauna species richness[a], total conservation score[bc], species of concern score[bc], and total bird numbers[b] found on permanent point count stations for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity[d] during years 1 and 2 post-treatment (April - June 2002 and April - June 2003) in the Mississippi Lower Coastal Plain[e].

	Treatment															P-value		
	1[f]			2[g]			3[hij]			4[kl]			5[m]					
	x̄		SE	x̄		SE	x̄		SE	x̄		SE	x̄		SE	Yr	Trt	Yr*Trt
Species Richness																		
2002	2.8		1.3	4.6		1.2	2.5		1.1	2.1		0.9	1.8		0.5		0.254	< 0.001
2003	7.8	A	0.5	14.8	B	2.0	6.5	A	1.0	7.1	A	0.7	5.2	A	1.0	< 0.001	< 0.001	
Total Conservation Score																		
2002	28.6		5.4	84.9		7.8	29.5		4.8	25.6		4.7	17.9		3.4		0.064	< 0.001
2003	77.5	A	4.1	135.5	B	7.7	58.8	AC	4.6	39.6	CD	3.6	23.0	D	2.8	< 0.001	< 0.001	
Species of Concern																		
2002	3.1		1.3	24.7		4.2	5.7		2.7	1.1		0.7	3.3		2.0		0.539	0.001
2003	34.1	A	3.0	59.3	B	5.0	19.5	C	2.0	13.7	C	2.4	3.9	D	1.1	< 0.001	< 0.001	
Total Bird Numbers																		
2002	5.3		1.5	15.0		1.5	5.5		1.2	4.9		1.2	3.4		1.0		0.066	0.001
2003	25.5	A	1.9	45.5	B	4.2	19.8	AC	2.5	13.8	CD	1.3	8.3	D	1.6	< 0.001	< 0.001	

[a] Species richness was standardized using rarefaction due to unequal repetitions between years. The computer program EstimateS was used to calculate the adjusted species richness (Colwell 2004).

[b] total conservation score = $\sum$ (mean abundance of all species in a treatment * Partners in Flight priority score)
species of concern score = $\sum$ (mean abundance of species with Partners in Flight score $\geq$ 19 in a treatment * Partners in Flight priority score)
total bird numbers = mean number of birds observed at 3 permanent point counts per treatment

[c] Partners in Flight assesses the conservation status of North American bird species. Seven factors are combined to obtain a species score: relative abundance, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, population trend, and regional abundance, each ranging from 1 (low vulnerability) to 5 (high vulnerability). Birds scoring $\geq$ 19 are considered species of concern.

[d] Treatment 1 = mechanical site preparation only with banded chemical control in year 1, Treatment 2 = herbicide site preparation only with banded chemical control in year 1, Treatment 3 = mechanical and chemical site preparation with banded chemical control in year 1, Treatment 4 = mechanical and chemical site preparation with broadcast chemical control in year 1, Treatment 5 = mechanical and chemical site preparation with broadcast chemical control in years 1 and 2.

Table 2.4. Continued

[e] Means within rows followed by the same letter do not differ ($P > 0.05$).

[f] Within-treatment year effect ($P < 0.001$): Species Richness, Total Conservation Score, Species of Concern, Total Bird Numbers

[g] Within-treatment year effect ($P < 0.001$): Species Richness, Total Conservation Score, Species of Concern, Total Bird Numbers

[h] Within-treatment year effect ($P < 0.001$): Species Richness

[i] Within-treatment year effect ($P < 0.05$): Species of Concern, Total Bird Numbers

[j] Within-treatment year effect ($P < 0.01$): Total Conservation Score

[k] Within-treatment year effect ($P < 0.01$): Species Richness

[l] Within-treatment year effect ($P < 0.05$): Species of Concern

[m] Within-treatment year effect ($P < 0.001$): Species Richness

CHAPTER III

BIRD RESPONSE TO HABITAT VARIABLES AFFECTED BY INTENSIVE PINE PLANTATION MANAGEMENT

ABSTRACT

The increase of intensive pine plantation management requires consideration of how management activities affect native biological diversity. I tested models comprised of 6 habitat variables to identify the most influential variables on abundance of breeding birds classified as species of concern. Variables included 1) % coverage of debris, 2) % coverage of grass and grass-like species, 3) % coverage of forbs and legumes, 4) % coverage of woody shrubs, trees, and vines, 5) % coverage of total vegetation and 6) snag density. Snag density produced the best model or among the best models in 19 of the 30 models. Models detected habitat factors that significantly influenced abundance of 13 species, several with multiple significant models and multiple years with significant models. Of those 13 species, only 1 did not have snag density as a best model for at least 1 year. Knowledge of habitat conditions that affect bird abundance on intensively managed pine plantations can aid managers interested in attaining forestry objectives, while providing habitat for avian communities.

Key words: AICc, breeding birds, habitat modeling, intensive pine plantation management, release, residual snags, site preparation

INTRODUCTION

The South is the largest source of timber in the U.S. in both area and volume (Haynes 2002). Area in pine plantations in the South is predicted to increase from 12.0 to 22.0 million hectares between 1999 and 2040 (Conner and Hartsell 2002, Prestemon and Abt 2002). With this increase in intensive management, the region will receive twice as much disturbance from harvest as any other region in the U.S. while contributing 79 % of future increases in softwood production (Haynes 2002).

Three main factors contribute to escalation of intensive management: the rising costs of accessing old-growth forests, technology that has increased productivity and yields of short rotation timber plantations, and social pressure to protect old-growth forests (Sedjo and Botkin 1997). As intensive management increases profitability, this trend toward increased intensity of management will likely become more common in southern pine plantations. Common practices in intensive timber management include planting improved stock, using herbicides to control competing vegetation, fertilizating, and thinning (Yin and Sedjo 2001).

Suppression of hardwoods and herbaceous plants through site preparation may affect wildlife requiring early successional habitats. Herbicides may influence breeding bird diversity by changing vegetative structure and composition (Cone et al. 1993, Brooks et al. 1994). By altering the vegetation structure, herbicides may affect density and behavior of songbirds (Morrison and Meslow 1984). Songbird populations can reflect changes in floral community complexity (Santillo et al. 1989, Schultz et al. 1992). Types of herbicide used may not be as important as the remaining number of snags after harvest in influencing habitat use by songbirds (Brooks et al. 1994).

Young pine plantations may include early successional habitat, but the habitat quality and length of suitability may differ due to site preparation and release methods. Management strategies addressing timber production and bird conservation can attend to human needs, commodity production, and maintenance of native biological diversity. Forest industries and conservation organizations, such as American Ornithological Union's Partners in Flight program, are currently promoting integration of commercial forest management with conservation of avifauna (Yarrow and Yarrow 1999).

To increase information on site preparation and release influences on habitat features and bird communities that will facilitate integration of timber production and wildlife conservation, I examined the effects of habitat change caused by 5 intensities of site preparation and release treatments on breeding birds in southern Mississippi. I tested models comprised of 6 habitat variables to identify the most influential variables related to abundance of species of concern.

STUDY AREA AND TREATMENTS

I monitored the effects of intensive pine plantation management on forest industry land in southern Mississippi ($n = 4$); 3 study sites were in the Mississippi Lower Coastal Plain (LCP) and 1 site was in the northern portion of the Coastal Flatwoods (Pettry 1977). The site located in George County exhibited soil and vegetative characteristics consistent with the LCP sites, although it was outside the graphical representation of the LCP. Potential study sites were submitted by cooperating forest management companies and selected based on timber harvest and regeneration schedule, size (> 40.5 ha), and edaphic similarity, and hydrological conditions.

Soil associations were similar among the study sites. The McLaurin-Heidel-Prentiss association was common to 2 stands and was comprised of gently sloping, moderately well-drained, sandy and loamy soils. The McLaurin-Savannah-Susquehenna association, comprised of poorly drained, nearly level upland soils, occurred on 1 stand. The Prentiss-Rossella-Benndale association occurred on 2 stands and was characterized by loamy and fine sandy loam soils.

Management regimes (i.e., treatments) represented a range of operational intensities in forest industry site preparation and release techniques, reflecting a gradient in vegetation management intensity and consequent potential of wildlife habitat quality and pine growth response. Treatments were arranged in a randomized complete block design where each treatment ($n = 5$) was randomly assigned to a > 8-ha area within each stand ($n = 4$) so that each treatment occurred only once per stand. Management intensity increased from "low" for treatment 1 to "high" for treatment 5.

Treatment 1, hereafter referred to as Mech+Band, consisted of mechanical site preparation using a combination plow to subsoil, disk, and bed, pulled behind a bulldozer with a V-blade attached to the front to clear debris. In year 1, a banded herbaceous control was applied using 11.8 kg/ha of Oustar®.

Treatment 2, hereafter referred to as Chem+Band, consisted of chemical site preparation using a mixture of 2.4 L/ha Chopper®, 5.3 L/ha Accord®, 5.3 L/ha Garlon 4, and 1% volume to volume (v/v) ratio of Timberland 90 surfactant (T90) in a total spray solution of 93.6 L/ha. In year 1, a banded herbaceous control was applied using 11.8 kg/ha of Oustar®. No mechanical preparation (i.e., bedding) occurred in Treatment 2.

Treatment 3, hereafter referred to as Combo+Band, consisted of the same mechanical site preparation as Mech+Band and the same chemical site preparation as Chem+Band. In year 1, a banded herbaceous control was applied using 11.8 kg/ha of Oustar®.

Treatment 4, hereafter referred to as Combo+Broad, consisted of the same mechanical site preparation as Mech+Band and the same chemical site preparation as Chem+Band. In year 1, a broadcast herbaceous control was applied using 11.8 kg/ha of Oustar®.

Treatment 5, hereafter referred to as Combo+2Broad, consisted of the same mechanical site preparation as Mech+Band and the same chemical site preparation as Chem+Band. In years 1 and 2, a broadcast herbaceous control was applied using 11.8 kg/ha of Oustar®.

All chemical site preparation was applied during July–August 2001, and all mechanical site preparation was performed during September–December 2001. Year 1 herbaceous controls were applied in March–April 2002 and year 2 herbaceous treatments were performed in March–May 2003.

Additional details were agreed upon by all forest industry cooperators to standardize stand management on study sites. Stands were planted during December 2001–January 2002. Pine tree seedlings were planted on a 3.0-m x 2.1-m spacing (i.e., 3.0 m between rows and 2.1 m between trees), totaling 1,551 trees/ha. Banded herbaceous control treatments were applied with a band width of 1.5 m, and broadcasted herbicide applications were aerially applied via helicopter. A broadcast fertilizer application of DAP at 280 kg/ha was applied during April 2002. All stands were

intended to be machine planted to facilitate banding applications by tractor. However, 2 stands were hand planted due to greater debris loads remaining post-harvest. Banding applications were conducted by hand on these 2 sites.

METHODS

I conducted breeding bird surveys from late April through early June in 2002 and 2003. Point counts were sampled 3 times in 2002 and 6 times in 2003 during the spring sampling period. Treatments were surveyed from sunrise until 9:30 a.m. during optimal weather conditions. I used a 10-minute, variable-radius point count. The observer identified each bird to species and recorded its estimated distance from the center point (Buckland et al. 1993). Three subplots were permanently marked in each treatment for the point counts.

Partners in Flight developed a system assessing the conservation status of North American bird species (Panjabi 2001). Seven vulnerability categories are scored yearly, from "1" for low vulnerability to "5" for high vulnerability. The 6 vulnerability factors cover relative abundance, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, and population trend. The seventh factor, area importance incorporates regional abundance depending on season. Summation of the scores generates priority species pools for physiographic regions, and a national watch list for species scoring greater than or equal to 19. Additionally, a score of 19 must be in combination with a population trend of at least 5, and 20 must match a population trend of at least 3.

I sampled vegetation for a companion study on all sites in June 2002 and 2003 (Edwards 2004). Percent coverage of understory herbaceous species, woody species, and debris was recorded using a modification of Canfield's (1941) line-intercept method. Within each treatment, 10 transects of 30 m were established to assess vegetation characteristics. Plants were identified by species and then grouped by growth form type. Snags were defined as any residual tree > 2 m in height. Snag density was quantified by randomly selecting one side of the established belt transects and counting the number of snags within 10 m of the centerline. Analysis factors included % coverage of debris, % coverage of grass and grass-like, % coverage of forbs and legumes, % coverage of woody shrubs, trees, and vines, % coverage of total vegetation, and snag density (Table 3.1). I chose these habitat variables due to inherent structural or floristic differences among these growth categories. I used this information to determine potential relationships between habitat variables and mean abundance of selected bird species (Daniel 1990, Hays et al. 1981, Morrison et al. 1992).

I used a mixed model to identify habitat conditions that influenced avifauna on newly established pine plantations in South Mississippi. The regression response variable was mean abundance of avian species being modeled. Analyzed species were Partners in Flight species of concern. Six independent variables were compared using all possible model combinations. These variables were snag density, % coverage of debris, grass and grass-like species, forbs and legumes, woody plants, and total vegetation. Best models were developed for each year from the –2 log likelihood from SAS Proc MIXED (SAS Institute 2000). The –2 log likelihood was converted to an Akaike Information Criterion (AIC) by the equation AIC = -2 log likelihood * (2 * K), where K = (number of

parameters in the model) + 2 (Burnham and Anderson 1998). AIC was then changed to an AICc to correct for small sample size, using the equation AICc = AIC + {[(2*K) (K+1)] / (# of observations - K - 1)}(Burnham and Anderson 1998). The models were ranked by AICc from lowest to highest, followed by calculation of differences between alternate models (ΔAICc) and their Akaike weights (w_i). After selecting models that had an AICc within 2.0 of the best model and the global model, which incorporated all parameters, r^2 was calculated (Burnham and Anderson 1998). The r^2 was determined by obtaining the expected mean avian values by way of the Solution option (Littell et al. 1996). The equation was $r^2 = 1 - \{(\text{observed - expected})^2 / (\text{observed - mean observed})^2\}$ (Kvålseth 1985). The r^2 value was adjusted to adjusted $r^2 = 1 - (1 - r^2)\,[(N - 1) / (N - k - 1)]$, where N = number of observations and k = number of parameters (Miles and Shevlin 2001). Adjusted r^2 were considered significant at adj $r^2 > 0.45$ (Miles and Shevlin 2001).

RESULTS

There were 16 species categorized as species of concern (See Appendix B.3 for list of species of concern scientific names). Fourteen species were present for both years of the study, and 2 species were present during only 1 year, creating 30 total model runs (Table 3.2). Snag density was the best model or among the best models in 19 of the 30 models.

Models detected habitat factors that significantly influenced abundance of 13 species, several with multiple significant models and multiple years with significant models. Of those 13 species, only field sparrow did not have snag density as a best model for at least 1 year. Four species were significantly influenced by models that

included snag density for 1 year, but not for the other year. During 2002, red-bellied woodpecker abundance was impacted by woody plant coverage, and during 2003, eastern kingbirds and field sparrows were affected by grass coverage, and yellow-breasted chats by debris coverage and total vegetation coverage.

DISCUSSION

Many authors have discussed the importance of snags for primary and secondary cavity nesters (Conner 1978, Davis 1983, Dickson et al. 1983, Land et al. 1989, Caine and Marion 1991, Lohr et al. 2002). Cavity nesters and other birds use snags for nest sites, perches, singing or drumming posts, sighting prey, and foraging (Johnson and Landers 1982, Dickson et al. 1983, Caine and Marion 1991, Schieck and Hobson 2000). Removing snags may reduce substrate for some insects, possibly reducing prey sources for insectivorous birds. The appearance of snag density as a best model for cavity nesters is not surprising. Abundance of red-bellied and red-headed woodpecker was influenced by snag density. Woodpeckers use snags for cavity nests, foraging, and mate attraction (drumming). When snags are available, red-bellied woodpecker may change their territories to include early successional plantations (Caine and Marion 1991). A secondary cavity nester, the great crested flycatcher, was also influenced by snag density. Great crested flycatchers may use snags as foraging sites, singing posts, perches, and nest sites. Caine and Marion (1991) found that great crested flycatcher territories were extended to include young plantations when snags and nest sites were available. Lohr et al. (2002) observed that snag removal reduced great crested flycatcher abundance.

Many studies have documented the relationship of primary and secondary cavity nesters to snags, but few report snag importance to other breeding birds. Brown thrasher, common ground dove, eastern towhee, orchard oriole, summer tanager, and yellow-breasted chat abundance was significantly related to snag density in at least 1 year of the study. Although a connection between these species and snags is not as obvious as for cavity nesters, perching, singing, and foraging sites provided by snags are important to these birds as well. All of these species were observed using snags as perches and singing posts during this study. Dunn and Garrett (1997) stated that snags or trees are required as singing perches for yellow-breasted chat. Snags induced eastern towhee and summer tanager to modify their territories, incorporating more early successional habitat even though they are wood-interior or wood-edge species (Caine and Marion 1991).

In this study, prairie warbler, northern bobwhite, and eastern kingbird were positively associated with habitat that included snags. These species were observed using snags for singing or perching. In contrast, Dickson et al. (1983) who found that prairie warbler were more abundant on plots devoid of standing snags. In addition to snags, prairie warbler abundance was significantly affected by grass coverage. Prairie warblers are a shrub-scrub species (Hunter et al. 2001). The influence of grass coverage is somewhat surprising for this species, but is possibly due to the random location of vegetation transects, in contrast to being bird centered. The vegetation transects described the treatment, but may not describe the specific areas the birds were using within the treatment. Northern bobwhite abundance was significantly influenced by debris coverage as well snag density. Northern bobwhite are grassland birds, and are associated with low cover and open foraging areas, so the influence of grass coverage

would be expected. Brennan (1999) states that northern bobwhite uses open areas that provide cover. Debris in this study was classified as any dead organic matter that covered the ground, so northern bobwhite may have used fairly open areas that had ground litter debris. Eastern kingbird abundance was influenced by snag density, but their abundance also was impacted by woody coverage, grass coverage, and debris coverage. Though they are described as chiefly savannah dwellers, they have a flexible habitat association and may also be found in residential areas, field, and wetland edges (Murphy 1996).

There were other habitat factors that influenced abundance of red-bellied woodpecker, eastern kingbird, field sparrow, and yellow-breasted chat. Red-bellied woodpecker abundance associated with woody plant coverage in 2002 may be a function of where they were recorded. Though they were recorded on snags, the treatments in which they were recorded were those with low snag densities (Hanberry, unpublished data). This may have caused another habitat factor to receive greater importance. Effect of grass coverage on eastern kingbird abundance may be due to its wide range of suitable habitats. Considering that field sparrow prefer old fields and brushy habitat (Hunter et al. 2001), it is not surprising that grass coverage influenced their abundance. Yellow-breasted chat forage in low, thick vegetation (Eckerle and Thompson 2001), so total vegetation coverage likely impacts their abundance. They also forage on the ground so they might be acquiring insects in the debris.

CONCLUSIONS

Snag density seems to be a highly influential habitat feature for many bird species in my study sites. Overall, habitat modeling may be used to provide information on potential explanatory habitat variables that may influence specific species (e. g. snags are important to woodpeckers). This type of modeling can also be conducted to test and confirm available literature on habitat features related to bird species. This study could be improved for habitat modeling by encompassing and measuring more habitat variables at the microsite, macrosite, and landscape level. Microsite habitat measurements should center around point count stations, rather than throughout the entire treatment, to measure features that may attract detected birds. However, vegetation measurements may never fully identify all of the conditions that influence bird habitat use and fulfillment of life requirements. Furthermore, time, personnel and budget limitations may prohibit additional habitat measurements at multiple scales.

LITERATURE CITED

Brennan, L. A. 1999. Northern bobwhite (*Colinus virginianus*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 397. The American Ornithologists' Union, Washington, D.C., USA.

Brooks, J. J., J. L. Rodrigue, M. A. Cone, K. V. Miller, B. R. Chapman, and A.S. Johnson. 1994. Small mammal and avian communities on chemically-prepared sites in the Georgia Sandhills. Proceedings of the Biennial Southern Silvicultural Research Conference 8:21-23.

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake. 1993. Distance sampling: Estimating abundance of biological populations. Chapman and Hall, London, England.

Burnham, K.P., and D.R. Anderson. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York, New York, USA.

Caine, L. A., and W. R. Marion. 1991. Artificial addition of snags and nest boxes to slash pine plantations. Journal of Field Ornithology 62:97-106.

Canfield, R.H. 1941. Application of the line interception method in sampling range vegetation. Journal of Forestry 39:388-394.

Cone, M. A., J. J. Brooks, B. R. Chapman, and K.V. Miller. 1993. Effects of chemical site preparation on songbird use of clearcuts in Georgia. Proceedings of the Southern Weed Science Society 46:175.

Conner, R. C., and A. J. Hartsell. 2002. Forest area and conditions. Pages 357-402 *in* Wear, D. N., and J. G. Greis, editors. Southern forest resource assessment. USDA, Southern Research Station, Asheville, North Carolina, USA.

Conner, R. N. 1978. Snag management for cavity nesting birds. Pages 120-128 *in* R. M. DeGraaf, editor. Proceedings of the workshop on management of southern forests for nongame birds. U.S. Department of Agriculture Forest Service General Technical Report SE-14.

Daniel, W. W. 1990. Applied nonparametric statistics. PWS-KENT Publishing Company, Boston, Massachusetts, USA.

Davis, J. W. 1983. Snags are for wildlife. Pages 4-8, *in* J. W. Davis, G. A. Goodwin, and R. A. Okenfels, technical coordinators. Proceedings of the symposium on snag habitat management. U.S. Department of Agriculture Forest Service General Technical Report RM-99.

Dickson, J. G., R. N. Conner, and J. H. Williamson. 1983. Snag retention increases bird use of a clear-cut. Journal of Wildlife Management 47: 799-804.

Eckerle, K. P., and C. F. Thompson. 2001. Yellow-breasted chat (*Icteria virens*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 575. The American Ornithologists' Union, Washington, D.C., USA.

Edwards, S. L. 2004. Effects of intensive pine plantation management on wildlife habitat in south Mississippi. Thesis, Mississippi State University, Mississippi State, Mississippi, USA.

Haynes, R. W. 2002. Forest management in the 21st century: Changing numbers, changing context. Journal of Forestry 100(2):38-43.

Hays, R. L., C. Summers, and W. Seitz. 1981. Estimating habitat variables. United States Fish and Wildlife Service FWS/OBS-81147.

Hunter, W. C., D. A. Buehler, R. A. Canterbury, J. L. Confer, and P. B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin 29:440-455.

Johnson, A. S., and J. L. Landers. 1982. Habitat relationships of summer resident birds in slash pine flatwoods. Journal of Wildlife Management 46:416-428.

Kvålseth, T. O. 1985. Cautionary note about R^2. American Statistician 39:279-285.

Land, D., W. R. Marion, and T. E. O'Meara. 1989. Snag availability and cavity-nesting birds in slash pine plantations. Journal of Wildlife Management 53:1165-1171.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS system for mixed models. SAS Institute, Cary, North Carolina, USA.

Lohr, S. M., S. A. Gauthreaux, and J. C. Kilgo. 2002. Importance of coarse woody debris to avian communities in loblolly pine forests. Conservation Biology 16:767-777.

Miles, J., and M. Shevlin. 2001. Applying regression and correlation: a guide for students and researchers. Sage Publications, London, England.

Morrison, M. L., and E.C. Meslow. 1984. Response of avian communities to herbicide-induced vegetation changes. Journal of Wildlife Management 48:14-22.

Morrison, M. L., B. G. Marcot, and R. W. Mannan. 1992. Wildlife-habitat relationships. The University of Wisconsin Press, Madison, Wisconsin, USA.

Murphy, M. T. 1996. Eastern kingbird (*Tyrannus tyrannus*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 253. The American Ornithologists' Union, Washington, D.C., USA.

Panjabi, A. 2001. The Partners in Flight handbook on species assessment and prioritization. http://www.rmbo.org/pif

Pettry, D. E. 1977. Soil resource areas of Mississippi. Mississippi Agricultural and Forestry Experiment Station Information Sheet 1278.

Prestemon, J. P., and R. C. Abt. 2002. Timber products supply and demand. Pages 299-325 *in* Wear, D. N., and J. G. Greis, editors. Southern forest resource assessment. USDA, Southern Research Station, Asheville, North Carolina, USA.

Santillo, D. J., P. W. Brown, and D. M Leslie, Jr. 1989. Response of songbirds to gyphosate-induced habitat changes on clearcuts. Journal of Wildlife Management 53:64-71.

SAS Institute. 2000. SAS/STAT User's Guide, Version 8. SAS Institute, Cary, North Carolina, USA.

Schultz, C. A., D. M. Leslie Jr., R. L. Lochmiller, and D. E. Engle. 1992. Herbicide effects on cross timbers breeding birds. Journal of Range Management 45:407-411.

Schieck, J., and K. A. Hobson. 2000. Bird communities associated with live residual tree patches within cut blocks and burned habitat in mixedwood boreal forests. Canadian Journal of Forest Research 30:1281-1295.

Sedjo, R. A., and D. Botkin. 1997. Using forest plantations to spare natural forests. Environment 39(10):14-30.

Yarrow, G. K., and D. T. Yarrow. 1999. Managing wildlife. Sweetwater Press, Birmingham, Alabama, USA.

Yin, R., and R. A. Sedjo. 2001. Is this the age of intensive management: A study of loblolly pine of Georgia's Piedmont. Journal of Forestry 99(12):10-17.

Table 3.1. Mean for habitat factors[a] used in modeling abundance of species of concern[b] for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity[c] during years 1 and 2 post-treatment (June 2002 and 2003) in the Mississippi Lower Coastal Plain.

	Treatment									
	1		2		3		4		5	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
% Coverage Debris										
2002	44.0	4.4	58.7	12.6	58.9	4.2	70.9	7.0	72.4	6.2
2003	13.0	3.6	22.0	4.2	14.9	6.5	19.6	2.6	65.9	8.8
% Coverage Grass and Grasslike										
2002	14.9	3.4	18.0	5.8	8.8	1.8	1.9	0.7	1.1	0.4
2003	28.7	6.7	32.9	4.9	22.1	6.4	21.3	7.0	10.4	2.9
% Coverage Forbs and Legumes										
2002	11.7	2.1	18.5	9.1	11.3	3.1	1.6	0.3	1.4	0.5
2003	21.9	7.4	27.7	9.9	26.6	9.1	27.5	5.4	6.9	5.3
% Coverage Woody Shrubs, Trees, and vines										
2002	19.5	2.7	8.5	4.2	8.8	3.1	3.5	0.5	2.8	0.3
2003	71.0	9.3	35.5	8.2	53.9	14.5	41.5	9.3	11.7	3.6
% Coverage Total Vegetation										
2002	46.2	5.9	45.0	18.5	28.9	4.2	6.9	1.1	5.3	1.2
2003	121.5	8.9	96.1	8.9	102.7	11.4	90.4	3.7	29.0	7.5
Snag Density										
2002	8.9	4.4	83.6	20.5	9.6	5.2	6.6	4.0	5.3	3.2
2003	8.0	4.2	78.9	18.5	8.5	4.4	6.0	3.4	4.9	2.8

[a] % Coverage debris, % coverage grass and grasslike, % coverage forbs and legumes, % coverage woody shrubs, trees, and vines, and % coverage total vegetation was obtained from a companion study (Edwards 2004).

Table 3.1. Continued

[b] Partners in Flight assesses the conservation status of North American bird species. Seven factors are combined to obtain a species score: relative abundance, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, population trend, and regional abundance, each ranging from 1(low vulnerability) to 5 (high vulnerability). Birds scoring $\geq$ 19 are considered species of concern.

[c] Treatment 1 = mechanical site preparation only with banded chemical control in year 1, Treatment 2 = herbicide site preparation only with banded chemical control in year 1, Treatment 3 = mechanical and chemical site preparation with banded chemical control in year 1, Treatment 4 = mechanical and chemical site preparation with broadcast chemical control in year 1, Treatment 5 = mechanical and chemical site preparation with broadcast chemical control in years 1 and 2.

Table 3.2. Habitat association best models and models with a $\Delta AICc \leq 2$ for avian species of concern[a] on 4 sites in South Mississippi for each year, 2002-2003.

Species		Model with independent variables[b]	AICc	ΔAICc	w_i	r^2	Adjusted r^2 [c]
Brown Thrasher							
	2002	SNAG	19.10	0.00	0.92	0.640	0.620
	2003	GRASS	51.40	0.00	0.46	0.320	0.283
Carolina Chickadee							
	2003	SNAG	19.10	0.00	0.92	0.406	0.373
Common Ground Dove							
	2002	DEBRIS[d]	97.70	0.00	0.44	0.057	0.005
		VEGTOT	99.70	2.00	0.16	0.052	0.000
	2003	SNAG	-5.90	0.00	0.81	0.555	0.530
Eastern Kingbird							
	2002	WOODY[d]	50.90	0.00	0.22	0.495	0.467
		GRASS	51.00	0.10	0.21	0.515	0.488
		SNAG	51.00	0.10	0.21	0.596	0.573
		DEBRIS	51.60	0.70	0.15	0.480	0.452
		FORB	52.90	2.00	0.08	0.512	0.484
	2003	GRASS	71.10	0.00	0.62	0.682	0.664
Eastern Towhee							
	2002	SNAG	42.80	0.00	0.72	0.515	0.488
	2003	SNAG	79.50	0.00	0.83	0.691	0.674
Field Sparrow							
	2002	DEBRIS[d]	19.50	0.00	0.33	0.347	0.046
		WOODY	20.00	0.50	0.25	0.345	0.043
	2003	GRASS	68.40	0.00	0.71	0.737	0.616
Gray Catbird							
	2002	WOODY[d]	-14.10	0.00	0.27	0.521	0.232
		GRASS	-13.50	0.60	0.20	0.448	0.194
		FORB	-13.40	0.70	0.19	0.359	0.064
		DEBRIS	-13.20	0.90	0.17	0.448	0.194
		SNAG	-12.10	2.00	0.10	0.405	0.130
	2003	GRASS[d]	4.10	0.00	0.31	0.153	-0.237
		SNAG	4.10	0.00	0.31	0.244	-0.105
		DEBRIS	5.70	1.60	0.14	0.097	-0.320

Table 3.2. Continued

Species	Model with independent variables[b]	AIC*c*	ΔAIC*c*	w_i	r^2	Adjusted r^2 [c]
Great Crested Flycatcher						
2002	SNAG	1.90	0.00	0.84	0.802	0.791
2003	SNAG	25.90	0.00	0.95	0.548	0.523
Loggerhead Shrike						
2002	WOODY[d]	30.90	0.00	0.32	0.380	0.346
	GRASS	31.60	0.70	0.23	0.385	0.350
	DEBRIS	32.30	1.40	0.16	0.369	0.334
	FORB	32.60	1.70	0.14	0.357	0.321
Northern Bobwhite						
2002	DEBRIS	3.60	0.00	0.86	0.409	0.376
2003	SNAG[d]	71.60	0.00	0.52	0.699	0.725
	DEBRIS	72.20	0.60	0.39	0.506	0.478
Orchard Oriole						
2002	GRASS[d]	4.10	0.00	0.41	0.365	0.330
	WOODY	6.00	1.90	0.16	0.305	0.267
2003	SNAG	60.40	0.00	0.95	0.837	0.828
Prairie Warbler						
2002	SNAG	30.50	0.00	0.61	0.472	0.443
2003	GRASS[d]	72.70	0.00	0.57	0.632	0.612
	SNAG	74.00	1.30	0.30	0.583	0.560
Red-bellied Woodpecker						
2002	WOODY	4.60	0.00	0.47	0.510	0.483
2003	SNAG	4.10	0.00	1.00	0.879	0.872
Red-headed Woodpecker						
2002	SNAG	6.60	0.00	0.81	0.832	0.823
2003	SNAG	-5.90	0.00	0.81	0.555	0.530
Summer Tanager						
2002	DEBRIS[d]	-16.50	0.00	0.39	0.301	0.263
	GRASS	-15.50	1.00	0.23	0.427	0.396
2003	SNAG	-30.90	0.00	0.82	0.555	0.530

Table 3.2. Continued

Species	Model with independent variables[b]	AIC*c*	ΔAIC*c*	w_i	r^2	Adjusted r^2 [c]
Yellow-breasted Chat						
	2002 SNAG	9.60	0.00	0.76	0.537	0.511
	2003 DEBRIS[d]	97.70	0.00	0.44	0.714	0.698
	VEGTOT	99.70	2.00	0.16	0.769	0.756

[a] Partners in Flight assesses the conservation status of North American bird species. Seven factors are combined to obtain a species score: relative abundance, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, population trend, and regional abundance, each ranging from 1(low vulnerability) to 5 (high vulnerability). Birds scoring ≥ 19 are considered species of concern.

[b] Debris = percent coverage of debris, Forb = percent coverage of forbs and legumes, Grass = percent coverage of grass and grass-like, Snag = snag density, woody = percent coverage of woody shrubs, trees, and vines, and Vegtot = total vegetation coverage

[c] An $r^2 > 0.45$ is equal to a p-value < 0.05.

[d] Denotes the best model of the multiple habitat variable models that were most influential to the bird species abundance.

CHAPTER IV

SYNTHESIS AND RECOMMENDATIONS

Most bird species associated with early successional habitat, consisting of grasslands and shrublands, are decreasing (Askins 2001, Hunter et al. 2001). Hunter et al. (2001) found declines in 27 of 37 grassland bird species and 27 of 40 shrubland bird species in eastern North America. Suppression of disturbance, mainly fire, has reduced the amount of early successional habitat (Askins 2000); clearcuts now provide necessary habitat for many disturbance-dependent bird species (Thompson and DeGraaf 2001).

Our study indicated that site preparation and release affects the quality of available early successional habitat in southern pine plantations. Transects and point counts showed that birds occupied the herbicide-only treatment the most. The other low intensity treatments, 1 and 3, provided preferential habitat for more birds than the higher intensity treatments. Mourning dove, field sparrow, and orchard oriole, declining shrub-scrub species (Hunter et al. 2001), had the greatest abundance in the herbicide-only treatment. Other declining shrub-scrub species, prairie warbler, common yellowthroat, and yellow-breasted chat (Hunter et al. 2001) had a greater abundance in the 2 lowest intensity treatments. Also, red-headed woodpecker, a declining species associated with disturbance-maintained woodlands (Hunter et al. 2001), had the greatest abundance in the herbicide-only treatment. Declining species associated with forest openings, eastern

towhee and indigo bunting (Hunter et al. 2001) had their greatest abundance in the herbicide-only treatment.

Snag retention appears to increase species richness and abundance of many species. In this study, snags confounded detection of differences between mechanical and chemical treatments. Contrasting herbicide site preparation treatments with and without snags could determine if snag density alone is most important, or if there is a synergistic effect between vegetation structure and snags. A comparison of different site preparation and release treatments in which all treatments contain residual trees, natural or artificial, is warranted. Future research should determine if residual snags mitigate the effects of more intensive site preparation and release treatments, and additionally if bird assemblages differ between high intensity with snags versus low intensity without snags.

Snag density seems to be the greatest habitat influence within these sites. However, habitat modeling may have limited usefulness; mostly providing habitat variables expected for species (e. g., snags are important to woodpeckers), and confirming available literature. This study could be improved for habitat modeling by encompassing and measuring more habitat variables at the microsite, macrosite, and landscape level. Microsite measurements should center habitat sampling around point count stations rather than throughout the entire treatment in an effort to measure features that may be attracting the detected bird. However, vegetation measurements cannot fully identify all factors that influence bird habitat use and fulfillment of species-specific life history requirements. Furthermore, time, personnel and budget limitations may prohibit additional habitat measurements at multiple scales.

LITERATURE CITED

Askins, R. A. 2000. North America's birds: lessons from landscape ecology. Yale University Press, New Haven, Connecticut, USA.

Askins, R. A. 2001. Sustaining biological diversity in early successional communities: the challenge of managing unpopular habitats. Wildlife Society Bulletin 29: 407-412.

Hunter, W. C., D. A. Buehler, R. A. Canterbury, J. L. Confer, and P. B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin 29:440-455.

Thompson, F. R., III, and R. M. DeGraaf. 2001. Conservation approaches for woody, early successional communities in the eastern United States. Wildlife Society Bulletin 29:483-494.

APPENDIX A

STUDY AREA MAPS

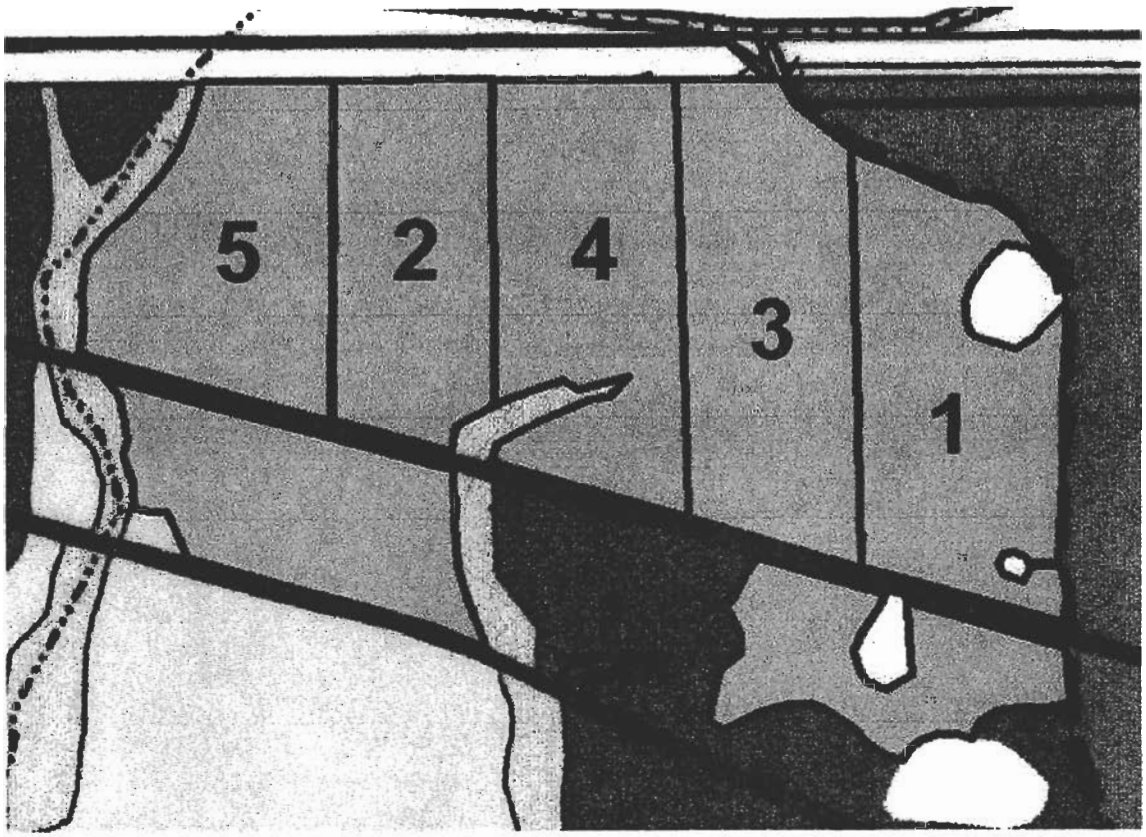


Figure A.1. Treatment allocation for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity within a 74-ha stand located in Section 3, T2S R9W, in George County, MS, owned by Plum Creek Timber Company.

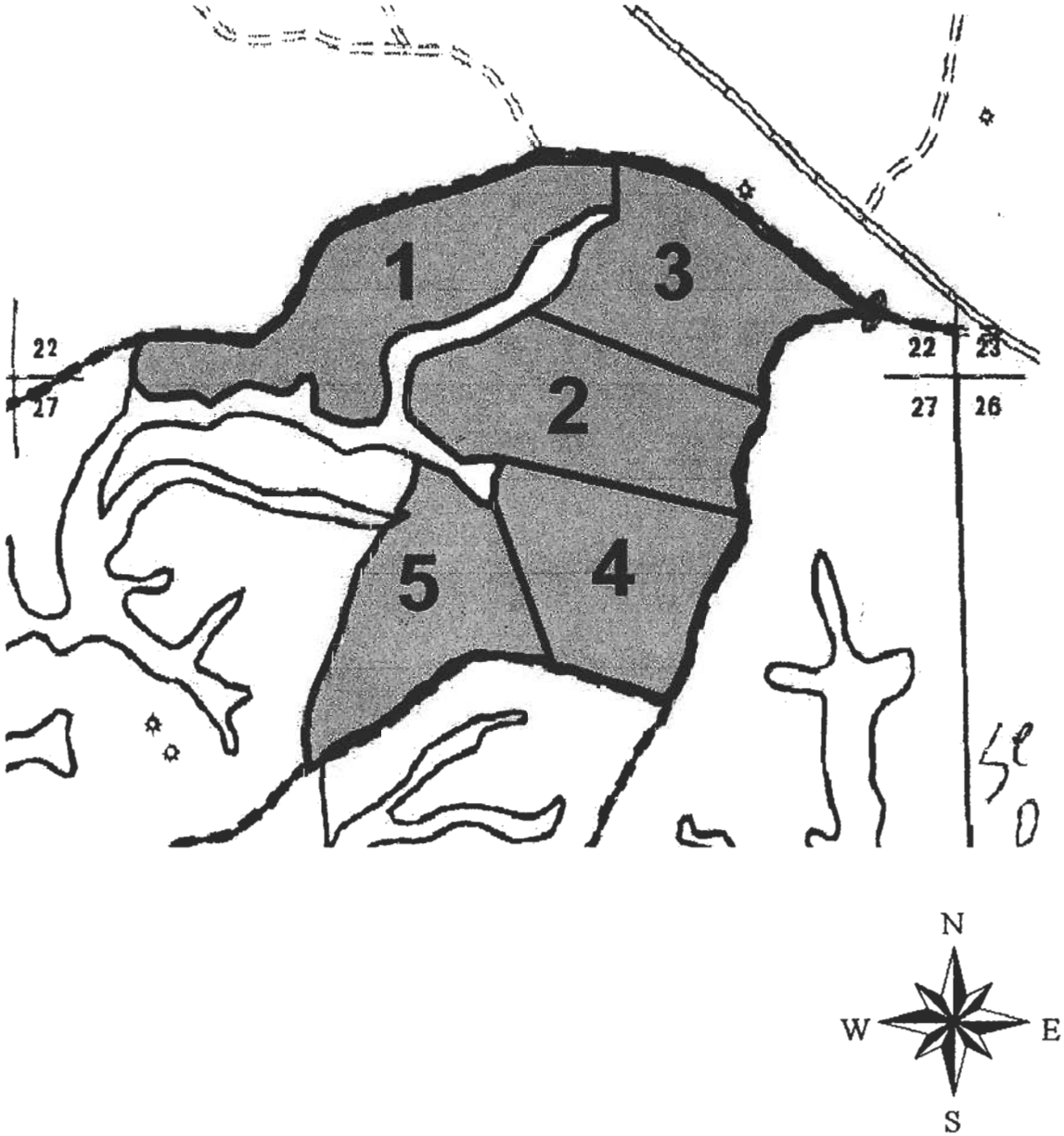
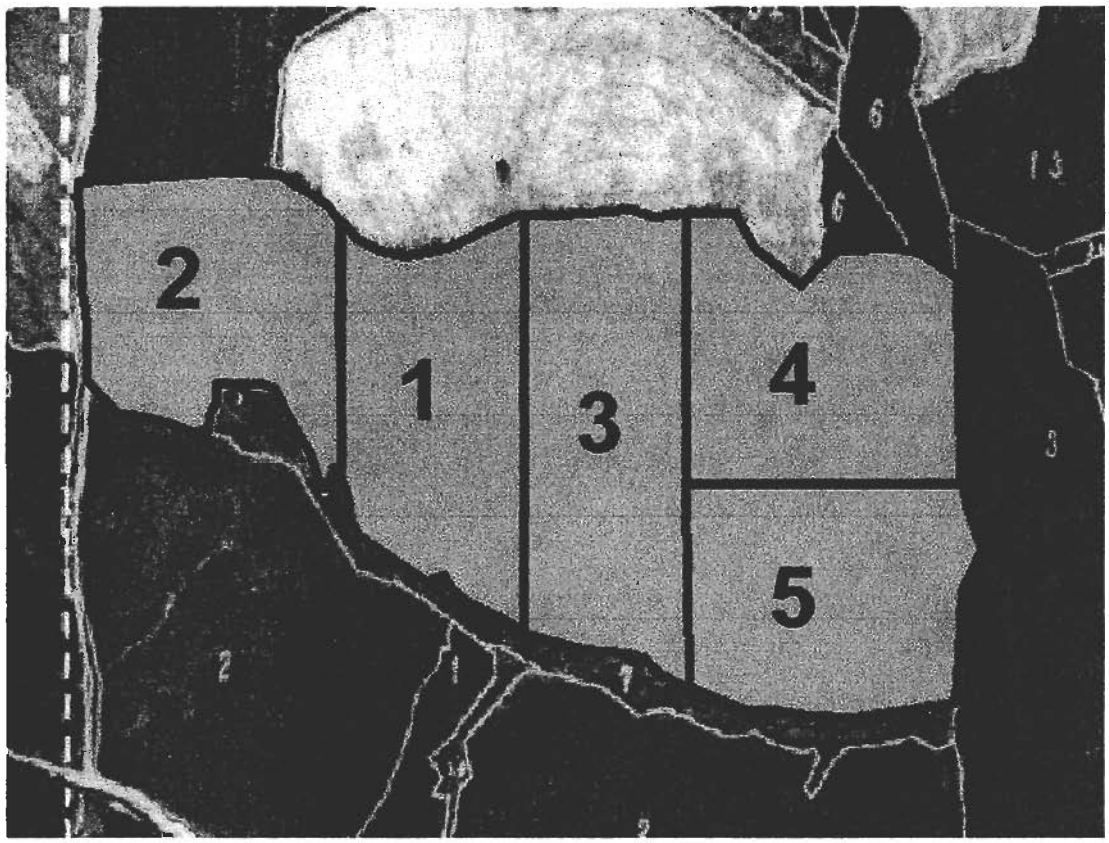


Figure A.2. Treatment allocation for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity within a 76-ha stand located in Sections 22 and 27, T1N R16W, in Lamar County, MS, owned by Weyerhaeuser Company.



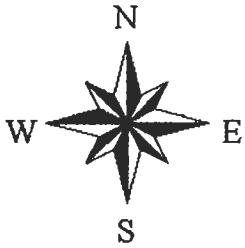


Figure A.3. Treatment allocation for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity within a 50-ha stand located in Section 34, T4N R9W, in Perry County, MS, owned by Molpus Timberlands.

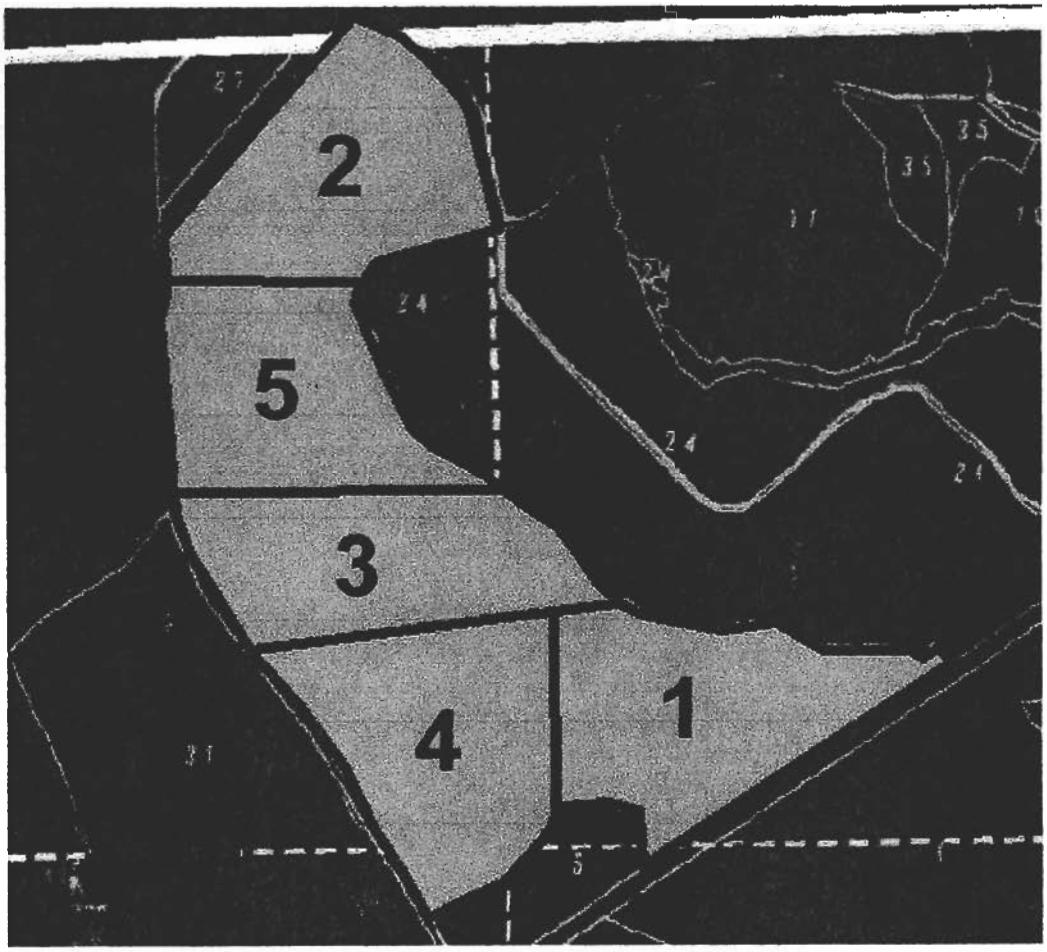


Figure A.4. Treatment allocation for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity within a 63-ha stand located in Sections 27, 28, 33, and 34, T4N R9W, in Perry County, MS, owned by Molpus Timberlands.

APPENDIX B

LIST OF AVIAN SPECIES DETECTED, SCIENTIFIC NAMES, AND CONSERVATION SCORE

Table B.1. Common name, scientific name, and Partners in Flight conservation score[a] for birds detected on transects for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity[b] during years 1, 2, and 3 post-treatment (February 2002, January - February 2003 and 2004) in the Mississippi Lower Coastal Plain.

Common Name	Scientific Name	Conservation Score
American Goldfinch	*Carduelis tristis*	9
American Robin	*Turdus migratorius*	11
Blue Jay	*Cyanocitta cristata*	17
Brown-headed Nuthatch	*Sitta pusilla*	26
Carolina Chickadee	*Poecile carolinensis*	20
Carolina Wren	*Thryothorus ludovicianus*	16
Chipping Sparrow	*Spizella passerina*	16
Common Ground Dove	*Columbina passerina*	19
Common Snipe	*Gallinago gallinago*	20
Common Yellowthroat	*Geothlypis trichas*	17
Dark-eyed Junco	*Junco hyemalis*	17
Downy Woodpecker	*Picoides pubescens*	17
Eastern Bluebird	*Sialia sialis*	16
Eastern Phoebe	*Sayornis phoebe*	16
Eastern Towhee	*Pipilo erythrophthalmus*	21
Field Sparrow	*Spizella pusilla*	23
Gray Catbird	*Dumetella carolinensis*	19
Hairy Woodpecker	*Picoides villosus*	14
Loggerhead Shrike	*Lanius ludovicianus*	22
Mourning Dove	*Zenaida macroura*	13
Northern Bobwhite	*Colinus virginianus*	22
Northern Cardinal	*Cardinalis cardinalis*	13
Northern Harrier	*Circus cyaneus*	20
Northern Mockingbird	*Mimus polyglottos*	15
Palm Warbler	*Dendroica palmarum*	21
Pine Warbler	*Dendroica pinus*	19
Red-bellied Woodpecker	*Melanerpes carolinus*	20
Ruby-crowned Kinglet	*Regulus calendula*	16
Savannah Sparrow	*Passerculus sandwichensis*	17
Sedge Wren	*Cistothorus platensis*	21
Song Sparrow	*Melospiza melodia*	17
Swamp Sparrow	*Melospiza georgiana*	19
Turkey Vulture	*Cathartes aura*	15
White-eyed Vireo	*Vireo griseus*	20
White-throated Sparrow	*Zonotrichia albcollis*	17
Winter Wren	*Troglodytes troglodytes*	16
Yellow-rumped Warbler	*Dendroica coronata*	14

[a] Partners in Flight assesses the conservation status of North American bird species. Seven factors are combined to obtain a species score: relative abundance, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, population trend, and regional abundance, each ranging from 1 (low vulnerability) to 5 (high vulnerability). Birds scoring $\geq$ 19 are considered species of concern.

[b] Treatment 1 = mechanical site preparation only with banded chemical control in year 1, Treatment 2 = herbicide site preparation only with banded chemical control in year 1, Treatment 3 = mechanical and chemical site preparation with banded chemical control in year 1, Treatment 4 = mechanical and chemical site preparation with broadcast chemical control in year 1, Treatment 5 = mechanical and chemical site preparation with broadcast chemical control in years 1 and 2.

Table B.2. Common name, scientific name, and Partners in Flight conservation score[a] for birds detected at permanent point count stations for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity[b] during years 1 and 2 post-treatment (April - June 2002 and 2003) in the Mississippi Lower Coastal Plain.

Common Name	Scientific Name	Conservation Score
American Crow	*Corvus brachyrhynchos*	12
Barn Swallow	*Hirundo rustica*	13
Blue Grosbeak	*Guiraca caerulea*	18
Blue Jay	*Cyanocitta cristata*	17
Brown-headed Cowbird	*Molothrus ater*	11
Brown Thrasher	*Toxostoma rufum*	19
Carolina Chickadee	*Poecile carolinensis*	20
Carolina Wren	*Thryothorus ludovicianus*	17
Chipping Sparrow	*Spizella passerina*	12
Common Ground Dove	*Columbina passerina*	19
Common Nighthawk	*Chordeiles minor*	17
Common Yellowthroat	*Geothlypis trichas*	16
Downy Woodpecker	*Picoides pubescens*	18
Eastern Bluebird	*Sialia sialis*	16
Eastern Kingbird	*Tyrannus tyrannus*	19
Eastern Towhee	*Pipilo erythrophthalmus*	19
Field Sparrow	*Spizella pusilla*	22
Gray Catbird	*Dumetella carolinensis*	19
Great Crested Flycatcher	*Myiarchus crinitus*	20
Indigo Bunting	*Passerina cyanea*	16
Killdeer	*Charadrius vociferus*	16
Loggerhead Shrike	*Lanius ludovicianus*	20
Mourning Dove	*Zenaida macroura*	13
Northern Bobwhite	*Colinus virginianus*	21
Northern Cardinal	*Cardinalis cardinalis*	15
Northern Mockingbird	*Mimus polyglottos*	14
Orchard Oriole	*Icterus spurius*	22
Pine Warbler	*Dendroica pinus*	18
Pileated Woodpecker	*Dryocopus pileatus*	17
Prairie Warbler	*Dendroica discolor*	24
Red-bellied Woodpecker	*Melanerpes carolinus*	19
Red-headed Woodpecker	*Melanerpes erythrocephalus*	21
Red-tailed Hawk	*Buteo jamaicensis*	12
Red-winged Blackbird	*Agelaius phoeniceus*	13
Ruby-throated Hummingbird	*Archilochus colubris*	17
Summer Tanager	*Piranga rubra*	19
Wild Turkey	*Meleagris gallopavo*	18
Yellow-breasted Chat	*Icteria virens*	19

[a] Partners in Flight assesses the conservation status of North American bird species. Seven factors are combined to obtain a species score: relative abundance, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, population trend, and regional abundance, each ranging from 1 (low vulnerability) to 5 (high vulnerability). Birds scoring $\geq$ 19 are considered species of concern.

[b] Treatment 1 = mechanical site preparation only with banded chemical control in year 1, Treatment 2 = herbicide site preparation only with banded chemical control in year 1, Treatment 3 = mechanical and chemical site preparation with banded chemical control in year 1, Treatment 4 = mechanical and chemical site preparation with broadcast chemical control in year 1, Treatment 5 = mechanical and chemical site preparation with broadcast chemical control in years 1 and 2.

Table B.3. Common name, scientific name, and Partners in Flight conservation score[a] for species of concern detected at permanent point count stations for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity[b] during years 1 and 2 post-treatment (April - June 2002 and 2003) in the Mississippi Lower Coastal Plain.

Common Name	Scientific Name	Conservation Score
Brown Thrasher	*Toxostoma rufum*	19
Carolina Chickadee	*Poecile carolinensis*	20
Common Ground Dove	*Columbina passerina*	19
Eastern Kingbird	*Tyrannus tyrannus*	19
Eastern Towhee	*Pipilo erythrophthalmus*	19
Field Sparrow	*Spizella pusilla*	22
Gray Catbird	*Dumetella carolinensis*	19
Great Crested Flycatcher	*Myiarchus crinitus*	20
Loggerhead Shrike	*Lanius ludovicianus*	20
Northern Bobwhite	*Colinus virginianus*	21
Orchard Oriole	*Icterus spurius*	22
Prairie Warbler	*Dendroica discolor*	24
Red-bellied Woodpecker	*Melanerpes carolinus*	19
Red-headed Woodpecker	*Melanerpes erythrocephalus*	21
Summer Tanager	*Piranga rubra*	19
Yellow-breasted Chat	*Icteria virens*	19

[a] Partners in Flight assesses the conservation status of North American bird species. Seven factors are combined to obtain a species score: relative abundance, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, population trend, and regional abundance, each ranging from 1 (low vulnerability) to 5 (high vulnerability). Birds scoring ≥ 19 are considered species of concern.

[b] Treatment 1 = mechanical site preparation only with banded chemical control in year 1, Treatment 2 = herbicide site preparation only with banded chemical control in year 1, Treatment 3 = mechanical and chemical site preparation with banded chemical control in year 1, Treatment 4 = mechanical and chemical site preparation with broadcast chemical control in year 1, Treatment 5 = mechanical and chemical site preparation with broadcast chemical control in years 1 and 2.

APPENDIX C

DENSITY AND ABUNDANCE ESTIMATES OF ALL BIRDS BY YEAR, STAND, AND TREATMENT

Table C.1. Density and abundance of birds observed on transects for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity[a] during years 1, 2, and 3 post-treatment (February 2002, January - February 2003 and 2004) in the Mississippi Lower Coastal Plain.

	2002				2003				2004			
Stands	D	95% CI	N	95% CI	D	95% CI	N	95% CI	D	95% CI	N	95% CI
George												
Trt 1	2.9	0.2 - 40.7	37.0	3.0 - 533.0	9.4	6.6 - 13.4	123.0	86.0 - 175.0	1.5	0.7 - 3.2	20	9.0 - 42.0
Trt 2	4.4	0.6 - 33.1	43.0	6.0 - 326.0	6.9	4.0 - 11.9	78.0	40.0 - 117.0	6.2	2.2 - 17.7	61	21.0 - 175.0
Trt 3	1.0	0.0 - 37.4	13.0	0.0 - 477.0	6.1	3.5 - 10.5	68.0	45.0 - 134.0	2.5	0.9 - 6.8	32	12.0 - 87.0
Trt 4	1.0	0.1 - 17.4	12.0	1.0 - 218.0	2.2	0.9 - 5.3	26.0	12.0 - 66.0	1.7	0.4 - 6.6	21	5.0 - 83.0
Trt 5	0.9	0.0 - 81.1	10.0	0.0 - 868.0	2.4	0.7 - 7.9	28.0	8.0 - 85.0	6	2.0 - 18.3	65	22.0 - 196.0
Lamar												
Trt 1	1.2	0.2 - 6.3	15.0	3.0 - 76.0	2.1	0.8 - 5.5	26.0	10.0 - 67.0	3.1	0.9 - 10.3	38	11.0 - 127.0
Trt 2	1.3	0.2 - 7.8	14.0	2.0 - 85.0	7.4	4.6 - 12.1	81.0	50.0 - 132.0	5.8	3.9 - 8.7	64	43.0 - 95.0
Trt 3	0.8	0.1 - 11.4	8.0	1.0 - 117.0	9.8	7.1 - 13.7	101.0	73.0 - 139.0	8.3	2.6 - 27.0	85	26.0 - 276.0
Trt 4	0.9	0.1 - 6.8	9.0	1.0 - 68.0	5.5	2.0 - 15.0	55.0	20.0 - 149.0	9.6	2.1 - 44.9	96	21.0 - 449.0
Trt 5	1.0	0.1 - 11.1	9.0	1.0 - 99.0	1.3	0.4 - 3.7	11.0	4.0 - 33.0	7.4	2.6 - 21.5	66	23.0 - 191.0
Perry A												
Trt 1	9.9	3.4 - 28.9	97.0	33.0 - 281.0	7.2	5.1 - 10.5	71.0	49.0 - 102.0	3	1.3 - 6.7	29	13.0 - 65.0
Trt 2	10.0	1.1 - 89.3	96.0	11.0 - 856.0	12.1	7.5 - 19.6	116.0	72.0 - 188.0	8.7	4.7 - 16.3	84	45.0 - 157.0
Trt 3	1.1	0.0 - 26.4	12.0	0.0 - 303.0	4.6	1.0 - 21.0	53.0	12.0 - 241.0	2.4	1.1 - 5.5	28	12.0 - 63.0
Trt 4	0.9	0.1 - 8.1	9.0	1.0 - 77.0	7.3	3.3 - 16.5	71.0	32.0 - 158.0	3	1.6 - 5.7	29	15.0 - 55.0
Trt 5	11.2	1.5 - 86.1	113.0	15.0 - 870.0	4.1	1.9 - 8.7	41.0	20.0 - 88.0	3.9	1.3 - 11.7	40	13.0 - 118.0
Perry B												
Trt 1	7.8	1.5 - 40.2	111.0	22.0 - 574.0	16.4	10.4 - 25.9	235.0	149.0 - 370.0	3.5	2.0 - 6.3	50	28.0 - 89.0
Trt 2	4.2	0.4 - 44.8	55.0	5.0 - 575.0	14.8	6.2 - 35.4	190.0	79.0 - 454.0	9.1	5.4 - 15.4	117	70.0 - 198.0
Trt 3	1.1	0.1 - 22.0	14.0	1.0 - 268.0	2.9	1.4 - 5.9	35.0	17.0 - 72.0	3.8	1.7 - 8.5	46	20.0 - 103.0
Trt 4	5.9	0.3 - 108.3	83.0	5.0 - 1516.0	1.8	0.8 - 3.9	25.0	11.0 - 55.0	3.1	1.4 - 7.0	44	20.0 - 98.0
Trt 5	1.1	0.2 - 7.5	13.0	2.0 - 89.0	2.1	0.6 - 6.65	25.0	8.0 - 79.0	4.4	2.2 - 9.0	53	26.0 - 107.0

[a] Treatment 1 = mechanical site preparation only with banded chemical control in year 1, Treatment 2 = herbicide site preparation only with banded chemical control in year 1, Treatment 3 = mechanical and chemical site preparation with banded chemical control in year 1, Treatment 4 = mechanical and chemical site preparation with broadcast chemical control in year 1, Treatment 5 = mechanical and chemical site preparation with broadcast chemical control in years 1 and 2.

Table C.2. Density and abundance of birds observed at permanent point count stations for 5 pine plantation establishment regimes varying from low (1) to high (5) intensity[a] during years 1 and 2 post-treatment (April - June 2002 and 2003) in the Mississippi Lower Coastal Plain.

	2002				2003			
Stands	D	95% CI	N	95% CI	D	95% CI	N	95% CI
George								
Trt 1	0.3	0.1 - 8.7	3.0	0.0 - 115.0	4.0	2.2 - 7.5	53.0	28.0 - 98.0
Trt 2	4.5	2.5 - 8.0	44.0	25.0 - 79.0	7.5	5.4 - 10.4	74.0	53.0 - 103.0
Trt 3	0.8	0.2 - 3.4	11.0	3.0 - 44.0	3.4	1.4 - 8.3	44.0	18.0 - 105.0
Trt 4	1.3	0.2 - 7.3	16.0	3.0 - 91.0	2.0	1.2 - 3.6	25.0	14.0 - 45.0
Trt 5	1.6	0.2 - 13.4	18.0	2.0 - 144.0	1.4	0.8 - 2.4	15.0	8.0 - 26.0
Lamar								
Trt 1	0.3	0.0 - 5.0	4.0	0.0 - 61.0	11.2	7.9 - 15.9	136.0	96.0 - 194.0
Trt 2	3.1	1.4 - 6.9	34.0	15.0 - 75.0	16.6	11.9 - 23.3	183.0	130.0 - 256.0
Trt 3	0.3	0.9 - 12.0	3.0	0.0 - 122.0	7.3	4.1 - 13.0	74.0	42.0 - 133.0
Trt 4	0.8	0.1 - 6.5	8.0	1.0 - 65.0	6.0	4.2 - 8.5	60.0	42.0 - 85.0
Trt 5	0.3	0.0 - 2.0	2.0	0.0 - 18.0	0.9	0.4 - 2.3	8.0	3.0 - 20.0
Perry A								
Trt 1	1.3	0.3 - 4.9	15.0	4.0 - 60.0	4.6	3.5 - 6.0	45.0	34.0 - 58.0
Trt 2	4.9	3.2 - 7.5	53.0	35.0 - 83.0	10.1	6.9 - 14.7	97.0	66.0 - 141.0
Trt 3	1.9	1.1 - 3.3	19.0	11.0 - 34.0	4.2	3.1 - 5.7	48.0	35.0 - 66.0
Trt 4	2.8	1.5 - 5.1	28.0	15.0 - 51.0	3.1	1.2 - 7.8	30.0	12.0 - 75.0
Trt 5	1.4	0.7 - 2.7	12.0	6.0 - 24.0	2.6	1.6 - 4.5	27.0	16.0 - 46.0
Perry B								
Trt 1	1.5	0.2 - 8.6	21.0	4.0 - 123.0	7.8	3.6 - 16.8	111.0	51.0 - 240.0
Trt 2	3.1	1.6 - 6.0	40.0	20.0 - 77.0	8.1	5.0 - 13.0	104.0	65.0 - 167.0
Trt 3	1.9	1.1 - 3.2	23.0	13.0 - 39.0	4.3	1.6 - 12.1	53.0	19.0 - 147.0
Trt 4	2.4	0.7 - 8.3	33.0	10.0 - 116.0	3.9	1.2 - 12.8	54.0	16.0 - 179.0
Trt 5	1.9	1.0 - 3.7	23.0	12.0 - 145.0	2.3	0.8 - 6.7	28.0	10.0 - 80.0

[a] Treatment 1 = mechanical site preparation only with banded chemical control in year 1, Treatment 2 = herbicide site preparation only with banded chemical control in year 1, Treatment 3 = mechanical and chemical site preparation with banded chemical control in year 1, Treatment 4 = mechanical and chemical site preparation with broadcast chemical control in year 1, Treatment 5 = mechanical and chemical site preparation with broadcast chemical control in years 1 and 2.