

# Importance of residual trees to birds in regenerating pine plantations

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Pine plantation establishment methods can alter vegetation composition and structure, thus affecting habitat important characteristics for declining early successional bird species. We evaluated eight vegetation characteristics, which varied due to a range of pine plantation establishment methods, to identify vegetation most closely associated with spring bird abundance in the Lower Coastal Plain of southern Mississippi, USA. Presence of residual trees and snags was positively related to relative abundance of 10 of 14 common species present in regenerating stands. Cover of woody vegetation was positively related to relative abundance of 4 species and negatively related to relative abundance of 2 species. For 5 species, increasing pine tree cover had a negative relationship with relative abundance. Residual trees and snags contributed to avian abundance and richness in regenerating pine plantations. Integration of habitat elements, such as residual trees that influence abundance of birds and other wildlife, with intensive pine plantation establishment can aid managers to attain wildlife conservation in intensively managed stands.

**Keywords:** Forest Management, Establishment, Habitat, Site Preparation, Snags

## Introduction

The southeastern United States is the largest national source of timber, supported by growth of intensively managed pine plantations (Haynes 2002). Common stand establishment procedures to control hardwood and herbaceous plant growth in pine plantations incorporate chemical or mechanical methods during site preparation before planting and chemical herbaceous controls after planting. Chemical herbaceous controls can be applied in a band along a row of crop trees or broadcast throughout a stand. Suppression of herbaceous vegetation and non-merchantable hardwoods through herbicides

and mechanical methods may affect wildlife by altering critical early successional habitat (Lautenschlager 1993). Intensity of vegetation disturbance, timing (at site preparation or as a later control after planting), and treatment type (herbicide versus mechanical or both) may affect wildlife differentially.

Vegetation provides nesting sites, foraging opportunities, cover from predators, and perches for song and display for birds (Martin 1988, Steele 1993, Holmes & Schultz 1988). Insects, the primary food source for birds during breeding season, may fluctuate in abundance and composition in response to vegetative changes (Santillo et al. 1989). Vegetative structure and composition affect nest predation and food limitation, which ultimately may impact reproduction (Martin 1995, Nagy & Holmes 2004). There has been some question about greater influence of vegetative structure or composition, but composition may vary geographically and therefore, be nested hierarchically within structure, with species-specific balances between both features (Robinson & Holmes 1984, Orians & Wittenberger 1991).

Diversity and provision for wildlife communities are important for many stakeholders, including the forest products industry, which has sustainable forestry certification systems in place (Jones et al. 2010a). Intensive pine plantation establishment may affect vegetation characteristics important to bird species, particularly early successional bird species that, in general, are declining across the eastern United States (Panjabi et al.

2005). The purpose of this study was to assess spring bird response to changes in vegetation generated by a stand establishment intensity continuum, which increased in intensity due to combinations of mechanical and chemical site preparation and chemical control after planting. We modeled relationships between avian species of concern to eight vegetation variables affected by different establishment practices in the lower Coastal Plain of southern Mississippi. Results from this study provide important information for integrating plantation and wildlife management.

## Methods

### Study area and plantation establishment

The four study sites, which averaged 66 ha (50 to 75 ha), were loblolly pine (*Pinus taeda* L.) plantations in the lower Coastal Plain, Mississippi, USA. The study sites were within 75 km of each other and similar in climate, vegetation, and management (Jones et al. 2009). Soil and topography varied: two sites were flat with somewhat poorly drained alfisols, one site was flat with well-drained ultisols, and one site was gently sloping from 95 to 121 m with well-drained primarily alfisols (Soil Survey Geographic SSURGO Database, USDA Natural Resources Conservation Service, <http://soildata-mart.nrcs.usda.gov>).

Apart from establishment practices of site preparation and herbaceous control after planting, management was standardized across all sites. All study sites were previously loblolly or slash (*P. elliotii* Engelm.) pine plantations, harvested during summer 2000-winter 2001 and planted with loblolly pine during winter 2001-2002. Each forest product industry cooperator provided proprietary genetically-improved seedlings. Tree spacing was 3.0 m between rows and 2.1 m between trees within a row, totaling 1 551 trees ha<sup>-1</sup>. Two sites were machine planted and two sites were planted by hand, due to greater post-harvest debris loads. Banded herbaceous control treatments were applied with a band width of 1.5 m to every tree row or broadcast herbicide applications were applied by helicopter. All treatments received a broadcast application of diammonium phosphate at 280 kg ha<sup>-1</sup> during spring 2002.

Each site contained 5 treatment levels, representing a range of operational stand establishment intensities. Each treatment was assigned randomly to a minimum of 8 ha per stand, in a randomized complete block design. Management intensity, and thus expected vegetative impact, increased from low for one type of site preparation only and a banded herbaceous control, CHEM and MECH, to high for two years of broadcast

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**Tab. 1** - Five stand establishment treatments varying from low (CHEM and MECH) to high (BROAD2) intensity in the Lower Coastal Plain of Mississippi, USA. Site preparation occurred before planting (2001 to 2002) and chemical herbaceous control occurred after planting. The banded chemical control covered the tree row and the broadcast chemical control was applied to the entire plot.

Establishment type	Establishment practice				
	CHEM	MECH	COMBO	BROAD	BROAD2
Site preparation	Chemical	Mechanical	Mechanical and Chemical	Mechanical and Chemical	Mechanical and Chemical
Chemical control	Banded 2002	Banded 2002	Banded 2002	Broadcast 2002	Broadcast 2002 & 2003

herbaceous control following site preparation, BROAD2 (Tab. 1).

- Chemical site preparation only, CHEM, consisted of a broadcast solution of 2.4 L ha<sup>-1</sup> Chopper® (BASF Corp., Research Triangle Park, North Carolina; imazapyr; 32 oz. acre<sup>-1</sup>), 3.5 L ha<sup>-1</sup> Accord® (Dow AgroSciences LLC, Indianapolis, Indiana; glyphosate; 48 oz. acre<sup>-1</sup>), 3.5 L ha<sup>-1</sup> Garlon 4 (Dow AgroSciences LLC, Indianapolis, Indiana; triclopyr; 48 oz. acre<sup>-1</sup>), and 1% Timberland 90© surfactant (UAP Timberland LLC, Monticello, Arkansas) during summer 2001 followed by a banded (along tree rows) chemical control with 0.9 kg ha<sup>-1</sup> of Oustar® (E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware; hexazinone and sulfometuron; 13 oz. acre<sup>-1</sup>) during spring 2002.
- Mechanical site preparation only, MECH, incorporated a combination plow to rip, disk, and bed the soil, and a V-blade to clear debris during fall 2001, and the same banded chemical control as CHEM.
- Site preparation for COMBO combined the mechanical and chemical site preparation of CHEM and MECH, along with the banded control.
- BROAD combined the same mechanical and chemical site preparation along with a single year of broadcast (over entire area) chemical control using 0.9 kg ha<sup>-1</sup> of Oustar® during spring 2002.
- BROAD2 was identical to BROAD except for an additional broadcast chemical control during spring 2003.

### Sampling

We surveyed breeding birds during mid-April through mid-June 2002-2006 with 10-minute point counts (Verner 1985). In each treatment, we established 3 point count stations ranging from 150-230 m apart and at least 50 m distant from treatment boundaries. Using a laser range finder to increase distance estimation accuracy, we recorded birds that were within 75 m of each station although we subsequently removed any observations > 50 m. We completed 3 survey repetitions during 2002 and 6 repetitions

during 2003-2006 that occurred between sunrise and 11:00 am during optimal weather conditions: no rain or low cloud cover, minimal wind and fog.

Vegetation was sampled during 2002 to 2006 in a companion study (Jones et al. 2009, Jones et al. 2010a - Appendix 1). Within each treatment, 10 3-m transects were established to assess vegetation characteristics. Percent coverage of understory herbaceous species, woody species, and debris were recorded using a modification of Canfield's (Canfield 1941) line-intercept method. Plants were identified to species and then grouped by growth form type (*i.e.*, grass and grass-like, forbs excluding legumes, legumes, pine trees, woody non-pine shrubs and trees, vines). Independent of the vegetation study, we counted residual trees and snags > 2 m in height or > 10 cm in diameter within 10 m along one side of an established belt transect for winter bird surveys.

A companion vegetation study showed the establishment intensity gradient created vegetation differences among treatments (Jones et al. 2009, Jones et al. 2010 - Appendix 1). During 2002-2006, total vegetation cover generally was greatest in MECH, least in BROAD2, and intermediate in COMBO, BROAD, and CHEM. During 2004-2006, height growth of pine trees averaged 1.36 m yr<sup>-1</sup> across all treatments. Increasing establishment intensity increased pine tree height, diameter, and coverage. CHEM had the lowest growth rate, while BROAD2 had the greatest, and the other treatments were intermediate. BROAD2 averaged 1.4 m taller and 2.4 cm greater in diameter than CHEM. Correspondingly, pine coverage was greatest in BROAD and BROAD2 and least in MECH and CHEM. Coverage of understory herbaceous plants in all treatments declined from 85-125% during 2004 to 44-76% during 2006. Coverage of understory herbaceous plants decreased with increasing intensity; BROAD2 averaged 65% of MECH. Woody plant coverage, excluding pines, had a marginal treatment effect ( $F_{4,42} = 2.56, P = 0.053$ ) and increased from 2004 to 2006.

### Modeling

We selected 14 bird species for modeling that indicated some difference among treatments (*i.e.*, probable response to vegetation;  $P$  value < 0.2 - Hanberry 2007), were regionally less common (Panjabi et al. 2005), and were not rare observations in the study sites (selected species had 39 to 707 observations). We also included brown-headed cowbird (*Molothrus ater*), a nest parasite, which was not a declining species. Vegetation variables consisted of coverage of bare ground and debris (BGandD), grass and grass-like (GandGL), forbs excluding legumes, legumes, pine trees, woody non-pine shrubs and trees, vines, and number of residual trees and snags (Snag).

We used a repeated measures, mixed model analysis of variance to model bird counts and vegetation using all possible combinations of vegetation through 5 predictor variables (PROC MIXED - SAS software, version 9.1, Cary, North Carolina, USA). Site was a random effect (because each site contained the five treatments) and year was a repeated measure. To account for time, year was a variable in all models. Using least AIC<sub>c</sub> (Akaike's Information Criterion corrected for small sample size) value, we selected the covariance structure with the best fit from autoregressive, compound symmetry, autoregressive heterogeneous, and compound symmetry heterogeneous options (Gutzwiller & Riffell 2007). We square-root transformed counts if data transformation reduced AIC<sub>c</sub> values. The models were ranked by AIC<sub>c</sub> from least to greatest value, followed by calculation of differences among models ( $\Delta$ AIC<sub>c</sub>) and their Akaike weights. For models within 2 AIC<sub>c</sub> units of the top model, we calculated a Pearson correlation coefficient (PROC CORR) by comparing observed bird abundance to predicted bird abundance based on the model for every sample point. Because many of the bird species had models of approximately equal weight and correlation, we removed models with more variables when there was a reduced model with fewer predictor variables.

### Results

Bird species that had models with relatively high prediction rates ( $r > 0.70$ ) along with greater abundance were yellow-breasted chat (*Icteria virens*: count = 707 observations), common yellowthroat (*Geothlypis trichas*: 373 observations), prairie warbler (*Setophaga discolor*: 389 observations), white-eyed vireo (*Vireo griseus*: 165 observations), indigo bunting (*Passerina cyanea*: 569 observations), and eastern towhee (*Pipilo erythrophthalmus*: 308 observations; Tab. 2). Field sparrow (*Spizella pusilla*: 57 observations), brown-headed cowbird (43 observations), brown thrasher (*Toxostoma rufum*: 39 observations), eastern kingbird

**Tab. 2** - Avian models from 5 pine plantation establishment practices varying from low to high intensity during years 1-5 post-treatment (April - June 2002 - 2006) in the Mississippi Lower Coastal Plain. (a): year is a variable in all models and produces 5 additional parameters; (b): snag is residual trees, BGandD is bare ground and debris, GandGL is grass and grass-like; (c): K is number of parameters; (d):  $r$  is correlation between observed bird abundance and predicted bird abundance.

Species	Model <sup>(ab)</sup>	K <sup>(c)</sup>	AIC <sup>(c)</sup>	$\Delta$ AIC <sup>(c)</sup>	Weight	$r$ <sup>(d)</sup>
Brown-headed cowbird	(+) Woody (+) Snag	9	-224.2	0.80	0.12	0.58
Blue grosbeak	(-) Woody	8	-85.2	0.50	0.15	0.47
Brown thrasher	(+) Woody (+) Snag	9	-222.0	1.60	0.31	0.60
Carolina chickadee	(+) Snag	8	-175.2	0.00	0.09	0.39
Carolina wren	(+) Snag	8	-171.2	0.00	0.28	0.59
Common yellowthroat	(-) Pine	8	17.9	1.00	0.07	0.80
Eastern kingbird	(+) Snag	8	-121.4	0.00	0.54	0.60
Eastern towhee	(-) Forb (+) Woody (+) Snag	10	-24.2	0.00	0.54	0.71
Field sparrow	(+) GandGL (+) Snag	9	-159.0	1.50	0.17	0.69
Indigo bunting	(-) BGandD (-) Woody (+) Snag	10	43.6	1.40	0.21	0.77
Orchard oriole	(+) BGandD (+) Forb (-) Pine	10	-71.5	0.30	0.33	0.45
Prairie warbler	(-) Pine (+) Snag	9	-31.0	0.00	0.40	0.81
White-eyed vireo	(-) Pine (+) Woody	9	-103.7	0.00	0.19	0.78
Yellow-breasted chat	(+) BGandD (-) Pine (+) Vine (+) Snag	11	0.3	1.90	0.22	0.80

(*Tyrannus tyrannus*: 39 observations), and Carolina wren (*Thryothorus ludovicianus*: 50 observations) had less powerful models with  $r$  values of 0.59-0.69. Vegetation explained less variation (models with  $r$  values of  $< 0.50$ ), despite relatively moderate abundance, for Carolina chickadee (*Poecile carolinensis*: 48 observations), blue grosbeak (*Passerina caerulea*: 94 observations), and orchard oriole (*Icterus spurius*: 110 observations).

The most frequently represented variable was residual trees, which were in models for 10 of 14 species and positively associated with relative abundance. Percent cover of woody vegetation was positively related to relative abundance of brown-headed cowbirds, brown thrasher, eastern towhee, and white-eyed vireo, but negatively related to detections of blue grosbeak and indigo bunting. Increasing pine tree cover had a negative relationship with relative abundance of common yellowthroat, orchard oriole, prairie warbler, white-eyed vireo, and yellow-breasted chat. Bare ground and debris, and the herbaceous variables of grasses and

grass-like, legumes, forbs, and vines were uncommon in models.

### Discussion

Tree retention was not a planned part of the establishment intensity gradient, but residual trees were an outcome of the chemical-only treatment. Mechanical site preparation, which often is used when drainage is poor or when competing vegetation is not sufficient to warrant chemical treatment (Fox et al. 2007), typically causes soil disturbance and alters the physical structure of the site. Thus, retention of trees and snags is more easily accomplished on sites prepared chemically.

Mature trees with large diameter and height, potential cavity sites, and well-developed bark are important for primary and secondary cavity nesters (Conner 1978, Davis 1983). Although retained trees all had diameters  $< 23$  cm, appearance of residual trees in models for secondary cavity nesters of Carolina wrens and Carolina chickadees was not surprising. Previous research has found that cavity nesters may extend their home range to include young plantations

when snags and nest sites were available (Dickson et al. 1983, Caine & Marion 1991). Lohr et al. (2002) reported that snag removal reduced abundance of Carolina wren but not Carolina chickadee in loblolly forests of South Carolina.

Although there is an obvious relationship between cavity nesters to snags, few studies emphasize importance of retained trees for other breeding birds. Many bird species also use trees for nest sites, perches, singing or display posts, sighting prey, and foraging. Additionally, snag removal may reduce substrate for some insects, possibly reducing prey sources for insectivorous birds. Snags in regenerating pine plantations may increase total abundance and species richness of avian species (Johnson & Landers 1982, Dickson et al. 1983, Caine & Marion 1991). Dickson et al. (1983) noted increased presence of yellow-breasted chats and brown-headed cowbirds in plots with snags versus snag-less plots in an east Texas, USA clear-cut. In contrast to our models, Dickson et al. (1983) found that blue grosbeak, field sparrows, and prairie warblers were more abundant on plots devoid of standing snags, whereas indigo buntings and common yellowthroats did not differ in abundance between snag and snag-less plots.

Woody shrubs and pine and non-pine trees were influential model variables and their proportions were altered by establishment treatments. Young woody vegetation provides habitat for early successional bird species in regenerating stands and thus produced a mix of generally positive but some negative relationships. For example, woody vegetation was important for brown thrasher, eastern towhee, and white-eyed vireo, which prefer thickets (Hopp et al. 1995, Greenlaw 1996, Cavitt & Haas 2000). Additionally, woody vegetation was more influential than grasses on abundance of other bird species and therefore, brown-headed cowbirds were associated with woody vegetation where their hosts were present. In contrast to other variables, pine trees were negative model variables. Growing pine trees replaced other vegetation over time, thus negative associations for five species may result from vegetation displacement rather than pine tree cover. Herbaceous variables of grasses, legumes, forbs, and vines were uncommon or absent in models and appeared to be less influential than residual trees, woody vegetation, and pine trees for the suite of species that were common in regenerating stands.

Although density is generally a good predictor of reproductive success (Bock & Jones 2004), higher quality habitat does not always equal greater density, and likewise, greater density does not necessarily equal higher quality habitat. Density and habitat quality can be decoupled by at least (1) territoriality and other social interactions, (2)

source-sink dynamics, (3) ecological traps, (4) migrant deception, or site tenacity after habitat change, (5) patchy resources, and (6) predation. In species with strong social interactions, particularly generalists with high reproduction rates, dominant individuals can force subdominants into marginal habitat to the extent that density is greater in lower quality habitats (Van Horne 1983). Density also can be inflated artificially in low quality population sinks that are supported by regional population sources (Pulliam 1988). Animals correctly evaluate habitat quality, yet source habitat is limited. Anthropogenic disturbance can disconnect habitat preference and reproduction (Bock & Jones 2004) in the overlapping cases of ecological traps and migrant deception. Density can be high yet reproductive success low in sink habitat that is preferred (Dwernychuk & Boag 1972, Battin 2004). For example, ecological traps can occur in locations with elevated numbers of nest predators or brood parasites, specifically in areas that historically contained reduced levels (Robertson & Hutto 2006), or grassland species can lose nests to early mowing. Disturbance-dependent species particularly may be vulnerable to ecological traps, mistaking artificial disturbance for natural disturbance (Weldon & Haddad 2005). Overstocking also may develop when birds settle in a previously successful breeding site, without recognizing recent habitat modification, whether from natural disturbance or land use and management (Wiens et al. 1986, Lautenschlager 1993). Density undersaturation can occur in high quality habitat when resources fluctuate spatially or temporally, due to factors such as weather, disturbance, or vegetation ecology (Wiens 1981, Van Horne 1983).

In this study, we modeled effects from chemical and mechanical alteration of vegetation and avian abundance. Many of the problems associated with count data were reduced by a randomized block design, where all sites contain every treatment. Adjacent treatments therefore were affected equally by outside and historical events, negating regional source/sink influences and reducing differential migrant deception, patchiness, and exposure to ecological traps. We also estimated associations within similar plant communities, which again minimized differences. In addition, modeling of species during breeding season avoided a heavy influx of juveniles and wandering flocks.

## Conclusions

Residual trees appeared to be a critical stand element for many bird species in the study sites and retaining trees may help realize integration of fiber production and management of wildlife diversity. Tree retention enriched avian assemblages in young, intensively established pine plantations in

this study and results should translate to other intensively managed stands across the southeastern United States and where residual tree density is low. Furthermore, a variety of small mammals, including bats, reptiles, and amphibians use mature trees and snags for foraging, nesting, roosting, and denning. Therefore, retaining trees at harvest and stand establishment is the primary management recommendation, particularly if the biomass industry increases removal of woody material, leaving stands cleaned of small diameter stems, snags, and cull trees. Tree retention requires knowledge of number, species, size, and spatial distribution of trees to most efficiently benefit birds and other wildlife. This information currently is undeveloped, particularly in the southeastern United States, and will require experimental manipulation along with model development.

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## Supplementary Material

**Appendix 1** - Vegetation cover from 5 pine plantation establishment practices varying from low (CHEM and MECH) to high (BROAD2) intensity during years 1 to 5 post-establishment (2002 to 2006) in the Lower Coastal Plain of Mississippi, USA.

**Link:** [Hanberry\\_616@suppl001.pdf](mailto:Hanberry_616@suppl001.pdf)