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Bird community dynamics and vegetation relationships among stand establishment practices in intensively managed pine stands

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ABSTRACT

Intensively managed pine occupies 22% of the forest land base in the southeastern United States. More fully understanding effects of standard silvicultural practices on biodiversity could improve wildlife management recommendations on intensively managed landscapes. Although multiple stand-establishment techniques (i.e., site preparation and chemical herbaceous control of competition) are used for forest regeneration, we lack an understanding of causal mechanisms for bird community responses during stand establishment through canopy closure. Therefore, we investigated bird community responses to five stand-establishment treatments in intensively managed pine (*Pinus* spp.) stands in the Lower Coastal Plain of Mississippi, USA as a function of changes in vegetation structure and coverage. We used a randomized complete block design of four pine stands (blocks) divided into five experimental units and with treatments randomly assigned to each unit. Our treatments represented available establishment practices and increased in intensity from mechanical or chemical site preparation with subsequent banded herbaceous control to mechanical and chemical site preparation with 2 years of subsequent broadcast herbaceous weed control applications. We sampled bird communities with point counts and measured visual obstruction, pine tree height, woody stem density, and vegetation structure and coverage by growth form (e.g., forb, fern, grass, legume, pine, sedge and rush, woody non-pine, vine). Bird communities had an overall negative response to increasing intensity of stand-establishment treatments, and temporal trends from site preparation to canopy closure were absent. Common species appeared relatively unaffected by treatments. However, presence of species with high conservation value and availability of early successional habitat conditions emphasized conservation potential of intensively managed pine forests for birds and justify further experimental investigation of bird community responses to stand-establishment treatments. We recommend forest managers continue to incorporate a variety of stand establishment practices to ensure habitat availability for a variety of bird species, and that researchers further investigate mechanistic factors of avian community responses to silvicultural practices.

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1. Introduction

Intensively managed pine (*Pinus* spp.) stands cover an estimated 18 million hectares in the southeastern United States (USDA Forest Service, 2007). Site preparation and early rotation management practices are usually used within these forests to improve stand establishment (i.e., increased seed survival and tree growth) by preparing sites for planting, temporarily reducing competition for crop trees, and increasing pine volume (Stanturf et al., 2003; Wagner et al., 2004; Jones et al., 2010a). Common practices include mechanical and chemical site preparation followed by herbaceous and/or woody competition control (Shepard et al., 2004). Multiple treatment combinations are often applied across a land base leading to conservation and habitat management opportunities on privately owned forest landscapes (Wigley et al., 2000). Selectivity and application methods of forest herbicides further increase vegetation management options without the complete weed control typical of row-crop agriculture (Miller and Miller, 2004; Shepard et al., 2004; Welch et al., 2004). Past research has focused on vegetation or bird responses to site preparation and herbaceous control treatments (e.g., O'Connell and Miller, 1994; Hanberry et al., 2012), but information is lacking regarding bird-vegetation relationships from site preparation through canopy closure (~year 8), particularly comparing varying intensities of treatments, in southeastern intensively managed pine stands (Lane et al., 2011).

Vegetation structure and community changes due to succession from stand establishment through canopy closure affect avian communities, including species of high conservation priority (Maurer, 1993; Nuttle et al., 2003; Jones et al., 2012). Additionally,

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various combinations of mechanical and chemical treatments during stand establishment have been shown to differentially alter successional trajectories, thus impacting wildlife communities through this indirect impact (Jones et al., 2012). For example, mechanical site preparation influences avian habitat characteristics by manipulating availability and distribution of down woody debris and snags (Landers and Mueller, 1986; Lohr et al., 2002; Jones et al., 2009a). Following stand establishment, avian habitat may be influenced by manipulation of vegetative structure through banded (tree row only) or broadcast (whole stand) chemical applications (Miller and Miller, 2004). Chemical treatment effects on vegetation communities depend on herbicide active ingredients, application rates and locations (i.e., banded versus broadcast applications), and site characteristics such as pre-treatment plant community, soil properties, and weather conditions (Miller and Miller, 2004). Unlike mechanical site preparation, chemical treatments can control re-sprouting vegetation, such as hardwood species, offering longer-term competition release relative to mechanical treatments (Shiver et al., 1990).

Many bird species of conservation concern in the southeastern United States are dependent on early successional habitat conditions (Brennan and Kuvlesky, 2005). Current short-rotation forest management practices of clear-cutting, site preparation, and chemical control creates early successional habitat components (Krementz and Christie, 2000; Jones et al., 2010b, 2012), but temporal availability of those habitat components in intensively managed pine stands may be limited at the stand level due to a short time period prior to canopy closure (Burger, 2001; Jones et al., 2010a,b). Quality of early successional habitat in regenerating pine forests for bird species of high conservation priority also may vary among stands treated with different combinations of stand establishment treatments. A variety of site preparation and herbaceous control treatments with different intensities applied across the landscape could increase diversity and availability of early successional habitat components (Miller et al., 1995; Zutter and Miller, 1998) and encourage development of diverse bird communities.

Investigating bird responses to changes in vegetation structure will help inform land managers how stand establishment choices impact bird communities, including high-priority bird species. Therefore, within the framework of an existing study (e.g., Hanberry et al., 2012; Jones et al., 2012), we investigated bird habitat associations from stand establishment through canopy closure with an experimental design that employed a gradient of stand establishment treatment combinations. We hypothesized that transitions in bird communities would reflect vegetation communities shifting from weed/forb/grass plant communities containing many high-priority bird species to shrub–scrub vegetation communities containing mostly lower-priority, forest generalists and edge associated bird species.

2. Methods and materials

2.1. Study sites and design

Our study sites consisted of four loblolly pine (*Pinus taeda*) stands owned and managed by Weyerhaeuser NR Company, Plum Creek Timber Company, and Molpus Timberlands, located in the Lower Coastal plain of Mississippi, USA. Pine stands were within a 75-km radius in Perry ($n = 2$), George ($n = 1$), and Lamar ($n = 1$) counties and ranged from 50–75 ha ($\bar{x} = 65$ ha). Climate was subtropical with annual mean minimum daily temperatures of 2 °C in January and mean daily maximum temperatures of 33 °C in July, 216–241 frost-free days, and 159 cm annual precipitation (152–166 cm; National Oceanic and Atmospheric Administration, 2012a,b). Stands were harvested summer 2000-winter 2001 and machine or hand-planted with cooperator-supplied 1–0 base root seedlings during winter 2001–2002 with trees spaced 2.1 m $\times$ 3.0 m (1587 trees ha^{-1}). Stands were fertilized aerially in March 2002 with diammonium phosphate (280 kg ha^{-1}) according to standard forestry practices.

We divided each stand into five plots and assigned randomly 1 of 5 treatments plot^{-1}, creating a randomized complete block design. We derived treatments from combinations of three levels of site preparation (e.g., mechanical only, chemical only, and combined mechanical and chemical) and three levels of herbaceous control (e.g., banded only in 2002, broadcast only in 2002, and broadcast in 2002 and 2003). Our treatment combinations created an intensity gradient of establishment practices ranging from least intense independent applications of mechanical or chemical site preparation followed by banded (tree row only) chemical herbaceous control (M or C, respectively) to the more intense treatments of combined mechanical and chemical site preparation followed by banded chemical herbaceous control (MC), one broadcast (i.e., aerial) chemical herbaceous control (B), or 2 years of broadcast chemical herbaceous control (BB; Table 1). We applied mechanical site preparation during fall 2001 and applied chemical site preparation in summer 2001. Mechanical site preparation was completed with a bulldozer equipped with a combination plow and V-blade used to prepare plant beds and clear debris, respectively. Chemical site preparation consisted of a broadcast solution of 2.4 L ha^{-1} Chopper® (BASF Corp., Research Triangle Park, North Carolina; 0.55 kg a.i. imazapyr ha^{-1}; 32 oz. acre^{-1}), 3.5 L ha^{-1} Accord® (Dow AgroSciences LLC, Indianapolis, Indiana; 1.68 kg a.i. glyphosate ha^{-1}; 48 oz. acre^{-1}), 3.5 L ha^{-1} Garlon 4 (Dow AgroSciences LLC, Indianapolis, Indiana; 1.68 a.i. triclopyr ha^{-1}; 48 oz. acre^{-1}), and 1% Timberland 90® surfactant (UAP Timberland LLC, Monticello, Arkansas). Chemical herbaceous control applications consisted of 0.91 kg ha^{-1} of Oustar® (E.I. du Pont de Nemours and Company, Inc., Wilmington, Delaware; 0.56 kg hexazinone and 0.11 kg a.i. sulfometuron methyl ha^{-1}; 13 oz. acre^{-1}) applied during spring to tree rows only (banded) or across the entire plot (broadcast).

2.2. Bird community

We sampled bird communities using 10 min point counts during late April–June 2003–2009 with 3 points plot^{-1}, 150–230 m apart, and with the first sample point $\geqslant$100 m from plot edges. We measured actual distances to adult bird locations (seen and/or heard) using a laser rangefinder during 2003–2007 and used distance bands during 2008–2009 (0–25 m, >25–50 m, >50–75 m) with a maximum distance of 75 m for all years. We visited sites 3–6 times per year during optimal weather conditions from sunrise to 11:00 a.m. (Robbins et al., 1986; Ralph et al., 1995), used one observer each year to minimize observer bias, and sampled plots in random order to avoid temporal bias (i.e., always sampling a plot first or last) and observer bias (i.e., sampling plots in an observer-preferred order). We limited treatment comparisons to bird species included in detection function analysis (see below) and assigned bird species to nesting and foraging guilds (Hamel, 1992) and conservation categories (Nuttle et al., 2003). Categories used by Nuttle et al. (2003), based on Partners in Flight prioritization scores, reduce influence by endangered or threatened species when calculating total avian conservation values for areas of interest and include: 0 for introduced species, 1 for species not at risk, 2 for species of low concern, 3 for species of moderate concern, and 4 for species of high concern.

2.3. Vegetation structure and coverage

We measured vegetation structure and cover by growth form (vine, woody, forb, grass, etc.), woody stem density (stems/ha),