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Influence of landscape- and stand-scale factors on avian communities to aid in open pine restoration

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ABSTRACT

Determining species occurrence in ecosystems of high conservation concern is especially important for recommending habitat management techniques and identifying suitable restoration sites. We investigated (1) how stand- and landscape-scale attributes affect occupancy of priority bird species associated with longleaf pine (*Pinus palutris*) ecosystems, (2) if these priority birds can be used as indicator species for desired open pine forest structure, and (3) if these indicator species are positively correlated with greater avian richness. We compared priority bird occupancy among 12 stand types (habitat types) throughout the historic range of longleaf pine in Mississippi. We found stands resembling the historic longleaf pine ecosystem were positively associated with Red-cockaded Woodpecker (*Picoides borealis*) and Bachman's Sparrow (*Peucaea aestivalis*) occupancy probabilities, but were not significantly correlated with Northern Bobwhite (*Colinus virginianus*) or Brown-headed Nuthatch (*Sitta pusilla*) occupancy. Both of which were too generalized in their occurrence to be useful indicators. Red-cockaded Woodpecker and Bachman's Sparrow occupancy probabilities positively correlated with desired forest structure metrics of longleaf pine ecosystems such as low midstory density (<10%) and basal area (9.2–16.1 m^2/ha) and 40–60% canopy cover suggesting they are effective indicators of historic longleaf pine conditions. Co-occurrence of Red-cockaded Woodpecker and Bachman's Sparrow was positively correlated with avian richness, indicating these species can be used in conjunction as effective indicators for desired open pine endpoints used for restoration and management. Inclusion of priority bird species in management efforts provides assurance that restored areas will incorporate desired forest structure endpoints that have been linked to open pine priority bird presence. Correlation between priority bird species and avian species richness ensures restored areas provide suitable habitat for local avian communities.

1. Introduction

Longleaf pine (*Pinus palustris* Mill.) ecosystems were once a co-dominant forest type across the southeastern United States from the Atlantic Coastal Plains to the West Gulf Coastal Plains, an area estimated at 37 million hectares (Frost, 1993). Today approximately 1.4 million hectares remain (a 96% loss from the original extent), making the longleaf pine ecosystem the third most endangered ecosystem in the United States (Noss and Peters, 1995; Van Lear et al., 2005; America's Longleaf, 2009). At present, longleaf pine ecosystems are associated with 27 species federally listed as endangered or threatened by the U.S. Fish and Wildlife Service (USFWS), 99 species that are proposed candidates for listing, and over 180 rare plant species (Walker, 1993; Noss et al., 1995; Noss and Peters, 1995). Much of the remaining area of longleaf pine does not resemble historic conditions that provided suitable habitat for these species (America's Longleaf, 2009; Aschenbach et al., 2010; McIntyre, 2012; Singleton et al., 2013). Today, estimated historic conditions of gulf coastal plain longleaf pine used as restoration objectives include an open canopy (⩽60% cover), low basal area (9.2–16.1 m^2/ha or 40–70 ft^2/acre), little to no midstory (<20% cover), and a dense herbaceous ground cover (>65%) comprised of native graminoids (Hedman et al., 2000; GCPOLCC, 2013). These conditions were historically maintained by frequent, low-intensity fires that burned over large areas and helped suppress hardwood understory and midstory, fostering a dense, herba-

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ceous ground cover (Varner et al., 2005; Brudvig and Damschen, 2011; Oswalt et al., 2012; Steen et al., 2013).

Decline in the extent and quality of longleaf pine ecosystems is attributed to the suppression of naturally occurring fire, increased urbanization, increased habitat fragmentation, unsustainable harvest, and conversion of old growth forests into timber plantations and agriculture lands (Frost, 1993; Noel et al., 1998). Priority bird species associated with longleaf pine ecosystems have similarly declined through loss of suitable habitat (Noss and Peters, 1995; Van Lear et al., 2005; Singleton et al., 2013). A priority species is a species of high conservation concern, usually selected by conservation organizations as a species of focus (e.g. endangered species, game species, or public interest species). An indicator species represents specific habitat characteristics of an ecosystem within an ecoregion (Landres et al., 1988). Several species can serve as an indicator species representing the local habitat conditions in which they occur (Landres et al., 1988; Caro and O'Doherty, 1999; Wiens et al., 2008). Selecting appropriate species to serve as indicator species requires knowledge about the species' ecology, and how the presence of these species is tied to local habitat and other wildlife (Landres et al., 1988). Priority species and indicator species are used to inform management decisions regarding wildlife habitat conservation and ecosystem restoration (McIntyre, 2012). Miller and Hobbs (2007) suggest the first step in ecosystem restoration is identifying target species that the restoration efforts will benefit and then focusing on the habitat conditions that will allow those target species to persist. This provides a systematic approach to restoration by creating practical management objectives tailored to the specific requirements of target species (Miller and Hobbs, 2007).

Federal agencies and their research partners identified priority bird species that are associated with longleaf pine ecosystems, and that have potential for use as indicators (McIntyre, 2012). These species, Red-cockaded Woodpecker (*Picoides borealis*), Bachman's Sparrow (*Peucaea aestivalis*), Brown-headed Nuthatch (*Sitta pusilla*), and Northern Bobwhite (*Colinus virginianus*), meet several criteria that make them potentially suitable indicator species, including being practical to monitor, possessing an ability to respond to restoration efforts, have a wide distribution throughout the range of longleaf pine, are perceived to be associated with high quality longleaf pine habitat, and are permanent residents (McIntyre, 2012). Determining which of these priority bird species to use as indicators of desirable open pine characteristics will aid in restoring longleaf ecosystems as they can be used as a metric to gauge suitable habitat for local wildlife and effectiveness of restoration efforts. Specifically, determining which landscape-scale and stand-scale factors are significantly related to the presence of these priority avian species would provide information to managers deciding what management techniques are important to longleaf restoration (Tirpak et al., 2006; McIntyre, 2012).

America's Longleaf Initiative established a 15-year restoration objective to increase the area of longleaf ecosystem coverage from the current 1.4 million to 3.2 million ha (America's Longleaf, 2009). Longleaf area in Mississippi was 100,912 ha as of 2009, with an ultimate desired area of 234,459 ha by America's Longleaf Initiative (America's Longleaf, 2009). However, increasing land coverage of longleaf pine alone may not translate proportionally to an increased presence of priority wildlife (McIntyre, 2012). The East Gulf Joint Venture and the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPOLCC) recommend specific forest structure and landscape endpoints to restore open pine habitat so that it will resemble historic conditions and provide habitat for local wildlife (GCPOLCC, 2013). Testing these forest structure and landscape endpoints will aid in restoration and management efforts for longleaf pine ecosystems.

Objectives of this study were to: (1) determine which stand- and landscape-scale factors influence priority bird species occupancy in different habitat types, referred to as stand types, in the historic range of longleaf pine in Mississippi, (2) evaluate which priority avian species could serve as indicators of open pine stands that resemble historic longleaf ecosystems, and (3) determine if these indicator species are correlated with greater avian species richness.

2. Methods

2.1. Study area

Longleaf pine habitat within Mississippi is distributed among National Forest (100,912 ha), U.S. Fish and Wildlife Service (5252 ha), County and Municipal (2020 ha) and private lands (46,864 ha), totaling 155,048 ha of longleaf pine habitat (America's Longleaf, 2009). We distributed study sites throughout the historic range of longleaf pine ecosystems in southern Mississippi including federal, state, and private lands. We sampled within 13 locations: Bienville National Forest (NF), Desoto NF, Homochitto NF, Grand Bay National Wildlife Refuge (NWR), Sandhill Crane NWR, Marion County Wildlife Management Area (WMA), Copiah County WMA, Theodore Mars WMA, and private lands in Greene, Perry, Marion, Copiah, and Lamar counties (Fig. 1). Several of these areas support populations of Red-cockaded Woodpeckers, with larger populations occurring on each of the national forests listed above, and study areas were within a few tens of km of these or other potential source populations, which is on the order of magnitude of documented dispersal distances of Red-cockaded Woodpeckers (e.g., Walters, 1991).

2.2. Sampling design

Stand-scale factors shown to affect occupancy probabilities of priority birds within longleaf systems include forest structure (canopy cover, midstory density, understory density, and basal area), vegetation composition (tree species and ground cover composition), and stand type (predefined habitat type; Table 1) (Willson, 1974). Landscape-scale factors addressed in this study were 'potential source areas', 'urban density', and 'stewardship' (public or privately owned) (Grand et al., 2009; Bonnot et al., 2013). A 'potential source area' refers to locations near large patches of potential habitat that could sustain priority bird source populations for colonization of smaller patches (Grand et al., 2009). Increased urbanization can decrease the amount of available habitat for local wildlife and impede the implementation of prescribed fire to maintain open pine ecosystems (Grand et al., 2009). We apply the term 'urban density' to represent how urbanized an area is based on density maps. 'Stewardship' reflects how an area is managed. Specifically, referring to private or public ownership. Public lands can be managed long term to meet varying objectives and the ability to apply prescribed fire is usually more feasible than on private lands (Grand et al., 2009). While conservation on private lands may be necessary for the conservation of some species, private land owners may have less capacity to manage for the appropriate conditions (e.g., via prescribed burning) (Cox and Engstrom, 2001). These landscape- and stand-scale attributes should be considered when restoring longleaf pine to ensure restored areas can be maintained to promote priority species presence and avian species richness. The Open Pine Decision Support Tool (OPDST) was developed using an overlay of several GIS layers pertinent to determine the suitability of an area to be restored to open pine (Grand et al., 2009). These GIS layers include priority bird potential source areas, an urban density layer (referred to as ability to burn in

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