

The Wilson Journal of Ornithology 119(4):737–741, 2007

Effect of Two Native Invasive Tree Species on Upland Pine Breeding Bird Communities in Georgia

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ABSTRACT.—Georgia land lottery maps from the 1820s reveal two tree species, water oak (*Quercus nigra*) and sweetgum (*Liquidambar styraciflua*), were formerly limited to major floodplains in the Piedmont and Coastal Plain. These species are now common in upland sites as a result of past land use and disruption of fire regimes. We investigated the effect this invasion had on breeding bird diversity in upland mixed pine (*Pinus* spp.) stands based on 90 point counts conducted in spring 2005. Half of these stands had no water oak or sweetgum (open stands) and half had a minimum of 25% of their basal area as water oak and/or sweetgum (invaded stands). Bird species richness and abundance were 42 and 41% lower, respectively, in invaded stands. Thirty-five bird species had more than 20 records and were tested for an association with invaded stands. No species were positively associated with invaded stands while 10 were negatively associated with invaded stands; these were mostly grassland pine savanna and shrubland bird species of high conservation value. Invasion of upland pine forest by these native tree species is similar to invasion by exotic species, and appears to disrupt ecosystem function causing declines in bird diversity. Received 11 September 2006. Accepted 7 January 2007.

Invasions by native species into novel habitats are often caused by human activity and have the potential for detrimental effects on local biodiversity similar to that from exotic invasive species (Myers 1985, Kupferberg 1996, McCay 2001). Examples are numerous and widespread (e.g., House Finch [*Carpodacus mexicanus*] eastward range expansion, bullfrog [*Rana catesbeiana*] range expansion and competitive exclusion of native frogs into the western United States, sand pine [*Pinus clausa*] invasion throughout the southeastern United States from forest industry plantings, and chickasaw plum [*Prunus angustifolia*] eastward introduction by Native Americans). Invasive exotic species are recognized as the second largest threat to bio-

diversity (Wilson 1992, Wilcove et al. 1998) following only habitat loss, yet effects of invasive native species remain largely unrecognized and unstudied.

Georgia land lottery maps from the early 1800s reveal a forest composition that is probably more similar, although possibly not identical, to prehistoric conditions and which is different from contemporary forests of the Piedmont and Coastal Plain (Nelson 1957). Changes in land use and fire regime following European immigration have caused many species to shift their distributions (Frost 1995, Cowell 1998, Lorimer 2001). One example is a substantial increase of water oak (*Quercus nigra*) and sweetgum (*Liquidambar styraciflua*) on upland sites. These species were absent from all but the floodplains of the largest rivers in the early 1800s. Land lottery maps indicate most Piedmont uplands were comprised of oaks, primarily post oak (*Quercus stellata*), and pine (*Pinus* spp.) while the coastal plain uplands were comprised of open stands of longleaf pine (*Pinus palustris*). Most of these forests were cleared in the late 1800s for agriculture. In the early 20th century, a period of farm abandonment began, which led to substantial re-growth of Georgia's forests (Brender 1974, Plummer 1975). The forest composition has changed, due to fire suppression, to a mixture of the original fire-dependent upland species of pine and oak, and fire-intolerant species including water oak and sweetgum (Cowell 1998). This forest type has been assumed to be a 'natural' upland forest type, although early researchers noted this change (e.g., Barrett 1943).

Unlike pines or upland oaks, leaves of water oak and sweetgum do not burn well and have the effect of suppressing fire. Both species are tardily deciduous and their leaves tend to lie flat, forming a cap on pine litter and other fuels that retain moisture, and act as a barrier to oxygen and heat. These species also have denser canopies, shading out the herba-

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ceous layer that is important for carrying fire. These characteristics have initiated a positive feedback cycle, whereby the presence of water oak and sweetgum further decreases fire frequency and intensity allowing these species to increase their dominance in upland ecosystems. We hypothesize that, by this mechanism, water oak and sweetgum have altered forest structure, species composition, fire regime, and wildlife habitat of upland ecosystems. We investigated the effect of upland invasion by water oak and sweetgum on the breeding bird communities of central Georgia in terms of bird species richness and abundance, and which species are positively and negatively related to the presence of water oak and sweetgum.

METHODS

Ninety sites were surveyed on four properties in the Piedmont (Oconee National Forest [33° 10' N, 83° 48' W], Brender Experimental Forest [33° 02' N, 83° 43' W], Rum Creek Wildlife Management Area [WMA] [33° 01' N, 83° 47' W], Sprewell Bluff Natural Area [32° 51' N, 84° 28' W]) and one in the Coastal Plain (three tracts of Mayhaw WMA [31° 10' N, 84° 46' W]). Sampling units were forest stands as designated by forest inventory data. The average stand size was 15 ha. All stands were former farm fields abandoned in the early 20th century that had naturally succeeded to loblolly pine (*P. taeda*) forest. Stands with at least 25% of their basal area in water oak or sweetgum (invaded

stands) were paired with stands with an equal basal area of pine to the nearest 0.09 m²/ha (10 ft²/ac), and less than 5% of their basal area in water oak or sweetgum (open stands). Open and invaded stands were also paired by pine size category: dominant trees <25 cm diameter at breast height (DBH) or >25 cm DBH on average. All stands showed evidence of fire in the last 10 years, although fire frequency was variable and likely differed over the history of the stands.

Ninety 100-m, fixed-radius point counts (Hamel et al. 1996) were conducted (one/stand) between 15 May and 5 June 2005. Bird surveys were conducted for 10 min between sunrise and 1000 hrs. Bird survey stations between each stand were separated by at least 200 m, usually considerably more, and were at least 100 m from the stand edge when possible. Stands were considered independent of each other for purposes of this study.

Bird species richness (number of species detected/point) and abundance (number of individuals/point) were calculated by stand type. Analysis of variance (PROC MIXED, SAS 2003) was conducted on bird richness and abundance by stand type. Probability of detection by stand type was tested for all bird species with more than 20 detections between stand types. A measure of the relative bird conservation value of open and invaded stands was calculated by summing the Partners in Flight (PIF) combined breeding season

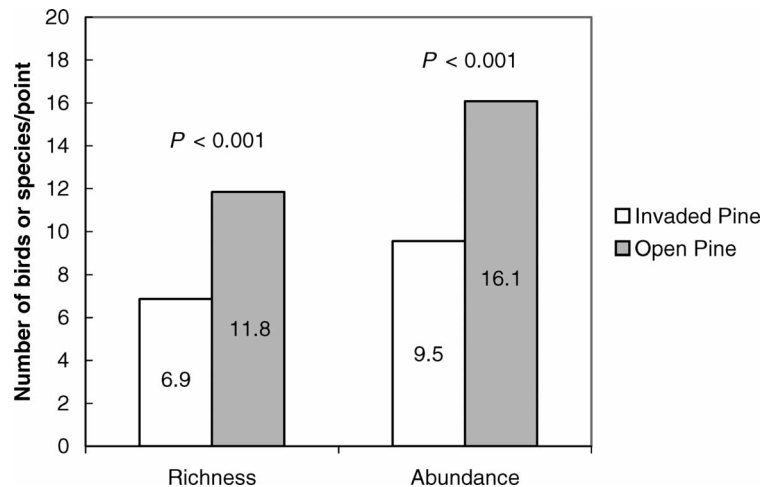


FIG. 1. Bird species richness and abundance in open and invaded Piedmont and Coastal Plain sites, Georgia.

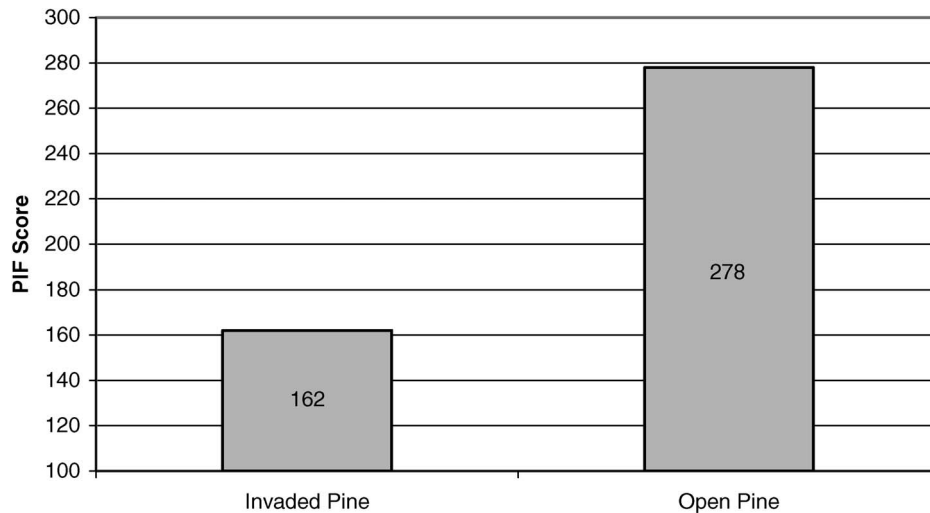


FIG. 2. Average summed Partners in Flight scores (bird conservation value) of invaded and open mixed pine stands in Piedmont and Coastal Plain sites, Georgia.

scores (Panjabi et al. 2005) of birds on each point and calculating the average of these scores by stand type.

RESULTS

We detected 954 individuals of 52 species across all points. Species richness averaged 11.8 species/point in open stands and 6.9 species/point in invaded stands (Fig. 1). Bird abundance was 16.1 individuals/point in open stands and 9.5 individuals/point in invaded stands. Richness and abundance were higher ($P < 0.001$) in open than invaded stands. Of 35 species that had more than 20 records, 10 were more common ($P < 0.05$) in open stands while no species were significantly more common in invaded stands (Table 1). Average conservation value was higher ($P < 0.001$) in open ($\bar{x} = 278$) than invaded stands ($\bar{x} = 162$) (Fig. 2). High conservation priority grassland and shrubland birds were negatively associated with presence of sweet gum and water oak.

DISCUSSION

Invasion of upland sites by water oak and sweetgum substantially lowered the number of bird species and individuals during the breeding season. Six of the top 10 species identified as high conservation priorities in Partners in Flight plans (Red-cockaded woodpecker [*Picoides borealis*], Bachman's sparrow [*Aimophila aestivalis*], Brown-headed Nuthatch [*Sitta pusilla*],

Prairie Warbler [*Dendroica discolor*], Northern Bobwhite [*Colinus virginianus*], and Red-headed Woodpecker [*Melanerpes erythrocephalus*]) declined or disappeared from upland pine stands when water oak and sweetgum comprised 25% or more of the canopy. Most species negatively associated with invaded sites were of two habitat guilds: grassland/pine savanna birds and shrubland birds. These groups have consistently shown the strongest population declines of all North American birds (Hunter et al. 2001).

The dense shade of water oaks and sweetgum reduced herbaceous and shrub cover, eliminating critical nesting and foraging habitat for many bird species. Invaded forests tended to have about half the plant species richness (invaded, $\bar{x} = 16$ species/m²; open pine $\bar{x} = 26$ species/m²; $P < 0.033$, $n = 6$) (L. Kruse, N. Klaus, and T. Keyes, unpubl. data), which may translate into reduced food resources for birds.

Most striking was that no bird species detected on our surveys was positively associated with invaded stands. This suggests that upland bird species have not specialized in upland pine stands dominated by water oak and sweetgum, and the invaded forest type may be an artifact of recent human land use. Reduction or elimination of sweetgum and water oak in upland mixed pine sites would improve habitat quality for declining grassland and shrubland birds, and may not negatively im-

TABLE 1. Species associations (+ or -, and *P* value from ANOVA) with invaded pine stands sorted by PIF breeding season score, Piedmont/Coastal Plain, Georgia.

Species	Scientific name	Invaded pine	Neutral	PIF score
Red-cockaded Woodpecker	<i>Picoides borealis</i>	(-) 0.089		23/20
Bachman's Sparrow	<i>Aimophila aestivalis</i>	(-) 0.003		21/18
Brown-headed Nuthatch	<i>Sitta pusilla</i>	(-) <0.001		20/18
Prairie Warbler	<i>Dendroica discolor</i>	(-) <0.001		18/18
Eastern Towhee	<i>Pipilo erythrophthalmus</i>		*	16/16
Northern Bobwhite	<i>Colinus virginianus</i>	(-) 0.117		16/16
Summer Tanager	<i>Piranga rubra</i>		*	16/15
Carolina Chickadee	<i>Poecile carolinensis</i>		*	16/15
Acadian Flycatcher	<i>Empidonax vireescens</i>		*	15/15
Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>	(-) 0.030		15/13
Wood Thrush	<i>Hylocichla mustelina</i>		*	15/16
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>		*	15/14
Yellow-throated Vireo	<i>Vireo flavifrons</i>		*	15/14
Pine Warbler	<i>Dendroica pinus</i>		*	14/14
White-eyed Vireo	<i>Vireo griseus</i>		*	14/11
Blue Jay	<i>Cyanocitta cristata</i>		*	14/13
Downy Woodpecker	<i>Picoides pubescens</i>		*	14/13
Indigo Bunting	<i>Passerina cyanea</i>	(-) 0.001		14/12
Pileated Woodpecker	<i>Dryocopus pileatus</i>		*	14/11
Carolina Wren	<i>Thryothorus ludovicianus</i>		*	13/13
Red-bellied Woodpecker	<i>Melanerpes carolinus</i>	(-) 0.003		13/12
Yellow-breasted Chat	<i>Icteria virens</i>	(-) 0.006		13/12
Common Yellowthroat	<i>Geothlypis trichas</i>		*	13/12
Tufted Titmouse	<i>Baeolophus bicolor</i>		*	13/12
Blue Grosbeak	<i>Passerina caerulea</i>	(-) 0.027		12/14
Great-crested Flycatcher	<i>Myiarchus crinitus</i>		*	12/10
Northern Cardinal	<i>Cardinalis cardinalis</i>		*	12/10
American Crow	<i>Corvus brachyrhynchos</i>		*	11/12
Eastern Bluebird	<i>Sialia sialis</i>		*	11/11
Mourning Dove	<i>Zenaidura macroura</i>		*	11/11
Red-eyed Vireo	<i>Vireo olivaceus</i>		*	11/10
Blue-gray Gnatcatcher	<i>Poliophtila caerulea</i>		*	11/10
Chipping Sparrow	<i>Spizella passerina</i>		*	9/10
American Goldfinch	<i>Carduelis tristis</i>		*	8/10
Brown-headed Cowbird	<i>Molothrus ater</i>	(-) 0.010		8/10

* = No significant relationship to stand type.

pect any other breeding bird species during the breeding season. Other species of oaks, primarily post oak, southern red oak (*Quercus falcata*), and black oak (*Q. velutina*) were observed in both stand types but did not appear to have a negative impact on bird species' richness or abundance. These trees tolerate fire well, do not produce dense shade or reduce fire intensity, and are at least comparable in the quality of mast production to water oaks.

Water oak and sweetgum are native to the southeastern United States, Georgia, and even the particular watersheds in our study areas but are exotic in the upland pine ecosystem. Invasion of uplands by water oak and sweetgum fol-

lows a pattern similar to the spread of invasive exotic species; they create a positive feedback cycle whereby ecosystem function is altered which promotes their continued growth. This study demonstrates that in upland forests of central Georgia, invasion by native trees species into novel habitats is associated with a decline in bird species, particularly the most specialized species (e.g., grassland/shrubland birds). This results in a significant decrease in diversity from the former ecosystem.

Sweetgum and water oak are native to the southeastern United States but they are not native to all habitats. Management objectives for conservation lands should consider where dominance of these tree species is appropriate.

Conservation of the most vulnerable bird species may necessitate removal of these tree species from upland habitats.

ACKNOWLEDGMENTS

We are grateful to Julie Robbins, Lisa Kruse, John Moore, Ken Lalumiere, and Alan Isler for field assistance. We also thank the Georgia Department of Natural Resources for funding this project and providing study sites, as well as staff of the Chattahoochee-Oconee National Forest and Georgia State Parks. Elaine Klaus and two anonymous reviewers improved this manuscript.

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