Managing mid-rotation pine plantations to enhance Bachman's sparrow habitat

James W. Tucker, Jr., Geoffrey E. Hill, and Nicholas R. Holler

Abstract Bachman's sparrow (*Aimophila aestivalis*) ranks high among the bird species of greatest management concern in the southeastern United States. Bachman's sparrows typically occur in mature pine (*Pinus* spp.) forests that have a limited shrub layer and a dense, herbaceous ground cover, and in recently planted (within 1–5 yrs) clearcuts. Middle-aged pine stands usually are not occupied by Bachman's sparrows. At Tyndall Air Force Base in northwest Florida, we found Bachman's sparrows exclusively within burned, mid-aged (17- to 28-yr-old) slash pine (*P. elliottii*) plantations. Bachman's sparrows were more abundant ($Z = 2.74$, $P = 0.006$) in burned stands than in similarly managed unburned stands. Within burned stands, a positive correlation existed between number of Bachman's sparrows and relative volume of grass ($r_s = 0.46$). Prescribed burning in pine plantations can produce suitable habitat conditions for Bachman's sparrow in stands younger than most studies have suggested.

Key words *Aimophila aestivalis*, Bachman's sparrow, forest management, pine plantations, prescribed burning

Before European colonization, longleaf pine (*Pinus palustris*) forests covered much of the coastal plain of the southeastern United States, stretching from Virginia to Texas (Chapman 1932). This ecosystem was characterized by large, widely spaced pines, virtually no midstory, and a dense ground cover of grasses and forbs (Noss 1988). Historically, the habitat was maintained by fires that regularly swept through the region (Platt et al. 1988). Even before human alteration of the ecosystem, longleaf pine forests apparently had relatively few species of breeding birds, but contained several largely endemic species such as the red-cockaded woodpecker (*Picoides borealis*), Bachman's sparrow (*Aimophila aestivalis*), and brown-headed nuthatch (*Sitta pusilla*; Jackson 1988).

During the last century, the landscape of the coastal plain of the southeastern United States has changed dramatically as longleaf pine forests have been subjected to fire suppression or converted to agricultural lands, including pine plantations (Frost 1993, Simberloff 1993). Today, most of the region that was originally longleaf pine forest exists as commercial stands of slash (*Pinus elliottii*) or loblolly pine (*P. taeda*). Two of the 3 birds most closely associated with longleaf pine, the red-cockaded woodpecker and Bachman's sparrow, have been reduced

This previously burned mid-aged slash pine plantation at Tyndall Air Force Base, Florida was occupied by Bachman's sparrows. Prescribed burns may be used to produce suitable habitat conditions for Bachman's sparrows in stands normally considered too young for use by the species.

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to relict populations in the few remaining stands that either were not subjected to fire suppression or have been restored from previous fire suppression.

Bachman's sparrow was formerly a Category 2 candidate for listing as threatened or endangered by the U.S. Fish and Wildlife Service (USFWS), but it was not formally listed because of insufficient information about its status and management (Pulliam et al. 1992). The USFWS no longer maintains a list of category species, but several states classify Bachman's sparrow as rare or endangered (Dunning 1993), and the species ranks among those at highest priority of management concern in the southeastern United States (Hunter et al. 1994).

The primary habitat of Bachman's sparrow is pine woodlands with an open understory and dense ground cover of grasses and forbs (Dunning 1993). The Bachman's sparrow has relatively strict habitat requirements (Dunning and Watts 1990), and habitat loss is probably responsible for declining populations (Haggerty 1988). Recent studies of Bachman's sparrow identify mature pine stands, and clearcuts that have been recently planted with pines (within 1–5 yrs), as important habitats for breeding (Dunning and Watts 1991, Dunning et al. 1995; see also Haggerty 1988, 1994). Clearcuts provide only temporary (≤5 yrs) habitat for Bachman's sparrows (Johnson and Landers 1982; Dunning and Watts 1990, 1991), and mature pine stands are important to maintain local populations (see Pulliam et al. 1992, Dunning et al. 1995). Studies by Dunning and Watts (1991) and Dunning et al. (1995) suggested that Bachman's sparrows do not occupy pine stands 5- to 80-years old. Although a few studies reported Bachman's sparrows occupying middle-aged pine stands (e.g., Johnson and Landers 1982, Dunning and Watts 1990, Gobris 1992), the implications of these observations for management of this abundant habitat for Bachman's sparrows have been largely overlooked.

Because of the association between conversion of longleaf pine to commercial pine stands and the loss of native bird species (Repenning and Labisky 1985), the general consensus among ornithologists has been that commercial timber production conflicts with the conservation of many bird species. However, methods of commercially growing pine trees vary greatly among landowners and have changed over time.

During a study that examined the distribution of Nearctic-Neotropical migrants among habitats along the Gulf Coast of northwest Florida (J. Tucker, G. Hill, and N. Holler, unpubl. data), we observed that Bachman's sparrows at Tyndall Air Force Base were restricted to burned, mid-aged (17- to 28-year-old) slash pine plantations. Our objectives were to document the presence of Bachman's sparrows in a habitat type (mid-aged pine stands) generally considered unsuitable for the species and to examine factors contributing to enhanced habitat quality for Bachman's sparrows. Although we did not design the primary study from which these data were gathered to examine the influence of within-habitat features on the distribution of birds, population trends we report provide valuable insight on the use of fire to improve habitat for Bachman's sparrows in intensively managed pine plantations.

Methods

Study areas

The study was conducted at Tyndall Air Force Base in northwestern Florida. Tyndall occupies approximately 36,000 ha along the northern coast of the Gulf of Mexico. Most forest at Tyndall consists of young (<30-yr-old) slash pine plantations that are intensively managed. We randomly selected 20 stands ranging in size from 3 to 139 ha from each of the 6 forested habitats available at Tyndall. Habitats examined were: coastal scrub; oak (*Quercus* spp.) hammocks; young (10- to 12-yr-old) pine plantations; unburned, mid-aged (17- to 28-yr old) pine plantations; burned (dormant season prescribed burns), mid-aged pine plantations; and unburned, mature (>50-yr-old) naturally seeded pine forests.

During this study, Bachman's sparrows were observed only within burned, mid-aged stands, an age class previously reported to be unoccupied by the species (Dunning and Watts 1991, Dunning et al. 1995); consequently, we examined mid-aged stands in greater detail. Both burned and unburned mid-aged stands were established by bedding and rowing followed by planting of slash pine seedlings at a 2- x 3-m spacing. All 20 burned stands and 11 of 20 unburned stands were thinned at 11–25 years of age by removal of every third row of trees. Nine unburned stands were not thinned. All 20 burned stands were prescription burned during winter once or twice during the previous 4 years. Unburned stands contained minimal herbaceous vegetation and a nearly impenetrable shrub layer (primarily gallberry [*Ilex glabra* and *I. Coriacea*], fetterbush [*Lyonia lucida*], and black titi [*Cliftonia monophylla*]) roughly 2- to 3-m tall, entangled with greenbrier (*Smilax* spp.), whereas burned, mid-aged stands had a dense cover of herbaceous vegetation and contained little shrub vegetation >1.0 m tall. The influence of fire on vegetation structure of southern pine forests is well documented (Lewis and Harshbarger 1976, Waldrop et al. 1992, Wilson et al. 1995).

Data collection

We conducted 7 point counts between 17 March and 20 May 1995 at each of the 120 stands. Counting points were established at stand centers, and points in adjacent but different habitats were ≥200 m apart. All points within a habitat type were in discrete stands separated by >1 km. Counts were conducted during the first 4 hours of daylight, and all birds seen or heard within 50 m of stand centers were recorded during a 5-minute period. Because stands were widely dispersed, sampling stands in random order was not feasible, so we sampled approximately equal numbers of stands within habitats each day and rotated the order in which stands were sampled (Grue et al. 1981). Before returning to a stand for an additional count, a complete rotation of all sites was made. One-way analysis of variance tests revealed that sampling time ($F = 0.0125$; 5, 834 df; $P = 0.987$) and sampling date ($F = 0.013$; 5, 834 df; $P > 0.999$) did not differ among habitats.

We randomly selected 20 points for vegetation sampling on each of the 20 burned, mid-aged plantations from a 100- x 100-m grid with 1-m spacing randomly oriented at stand centers. Vegetation was not sampled at unburned, mid-aged plantations. We used the pole method to measure relative vegetation volumes (Mills et al. 1991) in the first 4 meters above ground between 18 May and 23 May 1995. We identified all plants within a series of 0.1-m radius cylinders centered around each 0.1 m in height section of a pole positioned vertically at a sampling point. Relative volume of grasses (including sedges), forbs, and shrubs (including sprouts of trees) were calculated for each point by summing the number of 0.1-m tall sections that contained the vegetation type. Relative volumes for each stand were calculated by summing relative volumes across the 20 sampling points within stands. Only 21% of all sampling points ($n = 400$) contained shrub vegetation ≥1.0 m in height, whereas 95.2% of vegetation contacts were <1.0 m in height. Since grasses and forbs were restricted to ≤0.9 m in height, we defined the ground cover as vegetation <1.0 m in height and midstory as vegetation 1.0–4.0 m in height. Canopy cover was measured with a spherical densiometer. We obtained management history data (size of stand; years since planting, thinning, and burning; and number of burns) from records at the Natural Resources Division of Tyndall Air Force Base.

Data analysis

We used the mean number of Bachman's sparrows (No./count) detected per stand as an index of relative abundance. Differences between groups (i.e., burned vs. unburned stands; occupied vs. unoccupied stands) were tested using the normal approximation to the Mann-Whitney test. Spearman's rank correlation was used to test for linear correlations between site attributes (management history variables and relative vegetation volumes) and relative abundance of Bachman's sparrows. Nonnormally distributed data warranted the use of nonparametric statistics for analysis. Null hypotheses were rejected at $P < 0.05$.

Results

Bachman's sparrows at Tyndall Air force Base were restricted to burned, mid-aged slash pine plantations. Bachman's sparrows were detected at 8 of 20 burned stands examined. Within the 8 stands occupied by Bachman's sparrows, we detected 1 or 2 sparrows during 2–5 of the 7 counts at each stand (mean relative abundance of 0.46 sparrows [SE = 0.06] per stand). Because not all burned, mid-aged plantations were occupied by Bachman's sparrows, we compared management history variables and relative volumes of vegetation types between the occupied and unoccupied stands. Age, years since thinning, years since burning, number of burns, and stand size did not differ between the 8 occupied stands and the 12 unoccupied stands (Table 1). In addition, there was no correlation between any of the management history variables and the relative abundance of Bachman's sparrows (Table 2).

Relative volume of grass was the only measured vegetation variable to differ between stands occupied and unoccupied by Bachman's sparrows (Table 3). There also was a positive relationship between

Table 1. Means (±SE) for management history variables of burned, mid-aged[a] slash pine plantations occupied and unoccupied by breeding Bachman's sparrows at Tyndall Air Force Base, Florida during 1995.

Manage. variable	Occupied ($n = 8$) $\bar{x}$ (SE)	Unoccupied ($n = 12$) $\bar{x}$ (SE)	Z^b	P
Stand age	21.25 (0.16)	22.75 (0.83)	1.07	0.29
Yrs since thinning	6.75 (1.18)	5.50 (1.21)	1.21	0.23
Yrs since burning	2.12 (0.30)	2.08 (0.29)	0.20	0.84
No. of burns	1.62 (0.18)	1.50 (0.15)	0.54	0.59
Stand area (ha)	19.14 (3.27)	23.74 (5.44)	0.12	0.91

[a] Stands were 17- to 28-years old, thinned by third row removal, and prescribed burned during winter.

[b] Normal approximation to the Mann-Whitney test.

Table 2. Spearman's r and associated probability for rank correlation tests examining the influence of management history and vegetation variables on the relative abundance (No./count) of Bachman's sparrows in burned, mid-aged (17- to 28-year-old) slash pine plantations (n = 20) at Tyndall Air Force Base, Florida, 17 March to 20 May 1995.

Variable	Spearman's r	P
Stand age	−0.249	0.277
Yrs since thinning	0.327	0.154
Yrs since burning	0.033	0.885
No. of burns	0.109	0.636
Stand area (ha)	−0.061	0.789
% canopy	0.154	0.502
Grass[a]	0.465	0.043
Forb[a]	0.142	0.537
Trees/shrubs[a]	0.085	0.711
Midstory[b]	−0.149	0.517

[a] Measured as relative volume (sum of 0.1 m in height intervals containing vegetation within a 0.1-m radius of a 4.0-m pole positioned vertically at 20 sampling points per stand) <1.0 m in height.

[b] Measured as relative volume of trees/shrubs 1–4 m in height.

relative abundance of Bachman's sparrows and relative volume of grass (Fig. 1), but relative abundance of Bachman's sparrows was not correlated with relative volume of other vegetation variables (Table 2).

We compared management histories of burned and unburned, mid-aged stands to assess whether these 2 habitats were equivalent except for differences induced by prescribed burning. Stand size did not differ (Z = 1.136, P = 0.256) between burned ($\bar{x}$ = 21.90 ha, SE = 3.48) and unburned stands ($\bar{x}$ = 37.87 ha, SE = 8.23), nor did stand age differ (Z = 0.415, P = 0.678) between the 2 stand conditions (burned, $\bar{x}$ = 22.15, SE = 0.52; unburned, $\bar{x}$ = 22.30, SE = 0.73). However, years since thinning did differ (Z = 2.540, P = 0.011), because 9 of 20 unburned stands had not been thinned, whereas all 20 burned stands had been. Excluding the 9 unthinned stands from analysis, stand size (Z = 0.743, P = 0.457), stand age (Z = 1.106, P = 0.269), and years since thinning (Z = 0.105, P = 0.916) did not differ between burned and unburned, mid-aged stands. Thus, 11 of the unburned stands can be considered as a control group for comparing the influence of prescribed burning on relative abundance of Bachman's sparrows. Relative abundance of Bachman's sparrows was greater in burned, mid-aged stands than in the 11 similar unburned, mid-aged stands (Z = 2.735, P = 0.006).

Discussion

At Tyndall Air Force Base, Bachman's sparrow was a common breeding bird in slash pine plantations of an age class purported to be largely unoccupied by the species (Dunning and Watts 1991, Dunning et al. 1995; but see Johnson and Landers 1982, Dunning and Watts 1990). Additionally, we found Bachman's sparrows exclusively within stands that had been prescribed burned. Within burned stands, those occupied by Bachman's sparrows had greater grass volumes than did unoccupied stands (Table 3). All 20 of our burned, mid-aged stands had very similar management histories (Table 1), and we were unable to find differences among stands to explain the greater volume of grass at those occupied by Bachman's sparrows. However, the positive correlation between grass volume and relative abundance of Bachman's sparrows (Fig. 1) implies grass volume was an important feature of sparrow habitat in slash pine plantations. Factors potentially contributing to differences in grass volume that we did not examine include variation in soil types, soil moisture, buried seed reserves, and environmental conditions (e.g., fire intensity, weather conditions, and early or late winter) when prescribed burns were conducted (Streng et al. 1993, Glitzenstein et al. 1995). However, our observations have important management implications for the conservation of Bachman's sparrow.

The relatively strict habitat requirements of Bachman's sparrow (i.e., an open understory and dense herbaceous ground cover) are greatly affected by forest management practices (Dunning and Watts 1990,

Table 3. Mean (±SE) percent canopy cover and relative volume[a] of grass (including sedges), forb, and trees and shrubs in the ground cover (<1.0 m in height) and for the midstory vegetation (trees and shrubs 1.0–4.0 m in height) within burned, mid-aged (17- to 28-year-old) slash pine plantations occupied and unoccupied by breeding Bachman's sparrows at Tyndall Air Force Base, Florida during 1995.

Variable	Occupied (n = 8) $\bar{x}$ (SE)	Unoccupied (n = 12) $\bar{x}$ (SE)	Z[b]	P
% Canopy	41.08 (2.60)	39.45 (2.14)	0.46	0.64
Grass	60.13 (7.64)	34.00 (6.29)	2.16	0.03
Forb	17.50 (2.83)	19.92 (5.65)	0.54	0.59
Trees/shrubs	80.88 (4.07)	80.92 (10.31)	0.12	0.91
Midstory	7.00 (1.77)	12.25 (3.39)	0.82	0.41

[a] Sum of 0.1-m height intervals containing vegetation within a 0.1-m radius of a 4.0-m pole positioned vertically at 20 sampling points per stand.

[b] Normal approximation to Mann-Whitney test.

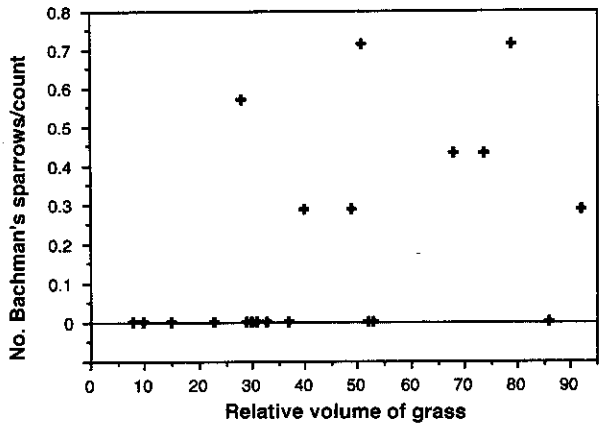

Fig. 1. Relative abundance of Bachman's sparrows plotted against relative volume of grass in burned, mid-aged (17- to 28-yr-old) slash pine plantations at Tyndall Air Force Base, Florida during 1995 (Spearman's $r = 0.46$, $P = 0.043$, $n = 20$). Relative volume of grass was calculated by summing the number of 0.1-m height sections ≤0.9 m above ground that contained grass within a 0.1-m radius of a pole positioned vertically at 20 sampling points per stand.

Plentovich et al. 1998). Prescribed burning, especially during the growing season, is an effective tool for maintaining an open understory and development of herbaceous ground cover (Brender and Copper 1968, Platt et al. 1991, Waldrop et al. 1992, Glitzenstein et al. 1995, Plentovich et al. 1998). Several studies have found Bachman's sparrows more abundant in stands managed by prescribed burning than in stands not managed by prescribed burning (e.g. Brennan et al. 1995, Wilson et al. 1995, Plentovich et al. 1998). However, Bachman's sparrows disappear from stands about 4–5 years following prescribed burning (Engstrom et al. 1984, Gobris 1992). Johnson and Landers (1982) found Bachman's sparrows present in 11- to 15-year-old slash pine stands only during the first 2 growing seasons post burning. Thus, frequent burning is key for maintenance of habitat for Bachman's sparrows.

Prescribed burning in mid-aged pine stands has been suggested as an important practice for conservation of Bachman's sparrow (Liu et al. 1995), but documentation that this practice benefits Bachman's sparrow is lacking. Our study provides empirical evidence that such management is feasible.

In addition to Bachman's sparrow, prescribed burning also benefits many other species. Fire is essential to maintain the diverse ground cover characteristic of longleaf pine forests and, thus, many of the animals associated with these forests (Engstrom 1993, Folkerts et al. 1993, Guyer and Bailey 1993). Several bird species of management concern find primary habitat in open pine forests of the East Gulf Coastal Plain (Hunter et al. 1994). Engstrom et al. (1984) found that birds characteristic of the open habitat in longleaf pine forests (e.g., Bachman's sparrow and loggerhead shrike [*Lanius ludovicianus*]) disappeared about 5 years after fire exclusion, and shrub-specialist species (e.g., prairie warbler [*Dendroica discolor*]; yellow-breasted chat [*Icteria virens*]) became most abundant during the second year after burning but began declining about 7 years after burning. Thus, prescribed burning at 3- to 5-year intervals appears to be the optimum strategy for management and conservation of birds characteristic of longleaf pine forests.

In conclusion, we found that prescribed burning of pine plantations produced suitable habitat conditions for Bachman's sparrows in stands younger than those found suitable in most previous studies. Although Johnson and Landers (1982) found Bachman's sparrows in burned pine stands ranging from 11- to 28-years-old that had not been thinned, thinning may be required in stands with dense, closed canopies before herbaceous ground cover will respond to burning. These recommendations are not only compatible with commercial forest management but complementary to it. Reduction of competition from hardwoods and shrubs in the understory increases growth and yield of pines (Bower and Ferguson 1968, Clason 1978), and prescribed fire is the most economical tool available for controlling understory growth (Cooper 1971). Middle-aged pine plantations occupy vast areas of the southeastern United States, and much of this area might support Bachman's sparrows by implementation of prescribed burning programs.

Acknowledgments. This study was funded by the U.S. Department of Defense, Tyndall Air Force Base through the Alabama Cooperative Fish and Wildlife Research Unit (cooperators: Biological Resources Division of the U.S. Geological Survey, Game and Fish Division of the Alabama Department of Conservation and Natural Resources, Wildlife Management Institute, and Auburn University [Alabama Agricultural Experiment Station, Department of Fisheries and Allied Aquacultures, and Department of Zoology and Wildlife Science]). Funds were provided through contract number 14-48-0009-93-1978 with Tyndall Air Force Base and National Biological Service Research Order 41 with Auburn University. We thank B. Bates, S. Shea, and other personnel of Natural Resources at Tyndall for their support, and M. Dunham, J. Gassner, and R. Harrison for assistance with field work. This manuscript benefited from constructive comments of J. Hagar, P. A. McLaren, C. C. Maguire, and an anonymous referee.

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