Microhabitat Characteristics as Predictors of Occupancy by Bachman's Sparrow in a Fire-managed Pine Forest of Louisiana

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Abstract: Longleaf pine forests have declined precipitously throughout the southeastern United States, partially because of reductions in prescribed burning. Populations of species associated with longleaf forests, such as Bachman's sparrow (*Aimophila aestivalis*), also have declined at alarming rates. Efforts to restore longleaf systems are ongoing throughout the region, and involve varying fire-return intervals. We assessed whether Bachman's sparrow detection probabilities and site occupancy were associated with differences in microhabitat caused by variations in fire regimes. The fire regimes we assessed were conducted within stands that averaged 3.5 ha. Our occupancy models suggested that the most suitable habitat for Bachman's sparrows in longleaf pine stands included a monoculture of longleaf pine overstory with limited intrusion of hardwood species and greater herbaceous layers for nesting cover. Our findings suggest that ensuring presence of Bachman's sparrows in restored longleaf pine forests will require biannual prescribed fire during the growing season (April–June).

Key words: Aimophila aestivalis, Bachman's sparrow, longleaf pine, Louisiana, prescribed fire

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Historically, longleaf pine (*Pinus palustris*) forests covered 25 million ha across the Southeast and were maintained for thousands of years by fires initiated by lightning or other causes, which often burned every two to four years (Platt 1988). However, European settlement, widespread commercial timber harvesting, urbanization, agriculture, and fire suppression have greatly reduced longleaf forests. Less than 809,371 ha of this cover type currently remains, representing a 97% decline (USFWS 1998). Restoration and management of longleaf pine savannahs across the Southeast is increasingly common, and includes prescribed burning regimes that vary by fire-return interval (Carter and Foster 2004) and season of application (Haywood et al. 2001).

Concurrent with the loss of longleaf pine forests have been declines in populations of many birds dependent on this forest system, such as the Bachman's sparrow (*Aimophila aestivalis*). Bachman's sparrow is particularly sensitive to changes that occur in understory vegetation because they nest and forage on the ground. Likewise, they have been found to be adversely affected by loss of herbaceous cover (Dunning and Watts 1990) and require a dense layer of ground cover (Dunning 1993). Previous studies have reported benefits of growing-season fire to birds associated with longleaf pine savannahs (Tucker et al. 2004), but few studies have directly examined relationships between the timing and season of fire and bird response. Our objective was to examine occupancy and detection probability of Bachman's sparrows relative to site-specific microhabitat conditions in a fire-managed longleaf pine forest. Secondarily, we evaluated potential influences of timing of fire and time since last fire on microhabitat variables essential to Bachman's sparrows.

Study Area

We conducted research at Sandy Hollow Wildlife Management Area, a 1422-ha tract of longleaf pine savannah owned and managed by the Louisiana Department of Wildlife and Fisheries. Sandy Hollow was composed of longleaf savannahs with understory plant communities dominated by broom sedges (*Andropogon* spp.) and other grasses. Longleaf stands contained scattered hardwoods such as blackjack oak (*Quercus marilandica*), and bluejack oak (*Q. incana*). The mean diameter at breast height (DBH) of longleaf was 16.33 cm ($N = 1899$, $SE = 0.19$), indicating that trees were in the mid-seral stages. Understory vegetation was intensively managed with prescribed burns beginning in 1986 and conducted annually during winter (December–March) until 2001. Growing season burns (April–August) were increasingly implemented in 2002 on an annual to biannual cycle. Average size of burned stands was 3.5 ha (range 1.4–11.1 ha).

Methods

During 2003–2004, we conducted point count surveys at 108 points and visited each point three times from April to June. We spaced point counts 125 to 150 m apart within selected forest stands and >100 m from roads or other habitat edges. We made all attempts to not count calling birds at multiple points by paying particular attention to direction and distance of each calling individual. Our sampled locations were within 5 different burn histories; we sampled 3 points within a particular forest stand. We sampled 6 points in stands burned 2 years prior during the growing season and then 1 month prior to our surveys (F1). We sampled 60 points that were historically burned during the dormant season annually and then 2 months prior to our surveys (F2), and 24 points in stands burned annually during the growing season (F12G). Likewise, we sampled 12 points in stands that were burned with dormant season burns every 2 years prior to our surveys (F24D). Finally, we sampled 6 points in stands burned during the growing season biannually for at least 4 years prior to our surveys (F24G). We conducted 10-min point counts from 30 minutes before sunrise to 4 h after sunrise and recorded every Bachman's sparrow seen or heard during our surveys.

To quantify micro-habitat characteristics associated with each point count location, we established a 100 × 4 m band transect to completely bisect each point count station. We identified, measured, and enumerated all trees (>8 cm in DBH) within the band transect and tallied and identified all woody species >1 m tall (<8 cm in DBH) located within the inner 2 m of each transect. We measured canopy closure every 10 m along the transect using a forest densiometer. At this same point, we measured ground cover classes using a 1 m^2 frame; cover classes included percentage grass, forb, woody, fern, and bare ground. We quantified habitat characteristics on each band transect during summer (June–July) of each year.

For our analysis, we combined percentage grass, fern, and forb to form percentage herbaceous cover. We also determined the percentage of hardwood trees, as well as shortleaf pine (*P. echinata*), longleaf pine, and loblolly pine (*P. taeda*) trees within each transect and included them as variables. We determined means and standard errors to summarize vegetation patterns based on the microhabitat variables examined.

We related occurrence and detection probabilities of Bachman's sparrows to 10 microhabitat explanatory variables (Table 1) using program PRESENCE, Version 2.2 (MacKenzie et al. 2005). We used the site occupancy models in PRESENCE to estimate the proportion of sites occupied by Bachman's sparrows and to evaluate the relative importance of habitat variables. We developed our models using *a priori* knowledge of Bachman's sparrow habitat requirements and examined detection probabilities and the set of models with habitat variables as covariates to occupancy. We used Akaike's Information Criterion corrected for small sample sizes

Table 1. Means ($\bar{X}$) and associated standard errors (SE) for microhabitat variables measured at point counts ($N = 108$) used to survey Bachman's sparrow at Sandy Hollow Wildlife Management Area, Louisiana, 2003–2004.

Microhabitat Variable	$\bar{X}$	SE
Percentage canopy closure	48.87	1.65
Percentage bare ground	9.05	0.71
Percentage herbaceous cover	51.40	1.41
Number of shrubs/200 m^2	136.84	8.74
Number of trees/400 m^2	26.33	1.49
Tree species richness	3.89	0.21
Percentage of hardwood trees	22.70	2.23
Percentage of shortleaf pine	4.67	1.16
Percentage of longleaf pine	58.06	3.51
Percentage of loblolly pine	14.39	2.09

(AIC_c) for model selection and calculated differences among AIC values (ΔAIC_c) to compare the best approximating model to competing models (Burnham and Anderson 2002). We also calculated normalized Akaike weights (w_i) to evaluate the relative evidence for each model (Burnham and Anderson 2002), given the data and the set of candidate models. After selecting the best model with habitat variables deemed important to detection probability and occupancy by Bachman's sparrows, we calculated means with 90% confidence intervals of the habitat variables relative to fire regime (F1, F2, F12G, F24D, and F24G).

Results

We detected Bachman's sparrows at 65 of 108 points, thus our naïve estimate of occupancy was 60.2%. Three models were equally plausible and accounted for 75% of Akaike weight; all modeled occupancy as a function of percentage herbaceous cover, longleaf pine, and bare ground (Table 2). The probability of a site being occupied by Bachman's sparrow (Ψ) was positively related to percentage longleaf pine (intercept = 0.76, SE = 0.41) and herbaceous cover (intercept = 0.49, SE = 0.28), but negatively related to percentage bare ground (intercept = –0.44, SE = 0.26). Detection probability was best modeled as a function of the negative linear effects of percentage of hardwood trees (intercept = –0.27, SE = 0.17), hence the probability of detecting a Bachman's sparrow decreased with increasing amounts of hardwoods.

Sites burned biannually during the growing season (F24G) were dominated by longleaf pines, and thus differed in tree composition from sites managed with the other 4 fire regimes. These sites, as well as sites burned biannually during the dormant season (F24D) had 52% to 81% less bare ground than sites burned during the dormant season 2 months immediately prior to our surveys (F2). Sites burned biannually during the dormant season (F24D) had 29% to 87% fewer hardwood trees than F2 sites. Sites burned biannually

Table 2. Model selection results and parameter estimates of site occupancy (Ψ) and detection probabilities (*p*) for Bachman's sparrows surveyed at 108 points in a fire-managed pine forest on Sandy Hollow Wildlife Management Area, Louisiana.

Model	–2*Log-likelihood	K	AIC	Akaike weight
Ψ (% Herbaceous cover [+], % longleaf pine [+], % bare ground [–]), *p*(% hardwood trees[–])	394.23	4	0	0.36
Ψ(% Herbaceous cover [+], % longleaf pine [+], % bare ground [–], % loblolly pine [–]), *p*(% hardwood trees [–])	393.06	5	0.83	0.24
Ψ(% Herbaceous cover [+], % longleaf pine [+], % bare ground [–], , % loblolly pine [–], tree richness [–]), *p*(% hardwood trees [–])	392.01	6	1.78	0.15
Ψ(% Herbaceous cover [+], % longleaf pine [+], % bare ground [–], tree richness [–]), *p*(% hardwood trees, # trees [–])	391.07	7	2.84	0.09
Ψ(% Herbaceous cover [+], % longleaf pine [+], % bare ground [–], tree richness, canopy [–]), *p*(% hardwood trees, # trees [–])	390.53	8	4.30	0.04
Ψ(% Herbaceous cover [+], % longleaf pine [+], % bare ground [–], % loblolly pine [–]), *p*(.)	394.63	6	4.40	0.04

Table 3. Mean value and 95% confidence intervals ($CI_{95\%}$) of microhabitat variables that influenced detection probabilities and occupancy of Bachman's sparrows within 5 fire regimes (F1 = growing season burn 1 month prior to surveys; F2 = dormant season burn 2 months prior to surveys; F12G = growing season burn 1 year prior to surveys; F24D = dormant season burn 2 years prior to surveys; F24G = growing season burn 2 years prior to surveys) at Sandy Hollow Wildlife Management Area, Louisiana, 2003–2004.

	F1 (*n* = 6)		F2 (*n* = 60)		F12G (*n* = 24)		F24D (*n* = 12)		F24G (*n* = 6)	
Microhabitat Variable	$\bar{X}$	$CI_{95\%}$	$\bar{X}$	$CI_{95\%}$	$\bar{X}$	$CI_{95\%}$	$\bar{X}$	$CI_{95\%}$	$\bar{X}$	$CI_{95\%}$
% Herbaceous cover	36.27	30.46–42.09	39.83	36.19–43.48	54.36[a]	46.23–62.48	46.74	39.46–54.02	65.15[a]	51.59–78.72
% Bare ground	10.15	3.48–16.83	12.67	11.08–14.25	4.14	3.95–12.22	3.74[b]	0.66–6.83	2.13[b]	0.00–4.75
% Hardwood trees	45.14	23.95–72.92	26.24	21.12–31.47	18.97	7.84–30.10	12.59[b]	2.75–22.43	0[c]	–
% Longleaf pine	19.24	0.58–37.90	55.96	48.11–63.80	61.76	45.00–78.51	59.63	34.16–85.11	100.00[c]	–

a. Significantly greater than in F1 and F2.
b. Significantly less than in F2.
c. Significantly less than in F1, F2, F12G, and F24D.

during the growing season (F24G) and sites burned 1 year prior during the growing season with a history of annual growing season burns (F12G) had up to 45% greater amounts of herbaceous cover than other sites (Table 3).

Discussion

Our occupancy model indicated that suitable habitat for Bachman's sparrows was confined to sites dominated (up to 100%) by longleaf pines with no intrusion of hardwood species, as well as those with more herbaceous cover and limited bare ground. Although Tucker et al. (2004) found that season of burn had little effect on vegetation structure; our results suggest that differences in fire regimes (both interval and season) result in differences in vegetative structure that influences occupancy by Bachman's sparrow. Sites burned biannually with growing-season fire provided more herbaceous cover and were dominated by longleaf pines—with correspondingly less bare ground and hardwoods—than sites burned more frequently and during the dormant season.

Frequent prescribed fires are known to be necessary in maintaining longleaf pine habitat (Engstrom et al. 1984), but there is much debate relative to the most effective burning regime. Bachman's sparrow populations may decline dramatically in longleaf pine forests where fire has been suppressed for more than 4 years (Gobris 1992, Tucker et al. 2006). However, there is a lack of information detailing effects of more frequent burns (annual) or burns immediately preceding the breeding season on Bachman's sparrows. We found that fires conducted annually, whether during the growing or dormant season, and within 2 months of the spring breeding season produced stands with less herbaceous cover, fewer longleaf pine, and more bare ground and hardwood trees. The resulting stand conditions were less suitable for Bachman's sparrow relative to sites burned biannually. Cox (2008) suggested that Bachman's sparrows temporarily disperse from stands after prescribed fires, potentially because of alterations to vegetative structure we observed in stands burned within 2 months of the breeding season.

Management Implications

We recommend that managers charged with maintaining longleaf pine savannahs consider burning regimes that focus on growing season fires conducted biannually rather than annually to provide suitable habitat conditions for Bachman's sparrows. Alternatively, managers unable to burn strictly during the growing season should strive to burn periodically during this period to ensure the continued presence of fire-dependent plant species. Doing so would necessarily lengthen the window of opportunity to conduct burns on a particular site. Regardless, our findings suggest that more frequent fire regimes, whether conducted during the growing or dormant season, result in reduced occupancy by Bachman's sparrows and should be avoided if Bachman's sparrow is a species of management interest.

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