Home range and survival characteristics of male Bachman’s Sparrows in an old-growth forest managed with breeding season burns

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ABSTRACT. Prescribed burning is essential for maintaining suitable habitat for Bachman’s Sparrows (Aimophila aestivalis), but burns conducted during the breeding season may lead to site abandonment and low survival or productivity. We monitored a color-banded population of Bachman’s Sparrow in Georgia for four breeding seasons to assess home range size, site fidelity, and survival in an area managed primarily using breeding season burns. Our study area was one of the last remaining tracts of old-growth longleaf pine (Pinus palustris), and alternating halves of the tract were burned during the breeding season during each year of our study. Mean home range size for males (N = 46) during the breeding season was 3.1 ha based on 95% fixed kernel analysis and 1.8 ha based on minimum convex polygons. Breeding season burning had no effect on male site fidelity and home range characteristics. The proportion of males remaining on burned areas was similar to the proportion remaining on unburned areas. Shifts in home range centroids pre- and postburn were also similar for males on unburned (median = 49.7 m) and burned (median = 65.6 m) areas. In addition, the size of home ranges that were burned (x̄ = 1.9 ha) was similar to that of home ranges that were not burned (x̄ = 2.1 ha). Estimated annual survival for males was 0.59. The median shift in annual home range centers calculated for 38 males observed during multiple breeding seasons was 63 m and, coupled with our survival estimates, suggest greater site fidelity than previously reported. These results suggest that breeding season burns were not as detrimental to Bachman’s Sparrows as reported at other locations, and such burns may be helpful in maintaining suitable habitat.

SINOPSIS. Ambito hogareño y características de sobrevivencia de individuos machos de Aimophila aestivalis en un bosque maduro con tratamiento de fuego durante la época reproductiva.

La quema por prescripción es esencial para mantener hábitat adecuado para el gorrión Aimophila aestivalis, pero las quemazas durante la época de reproducción pueden ocasionar abandono del lugar, baja sobrevivencia o productividad. Monitoreamos una población de Aimophila aestivalis marcada con anillas de colores durante cuatro temporadas reproductivas, para determinar el ámbito hogareño, fidelidad a la localidad y sobrevivencia en un área manejada con quema por prescripción. Nuestra área de estudio fue uno de los últimos remanentes de bosques de Pinus palustris y mitades alternas fueron quemadas anualmente durante la época de reproducción a lo largo de todo el periodo de estudio. Durante la época de reproducción, el ámbito hogareño promedio para los machos (N = 46) resultó ser de 3.1 ha basado en un análisis de centro fijo de 95% y 1.8 ha basado en polígono mínimos convexos. En los machos, la quema durante la época de reproducción no tiene efecto en la fidelidad a localidades y en las características del ámbito hogareño. La proporción de machos que se quedaron en las áreas quemadas fue similar a los que se quedaron en las áreas no manejadas. Cambios en el centroide del ámbito hogareño pre- y post-quema fueron similares a la proporción de aquellos que se mantuvieron en áreas sin quemas (mediana = 49.7 m) y quemadas (mediana = 65.6 m). Además, el tamaño del ámbito hogareño que fue quemado (x̄ = 1.9 ha) fue similar al del ámbito hogareño no quemado (x̄ = 2.1 ha). La estimación anual de sobrevivencia para los machos fue de 0.59. El cambio en la mediana de los centros del ámbito hogareño en un periodo anual, calculado para 38 machos observados durante múltiples épocas reproductivas, fue de 63 m, y unidos a nuestras estimaciones de sobrevivencia, sugieren que hay mayor fidelidad a las localidades que lo informado previamente. Estos resultados sugieren que la quema prescrita a la época reproductiva no afectó al gorrión como ha sido informado para otras localidades y que dichas quemazas pueden ser útiles para mantener el hábitat adecuado.

Key words: Aimophila aestivalis, Bachman’s Sparrow, home range, prescribed burning, site fidelity, survival

Bachman’s Sparrows (Aimophila aestivalis) forage and nest exclusively on the ground in areas with dense herbaceous vegetation (Dunning 1993, Haggerty 1998). Habitat suitability is closely linked to the frequent use of prescribed fire (Dunning and Watts 1990, Tucker et al. 2004), and sparrows may abandon areas if fire is excluded for more than 3 yr (Engstrom et al. 1984, Tucker et al. 2004). Fire also may have
negative short-term effects because herbaceous ground cover is temporarily eliminated and could lead to site abandonment by sparrows (Seaman and Kremenetz 2001). Prescribed fires set during the breeding season may destroy nests.

Populations of Bachman’s Sparrows have declined throughout much of their range in the southeastern United States in recent decades (Dunning and Watts 1990). Although this trend underscores the need for better habitat and population management (Hunter et al. 1993, Tucker et al. 2006), the effects of some management practices have not been adequately documented (Dunning 1993, Tucker et al. 2006). Tucker et al. (2004) noted the increased application of prescribed burns during the breeding season and stressed the need for information about responses to such burning. Annual survival rates of Bachman’s Sparrows are also not well known (Pulliam et al. 1992, Dunning 1993), but are essential for demographic models developed to assess sparrow population viability (Pulliam et al. 1992).

We studied Bachman’s Sparrows on the Wade Tract, one of the last remaining old-growth longleaf pine (Pinus palustris) forests in the southeastern United States (Means 1996, Varner and Kush 2002). The Wade Tract serves as an important reference site for longleaf forests (Landers and Boyer 1999, Varner and Kush 2002, Gilliam and Platt 2006) because live trees have never been logged, the tract contains intact fauna and flora, and the tract has been maintained for decades using frequent burn intervals (about 2-yr intervals; Engstrom et al. 2001). Accordingly, studies on the Wade Tract have led to new insights about several pine-dependent species (Burke 1989, Grace and Platt 1995, Engstrom and Sanders 1997). Our objectives were to examine sparrow movements and site fidelity (primarily for males) in an old-growth forest managed using frequent prescribed burns during the breeding season, estimate annual survival, and determine whether the characteristics of home ranges varied with changes in forest conditions.

METHODS

We studied Bachman’s Sparrows from 2003 to 2006 on the Wade Tract (80 ha) in Thomas County, Georgia (30°45′N, 84°00′W). This tract is dominated by longleaf pine (>95% of total basal area and >75% of total stems), including many trees >250 yr old (Platt et al. 1988), and is conserved by an easement that prohibits logging, road building, and plowing (Engstrom et al. 2001). The tract is primarily surrounded by mature (>70 yr old) longleaf pine forests with undisturbed ground cover (sensu Ambrose 2001) that are also managed using frequent, prescribed fires (ca. 2-yr interval; Engstrom and Baker 1995). Approximately half the tract (40 ha) is burned each year in an alternating manner (half not burned). Burns also typically encompass an additional 35–60 ha of the surrounding forest (Engstrom et al. 2001). Burns were conducted annually from May to July and coincided with peak nesting period of Bachman’s Sparrows (Haggerty 1988). Prior to our study, 9 of 13 annual burns were conducted during the breeding season (Tall Timbers Research Station, unpubl. data). Ground vegetation recovers quickly after burns and generally attains a height ≥0.7 m within 6 weeks (Tall Timbers Research Station, unpubl. data).

Most male Bachman’s Sparrows were captured using playback of conspecific songs near mist nets. A few males and all females were banded through constant-effort mist netting (Nur et al. 1999) at four locations (about 500 net-hours per year). Sex was determined using the presence (females) or absence (males) of a brood patch (Pyle 1997), presence or absence of a cloacal protuberance (Pyle 1997), and behavioral observations. Banded birds were fitted with one federal (USGS) aluminum band and three color bands (two bands per leg).

Surveys (three or more per week) to locate singing males were conducted from April to early August along 500-m transects spaced 100–150 m apart. Each survey covered approximately 25% of the tract and took 3–4 h to complete. Locations of color-banded individuals were recorded using a hand-held global positioning system (GPS) with <5 m accuracy (Trimble GeoExplorer II; Trimble Navigation Limited, Sunnyvale, CA, USA). Locations were processed for analysis in a geographic information system using a Universal Transverse Mercator projection (zone 16, North American datum 1983). Although we also conducted monthly surveys within a 1-km buffer extending outside our primary study area to locate dispersing individuals, none was observed.
Home range estimations and other spatial analyses were performed using ArcView (ESRI 1998) and the Animal Movement extension (Hooge and Eichenlaub 1997). Home range polygons were created for males observed for more than 2 mo and with >20 locations in a year (Ackerman et al. 1990). Home range polygons were generated using both 95% fixed kernel (FK95) and minimum convex polygon (MCP) procedures (Hooge and Eichenlaub 1997) because both procedures have been used elsewhere. However, all statistical comparisons were based on FK95 estimates. Separate polygons were created for each breeding season if a male was observed for ≥2 yr, but, unless otherwise indicated, we used one randomly selected polygon for males observed for ≥2 yr in statistical comparisons in which independent observations were required. Color-banded females (N = 18) were rarely observed during surveys, but three banded females were observed carrying food to young.

Areas of ground cover vegetation that did not burn (minimum size = 0.01 ha) were digitized after each burn using the GPS. Unburned patches (x̄ = 48 ± 18.9 [SD] per year, with a mean area of 0.18 ± 0.76 ha) were removed from a polygon depicting the burn block to create a geographic information system (GIS) layer corresponding to areas where burning eliminated ground cover. Burned areas were cross-tabulated with home range polygons (FK95) to identify the extent to which territories were affected by burns. Territories where >75% of the ground cover was eliminated were classified as burned, whereas territories where <25% of the ground cover was eliminated were classified as unburned.

We used three other procedures to assess the potential effects of breeding season burns. First, we noted the banded males observed before each burn and calculated the proportion observed on our study area >3 weeks after burns. These proportions were subdivided into males initially observed on areas burned versus males observed on areas not burned in a given year. Second, we calculated the average x–y coordinates for all locations recorded for banded males prior to burns and compared these to the average coordinates recorded for the same individual after burns (hereafter called pre- and postburn centroids). Finally, we used GIS to calculate the maximum distance between all sightings of a male in a given year and used this to identify long-distance movements that might have been induced by burning.

We used two procedures to assess site fidelity between breeding seasons. First, we averaged x–y coordinates recorded for an individual in a given year (hereafter called annual centroids) and compared the distance between annual centroids observed for an individual in subsequent years. Second, for males that satisfied the minimum criteria needed for home range estimates for at least 2 yr, the extent of overlap between years was estimated by dividing the area held in common during both years by the total area used during the earlier year (using FK95).

We quantified forest conditions within home range polygons (FK95) using a tree inventory initiated by Platt et al. (1988). All trees >4-cm diameter at breast height (DBH; N > 22,000) have been tagged, measured (most recently in 2004), and geographically referenced within a 40-ha area of the Wade Tract. Forest data coincided with 24 home range polygons, and timber variables quantified for each home range polygon included pine and hardwood basal area and pine stems per hectare for three size classes of trees (<10-, 10–25, and >25-cm DBH). Another variable included in these comparisons was elevation as measured at the annual centroid. We hypothesized that higher soil moisture associated with low-lying areas might influence habitat suitability and home range size.

Statistical analysis. Kurtosis and skewness were assessed for all variables using Systat (Wilkinson 1998) to determine whether parametric or nonparametric statistical procedures were appropriate. Forest attributes and elevation showed no significant deviations from parametric assumptions, and associations between these variables (N = 6) and home range size were assessed using Pearson correlations in Systat with P-values adjusted using Bonferroni approximations (Wilkinson 1998). When an individual used a similar area over multiple years, only one randomly selected home range was used. Area and distance measures all exhibited significant skewness. Nonparametric Mann-Whitney U statistics were used in Systat to test for differences involving area and distance variables. Most measures are presented as mean ± 1 SD, but medians are also provided for area and distance measures because of skewness and kurtosis.

Survival analysis for males (female observations were too few) was performed using the
Cormack-Jolly-Seber model in Program MARK (White and Burnham 1999), and resightings were made early in subsequent breeding seasons (April to May). A model using constant survival and detection was compared using information-theoretic methods (Anderson et al. 2000) to models with annual variation in detection and survival parameters. Goodness of fit, independence, and homogeneity were analyzed using parametric bootstrapping methods provided in Program MARK. Chi-square was used to assess independence among the proportions of males observed before and after burns.

RESULTS

Mean home range size for Bachman’s Sparrows in our study (N = 46) was 3.1 ± 3.5 ha based on FK95 and 1.8 ± 1.4 ha based on MCP. Home range size (FK95) was not correlated with the forest attributes we measured (Table 1). The size of home ranges (FK95) that were burned (N = 23) did not differ from those (N = 17) that were not burned (U = 307; \( \chi^2 = 1.05, P = 0.30 \)). The median size of unburned male home ranges (FK95) was 2.0 ha (\( \bar{x} = 2.1 \pm 1.1 \) ha), whereas the median size of the male home ranges that were burned was 1.8 ha (\( \bar{x} = 1.9 \pm 1.6 \) ha).

Over a 3-yr period (2004–2006), the mean proportion of banded males observed >3 weeks after burns was 0.77. Proportions observed in burned areas (\( \bar{x} = 0.73 \pm 0.04 \)) were similar to those in unburned areas (\( \bar{x} = 0.79 \pm 0.05 \); \( \chi^2 = 1.04, P = 0.61 \)). There also was no significant difference (U = 254; \( \chi^2 = 1.5, P = 0.22 \)) in the displacement of pre- and postburn centroids for males whose home ranges were burned (median = 65.6, \( \bar{x} = 152.6 \pm 240.3 \) m) versus those whose home ranges were not burned (median = 49.7 m, \( \bar{x} = 78.5 \pm 90.4 \) m).

The median maximum movement (N = 55) within a year was 129 m (\( \bar{x} = 172.8 \pm 178.7 \) m), and <5% of maximum movements were >300 m. Relationships between burn events and the movements of 16 males whose maximum movements exceeded 300 m were not consistent. The home ranges of five males (31%) shifted from unburned areas to burned areas a few weeks after burns. In contrast, five males (31%) moved from burned areas to unburned areas soon after burns were conducted, whereas six males (38%) made long-distance movements apparently unrelated to breeding season burns.

The median displacement of annual centroids was 63 m (\( \bar{x} = 109 \pm 114 \) m, N = 38), whereas the mean proportional overlap for home ranges occupied by the same male in different years (N = 16) was 0.68 ± 0.29. The displacement distance of one female sighted in successive years was 138 m, whereas displacement distances for two females banded in 2004 and resighted in 2006 (not observed in 2005) were 821 and 194 m, respectively.

Results from Program MARK indicated that data were overdispersed, so a correction factor (\( \varepsilon \)-hat) of 1.712 was applied to parameter estimates. The most parsimonious model emerging from Program MARK held survival and detection constant over time (\( \text{QAIC}_c = 91.26, \text{QAIC}_c \) weight = 0.441). Estimated annual male survival for this model was 0.59 (± 0.09); however, the 95% confidence interval was large (0.41–0.75) and pointed to low confidence in the estimate. A second model with a low \( \text{QAIC}_c \) (\( \text{QAIC}_c = 738, \text{QAIC}_c \) weight = 0.306) incorporated annual variation in survival (\( \Phi = 0.78, 0.43, \) and 0.79 for the three years monitored) and held detection probabilities constant (\( \Delta \text{QAIC}_c = 0.71 \)). The \( \Delta \text{QAIC}_c \) for all other models was >2.0 and indicated less support for these models. Two males banded as adults in 2003 were observed in all 4 yr of study, and five males were at least 3-yr old when they were last observed.

DISCUSSION

Seaman and Krementz (2001) found that Bachman’s Sparrows abandoned sites after breeding season burns. In contrast, most banded males (ca. 75%) monitored in our study remained on territories after breeding season burns, and
burns did not appear to influence several home range characteristics. Although a variety of factors may contribute to such differences, our results suggest that some of the negative effects of breeding season burning noted by Seaman and Krementz (2001) were less severe on the Wade Tract. Because fire is the most important tool for maintaining sparrow habitat (Haggerty 1998, Tucker et al. 2006), breeding season burns may be beneficial if the burns help to achieve the high frequencies (<3 yr; Tucker et al. 2004) needed to maintain suitable habitat conditions and mimic historic frequencies (Huffman 2006).

Although some males in our study abandoned territories after breeding season burns, an equal number moved into burned areas and established new territories. In addition, one color-banded male moved >500 m into the burned area and was recaptured with an unbanded female (brood patch present) and three fledglings about 20-d old. Six weeks earlier, the male had been observed paired with an unmarked female in an unburned area. Following the second capture, both banded adults were observed feeding the banded fledglings in the burned area for 3 weeks. We are not sure whether other family groups undertook similar movements, but we frequently observed unbanded adults and fledged young in the territories of marked males in burned areas.

Stober and Krementz (2006) found that home ranges of Bachman’s Sparrows were smallest in young (<4 yr), open-timber stands and largest in mature stands, and suggested that differences in food availability might explain this variation. Our home range estimates were similar to those reported by Stober and Krementz (2006) for open stands, suggesting that relationships between home range characteristics and forest maturity may be complex. Forest conditions in old-growth settings such as the Wade Tract vary considerably (e.g., pine basal area varies from 4 to 20 m²/ha; Platt et al. 1988), and the corresponding variation in canopy cover may improve food resources in old-growth settings in comparison to more uniform canopy cover often found in mature stands managed for timber resources. In addition, ground cover on the Wade Tract is dominated by native grasses that recover quickly when burned, and native grasses have also been found to support higher densities of sparrows (Rutledge and Conner 2002).

Previous estimates for annual survival in Bachman’s Sparrow ranged from 0.50 to 0.60 (Haggerty 1988, Pulliam et al. 1992, Seaman and Krementz 2001). Our estimates were at the high end of this range, and, although confidence intervals were large for the two models that emerged from program MARK with similar support (ΔQAICc < 2.0), one of the contending models provided annual male survival estimates >0.75 in 2 yr. Seaman and Krementz (2001) used an estimated survival of 0.50 to suggest that breeding season burns might eliminate breeding opportunities for most adults (i.e., lifespan average less than 2 yr). Two males observed during all 4 years of our study represent a new longevity record and suggest the possibility of multiple breeding opportunities on frequently burned sites. Maximum survival rates exceeding 0.70 also have been documented in another Aimophila sparrow (Morrison et al. 2004). Our estimates for male survival coupled with extensive overlaps in territories over multiple years also suggest greater site fidelity than Haggerty (1988; ca. 20%) reported.

Additional information about the effects of breeding season burns on productivity and female survival is needed. We found evidence of postburn breeding during each year of our study, including two nests in areas treated with burns, but breeding season burning destroys many nests and should be used carefully until additional studies are completed. The scale of breeding season burning also deserves attention. Burns conducted in this study affected about 10% of the suitable pine habitat within 2 km, but breeding season burns covering a larger portion of the available habitat could produce different results.

Another subject warranting further study is the cohesion and movement of postfledging family groups. At least one male and his fledged young moved >500 m into a burned area during the postfledging phase. We also failed to resight several males late in the breeding season whose home ranges were not burned (ca. 20%). We believe detection probabilities decrease as the breeding season advances and male behavior shifts from defending territories to caring for young. Postfledging movements similar to those we observed for one family group also obviously influence home range estimates (Bayne and Hobson 2001, Vega Rivera et al. 2003).
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