Home range and survival of breeding painted buntings on Sapelo Island, Georgia

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Abstract   The southeastern United States population of the painted bunting (*Passerina ciris*) has decreased approximately 75% from 1966–1996 based on Breeding Bird Survey trends. Partners in Flight guidelines recommend painted bunting conservation as a high priority with a need for management by state and federal agencies. Basic information on home range and survival of breeding painted buntings will provide managers with required habitat types and estimates of land areas necessary to maintain minimum population sizes for this species. We radiotracked after-second-year male and after-hatching-year female buntings on Sapelo Island, Georgia, during the breeding seasons (late April–early August) of 1997 and 1998. We used the animal movement extension in ArcView to determine fixed-kernel home range in an unmanaged maritime shrub and managed 60–80-year-old pine (*Pinus* spp.)–oak (*Quercus* spp.) forest. Using the Kaplan-Meier method, we estimated an adult breeding season survival of 1.00 for males ($n = 36$) and 0.94 (SE = 0.18) for females ($n = 27$). Painted bunting home ranges were smaller in unmanaged maritime shrub (female: kernel $\bar{x}$ = 3.5 ha [95% CI: 2.5–4.5]; male: kernel $\bar{x}$ = 3.1 ha [95% CI: 2.3–3.9]) compared to those in managed pine–oak forests (female: kernel $\bar{x}$ = 4.7 ha [95% CI: 2.8–6.6]; male: kernel $\bar{x}$ = 7.0 ha [95% CI: 4.9–9.1]). Buntings nesting in the managed pine–oak forest flew long distances ($\geq$300 m) to forage in salt marshes, freshwater wetlands, and moist forest clearings. In maritime shrub buntings occupied a compact area and rarely moved long distances. The painted bunting population of Sapelo Island requires conservation of maritime shrub as potential optimum nesting habitat and management of nesting habitat in open-canopy pine–oak sawtimber forests by periodic prescribed fire (every 4–6 years) and timber thinning within a landscape that contains salt marsh or freshwater wetland openings within 700 m of those forests.

Key words   Georgia, home range, maritime shrub, movement, painted bunting, *Passerina ciris*, pine–oak forest, Sapelo Island, wetlands

Biologists and resource managers are concerned about population decreases of Nearctic–Neotropical migratory songbirds, especially those documented during the last half of the 20th century (Peterjohn et al. 1995). To address songbird population decreases, we need information on songbird habitat and resource requirements to incorporate these species into land management plans. Much concern has focused on the negative effects of forest fragmentation on interior forest birds (Faaborg et al. 1995). Species such as the painted bunting (*Passerina ciris*) and golden-winged warbler (*Vermivora chrysoptera*), which use early-successional habitats, also are becoming more rare (Sauer

et al. 1997). The spectacularly colored painted bunting, which is easily viewed on backyard bird feeders, attracts many people's attention. Aesthetic value (to see, admire, and enjoy) is an important wildlife conservation objective (Leopold 1933). The bunting's attractiveness makes it an excellent featured species for public awareness and a challenge to understand the value of songbird conservation.

Breeding Bird Survey data indicated a –5.6% annual decrease in the southeastern United States from 1966–1996 (Sauer et al. 1997). Because of the bunting's negative population trend and loss of potential coastal habitat, Partners in Flight listed it as a species of special concern for southeastern United States (Hunter et al. 1993*a*, *b*). Coastal development and land-use changes may threaten the eastern painted bunting population if these changes reduce the amount and quality of habitats available to this species (Turner and Ruscher 1988).

Painted buntings use a variety of successional and forest habitats, including pastures, fallow fields bordered by woodlands, maritime shrub, open-canopy upland forest, managed 2- to 4-year-old pine plantations, and shrub (Norris and Elder 1982, Lanyon and Thompson 1986, Womer 1987). The eastern population inhabits the Atlantic Coastal Plain from North Carolina to northern Florida (Lowther et al. 1999). In this region and especially in Georgia, undeveloped barrier islands have some of the highest concentrations of painted buntings in North America (J. M. Meyers, United States Geological Survey [USGS], Patuxent Wildlife Research Center, unpublished data). State and federal governments own and manage most of these islands as wildlife refuges and management areas.

During the last 200 years, agriculture land uses dominated much of the bunting's nesting areas in the southeastern states. Forests now occupy abandoned agricultural fields, and barrier islands possess a mosaic of forest, shrub, salt marsh, and wetland vegetation communities (Johnson et al. 1974). Currently, government-owned barrier islands in Georgia are relatively undeveloped and may provide source habitat to sustain bunting populations found in more developed mainland areas (Pulliam 1988, Pulliam and Danielson 1991).

Studying the dynamics of bunting movement and home-range patterns in a relatively undeveloped habitat will improve understanding of the resource requirements of this species. Understanding how painted buntings use habitats outside their territories may provide important insights for management. Usually, birds rarely vocalize outside their territories, which makes observation difficult.

We hypothesized that painted buntings, which feed mainly on the ground, would need different home ranges in areas that had different ground cover (in relation to the amount of overstory cover), but similar nesting cover (shrub cover). Differences in type and amount of vegetation, <1 m above ground, may influence availability of insects and seeds for foraging buntings. We also hypothesized that sexes would respond similarly to these vegetative differences and therefore have similar home-range sizes within similar habitats. Female buntings build nests, incubate, and feed nestlings. Male buntings usually feed fledglings if the female renests (Parmalee 1959). Female buntings may restrict their movements to areas near their nests while male buntings also may restrict their movement to areas near their territories to defend resources or guard females from extra-pair copulations. In addition, we hypothesized that adult breeding season survival did not limit painted bunting populations. We had 2 objectives: to determine the 1) home range of male and female painted buntings during the nesting season in maritime shrub and open pine–oak forest habitats and 2) survival of adult painted buntings during the ~100-day breeding season.

Study area

Sapelo Island covered an area of 4.8 km east to west and 16.0 km north to south, totaling about 44 km^2 (Johnson et al. 1974). The island was located 64 km south-southwest of Savannah in McIntosh County, Georgia. The state of Georgia owned and managed most of this barrier island, which included R. J. Reynolds Wildlife Refuge and Management Area and Sapelo Island National Estuarine Research Reserve. The southern end, about 20% of the island, was developed and, at the time of the study, was occupied by the University of Georgia Marine Institute, Georgia Department of Natural Resources (DNR) offices, and private residences (175 ha).

Primary succession (accretion of sand) created the unmanaged maritime shrub site on Sapelo Island (Chalmers 1997). Vegetation began at the primary dune (sea-oats, *Uniola paniculata*) and rapidly changed to shrubs, especially wax myrtle (*Myrica cerifera*) and rattanvine (*Berchemia scandens*), on secondary dunes away from the beach

(Bellis 1995). Pink muley (*Muhlenbergia filipes*), dog-fennel (*Eupatorium* spp.), paspalum (*Paspalum* spp.), and sandbur (*Cenchrus tribuloides*) dominated the ground cover between the shrubs, depending on moisture and dune elevation.

Sixty- to 80-year-old loblolly (*Pinus taeda*) and slash (*P. elliottii*) pine dominated the overstory of the managed pine–oak site (11–14 m²/ha basal area). Live oak (*Quercus virginiana*), water oak (*Q. nigra*), and other oaks (*Quercus* spp.) were interspersed within the pines. Wax myrtle, young pines (*Pinus* spp.), red bay (*Persea borbonia*), and Carolina buckthorn (*Rhamnus caroliniana*) dominated the understory. Spanish-moss (*Tillandsia usneoides*), an epiphyte, hung from the branches of most oak trees. A variety of grasses and herbaceous plants also covered the ground (e.g., *Paspalum* spp., *Sorghastrum* spp., *Panicum* spp., *Setaria* spp.). The site bordered salt marsh to the west, and a small inlet of the marsh extended east-northeast 300 m into it. Georgia DNR prescribe-burned the site during the winter of 1995, and a small timber operation occurred in the site (0.5-ha log-loading area) during the winter of 1997. Plant taxonomic authority used included Radford et al. (1968) and Duncan and Duncan (1987).

Methods

Site selection

We conducted our study from late March to early August of 1997 and 1998. We surveyed all habitats occupied by nesting painted bunting using aerial photographs, Geographic Information System (GIS) habitat maps (Georgia Department of Natural Resources, unpublished data), and site visits; classified them by size and type; and randomly selected a 64-ha study site each from unmanaged maritime shrub and managed 60–80-year pine–oak vegetation communities. The maritime shrub site was located in the southeastern corner of Sapelo Island at Nanny Goat Beach, and the managed pine–oak site was located midway along the western shore of Sapelo Island south of the Chocolate ruins. Within each study site (400 m × 1,600 m), we established a 100 × 100-m marked grid with known UTM coordinates (GPS, 2–3 m accuracy).

Telemetry

We captured painted buntings with mist nets (2.6 × 12 m). Within a male's territory, we attracted buntings into nets with decoys (preserved buntings) and taped playback of recorded bunting songs. We also conducted systematic netting throughout the sites (100 × 100-m grid). We opened and monitored nets from predawn to 0900–1000 hours. We staggered capture from 26 April to 13 July to make logistics of tracking radiomarked birds manageable, allow for bird capture over the entire nesting season (survival), and track birds throughout the breeding season. Each captured bird was banded with a numbered aluminum band from the USGS Biological Resources Division and a unique combination of 3 colored plastic leg bands (cellulite bands: A. C. Hughes, Middlesex, England). We weighed each bird before attaching radiotransmitters. We attached radiotransmitters (2-stage model BD-2; Holohil Systems, Ltd., Carp, Ont., Canada), using the thigh harness method, to 64 painted buntings (Rappole and Tipton 1991). After-hatch-year females and after-second-year males were radiomarked. After mounting, a radiotransmitter remained buried in feathers. Only a third of the antenna protruded along the surface of the tail but terminated before the end of the tail. We released buntings at their point of capture immediately after radiomarking to avoid undue stress.

The weight for each radiotransmitter with harness was <0.8 g or approximately 5% of a painted bunting's average mass. The 5% rule is conservative, so radiotransmitters should have had little effect on each bird's survival or behavior (Aldridge et al. 1988, Brigham 1988, Neudorf and Pitcher 1997, Powell et al. 1998, Naef-Daenzer et al. 2001). Mean battery life for the radiotransmitters was 24 days. Problems with early battery failure and damaged antennas did not allow us to collect acceptable location data on all 64 radiomarked birds, resulting in a reduced sample ($n=45$) for estimation of home ranges.

We tracked radiomarked birds daily and located each bird several times using the homing technique (Mech 1983, White and Garrott 1990). Because time of day may influence bird behavior and movement patterns, we divided each day into 4 equal sampling periods between sunrise and sunset. Sampling equally during all periods ensured that the calculated home ranges were representative of daily movement patterns. Tracking was accomplished using a hand-held 3-element Yagi antenna and vehicle-mounted 5-element Yagi antenna. In the field we found the coordinates of each bird's location by taking a compass bearing and distance

(by pacing) to the nearest grid marker. We calculated UTM coordinates for each bird's location from the bearing and distance data of each location with respect to the known GPS location (grid marker) using basic trigonometric principles. We obtained locations outside the grid (>50 m) using GPS with 2–3 m accuracy.

Home-range analysis

We calculated home ranges of radiomarked birds using 2 methods: fixed-kernel and minimum convex polygon (MCP). We used the MCP because it provides results that are comparable to other studies (Harris et al. 1990). This approach plots a polygon of minimum area around 95% of observed locations. We used the fixed-kernel method to plot utilization distribution contours and identify core areas (Worton 1989). We used the animal movement extension written for ArcView 3.1 (Environmental Systems Research Institute, Inc. 1998) to calculate both MCP and fixed-kernel home ranges (Hooge and Eichenlaub 1997). This movement extension calculated Schoener's statistic to test for independence of data points (Swihart and Slade 1985). We resampled locations in ArcView before calculating MCP to create a 95% area use polygon. We used a bootstrapping procedure to test whether home-range size reached an asymptotic value with an increase in bird locations (Harris et al. 1990). We included only birds with home ranges that reached an asymptotic value in the results ($n = 45$). We used 2-way analysis of variance (ANOVA) to test whether mean home range size differed between habitats and sexes for MCP and kernel methods. We used t-tests to determine differences in home range between habitats and sexes. We also used a paired t-test to determine differences for home-range methods (MCP and kernel). For all statistical tests $\alpha = 0.05$.

Survival analysis

We used the Kaplan-Meier method (Pollock et al. 1989*a*), adapted to allow for the staggered entry of birds (Pollock et al. 1989*b*), to estimate the breeding season (87 days, 5 May–30 July) survival rate of adult buntings. We censored birds that died or disappeared from the area during the first 3 days after transmitter attachment to ensure that birds had adjusted to carrying the radio. We classified birds as survived, died, or censored. We treated buntings as alive for analysis purposes until the last day they were radiotracked, which averaged 24 days (battery life) for survived birds. The status of all but 8 painted buntings that were censored was obtained by field observations. We tested variation in survival rates between sexes using the log-rank test (Bunck and Pollock 1993). We considered a bird alive if we saw or heard (singing or calling) the bird during tracking or if the radiotransmitter signal indicated that the bird was moving. Survival data were collected daily for each bird. We used SAS programming language to compute survival rates (SAS Institute Inc. 1989).

Results

We used 63 of 64 radiomarked painted buntings in survival analysis. We excluded 1 female because it did not survive the 3-day acclimation period in 1998. In the maritime shrub site, we captured and radiomarked 13 painted buntings (6 F, 7 M) in 1997 and 19 (11 F, 8 M) in 1998. In the managed pine–oak site, we captured and radiomarked 13 (7 F, 6 M) and 19 painted buntings (6 F, 13 M) in 1997 and 1998, respectively.

We estimated adult painted bunting survival to be 0.96 (95% CI=0.76–1.00) during the nesting season (87 days/year). The only female bunting considered dead was presumed dead (radiomarked and lost) because of abandonment of 3 nestlings in the maritime shrub site in 1998. This mortality reduced female breeding season survival to 0.94, ($n = 27$, 95% CI=0.63–1.00). We estimated male painted bunting survival at 1.00 ($n = 36$, all survived). Survival rates for adult painted buntings were not different between sexes (log-rank test, $P = 0.79$). We lost radiotransmitter signals for 8 buntings after <1 week of tracking. We censored these birds from survival analysis on the date they were last located.

There was no effect of sex on home-range size for kernel ($F_{1, 37} = 1.03$, $P = 0.32$) or MCP ($F_{1, 37} = 0.66$, $P = 0.42$). Habitat, however, did affect home-range size (kernel: $F_{1, 37} = 10.40$, P=0.003; MCP: $F_{1, 37} = 15.16$, $P < 0.001$). Home-range size of breeding painted buntings did not differ between years for fixed-kernel ($F_{1, 37} = 1.61$, $P = 0.21$) or MCP ($F_{1, 37} = 1.32$, $P = 0.26$) estimates. Therefore, we pooled home-range data from 1997 and 1998 for further analysis. The interaction terms were not significant ($P > 0.05$), but habitat $\times$ sex did show signs of potential interaction effects (kernel: $F_{1, 37} = 3.22$, $P = 0.08$; MCP: $F_{1, 37} = 2.86$, $P = 0.10$). In maritime shrub we found no difference between sexes (kernel: $t_{22} = 0.62$, $P = 0.54$; MCP: $t_{22} = 1.31$, $P = 0.27$) in the
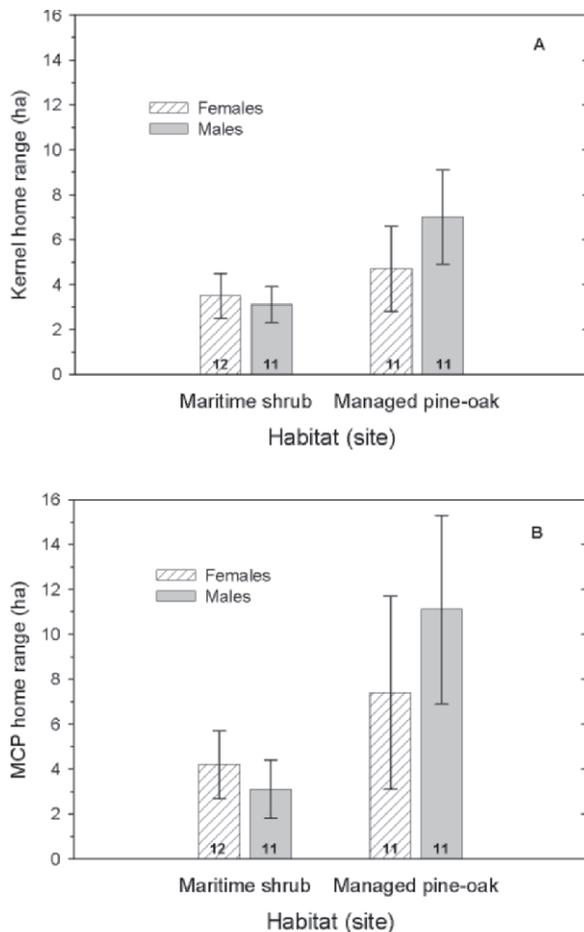
Figure 1. (A) Mean fixed-kernel and (B) mean minimum convex polygon home range (ha) with 95% CI for male and female painted buntings in maritime shrub and managed pine–oak habitats, Sapelo Island, Georgia, 1997–1998 (year data pooled). Numbers at base of bars are sample sizes.

bunting's home range size (female: kernel $\bar{x}$=3.5 ha [95% CI: 2.5–4.5]; MCP $\bar{x}$=4.3 ha [95% CI: 2.6–5.9] and male: kernel $\bar{x}$=3.1 ha [95% CI: 2.3–3.9]; MCP $\bar{x}$=3.1 ha [95% CI: 1.8–4.4]) (Figure 1.). We also found no home-range differences (kernel, t_{19}= –1.63; P=0.12; MCP t_{19}= –1.40, P=0.18) between sexes in managed pine–oak habitat (female: kernel $\bar{x}$=4.7 ha [95% CI: 2.8–6.6], MCP $\bar{x}$=7.4 ha [95% CI: 3.0–11.8]; male: kernel $\bar{x}$=7.0 ha [95% CI: 4.9–9.1], MCP $\bar{x}$=11.1 [95% CI: 7.0–15.3]) (Figure 1).

Male bunting home-range size was larger (kernel: t_{20}= –3.46, P=0.003; MCP: t_{20}= –4.13, $P<0.001$) in managed pine–oak forest than maritime shrub (Figure 1). For females, we did not find any difference in home-range size (kernel: t_{21}= –1.23, P=0.23; MCP: t_{21}= –1.71, P=0.10) between habitats (Figure 1). Kernel and MCP home-range analysis

produced similar results (paired t-test, t_{22}= –0.91, P=0.37) in maritime shrub; but in managed pine–oak forest, the MCP method overestimated home ranges compared to the kernel method (paired t-test, t_{20}= –2.65, P=0.02) by >150% for both females and males (Figure 1). We found large (5.1–9.9 ha) kernel home ranges for 3 of 12 and 3 of 11 female buntings in maritime shrub and managed pine–oak forest, respectively. For males, we found large (5.1–14.1 ha)-kernel home ranges for 1 of 11 and 8 of 11 individuals in maritime shrub and managed pine–oak forest, respectively. These large home ranges were caused by movement outside the core areas (9 of 11 males in managed pine–oak forests).

Discussion

The decline in the painted bunting population in the southeastern United States does not appear to be related to adult breeding season survival in optimum habitats, such as those found on Sapelo Island. We found no difference in adult survival between buntings nesting in maritime shrub and managed pine–oak habitats. Painted bunting population declines may be attributed to low reproductive success, poor juvenile survival, and habitat loss in winter and summer ranges. In the southeastern United States, other researchers have reported high survival rates for breeding songbirds consistent with our findings on Sapelo Island (1.00 for males and 0.94 for females) (Stober 1996, Powell et al. 2000, Seaman and Krementz 2000).

We found no difference in home-range size between male and female painted buntings within the same habitat. Home-range size, however, increased in habitat with more overstory canopy cover similar to home ranges of Bachman's sparrow (*Aimophila aestivalis*) in Arkansas (Haggerty 1998). Male painted buntings had larger home ranges in managed pine–oak forest than females and males in maritime shrub, which accounts for potential interaction of sex and habitat in our analysis. Larger home ranges resulted from foraging outside their defended or core territory (300–700 m) in freshwater wetland, salt marsh, and thinned moist-forest habitat near the managed pine–oak site.

Male painted buntings in managed (mowed) open oak–pine habitat of St. Catherine's Island, Georgia, had smaller territories (home ranges not measured) on edges (1.5–1.7 ha) at the salt marsh than in more inland areas (2.1–2.7 ha) (Finke

1979). St. Catherine's buntings traveled regularly to the salt marsh for foraging, similar to buntings nesting in managed pine–oak forest on Sapelo Island. Finke (1979) used resighting of color-marked painted buntings and grid-cell analysis (similar to MCP estimation technique) to obtain estimates of territory size. Use of radiotelemetry will provide better habitat (home range) and behavioral data when compared to visual locations of nonradioed birds (Hanski and Haila 1988).

In maritime shrub MCP home ranges of male radiomarked buntings averaged 3.1 ha, similar to an average territory size of 3.2 ha for buntings resighted by color leg bands in similar habitats of pastures and fallow fields in Missouri (Norris and Elder 1982). The large territory size (3.2 ha) of buntings in Missouri may be attributed to the low bunting densities. In high-density areas, painted buntings with adjoining territories averaged only 1.4 ha for territory size (Norris and Elder 1982).

Overlap of painted bunting home ranges in managed pine–oak forest may be caused by abundant local food resources away from the nesting territory. Williams (1990) discovered that northern orioles (*Icterus galbula*) moved up to 1 km outside their territories to forage. Orioles from several different nests used these foraging areas at the same time. Painted bunting foraging areas also may have been used communally because overlap in home ranges among males occurred in these areas. Fewer female home ranges overlapped, especially in managed pine–oak forests, where fewer females (4 of 10) traveled outside their core areas compared to males that did (9 of 11). Overlap at the periphery of home ranges occurred for painted buntings on Sapelo Island, which was similar to overlap of home ranges of great and blue tits (*Parus major* and *P. caeruleus*) in Europe (Naef-Daenzer 1994). Bunting core areas, defined as areas of dense use (50% utilization distribution), did not overlap and may have represented defended territories for males. Singing perches that occurred within the core areas may have served in territorial defense (Lowther et al. 1999).

Potential biases in sampling may have caused an underestimation of fixed-kernel home-range size for buntings nesting in managed pine–oak forest. When buntings foraged in dense habitats, especially on the ground, the radiotransmitter signal was detectable only at ~100 m. In managed pine–oak forest, 9 buntings moved >300 m off the site, making them difficult to locate. These buntings disap-

peared from the site for ~1 hour and returned to the area often before their remote positions were precisely located. Buntings moved continuously while foraging in remote interior freshwater wetlands and thinned forests that were far (300–700 m) from their core areas. Radiomarked bunting locations in managed pine–oak, therefore, tended to be biased toward points within the bird's territory, which underestimated home range. Remote receivers with scanners and recorders at communal foraging areas may have provided better home-range data for these buntings.

Management implications

High survival rate, relatively small home-range size, and limited movements by painted buntings outside the core of their home range indicate that maritime shrub may be high-quality habitat for painted buntings. Maritime shrub habitat, however, is not common on the Atlantic coast, and development in beach dunes may threaten this important bunting habitat. Conservation of remaining maritime shrub habitat along the Atlantic coast will be critical for restoring the southeastern United States population of the painted bunting. We do not recommend prescribed fire in maritime shrub habitat because high temperatures, drought, salt spray, and wind maintain this habitat (Chalmers 1997). These natural forces create open areas with grasses and shrubs that are needed by painted buntings for foraging and nesting.

To provide good bunting habitat, pine–oak forests should be open-canopy (<75% canopy cover) with >50% ground cover and patches of shrubs throughout the understory of Sapelo Island (J. M. Meyers, USGS, Patuxent Wildlife Research Center, unpublished data). Managers should use periodic prescribed fires (3–6-year intervals, depending on site) to maintain ground and shrub cover within the forest. Although managed pine–oak habitat provides nesting cover and some foraging habitat for buntings, they also may need additional foraging areas within a maximum of 300–700 m from the nest or territory. These additional areas include small forest openings (<1 ha), salt marshes, freshwater wetlands, roadsides, and well-thinned (shelterwood cut) pine sawtimber stands. Properly managed pine–oak forests adjacent to salt marshes provide important nesting habitat for painted buntings.

Managed pine–oak forest and maritime shrub

habitats of relatively undeveloped barrier islands such as Sapelo Island may be important population sources of buntings on the mainland. We will need additional data from these island habitats for reproductive success before they can be designated critical source habitats (Pulliam 1988). Continued protection and management of source habitat may be important to maintaining the painted bunting population in the southeastern United States.

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