Home Range and Habitat Use of Eastern Bluebirds in South Carolina

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Abstract: Adult eastern bluebirds (*Sialia sialis*) were monitored by radio-telemetry during the breeding (5M:5F) and wintering (5M:5F) seasons to obtain home range and habitat data. All birds used natural cavities on forested land in west-central South Carolina. Mean home range size of breeding season bluebirds was 19.2 ± 4.4 ha ($\bar{x}$ ± SE) for males and 13.7 ± 4.4 ha for females. Wintering season home ranges were 105.9 ± 15.5 ha and 120.8 ± 16.6 ha for males and females, respectively. Home ranges did not differ (P >0.05) by sex but did by season. Mean minimum total distance moved was similar for both sexes and was larger during the wintering season (3,757 ± 229 m) than during the breeding season (1,836 ± 698 m). Habitat preference varied by sex and season, but edge and clearcut habitats were always used more than expected. Dense pine stands were never used. Pine stands with open understories were preferred more than those with closed understories. Bottomland hardwoods and beaver ponds were important winter habitats.

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Although a large percentage of bluebirds use artificial nest sites, there are still large populations of bluebirds in the southeastern United States using forested land and nesting in natural cavities. The extensive forest plantations provide large expanses of habitat for bluebirds. Clearcuts (Conner and Adkisson 1974, Crawford et al. 1981) and young pine stands (Hurst 1981, 1983) make acceptable bluebird habitat if nesting sites are available. Fire, which is widely used as a silvicultural tool in the Southeast, improves habitat for bluebirds (Ahlgren and Ahlgren 1960, Stoddard 1963, Pinkowski 1976, Crawford et al. 1981).

Fifty-seven percent of the southeastern United States is forested (USDA For. Serv. 1987), yet few researchers (Bent 1949, Pinkowski 1974) have studied bluebirds on forested lands. As a result, the potential of this large resource as bluebird habitat is not well understood. Our objective was to determine home range and habitat use during the breeding and winter seasons by adult eastern bluebirds using natural cavities on forested land in west-central South Carolina.

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Methods

The study was conducted on the Department of Energy's 810-km^2 Savannah River Site (SRS) in west-central South Carolina. The SRS contains mostly sandy soils which are low in fertility. The mean winter temperature is 9 C, and the mean summer temperature is 27 C. Average annual rainfall is 119 cm (Langley and Marter 1973). The SRS is characterized by upland planted pine stands, bottomland hardwood and some upland hardwood. Forest practices are intensive, and stands have distinct boundaries. About 890 ha are cut and planted each year. Commercial thinnings and prescribed burns are common.

Bluebirds were captured most commonly using mist nets (3.175-cm mesh) set in a horizontal "V" shape with a recording of the territorial song and a male decoy placed between the "V." During the nesting season, females were netted directly from the cavity while they were incubating eggs or brooding young. During the winter, most birds were captured by placing mist nets in high-use areas.

During the breeding season (Apr–Jul 1985) and again during the winter (Nov 1985–Feb 1986), 10 (5M:5F) adult eastern bluebirds were outfitted with radio transmitters (Allen and Sweeney 1989). Transmitter package weights ranged from 2.26–2.50 g and represented 7%–9% of a bird's body weight. Monitoring 20 bluebirds for 10–25 days each in the breeding and wintering season revealed little or no apparent influence of transmitter package on behavior of birds (Allen and Sweeney 1989). An attempt was made to locate each bird hourly from ½ hour before daylight until ½ hour after dark daily for the first 10 days and every third day thereafter. One to 4 birds were monitored each day. Telemetric homing (Cochran 1980) was used to obtain a visual confirmation of each location, resulting in no telemetric error for these locations. Once roost locations were identified by homing and visual confirmation, subsequent use of these locations was recorded by triangulation to minimize disturbance. Telemetric error for these later locations was not measured, but was considered to be minimal.

In this study, the term "home range" (the area used by an individual in its normal daily activities) is used as an inclusive term for the breeding territory or the winter home range. "Territory" is used only for areas that were known to be defended.

Home range boundaries were determined by the minimum area method (Mohr 1947). Home range size and percentage of each habitat within the home range were calculated using a polar planimeter and dot grid, respectively. Cumulative area curves (Odum and Kuenzler 1955) were used to determine if each bird's home range had been completely defined. Mean minimum total distance (MTD) values, defined as the mean sum of the distances between sequential locations in a diel tracking period (Marchinton and Jeter 1966), and interval movement rate (IMR) values, defined as the mean of the individual distances moved per 2-hour interval per diel tracking period (Buie 1980), were calculated with the following modifications. Readings were taken hourly instead of every 2 hours. Birds were tracked daily from dawn until dark as opposed to a 24-hour diel once a week. Finally, IMR values were placed into 1 of 4 time periods: early morning, from daylight until 0759 during the breeding season or until 0859 during the winter; late morning, from the end of the early morning period until 1159; afternoon, from 1200 until 1559; and evening, which was from 1600 until dark. Factorial analysis of variance was used to test home range and movement data by sex and season. Fisher's protected LSD was used for pairwise comparisons of IMR values between sex-season subgroups within a time period.

Habitat types were classified as pine with an open understory (>15-year-old stands with no vegetation at eye level for ≥50 m in ≥50% of the directions), pine with a closed understory (complement of above), bottomland hardwood, upland hardwood, clearcut (unplanted fields and stands ≤5 years of age), edge (roads, railroads, powerlines, the first 5 m into clearcuts and 5 m into the adjacent stands), dense pine (6- to 15-year-old stands before thinning or burning), and beaver pond. We described understory vegetation structure following Nudds (1977) except coverage was estimated to the nearest 10%. If overstory existed, percent canopy cover, basal area (1 factor metric prism) and stand age were taken. The number of snags/ha (≤7.62 cm DBH) were estimated by a random sample of 0.1-ha plots. Maps of the study area were traced from enlarged aerial photographs. A compass and hip chain were used to map boundaries of habitat types that could not be delineated from the aerial photographs. Bird locations were plotted on these maps.

The proportion of radio-locations within each habitat type was compared with the proportion of the home range that each respective habitat represented. Chi-square goodness-of-fit tests and the Bonferroni procedure of these comparisons were used to determine if use differed from habitat availability (Neu et al. 1974, Byers et al. 1984). Analysis of variance and Fisher's protected LSD were used to determine if differences existed in habitat variables (i.e., understory structure, age, snag density) among habitat types. Differences were considered significant at $P < 0.05$.

Results

Home Range and Movement

Cumulative area curves indicated that all home ranges had been sufficiently delineated for the time period in which birds were monitored. No difference between mean home range size of males and females within a season was found (Table 1).

Table 1. Telemetry data collected for eastern bluebirds on the Savannah River Site, South Carolina, 1985–1986.

	Observation period	Mean (± SE)		
		N days	N locations	Home range (ha)
Breeding males (N = 5)	03 Apr–25 Jul	20 ± 2	302 ± 25	19.2 ± 4.4
Breeding females (N = 5)	18 Apr–14 Jul	14 ± 2	222 ± 26	13.7 ± 4.4
Winter males (N = 5)	19 Nov–13 Feb	18 ± 1	216 ± 17	105.9 ± 15.5
Winter females (N = 5)	04 Dec–19 Mar	18 ± 2	220 ± 21	120.8 ± 16.6

However, home ranges were larger for both sexes during winter. Mean home range size of breeding bluebirds was 16.4 ± 3.1 ha, whereas mean home range size of wintering bluebirds was 113.1 ± 11.0 ha. Home ranges were larger in April and May ($\bar{x}$ = 24.6 ± 6.8 ha; N = 5, 3M:2F) than in June and July ($\bar{x}$ = 8.3 ± 1.6 ha; N = 5, 2M:3F).

During the breeding season, territories of males and females within a pair overlapped entirely. Territories of adjacent pairs did not overlap. Wintering bluebirds usually stayed in groups of 4–10. Home ranges of transmitted individuals in these groups overlapped other transmitted individuals from 11 to 100%. Males overlapped other males from 81% to 100%, whereas females overlapped other females from 13%–67%.

Bluebirds often moved quickly across their home range. Because locational readings were taken hourly only, movement data likely underestimated true distances moved. Consistent with increased home range sizes, MTD values were similar for both sexes and were larger during winter (3,757 ± 229 m) than during the breeding season (1,836 ± 698 m).

Winter males had larger IMR values ($\bar{x}$ = 1,918 ± 380 m/hour) than any other sex-season subgroup ($\bar{x}$ = ≤238 ± 403 m/hour) for the early morning time period. When data for sexes were combined, winter bluebirds had larger IMR values than did breeding birds for the early morning (1,078 ± 227 m/hour versus 117 ± 269 m/hour, respectively) and evening (694 ± 171 m/hour versus 130 ± 168 m/hour, respectively) time periods.

Habitat Use

Dense pine stands were never used. Understory density was greater in this than any other habitat type (Table 2).

Clearcuts and edges were preferred habitats (Table 3). Both sexes used these habitats during both seasons more than expected from availability. The first 0.5 m above ground was more dense in clearcuts than in 5 of the 7 other habitats. However, from 1.0 m upward, clearcuts contained less vegetation than any other habitat except beaver ponds. Snag density was less in clearcuts than hardwoods or beaver ponds but not different from any of the pine habitats. Birds using clearcuts with low snag densities ($\bar{x}$ = 12 snags/ha) used edges more than birds using clearcuts with high

Table 2. Means of selected variables for eastern bluebird habitat on the Savannah River Site, South Carolina, 1985–1986.

Habitat type	Snag density (snags/ha)	Age (years)	Basal area (m^2/ha)	Canopy cover (%)	Understory density[a] (% coverage)			
					0.0–0.5m	0.5–1.0m	1.0–2.5m	0.0–2.5m
Dense pine	0.1A[b]	12A	15A	63A	91A	80A	65A	73A
Clearcut	1.6AB	3B	0B	0B	61B	26B	2B	18B
Pine, open understory	1.8BC	29C	20C	70AC	25C	14C	6C	12C
Pine, closed understory	1.5AC	27C	20C	72D	54D	48D	38D	43D
Bottomland hardwood	4.6D	51D	26D	85D	58BD	48D	41D	46D
Upland hardwood	2.5D	45E	20C	77E	37E	28E	26E	29E
Beaver pond	21.1E	0B	0B	0B	25CE	18BC	1BC	9C

[a]Based on Nudds (1977).
[b]Means within columns without a common capital letter are different ($P < 0.05$).

snag densities ($\bar{x}$ = 28 snags/ha). Pine stands with an open understory were used much more than those with a closed understory (Table 3). Every bird's home range contained at least some pine with an open understory. Males used open understory pine stands more than expected during the breeding season and less than expected during winter (Table 3). Females used this habitat in proportion to its availability during both seasons. Closed understory pine stands were always used less than expected by both sexes. The understory was less dense in open understory pines than in closed understory pines (Table 2).

During the breeding season, bottomland hardwood habitats were used less than expected, whereas more use of this habitat was made in winter (Table 3). Mean age, basal area, and canopy cover were all significantly greater for bottomland hardwood stands than any other habitat type (Table 2). Understory density was equal to or greater than understory densities in all habitats except dense pine.

Although beaver ponds represented a small portion of total area, this habitat was used more often than expected by both sexes during the winter. Snag density was higher in this than any other habitat and total understory (0–2.5 m) had less vegetation than any habitat except open understory pine (Table 2).

Discussion

Home Range and Movement

Mean territory size of individual breeding bluebirds in this study was greater than previously reported. Territories reported in the literature varied from 1.1 ha for males in forested habitat in northwest Michigan (Sloan and Carlson 1980) to 7.4 ha for breeding males in old fields in southeast Michigan (Pinkowski 1979). Pinkowski (1979) reported that breeding territories in lumbered and burned areas were smaller than those in old fields and attributed this to the optimum habitat conditions of the former.

There are many possible reasons for the larger home ranges found in this

Table 3. Simultaneous Bonferroni confidence intervals for eastern bluebird habitat use on the Savannah River Site, South Carolina, 1985–1986.

Habitat type	Season/ sex[a]	Expected proportion of usage[b]	Bonferroni interval	Actual proportion of usage[c]
Clearcut				
(21.1)[d]	BM	0.212	$0.248 \leq P \leq 0.312$	0.280
(12.6)	BF	0.184	$0.397 \leq P \leq 0.476$	0.436
(52.9)	WM	0.100	$0.228 \leq P \leq 0.308$	0.268
(37.0)	WF	0.061	$0.095 \leq P \leq 0.148$	0.121
Edge				
(18.4)	BM	0.191	$0.358 \leq P \leq 0.427$	0.392
(20.0)	BF	0.293	$0.308 \leq P \leq 0.384$	0.346
(82.6)	WM	0.156	$0.250 \leq P \leq 0.332$	0.291
(82.6)	WF	0.155	$0.317 \leq P \leq 0.403$	0.360
Pine, open understory				
(13.9)	BM	0.145	$0.165 \leq P \leq 0.221$	0.193
(11.8)	BF	0.173	$0.127 \leq P \leq 0.185$	0.156
(68.2)	WM	0.129	$0.062 \leq P \leq 0.113$	0.088
(154.5)	WF	0.256	$0.244 \leq P \leq 0.324$	0.284
Pine, closed understory				
(32.3)	BM	0.336	$0.039 \leq P \leq 0.071$	0.055
(21.7)	BF	0.318	$0.034 \leq P \leq 0.070$	0.052
(236.0)	WM	0.446	$0.036 \leq P \leq 0.078$	0.057
(149.6)	WF	0.248	$0.014 \leq P \leq 0.045$	0.030
Bottomland hardwood				
(6.6)	BM	0.068	$0.020 \leq P \leq 0.046$	0.033
(2.2)	BF	0.032	$0.001 \leq P \leq 0.016$	0.009
(71.1)	WM	0.135	$0.212 \leq P \leq 0.291$	0.252
(94.8)	WF	0.157	$0.108 \leq P \leq 0.169$	0.138
Upland hardwood				
(13.4)	WM	0.025	$0.015 \leq P \leq 0.046$	0.031
(42.9)	WF	0.071	$0.025 \leq P \leq 0.061$	0.043
Beaver pond				
(3.8)	BM	0.040	$0.031 \leq P \leq 0.061$	0.046
(0.3)	WM	0.001	$0.004 \leq P \leq 0.025$	0.014
(0.6)	WF	0.001	$0.010 \leq P \leq 0.037$	0.023

[a]B = breeding, W = winter, M = male, F = female.
[b]Expected proportion not within interval indicates significance.
[c]Dense pine was never used and thus excluded from the table.
[d]Area (ha) of each habitat within home range.

study, including differences in habitat type. Another factor was our ability to more completely define the birds' home ranges as a result of the use of radio-telemetry. Nesbitt et al. (1978), who first used radio-telemetry on red-cockaded woodpeckers, also reported home range size of birds to be larger than most previously reported ranges. Although Sloan and Carlson (1980) used radio-telemetry, the territories they found were the smallest reported ($\bar{x}$ = 1.1 ha). Their comparatively small home ranges may have been a result of: (1) addition of nesting boxes, with a resultant increase in density of nesting pairs and thus a decrease in territory size, (2) a difference in study areas, or (3) the transmitters on the birds having been too heavy (4 g).

As in this study, Krieg (1971) and Pinkowski (1979) observed larger home ranges at the start of the breeding season than at the end. Pinkowski (1979) felt that this was related to the larger foraging area needed early in the season. However, this is probably not the case in South Carolina where insects are readily available throughout the breeding season. The difference in this study was due at least partially to a shift in which individuals were being monitored. Birds monitored early in the breeding season used areas which were apparently less than ideal. All birds monitored at this time used home ranges with more pine with a closed understory and less clearcut habitat. Three of the 5 birds monitored in April and May had home ranges which contained no clearcuts at all, and 1 pair used a clearcut which contained tall, thick grass. Birds monitored late in the breeding season used clearcuts that had higher densities of snags ($\bar{x}$ = 28 ± 4/ha) than clearcuts used by birds monitored early in the season ($\bar{x}$ = 12 ± 3/ha).

Increased energy demands in winter combined with less available preferred foods (insects) probably contributed to an increase in movement and home range size relative to the breeding season. Also, a shift in the diet to include more berries may have contributed to use of areas not previously exploited. Furthermore, breeding birds defended a territory and were often caring for young which restricted movement.

Pinkowski (1978) found no differences in feeding rates throughout the day. Assuming activity or movement is indicative of feeding rate, this study supports his findings. Based on IMR values, bluebirds appeared to be active throughout the day, with no peaks or troughs.

Habitat Use

In general, edge has not been presented in past bluebird literature as a distinct habitat type, yet edge was used more often than any other habitat type in this study. Edges of clearcuts seemed especially important if perches were not available in the clearcut. Edge probably provided favorable foraging sites and partial protection from predators and environmental conditions such as hot sun, wind, and rain.

Bluebirds use pine-oak woodlands with sparse ground cover (Pinkowski 1974) and open woods (Bent 1949). We found that breeding males used open understory pine stands more than expected, and that during both seasons, female bluebird use was in proportion to open understory pine availability. Wintering males were found to use this habitat less than its availability. However, a mobile species such as bluebirds probably makes an initial habitat selection when establishing the location of its home range. Preliminary landscape analysis of forest inventory data from a companion study indicated some initial selection at this level (unpubl. data). Although use of specific pine habitat could not be differentiated according to understory from these data, home ranges of breeding bluebirds contained a higher percentage of clearcuts and a lower percentage of hardwoods than the overall study area. This suggests preferred habitats may be very abundant within a bird's home range.

Therefore, when using percent occurrence of habitats within the home range as a measure of relative availability for the Chi-square test of habitat use based on the Bonferroni approach, preferred habitats which are abundant within a home range may only show up as having non-significant, or even less than expected, use. Except for high use of bottomland hardwoods by wintering males, pine with an open understory was 1 of the 3 most frequently used habitats and should be considered important for bluebirds.

Bottomland hardwoods apparently were important to bluebirds during the winter. Winter home ranges included a higher percentage of this habitat than breeding territories. Furthermore, bluebirds used this habitat equal to or more than expected in the winter. Stand analyses indicated that this habitat had greater diversity and/or greater vegetative cover than any other habitat, suggesting a more plentiful or diverse berry supply. Although insect production continued during the winter, berries were used to supplement the diet. Activity data taken concomitant with locational data revealed that virtually all feeding in bottomland hardwoods was on berries. As a result, bottomland hardwoods became increasingly important.

Beaver ponds were a small but apparently important part of bluebird winter home ranges, since their use at this time was greater than expected. Other researchers also have found bluebirds to use beaver ponds (M.L. Crocker, R. Hoppe, pers. commun.). High winter use of beaver ponds which had higher snag densities and less understory than most habitats suggests beaver ponds complement bottomland hardwoods as winter feeding habitat. Whereas bottomland hardwoods probably provide more berries, beaver ponds probably provide access to insects emerging on warm winter days.

Management Implications

Intensive forest management programs such as on the SRS can benefit bluebirds. Although dense pine stands are not used, these conditions prevail for only 10–15 years in each rotation cycle. Stands that are ≤5 years old (after clearcut) are used considerably by bluebirds. Clearcuts should be designed to maximize edge, and snags should be left for perch sites and nesting. After stands reach 15–20 years, they should be commercially thinned and burned. These practices create stands with open understories, which are important to bluebirds. The importance of bottomland hardwoods and beaver ponds as winter food sources should not be overlooked.

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