Habitat-area Relationships of Shrub-scrub Birds in South Carolina

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Abstract: Sensitivity to reductions in habitat area are widely accepted as a factor in the declines of many mature-forest passerines. Although evidence from a number of sources shows significant declines among many Neotropical migratory (NTMB) and temperate migrant (TMR) early-successional birds, little information exists regarding the potential for area-sensitivity in those species. Here we report the results of research on habitat-area considerations of birds in clearcut habitats in some upland forests in South Carolina. Using single, fixed-radius point counts in each clearcut, we measured avian community composition in 21 piedmont clearcuts (0.5–13 ha) and 28 (4–25 ha) mountain clearcuts. Analysis by simple linear regression showed that estimates of richness and relative abundance for NTMBs, edge-interior species and shrub-scrub species varied positively with increasing clearcut size in piedmont sites ($P \leq 0.05$). Community level responses to clearcut area were not statistically significant in mountain sites. Incidence functions describing responses of several species to clearcut size class suggested sensitivity to patch size in piedmont sites but not in mountain sites. Potentially area-sensitive species in the piedmont included the prairie warbler (*Dendroica discolor*), yellow-breasted chat (*Icteria virens*), field sparrow (*Spizella pusilla*), and eastern towhee (*Pipilo erythrophthalmus*). These results suggest that patch size should be considered in early-successional forest bird conservation.

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Conservation efforts for passerines, especially Neotropical migrants, have been heavily influenced by studies that have documented positive species-area relationships and species sensitivities to reductions in habitat area (Robbins 1979, Robbins et al. 1989, Whitcomb et al 1981). The positive relationships between reductions in habitat area and NTMB population viability are frequently associated with increased rates of nest predation and brood parasitism in small, insular forest patches that suppress survival and breeding success (Brittingham and Temple 1983, Wilcove 1985, Robinson 1992). Although several lines of evidence suggest that populations of some

early-successional species are declining at precipitous rates (Askins 1993, Sauer and Droege 1992, James et al. 1992, Hunter et al. 1993), almost all of the published studies addressing habitat-area relationships of passerines have focused on mature forest habitats and forest-interior species. Previous studies of bird-habitat relationships in forested habitats suggest that area is an important factor in determining the richness and diversity of avian communities and also a reliable determinant in predicting the presence or absence of certain area-sensitive bird species. However, there has only been 1 published study that has addressed species-area issues of early-successional species in managed, eastern forests (Rudnicky and Hunter 1993). To date, little or no information has been published addressing habitat-area relationships or conservation and management strategies for early-successional birds and communities in managed upland forests of the Southeast.

In order to maintain regional avifaunal diversity, both mature forest and early-successional habitats and communities must be considered in management initiatives. Wildlife conservation goals in most cases must be accomplished while maintaining the production of timber and other consumptive resources. However, because little or no information has been published addressing the role of early-successional habitats in NTMB conservation in the Southeast, informed decisions regarding the management of the entire avian community are not possible. By documenting the relationships between clearcut patch size and attributes of avian communities such as richness, abundance, and frequency of occurrence, better decisions may be made regarding songbird conservation and consumptive management. To assess the role of area and other patch metrics on assemblages and species of birds the following null hypothesis was tested: Ho: There is no relationship between clearcut patch size and measures of avian community composition (richness, diversity, evenness, relative abundance, frequency of occurrence).

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Methods

This study was conducted in the Andrew Pickens Ranger District of the Sumter National Forest (SNF) in Oconee County, South Carolina, and in the northern portion of the Clemson Experimental Forest (CEF) in Pickens and Oconee counties, South Carolina. While both study areas are located in the northwestern corner of South Carolina and are relatively close in proximity (12km), the SNF is in the Blue Ridge physiographic province and the CEF is in the Lower Foothills subregion of the Piedmont physiographic province (Myers et al. 1986). Current landscape conditions differ due to management history and the degree of human development in each of these areas (Table 1).

Table 1. Characteristics of the Sumter National Forest (SNF) and Clemson Experimental Forest (CEF) study areas (all measurements are in hectares).

	SNF	*N* stands	CEF	*N* stands
Total area	47,400	1,666	4,500	1,490
Mean stand size	28.45		3.02	
Area in hardwoods	12,000	575	2,000	647
Area in pines	19,000	887	1,600	644
Area undefined	16,400	204	900	199
Shrub-scrub habitat				
Total area	4,000	277	700	222
Mean patch size	13.28	277	2.96	222
Patch density (patches/ha)	0.006	277	0.050	222
Mature forest habitat				
Total area	43,400	1,185	3,800	1,272
Mean patch size	22.84	1,185	3.01	1,272

The SNF lanscape was characterized by a montane topography with elevations ranging from 488 to 1,067 m above sea level. Major forest associations included Virginia pine (*Pinus virginiana*), shortleaf pine (*P. echinata*), chestnut oak (*Quercus prinus*), and *scarlet* oak (Q. *coccinea*) on xeric sites; white pine (*P. glabra*), eastern hemlock (*Tsuga canadensis*), yellow-poplar (*Liriodendron tulipefera*), and mixed mesophytic hardwoods on mesic sites; and pine-hardwood associations on intermediate sites (Myers et al. 1986). As a transition zone between the upper foothills and the Midlands Plateau subregions, the Lower Foothills subregion is characterized by greater relief than lower latitude Piedmont sites (Myers et al. 1986). Mean elevation in the CEF is 244 m above sea level. Major forest associations in the study area included upland, cove, and bottomland-hardwoods, planted and natural stands of loblolly (*P. taeda*) and shortleaf pine (*P. echinata*), and pine-hardwood mixtures.

A population of 49 naturally regenerating pine-hardwood clearcuts (3–5 years post harvest) were chosen in the SNF (28) and CEF (21) landscapes. These sites included all of the known areas meeting a 3- to 5-year post-harvest criterion. Clearcut size data for the 28 SNF and 21 CEF clearcuts were obtained from the USDA Forest Service (unpubl. data, Andrew Pickens Ranger Station, Walhalla, S.C.) and Clemson Experimental Forest stand information data (unpubl. data, Dept. Forestry, Clemson Univ., S.C.), respectively. Clearcuts in the CEF were placed in the following size classes: <1 ha, $N = 3$; 1–2 ha, $N = 5$; 3–4 ha, $N = 4$; 5–7 ha, $N = 5$; 9–13 ha, $N = 4$. Size classes of clearcuts in the SNF were as follows: 5–7 ha, $N = 4$; 9–13 ha, $N = 12$; 15–9 ha, $N = 7$; 20–25 ha, $N = 6$.

A total of 49 20-minute 50-m fixed-radius point counts were conducted in SNF and CEF clearcuts with each site sampled once during the breeding season (15 May-30 Jun) in 1995. Censuses were conducted on nonwindy, nonrainy days from approximately 0600 to 1000 hours. All birds seen or heard during the census period were recorded as occurring at 0–25 m, 26–50 m or >50 m from the center of the point count census station. Species were categorized according to migratory strategy (Neo-

tropical migrant = NTMB, temperate migrant-resident = TMR), and primary habitat association (forest-interior, edge-interior, shrub-scrub).

We used simple linear regression to estimate the proportion of the variances in responses that were attributable to clearcut patch size. Our null hypotheses of "no relationship between clearcut patch size and avian community (or focal species) response" were rejected at $P \leq 0.05$. The response variables regressed against clearcut patch size were overall species richness, abundance (= *N* individuals/patch), Shannon's diversity [$H' = \Sigma(p_1)(\log p_1)$], Shannon's evenness ($J' = H'/H'_{max}$), and richness and density estimates of edge-interior, forest-interior and shrub-scrub guilds. The abundances of several focal species were also regressed against clearcut patch size. Shrub-scrub neotropical migrant focal species included in the clearcut size vs. abundance portion of the analyses were the indigo bunting (*Passerina cyanea*), prairie warbler, yellow-breasted chat, white-eyed vireo (*Vireo griseus*), and blue grosbeak (*Guiraca caerulea*). Temperate-migrant shrub-scrub species included the mourning dove (*Zenaida macroura*), American goldfinch (*Carduelis tristis*), eastern bluebird (*Sialia sialis*), and field sparrow. Temperate-migrant, edge-interior species included the brown thrasher (*Toxostoma rufum*), eastern towhee, and brown-headed cowbird (*Molothrus ater*). The yellow-billed cuckoo (*Coccyzus americanus*) was the only neotropical migratory edge-interior species considered in this analysis.

Simple indices of area-sensitivity for several focal species were obtained using incidence functions. These functions define the probability of occurrence for a species within a specific area of habitat or as the proportion of patches of a given size where a species is present (Moore and Hooper 1975, Morrison et al. 1992). Frequency of occurrence estimates (= *N* occurrences of species / *N* sites in a given size class) for 4 early-successional species (prairie warbler, yellow-breasted chat, indigo bunting, field sparrow) and 2 edge-interior species (eastern towhee, brown-headed cowbird) were plotted against clearcut size classes in each study area to derive these incidence functions.

Results

This study documented community-level and species-specific responses to area within 2 landscapes. In the Upper Piedmont sites of the CEF, species richness and all of the component species richness estimates except forest-interior richness, were positively correlated with clearcut patch size. Regression analysis revealed no statistically significant species-area relationships among SNF clearcut size classes. Therefore the null hypothesis of "no relationship between patch size and the respective community attributes in the SNF" was not rejected. However, several significant relationships did emerge from the CEF analyses. The relationship between species richness vs. clearcut patch size and species abundance vs. patch size were both significant in CEF sites. This resulted in rejection of the null hypotheses of "no relationship between species richness/abundance and clearcut patch size in the CEF." The analysis also showed that clearcut patch size in the Piedmont accounted for significant

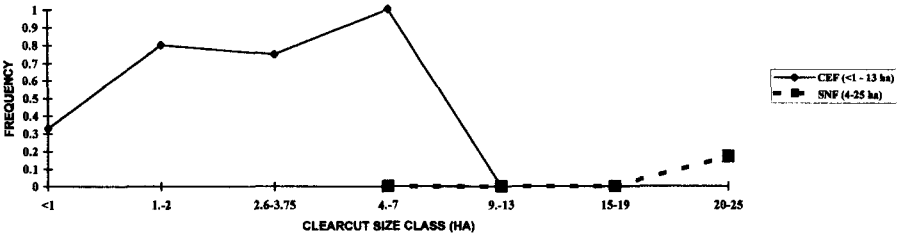

Figure 6. Brown-headed cowbird frequency of occurrence.

Indigo buntings appeared in most (70%) of the smallest (<1 ha) openings in the CEF. They also occurred in 100% of each of the other size classes, suggesting a lack of response to forest opening size class in that landscape (Fig. 4). Although the frequency of occurrence estimates for indigo buntings decreased among progressively larger clearcut size classes in the SNF, they maintained the highest response levels across all size classes of all the focal species studied, occurring most frequently in 5–7 ha clearcuts.

Field sparrows had decreasing frequency of occurrence estimates in sites larger than the 5–7 ha clearcut size class in SNF sites (Fig. 5). In the SNF they were the most infrequently observed of the selected species, occurring most often in 9–13 ha clearcuts but only at a 20% frequency rate. Field sparrows in the mountains were not recorded in either the 5–7 ha size class or in the 20–25 ha size class.

Numbers of brown-headed cowbirds also had decreasing frequency of occurrence estimates in sites larger than the 5–7 ha clearcut size class in CEF sites (Fig. 6). Although responses in the SNF could be construed as positive, low numbers of observations preclude conclusions regarding potential responses to patch size.

Discussion

Most research and management efforts directed at mitigating declining trends in population of NTMBs have focused on the conservation of large, contiguous tracts of mature forest. While these efforts are perceived to be the best alternative for slowing declines in populations of area-sensitive, forest-interior species, little or no attention has been given to the habitat-area requirements of early-successional species.

One of the most widely accepted tenets of songbird conservation has been the connection between habitat fragmentation and the declines in reproductive success associated with increases in brood parasitism and nest predation. Conservation of large patches of mature forest are believed to confer some protection from nest predation and brood parasitism. Likewise, larger early-successional habitat patches in a more disturbed landscape may confer some of the same benefits to shrub-scrub species that large patches of mature forest habitat confer to forest-interior obligates in fragmented landscapes. Although we did not explicitly quantify the differences

between the montane SNF and Piedmont CEF landscapes, some basic, qualitative comparisons between the 2 landscapes might lend validity to this hypothesis. Based upon a cursory examination of landscape characteristics such as average clearcut patch size and landscape context, the CEF landscape, in terms of early-successional habitats, might be more prone to display positive species-area and area-sensitivity relationships than the SNF. The smaller CEF is surrounded by development and has smaller early-successional patch sizes (Table 1). This contrasts dramatically with the more contiguously forested, less disturbed SNF landscape where the average clearcut patch size was much larger (Table 1). Studies documenting lower rate of predation in progressively larger grassland habitats (Johnson and Temple 1990, Best 1978) coupled with the data from this study showing lower incidences of cowbirds in the larger, less disturbed landscape of the SNF support the argument for the existence of similar relationships in the early-successional habitats in landscapes like the CEF.

Community-level responses to patch area in some landscapes may also be driven by resource abundance within patches. Larger forest openings tend to be more variable in terms of physical parameters (Runkle 1982). Thus, habitat diversity (vegetative stratification, patchiness, and diversity) may be greater in larger clearcuts. Because increase in foliage height diversity and horizontal patchiness have been shown to be associated with increases in bird species diversity (MacArthur 1971, MacArthur and Levins 1967, Ambuel and Temple 1983, Blake and Karr 1987) it is possible that species richness might be greater in larger early-successional patches because of increases in habitat heterogeneity.

This study did not involve experimental manipulation and therefore did not establish causal relationships between patch size and shrub-scrub birds. Moreover, relatively small sample sizes, narrow ranges of patch sizes, short study duration, and lack of true landscape "characterization" limit the scope of our findings. However, data from this study do suggest that species-area and area sensitivity relationships similar to those documented between mature forests and forest-interior species and communities may exist between early-successional habitats and the species dependent upon them. As a result, the spatial scale of clearcutting and other large-scale anthropogenic disturbances that create early-successional habitats may affect the success of shrub-scrub songbird conservation. However, these patterns may only be evident in some areas; early-successional patch size may be an important determinant of shrub-scrub bird ecology in some landscapes but not in others. Ultimately, landscape composition may play as vital a role as the metrics of the patches themselves in determining what species occupy early-successional habitats.

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