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EFFECT OF LANDSCAPE MATRIX TYPE ON NESTING ECOLOGY OF THE NORTHERN CARDINAL

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Introduction

Spatial distribution of forests relative to other habitats in a landscape may influence nest success of songbirds. For example, nest predation in mature forests increases as the percentage of clearcut land in the surrounding matrix increases (Yahner and Scott 1988). Blake and Karr (1987) noted that birds breeding in forest fragments may incorporate adjacent habitats, such as second growth forests, into their territories. In the southeastern United States, many hardwood forests exist as small stands in association with extensive pine forests, the dominant forest cover in the region. Pine forests comprise about 28% of South Carolina's land area (Tansey and Hutchins 1988). We tested the hypothesis that a pine forest matrix would function as a buffer, insulating birds in hardwood forests from the high nest predation and parasitism rates commonly recorded in truly isolated forests. We compared the nest success and nest-site selection of Northern Cardinals (*Cardinalis cardinalis*) in South Carolina hardwood forests enclosed by a matrix of either mature pine forest or agricultural fields.

Study Area and Methods

Study sites were on and adjacent to the 77,891-ha Savannah River Site (SRS) in the Upper Coastal Plain of South Carolina. Upland hardwood sites ranged in size from 0.5-40 ha, and were characterized by various oaks (*Quercus* spp.), mockernut hickory (*Carya tomentosa*), and black cherry (*Prunus serotina*). Mid- and understory species included flowering dogwood (*Cornus florida*), American holly (*Ilex opaca*), and vines and shrubs of the genera *Rubus* and *Vaccinium*. The dominant land cover of the SRS landscape differed from that of the landscape surrounding the SRS (Kilgo et al. 1997); isolated hardwood forests on the SRS ($n = 10$) were enclosed by a pine forest matrix (*Pinus taeda* and *P. palustris* pine-enclosed stands–PES), whereas such sites adjacent to the SRS ($n = 8$) were isolated from other forested habitat by agricultural fields (field-enclosed stands–FES). Mean shrub densities in FES were higher than in PES (Sargent et al. 1998). No other differences in habitat variables (i.e., ground cover, canopy cover, and basal area of woody stems $\geq$3.0 cm) were detected between the site types.

Each site was searched for nests every 1-2 weeks during May-July 1993-94, and nests were monitored every 3-4 days until an outcome was determined. Human-related disturbances near nests were minimized to reduce the possibility of nest abandonment from repeated visitation (Martin and Geupel 1993). The techniques of Best and Stauffer (1980) were employed to assess the outcome of each nesting attempt. Daily survival rates of nests and Mayfield nest survival were calculated (Mayfield 1961, 1975). The nest survival rates for the incubation and nestling intervals were assumed to be similar within landscape matrix type because sample sizes were limited (Klett and Johnson 1982). Mayfield nest success rates were compared between matrix types using Chi-square contingency tables. Differences in daily survival rates between site types were evaluated using a two-tailed Z-test. Student's two-sample *t*-test was used to compare the number of young fledged per successful nest per site type. Because of limited sample sizes, differences were considered to be significant at $P \leq 0.10$. Vegetative parameters of nest sites located in 1994, their associated nest patches, and non-use patches were measured. We recorded nest substrate species, nest height, height and diameter at breast height (dbh) of nest substrate, nest concealment in a 25-cm radius circle centered on the nest, canopy cover, nest distance from the main stem, nest distance from the plant edge, nest distance from the site edge, and number and diameter of supporting branches (Ralph et al. 1993). The nest patch was defined as a 5-m radius circle centered on the nest site. Within the nest patch, we recorded the basal area of plants ≥3 cm dbh, number of plants of the same species and dbh (±3.0 cm) as the nest substrate, and vegetation profile in the four cardinal directions using a 3-m density board subdivided into 0.5-m intervals (Martin and Geupel 1993). Non-use nest patches were selected by walking 35 m in a randomly chosen direction from each nest site (Ralph et al. 1993). The sampling plot was centered on the nearest plant of the same species and approximate dbh as the actual nest substrate. Measurements taken at the nest patch were repeated at the non-use patch.

Wilcoxon's rank-sum test was used for analysis of index (i.e., nest concealment and vegetation profile) data. Canopy cover percentages were arcsine-transformed for analysis. Count data were tested for normality and equality of variance assumptions, and data were compared using either a paired *t*-test or a two-sample *t*-test, when appropriate.

Results and Discussion

Eleven of 20 active Northern Cardinal nests located in PES were successful, and 16 of 22 cardinal nests located in FES were successful (Table 1). The mean hatch and fledge dates for nests in PES were 26 May (1 May-11 July) and 6 June (11 May-21 July), respectively. The corresponding dates for nests in FES were 7 June (3 May-15 July) and 17 June (13 May-15 July).

The daily survival rate of nests in PES (0.963) was less ($Z = 1.08$, $P = 0.07$) than that of nests in FES (0.979), but overall nest success did not differ between matrix types ($X^2 = 2.00$, $P = 0.16$) (Table 1). The number of young fledged per successful nest also did not differ between matrix types (2.6 in PES and 2.4 in FES; $t = 0.54$, $P = 0.60$, 25 *df*). A concurrent study using shrub-level artificial nests indicated lower predation in the PES than in FES (Sargent et al. 1998). However, these data on Northern Cardinal nests suggest that real nests may not be buffered from predation by the presence of a forested matrix. In fact, nesting success of Northern Cardinals tended to be greater (non-significantly) in FES than PES, and Northern Cardinals were more abundant in the agricultural landscape surrounding the SRS than in the pine-forested SRS landscape (Kilgo et al. 2000). Thus, although some forest interior species do not occur in the FES (Kilgo et al. 1997), the potential benefits of the forested matrix to nesting success of shrub-nesting birds in these landscapes are unclear. Nest failures were attributed to predation (93%) or abandonment (7%). No nests were parasitized by Brown-headed Cowbirds (*Molothrus ater*). The Brown-headed Cowbird is uncommon in the Upper Coastal Plain of South Carolina in summer (Post and Gauthreaux 1989). In a concurrent study, we found no cowbird eggs in Wood Thrush (*Hylocichla mustelina*) (Sargent et al. 1996) or Kentucky Warbler (*Oporornis formosus*) (Sargent et al. 1997) nests (n = 20 and 26, respectively), and an 18% parasitism rate on Hooded Warbler (*Wilsonia citrina*) nests (n = 33) (Sargent et al. 1997).

Nest success rates of Northern Cardinals vary among regions and habitats. Reported success rates range from 15% Mayfield success in southwestern Ohio (Filliater et al. 1994), to 53% apparent success rate in a mixed hardwood-pine forest in east Texas (Conner et al. 1986) and 65% apparent success rate in southern Georgia (Patnode and White 1992). Generally, nesting success in our study was similar to, or greater than, those reported previously. The greater daily survival rates of nests in FES may have been influenced by the greater shrub densities in these sites. The greater shrub densities may have inhibited predator efficiency because foraging success of predators may be reduced in vegetatively complex habitats (Bowman and Harris 1980). Although no differences in nest patch variables were detected between site types, the probability of nest predation in FES may have been decreased because the number of patches that predators must search in these sites was greater than that in PES, or because there were perhaps more additional food resources (e.g., fruits, seeds, insects, etc.) from which to choose in the FES. Alternatively, the nest predator population within close proximity to the agriculture-enclosed fragments may have been less diverse or abundant relative to the pine-enclosed fragments due to the lack of contiguous or nearby forested cover which would serve as refugia, especially for small mammals (i.e., the FES were often extremely isolated from other forests).

Most nests were located in small trees and shrubs (i.e., the mean substrate height was $\leq$4.3 m) within 16 m of a site edge, and were supported by numerous small branches and vines (Table 2). Twenty-two of 24 nests were either partially or completely supported by vines, particularly muscadine (*Vitis rotundifolia*), yellow jessamine (*Gelsemium sempervirens*), poison ivy (*Toxicodendron radicans*), greenbriar (*Smilax* spp.), wild grape (*Vitis* spp.), trumpet creeper (*Campsis radicans*), and wisteria (*Wisteria* sp.). Nest concealment generally was greatest from above and lowest from below. Nest concealment was greater (P = 0.06) from above in PES than in FES. Bent (1968) reported that most Northern Cardinal nests were constructed in tangles of vines, thickets, or dense shrubs, with no apparent substrate preference. In our study, nests usually were located in the lower branches of the plants; consequently, nest concealment often was greater from above than below. The mean nest height was greater in PES than in FES, possibly a result of the more limited availability of shrubs in the former.

Nest patch variables did not differ between site types (Table 3). Nest patches featured a dense canopy (i.e., >85% cover) and an open understory with a low basal area of saplings. The basal area of stems ≥3.0 cm in PES was greater (P = 0.08) in non-use patches than in nest patches. The number of potential nest substrates in FES was greater (P = 0.07) in non-use patches than in nest patches.

Northern Cardinals appear to select nest sites and nest patches that contain specific structural features, despite the nature of the surrounding landscape (Ehrhart and Conner 1986). A pine forest matrix does not appear to diminish predation rates on Northern Cardinal nests in hardwood fragments. Rather, nest survival in these enclosed sites may be reduced relative to that in isolated sites, possibly because the lower densities of nest substrates (shrubs) in the former allow greater predator foraging efficiency, or because there are more food options in addition to bird nests for predators to select in the more densely-vegetated isolated sites. Perhaps the abundance of nest predators, particularly mammalian species, is smaller than normal in hardwood fragments that occur in especially fragmented landscapes, far from forested matrices that serve as source habitats for these species.

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Literature Cited

Bent, A.C. 1968. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. Dover Press, New York.

Best, L.B., and D.F. Stauffer. 1980. Factors affecting nesting success in riparian bird communities. Condor 82:149-158.

Blake, J.G., and J.R. Karr. 1987. Breeding birds of isolated woodlots: area and habitat relationships. Ecology 68:1724-1734.

Bowman, G.B., and L.D. Harris. 1980. Effect of spatial heterogeneity on ground-nest predation. J. Wildlife Manage. 44:806-813.

Conner, R.N., M.E. Anderson, and J.M. Dickson. 1986. Relationships among territory size, habitat, song, and nesting success of Northern Cardinals. Auk 103:23-31.

Ehrhart, R.L., and R.N. Conner. 1986. Habitat selection by the Northern Cardinal in three eastern Texas forest stands. Southwest. Nat. 31:191-199.

Filliater, T.S., R. Breitwisch, and P.M. Nealen. 1994. Predation on Northern Cardinal nests: does choice of nest site matter? Condor 96:761-768.

Kilgo, J.C., R.A. Sargent, K.V. Miller, and B.R. Chapman. 1997. Landscape influences on breeding bird communities in hardwood fragments in South Carolina. Wildlife Soc B. 25:878-885.

________, K.E. Franzreb, S.A. Gauthreaux, Jr., K.V. Miller, and B.R. Chapman. 2000. Effects of long-term forest management on a regional avifauna. Studies in Avian Biol. 21:81-86.

Klett, A.T., and D.H. Johnson. 1982. Variability in nest survival rates and implications to nesting studies. Auk 99:77-87.

Martin, T.E., and G.R. Geupel. 1993. Methods for locating nests and monitoring success. J. Field Ornithol. 64:507-519.

Mayfield, H.F. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255-261.

________. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456-466.

Patnode, K.A., and D.H. White. 1992. Effects of habitat on avian productivity in abandoned pecan orchards in southern Georgia. J. Field Ornithol. 63:77-85.

Post, W., and S.A. Gauthreaux, Jr. 1989. Status and distribution of South Carolina birds. Contributions to the Charleston Museum, Charleston, South Carolina.

Ralph, C.J., G.R. Geupel, P. Pyle, T.E. Martin, and D.F. DeSante. 1993. Handbook of field methods for monitoring landbirds. U.S. Forest Service General Technical Report, PSW-GTR-144.

Sargent, R.A., J.C. Kilgo, B.R. Chapman, and K.V. Miller. 1996. Success and location of Wood Thrush nests in riparian and upland hardwoods of South Carolina. In: K.M. Flynn, ed. Proceedings of the Southern Forested Wetlands Ecology and Management Conference, Consortium for Research on Southern Forested Wetlands, Clemson University, Clemson, SC. Pgs. 208-212.

________, ________, ________, and ________. 1997. Nesting success of Kentucky and Hooded Warblers in bottomland forests of South Carolina. Wilson Bull. 109:233-238.

________, ________, ________, and ________. 1998. Predation of artificial nests in hardwood fragments enclosed by pine and agricultural habitats. J. Wildlife Manage. 62:1438-1442.

Tansey, J.B., and C.C. Hutchins, Jr. 1988. South Carolina’s forests. U.S. Forest Service Research Bulletin SE-103.

Yahner, R.H., and D.P. Scott. 1988. Effects of forest fragmentation on depredation of artificial nests. J. Wildlife Manage. 52:158-161.

Table 1. Nesting success estimates for Northern Cardinals in hardwood fragments enclosed by pine forests (PES) or by agricultural fields (FES) in South Carolina, 1993-1994.

Parameter	**PES**	**FES**
Active nests	20	22
Successful nests (%)	55.0	72.7
Mayfield success rate (exposure days)	43.6 (242)	62.7 (290)
Daily survival rate (x $\pm$ S.E.)	0.963 (0.012)	0.979 (0.008)
Mean clutch size (x $\pm$ S.E.)	2.9 (0.1)(n = 17)	2.9 (0.1)(n = 17)
Young fledged/successful nest (x $\pm$ S.E.)	2.6 (0.2)	2.4 (0.2)

Table 2. Microhabitat variables (x $\pm$ SE) for Northern Cardinal nest sites within hardwood fragments enclosed by pine forests (PES; n = 13) or agricultural fields (FES; N = 11) in South Carolina, 1994.

Variable	**PES**	**FES**	***P*[a]**
Nest location/host plant characteristics			
Height (m)	2.6 $\pm$ 0.3	1.8 $\pm$ 0.3	0.05
Distance to main stem (cm)	28.0 $\pm$ 7.0	134.0 $\pm$ 98.6	0.32
Distance to substrate edge (cm)	39.0 $\pm$ 5.2	34.0 $\pm$ 3.0	0.43
Distance to study site edge (m)	16.4 $\pm$ 3.5	15.6 $\pm$ 4.0	0.89
Number of supporting branches	4.9 $\pm$ 0.8	5.3 $\pm$ 0.5	0.66
Diameter of supporting branches (cm)	0.5 $\pm$ 0.1	0.5 $\pm$ 0.1	0.74
Nest concealment[b]			
above	3.5 $\pm$ 0.1	2.9 $\pm$ 0.3	0.06
below	1.2 $\pm$ 0.3	1.2 $\pm$ 0.1	0.68
Nest substrate			
height (m)	3.5 $\pm$ 0.3	4.3 $\pm$ 1.3	0.50
dbh (cm)	6.6 $\pm$ 1.4	9.0 $\pm$ 4.1	0.59

[a] Comparison of variables between site types.
[b] Index of percent foliar coverage: 0 = 0%, 1 = 1-25%, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%.

Table 3. Comparison of microhabitat variables (x ± SE) within nest patches centered on Northern Cardinal nest sites with nonuse nest patches within hardwood fragments enclosed by pine forests (PES; n = 13) or agricultural fields (FES; n = 11) in South Carolina, 1994.

	PES			FES			
Variable	**Nest patches**	**Nonuse patches**	***P***	**Nest patches**	**Nonuse patches**	***P***	***P*[a]**
Basal area (m^2)	0.7 ± 0.2	1.4 ± 0.4	0.08	1.0 ± 0.2	1.8 ± 0.4	0.12	0.30
Vegetation profile[b]							
0.0-0.5 m	1.1 ± 0.3	1.5 ± 0.2	0.18	1.2 ± 0.2	1.1 ± 0.2	0.86	0.75
0.5-1.0 m	1.0 ± 0.3	1.1 ± 0.2	0.42	0.9 ± 0.1	0.9 ± 0.2	0.86	0.84
1.0-1.5 m	1.1 ± 0.2	1.0 ± 0.2	0.66	0.8 ± 0.1	0.7 ± 0.2	0.77	0.19
1.5-2.0 m	1.1 ± 0.2	1.1 ± 0.2	0.82	0.9 ± 0.2	0.7 ± 0.1	0.52	0.64
2.0-2.5 m	1.0 ± 0.2	0.9 ± 0.1	0.96	0.7 ± 0.2	0.6 ± 0.2	0.72	0.32
2.5-3.0 m	1.1 ± 0.2	0.8 ± 0.2	0.34	0.7 ± 0.2	0.7 ± 0.2	0.89	0.14
Canopy cover (%)	88.7 ± 4.2	87.9 ± 6.0	0.29	85.2 ± 5.2	94.7 ± 2.1	0.80	0.74
Same substrate[c]	0.8 ± 0.4	0.2 ± 0.1	0.21	0.1 ± 0.1	0.7 ± 0.3	0.07	0.12

[a] Comparison of nest patch variables between site types.
[b] Index of percent foliar coverage: 0 = 0%, 1 = 1-25%, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%.
[c] Number of plants that were the same species and dbh (±3.0 cm) as the nest substrate.