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POTENTIAL FOR PREDATOR LEARNING OF ARTIFICIAL ARBOREAL NEST LOCATIONS

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ABSTRACT.—We examined the potential for predators to learn the location of artificial arboreal (1.5 m above ground) nests in a managed forested landscape of central Pennsylvania from June–July 1995. We tested the hypothesis that predators do not learn the location of artificial arboreal nests placed repeatedly at the same sites (fixed nests) versus those placed at random sites in three habitats created by clearcutting (forested patches, forested corridors, contiguous forest). Sixty-nine (23%) of 299 total nests in five combined trials were disturbed by predators; 11 (16%) of these disturbances were attributed to corvids. Predation rates were greater on nests placed at random (28%) compared to fixed sites (18%, $P < 0.05$), indicating predators did not learn or return to the location of arboreal nests during our study. Predation rates varied significantly ($P < 0.001$) among habitats, with 49% of the nests disturbed in the forested-patch habitat versus only 7% and 13% in forested-corridor and contiguous-forest habitats, respectively. We propose that predation was higher in forested patches than in the other two habitats because the former had greater amounts of edge. *Received 12 Nov. 1998, accepted 10 May 1999.*

Artificial nest studies have been useful in examining the relationships between avian nesting success and landscape patterns (e.g., Paton 1994, Bayne and Hobson 1997). Several investigators have indicated that depredation of artificial and natural avian nests in managed forests varies with landscape patterns created by clearcutting (Yahner and Ross 1995, Vander Haegen and DeGraaf 1996, Yahner and Mahan 1996a). However, if predation rates on artificial nests are used as an indicator of temporal or spatial trends in avian nesting success (Yahner 1996, Sargent et al. 1998, Wilson et al. 1998), then the potential effect of the ability of predators to learn the locations of artificial nests needs to be determined. For example, as a consequence of clearcutting in a localized area, the availability of suitable nest sites may decline, thereby enabling predators to find nests located in the remaining uncut forested tracts (patches or corridors).

Forest clearcutting for Ruffed Grouse (*Bonasa umbellus*) at the Barrens Grouse Habitat Management Area (GHMA) in central Pennsylvania provided us with an ideal opportunity to test the hypothesis that predation rates did not vary between artificial arboreal (1.5 m above ground) nests placed at sites used repeatedly (fixed nests) versus random sites in a managed forested landscape. To our knowledge, predation rates on artificial nests at fixed vs random sites has been examined only with ground nests (Yahner and Mahan 1996a).

STUDY AREA AND METHODS

Our study was conducted on a 1166-ha Barrens GHMA, State Game Lands 176, Centre County, Pennsylvania, where a series of experimental studies dealing with depredation of artificial and actual nests have been conducted (e.g., Yahner and Wright 1985, Yahner 1991, Yahner and Ross 1995, Yahner and Mahan 1996a). The Barrens GHMA includes reference (contiguous forest habitat) and treated (forested-patch and forested-corridor habitats) sectors of similar size (Fig. 1). The treated sector is divided into 136 contiguous 4-ha blocks, and each block is partitioned into four 1 ha (100 × 100 m) plots arranged in a clockwise pattern (plots A–D). At the first cutting cycle (winter 1976–1977), plot A was clearcut in each block. At the second cycle (winter 1980–1981), plot B was clearcut in each block of the forested-patch habitat. At the third and last cycle (winters 1985–1986 and 1986–1987), plot B in each block of the forested-corridor habitat and plot C in each block of the forested-patch habitat were clearcut. The remaining uncut plots in the treated sector and forest in the reference sector have not been clearcut for 75–80 years. As a result of these three cutting cycles, a mosaic of uncut plots (plot D) entirely surrounded by clearcut plots of three age classes (plots A–C) occurred in the forested-patch habitat, whereas 100 m wide corridors of uncut plots (plots C–D) remained in the forested-corridor habitat (Fig. 1).

We placed artificial arboreal (1.5 m above ground) nests during five time periods (trials) from early June through July 1995 (Yahner and Mahan 1996a). A trial was 6 days in length, with 8 days between trials. At

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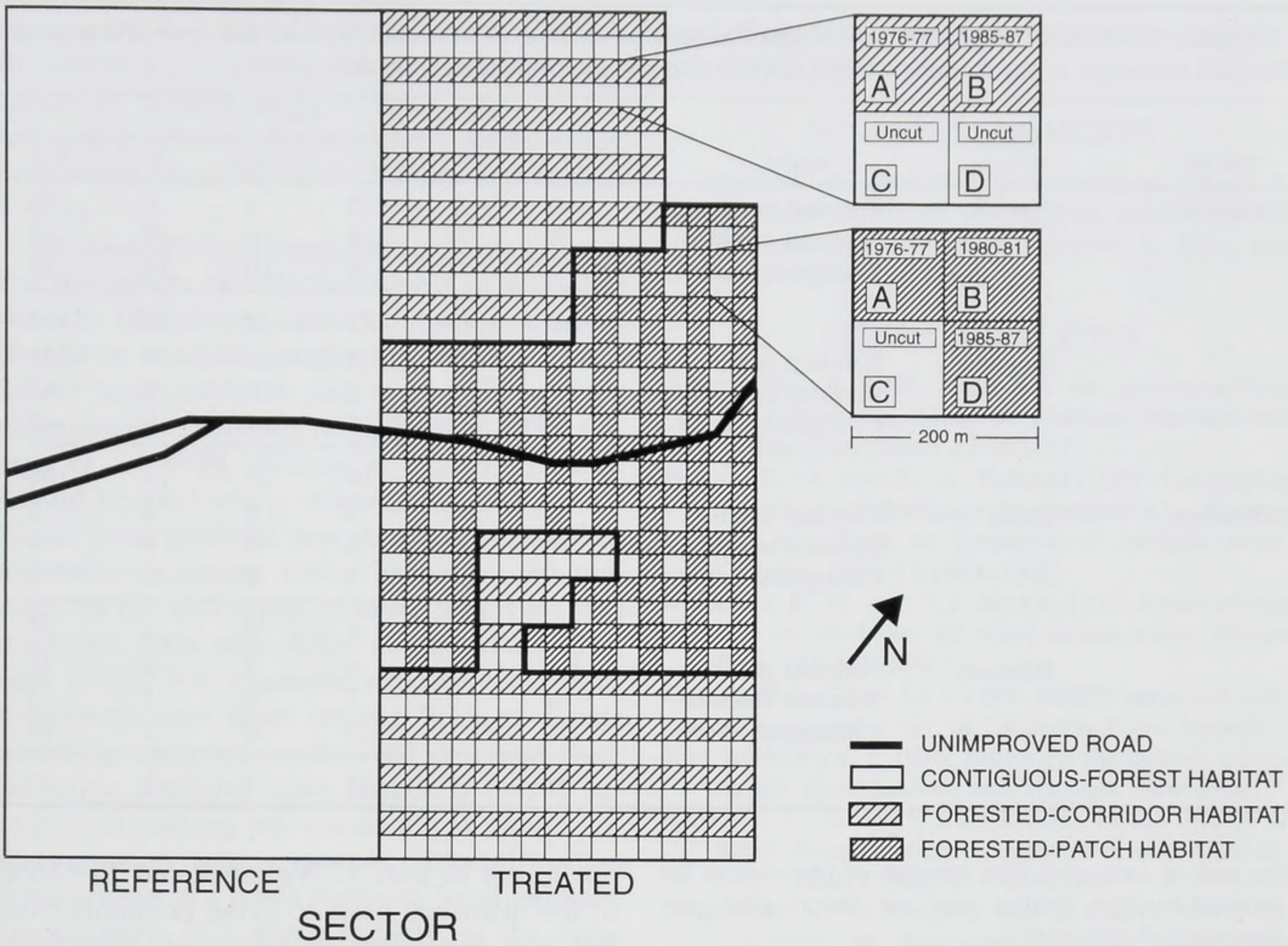

FIG. 1. Schematic of reference and treated sectors at the Barrens GHMA, Centre County, Pennsylvania. Dates of cutting cycles are given in plots A and B of the 76 blocks in the forested-corridor habitat of forest clearcutting and in plots A–C of the 60 blocks in the forested-patch habitat of clearcutting. Forest in the contiguous-forested habitat of clearcutting (reference sector), in plots C and D of the forested-corridor habitat, and in plot D of the forested-patch habitat.

the beginning of the study, 10 uncut plots (plot D) were chosen randomly in both forested-patch and forested-corridor habitats and 10 sites were randomly selected in the contiguous forest. These 30 sites were designated as fixed nests and were used in all trials (1–5) for nest placement. For each trial, we randomly chose 10 additional uncut plots (plot D) each in both forested-patch and forested-corridor habitats and 10 sites in the contiguous forest; these additional 30 sites were termed random nests. This resulted in 60 nests/trial, with 20 nests/habitat (forested patch, forested corridor, and contiguous forest) and 30 nests/nest-site type (fixed and random).

Artificial nests (10 cm diam and 10 cm deep) were constructed of chicken wire painted flat black to reduce glare and lined with leaf litter; nests were attached to the nearest woody stem (1–5 cm dbh) with green wire (Yahner and Scott 1988). Two fresh, brown chicken eggs were placed in each nest and sunk slightly below the rim of the nest to minimize detection. We chose large brown chicken eggs in this study because they allowed us to directly compare our results with those obtained in other studies at the study site, including artificial ground and arboreal nest studies conducted before the third cutting cycle (e.g., Yahner and Wright 1985, Yahner and Scott 1988), an artificial ground nest study conducted after the third cutting cycle (Yahner and Mahan 1996a), and a study of Wood Thrush nesting success after the third cutting cycle (Yahner and Ross 1995). One nest was established at each site. In forested-patch and forested-corridor habitats, nests were located 50 m from an edge in the center of plot D; in the contiguous forest, nests were placed at least 50 m from an edge (e.g., logging road). Rubber gloves and boots were worn when placing nests to reduce human scent (Nol and Brooks 1982).

We determined the fates of nests (e.g., undisturbed, disturbed by an avian predator, disturbed by a nonavian predator) at the end of each trial (Yahner and Mahan 1996a). Nest predators were classified by mode of disturbance and general nest appearance; eggs with peck holes were categorized as preyed upon by birds, and nests without eggs or with crushed eggs were classified as preyed upon by nonavian predators (Rearden 1951, Yahner and Scott 1988, Hernandez et al. 1997). Eggs and egg fragments were removed from nests at

TABLE 1. Fate of artificial arboreal nests in relation to type of nest site, habitat, and trial in a managed forested landscape at the Barrens GHMA, Centre County, Pennsylvania, June–July 1995.

Nest fate	Type of nest-site	Habitat	Trial 1	2	3	4	5	Total
Undisturbed	Fixed	Forested patch	8	7	5	4	6	30
		Forested corridor	8	9	8	10	10	45
		Contiguous forest	9	9	9	10	10	47
			25	25	22	24	26	122
	Random	Forested patch	7	3	4	3	4	21
		Forested corridor	10	10	8	10	9	47
		Contiguous forest	7	9	6	10	8	40
			24	22	18	23	21	108
Disturbed	Fixed	Forested patch	2	3	5	6	4	20
		Forested corridor	1	1	2	0	0	4
		Contiguous forest	1	1	1	0	0	3
			4	5	8	6	4	27
	Random	Forested patch	3	7	6	7	6	29
		Forested corridor	0	0	2	0	1	3
		Contiguous forest	3	1	4	0	2	10
			6	8	12	7	9	42

the end of each trial. The location of one nest in the forested-corridor habitat was not found after nest placement during trial 1.

Common bird species nesting in uncut forest within 2 m of ground level at the Barrens Grouse HMA were Wood Thrush (*Hylocichla mustelina*) and Eastern Towhee (*Pipilo erythrophthalmus*; Yahner 1991). Potential predators on artificial arboreal nests were American Crow (*Corvus brachyrhynchos*), Blue Jay (*Cyanocitta cristata*), and raccoon (*Procyon lotor*; Yahner and Scott 1988, Yahner and Morrell 1991). Smaller mammalian predators, e.g., eastern chipmunk (*Tamias striatus*) and white-footed mice (*Peromyscus leucopus*), probably had minimal effect on our artificial nests because of the relatively large egg size (see Roper 1992, Haskell 1995, DeGraaf and Maier 1996, Yahner and Mahan 1996b).

We examined dependency of nest fate (undisturbed and disturbed) on nest-site type (fixed versus random), habitat (forested patch, forested corridor, and contiguous forest), and trial (1–5) using a four-way test-of-independence (BMDP4F, Log-Linear Model; Dixon 1990). Likelihood ratios (G^2) were used to determine interactions of nest fate with the three other variables using log-linear models (Dixon 1990, Sokal and Rohlf 1995). If nest fate was dependent on a variable with more than two levels, we used 2 × 2 *G*-tests-of-independence about the cell(s) of interest.

RESULTS

Sixty-nine (23%) of the 299 artificial arboreal nests were disturbed during the five trials combined (Table 1); one nest location was not found in trial 1. We attributed 11 (16%) of the disturbed nests to avian predators. Nest fate was dependent on nest type, with fewer arboreal nests disturbed at fixed than at random sites (18% vs 28%, respectively; $G = 4.0$, df = 1, $P < 0.05$).

Nest fate varied with habitat ($G = 55.8$, df = 2, $P < 0.001$). Rate of nest disturbance was higher in the forested-patch habitat (49%) compared to either forested-corridor (7%) or contiguous-forested habitats (13%; $G \geq 22.3$, df = 1, $P < 0.001$). The number of disturbed nests in the forested-corridor habitat, however, was similar to that in the contiguous-forest habitat ($P > 0.05$). In contrast, nest fate was not associated with trial or with interactions of two or more variables ($P > 0.05$).

DISCUSSION

We believe that predators did not learn the location of arboreal nests in our study (Eibl-Eibesfeldt 1970, Krebs 1978, Yahner and Wright 1985) because disturbance rates were higher at random than at fixed sites and because rates did not vary among trials. In another study of artificial nests, both avian and mammalian predators preyed upon nests randomly and did not learn the location of experimental nests (Angelstam 1986). In contrast, previous work at the Barrens GHMA showed that predators probably learned the location of ground nests at fixed nests in the forested-patch sector, particularly as the study progressed (trials 4 and 5; Yahner and Mahan 1996a).

Because artificial nests pose potential biases and the debate on their usefulness in assessing success of natural nests continues, caution should be used in interpreting the results obtained from artificial nest studies in making management decisions (e.g., Yahner 1996, Ortega et al. 1998, Wilson et al. 1998). Care should be used when extrapolating results obtained from artificial nest studies compared to naturally occurring nests because predation rates on the two types of nests may vary and predation rates may differ among years (Storaas 1988). For example, predators may use behavioral cues from nesting birds to locate naturally occurring nests. Well designed studies using artificial nests remain a useful approach to making inferences about factors affecting avian nesting success, especially when comparisons are made between local habitats, among nests in a given locality, at the same locality over several years, or in detecting trends in rates of predation (Roper 1992, Yahner and Mahan 1996a, Wilson et al. 1998).

Our study and others provided evidence that uncut wooded corridors, which are at least 100 m wide in a forested landscape affected by clearcutting, may provide considerably more secure nesting habitat for breeding birds than small uncut forest stands. For example, Yahner and Ross (1995) found lower predation on Wood Thrush nests in the forested-corridor habitat (50%) than in the contiguous forest (61%) or forested-patch habitats (100%). Based on a study of nest predation along uncut buffer strips retained after clearcutting near streams in Maine, Vander Haegen and DeGraaf (1996) provided evidence that relatively wide ($\geq$150 m) strips enhanced nesting success of forest birds. Their study included artificial ground and arboreal nests containing Japanese Quail (*Coturnix coturnix*) eggs. Despite conflicting evidence for predator learning of the location of artificial arboreal versus ground nests, we recommend that investigators using artificial nests in fragmented forested landscapes carefully randomize nest placement in order to mitigate detection of nests by predators (see Yahner and Mahan 1996a).

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