

DYNAMICS OF DEPREDAATION ON ARTIFICIAL GROUND NESTS IN HABITAT MANAGED FOR RUFFED GROUSE

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ABSTRACT.—We tested the hypothesis that depredation on artificial ground nests did not differ with plot age, nest location, or time period in an area under intensive Ruffed Grouse (*Bonasa umbellus*) management in central Pennsylvania after a third cutting cycle from May–August 1991. We also compared depredation of nests in the third cycle to that observed in the second cycle on the management area. Sixty-eight (22%) of the nests were disturbed during five trials after the third cutting cycle. Nest fate was independent of age of plot, nest location, and time period ($P > 0.10$). Depredation on artificial nests declined ($P < 0.05$) in most plots from the second to third cutting cycles. We attributed lower rates of depredation after the third cutting cycle to lower relative abundance of corvids compared to the era between the second and third cycles. We concur with other investigators that effects of localized fragmentation on avian nesting success must consider the dynamics of predator abundance to better understand impacts of predators. Received 28 May 1992, accepted 5 Oct. 1992.

An even-aged system of clearcutting to evaluate the effects of forest management on Ruffed Grouse (*Bonasa umbellus*) in central Pennsylvania (Barrens Grouse Habitat Management area [HMA]) resulted in a mosaic of small (1 ha) forest plots that differed in age (Yahner 1989). Previous studies of artificial ground nests on this area demonstrated that depredation was principally due to corvids and that rates varied with plot age and extent of localized forest fragmentation created by intensive habitat management for Ruffed Grouse (Yahner and Wright 1985, Yahner and Cypher 1987, Yahner and Scott 1988). Since the study by Yahner and Wright (1985), the third cutting cycle has occurred, resulting in an increase in forest fragmentation by creation of a contiguous pattern of different forest-age classes on a portion (hereafter termed the 75% area) of the Barrens Grouse HMA (Yahner 1992). Thus, the Barrens Grouse HMA provided a unique opportunity to examine depredation on artificial ground nests in habitat managed intensively and specifically for Ruffed Grouse, as well as to compare our findings with those reported from the same area prior to the third cutting cycle (Yahner and Wright 1985). We tested the hypotheses that (1) depredation on artificial ground nests in an area under intensive Ruffed Grouse habitat management after a third cutting cycle did not differ with age of plot, nest location (distance from edge), or time period and (2) depredation on nests did not vary between the second

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(Yahner and Wright 1985) and third cutting cycles at the Barrens Grouse HMA.

STUDY AREA AND METHODS

Our study was conducted on a 128-ha portion (75% area) of the Barrens Grouse HMA, State Game Lands 176, Centre County, Pennsylvania, the site of an earlier study of depredation on artificial ground nests (Yahner and Wright 1985). The 75% area was within the treated sector of the Barrens Grouse HMA which was managed, using an even-aged system of forest clearcutting under the supervision of the Pennsylvania Game Commission, to create habitat for Ruffed Grouse (Yahner 1991, 1992).

The treated sector consisted of 50 and 75% cut areas, corresponding to the extent of forest fragmentation resulting from clearcutting. The sector contained 136 contiguous, 4-ha blocks, and each block was subdivided into four 1-ha (100 × 100 m) plots arranged in a clockwise pattern (plots A–D). Plot A (western plot) in each block was clearcut during winter 1976–1977 (first cutting cycle). Plot B (northern plot) in each block of the 75% area was clearcut during winter 1980–1981 (second cycle). In addition, a third plot C (eastern plot), in each block of the 75% area was clearcut during winters 1985–1986 and 1986–1987 (third cycle), thereby giving three clearcut plots of different ages and an uncut plot (plot D) in each block of the 75% area (Yahner 1989, 1991, 1992).

Overstory trees (>7.5 cm dbh and >1.5 m tall) in uncut plots were about 60 years old and were primarily bigtooth aspen (*Populus grandidentata*), quaking aspen (*P. tremuloides*), oak (*Quercus* spp.), and pitch pine (*Pinus rigida*). Major understory trees (2.5–7.5 cm dbh) and shrubs (≤2.5 cm in diam) in clearcut and uncut plots were aspen (*Populus* spp.), scrub (*Quercus ilicifolia*), and dwarf chinkapin oak (*Q. prinoides*), and blueberry (*Vaccinium* spp.) (Yahner et al. 1989).

Birds nesting at ground level at the Barrens Grouse HMA included Wild Turkey (*Meleagris gallopavo*), Ruffed Grouse, American Woodcock (*Scolopax minor*), Ovenbird (*Seiurus aurocapillus*), Rufous-sided Towhee (*Pipilo erythrophthalmus*), and Field Sparrow (*Spizella pusilla*) (Yahner and Wright 1985, Yahner 1986). Potential avian predators on ground nests at the Barrens Grouse HMA included American Crow (*Corvus brachyrhynchos*) and Blue Jay (*Cyanocitta cristata*); potential mammalian predators were Virginia opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), weasel (*Mustela* spp.), red fox (*Vulpes vulpes*), and gray fox (*Urocyon cinereoargenteus*) (Therres 1982).

We placed artificial nests during five time periods (trials) from late May to early August 1991 (Table 1). An artificial nest consisted of three fresh, brown chicken eggs put in a slight depression in leaf litter adjacent to a log, stump, or overstory tree (Yahner and Wright 1985). Each trial was six days in length, with eight days between trials. During each trial, we randomly selected eight blocks and established two nests in each plot (C, B, A, and D; hereafter also termed 6-year-old, 10-year-old, 14-year-old, and uncut plots, respectively) between sunrise and 12:00 h. One nest was placed in the center of the plot (interior nest), and the other was positioned medially along and 5 m from the northern boundary of the plot (edge nest) (Yahner and Wright 1985). This experimental design gave a sample size of 64 nests/trial, with 16 nests/age class of plot (A–D) divided equally between interior and edge nests (four of 320 nests were omitted from analyses due to incorrect placement). We wore rubber gloves and boots to minimize human scent at the nest (Nol and Brooks 1982).

We determined the fate (undisturbed, disturbed by an avian predator, disturbed by an unknown predator) of nests six days after placement from sunrise to 12:00 h during each trial. A disturbed nest had one or more broken or missing eggs by day 6. Appearance and mode of disturbance of nests and eggs were used to categorize predators as avian or nonavian

TABLE 1
FATE OF ARTIFICIAL GROUND NESTS IN MANAGED RUFFED GROUSE HABITAT, THE
BARRENS GROUSE HMA, CENTRE COUNTY, PENNSYLVANIA, MAY–AUGUST 1991

Plot age (years)	Location	Trial	Nest fate (N)	
			Undisturbed	Disturbed
6	Interior	1	7	1
		2	5	3
		3	5	3
		4	5	2
		5	7	1
	Subtotal		29	10
	Edge	1	7	1
		2	7	1
		3	7	1
		4	5	2
		5	8	0
	Subtotal		34	5
10	Interior	1	6	2
		2	6	2
		3	6	1
		4	8	0
		5	6	2
	Subtotal		32	7
	Edge	1	7	1
		2	7	1
		3	5	3
		4	6	2
		5	5	2
	Subtotal		30	9
14	Interior	1	6	2
		2	6	2
		3	7	1
		4	6	2
		5	5	3
	Subtotal		30	10
	Edge	1	8	0
		2	7	1
		3	8	0
		4	7	1
		5	2	6
	Subtotal		32	8
Uncut	Interior	1	7	1
		2	6	2
		3	4	4

TABLE 1
CONTINUED

Plot age (years)	Location	Trial	Nest fate (N)	
			Undisturbed	Disturbed
		4	6	2
		5	5	3
	Subtotal		28	12
	Edge	1	6	2
		2	8	0
		3	7	1
		4	6	2
		5	6	2
	Subtotal		33	7

(Rearden 1951, Yahner and Wright 1985). Eggs and eggshell fragments were removed at the end of each trial. We counted the numbers of potential avian predators (American Crows and Blue Jays) while slowly walking (<3 km/h) within 200 m of artificial nests at time of placement and removal (Yahner and Scott 1988, Yahner et al. 1989); time spent at a visit to each nest was approximately five minutes.

We examined dependency of nest fate (undisturbed vs disturbed) on age of plot (6-year-old, 10-year-old, 14-year-old, or uncut), nest location (interior vs edge), and time period (trials 1–5) using a four-way test-of-independence (Dixon 1985), the same three independent factors examined by Yahner and Wright (1985) prior to the third cutting cycle. Likelihood ratios (G^2) were used to test for interactions of nest fate with other variables, using log-linear models (Sokal and Rohlf 1981, Dixon 1985).

We also compared nest fate (undisturbed vs disturbed) between the second cutting cycle (Phase III, Yahner and Wright 1985) and the third cycle (present study) on the same 128-ha portion (75% area) of the Barrens Grouse HMA. In each of three separate analyses, we determined the dependency of nest fate on cutting cycle in plots of three age classes (10-year-old [plot B], 14-year-old [plot A], or uncut [plot D]) to examine whether or not rates of nest depredation changed in the same plots over an 8-year period (1983 vs 1991). We used two-way G -tests-of-independence in these analyses and applied Yate's correction for continuity to each cell prior to analysis (Sokal and Rohlf 1981).

Because avian predators were the major cause of nest failure at the Barrens Grouse HMA (Yahner and Wright 1985), we qualitatively compared average numbers of crows and jays/day (placement and removal of nests) to those recorded in 1986 (Yahner and Scott 1988) and 1988 (Yahner et al., 1989); numbers of crows or jays were not noted in 1983 (Yahner and Wright 1985). In addition, we examined if total number of nests disturbed by predator type (avian vs nonavian) varied between the second cutting cycle (Yahner and Wright 1985) and the third cycle (present study) using a two-way G -test-of-independence and Yate's correction for continuity (Sokal and Rohlf 1981).

RESULTS

Sixty-eight of 316 artificial ground nests (22%) were disturbed during the five trials (Table 1). Nest fate was independent of age of plot ($G =$

0.90, $df = 3$, $P > 0.90$), nest location ($G = 1.88$, $df = 1$, $P > 0.10$), and time period ($G = 4.31$, $df = 4$, $P > 0.30$). Percentage of disturbed nests ranged from 19% in six-year-old plots to 24% in uncut plots. Twenty-five percent of the interior nests were disturbed compared to 18% of the edge nests. Percentage of disturbed nests/trial varied from 16% in trial 1 to 30% in trial 5.

Nest fate differed between second and third cutting cycles (1983 vs 1991) in plot B ($G = 7.84$, $df = 1$, $P < 0.01$) and plot D ($G = 16.05$, $df = 1$, $P < 0.001$) but not in plot A ($G = 1.88$, $df = 1$, $0.05 < P < 0.10$). Forty-one percent of the nests in plot B were disturbed subsequent to the second cutting cycle compared to 21% after the third cycle; similarly, more nests were disturbed in plot D after the second (55%) than after the third cycle (24%). In plot A, 32 and 23% of the nests were disturbed subsequent to second and third cycles, respectively.

We noted an average of 2.3 crows/day and 4.6 jays/day (placement and removal) in our study. More crows (61%) and jays (35%) were observed in trial 1 than in any of the other four trials; when trial 1 was excluded, averages of only 1.1 crows/day and 3.7 jays/day were noted (trials 2–5). In contrast, greater numbers of avian predators were observed in previous studies of artificial nests at the Barrens Grouse HMA. In 1986, averages of 2.4 crows/day and 6.2 jays/day were found (Yahner and Scott 1988); in 1988, 2.4 crows/day and 5.3 jays/day were observed (Yahner et al. 1989). Furthermore, nest fate was dependent on cutting cycle, with 36% of the ground nests lost to avian predators in 1983 (Yahner and Wright 1985) compared to only 9% in the present study ($G = 14.52$, $df = 1$, $P < 0.001$).

DISCUSSION

The rate of nest disturbance in our study (22%) was lower than rates reported in previous studies of depredation of artificial ground nests at the Barrens Grouse HMA (32–42%, Yahner and Wright 1985, Yahner and Scott 1988, Yahner et al. 1989). Redmond et al. (1982) noted a relatively low rate of nest loss (17%) for Spruce Grouse (*Canachites canadensis franklinii*) in Alberta that established nests in habitats with dense, shrubby vegetation; in their study, all nest predation was attributed to mammals. In contrast, Redmond et al. (1982) found 70% of nests established by Spruce Grouse (*C. c. canace*) in new Brunswick were lost to mammalian predators; these nests were in habitats with relatively sparse vegetation near ground level. Similarly, Yahner and Morrell (1991) observed an 80% loss of artificial ground nests, principally due to high abundance of raccoons, in irrigated forested stands located 10 km from the Barrens Grouse HMA.

Ground nests may be less susceptible to predation than arboreal nests

(Joern and Jackson 1983, Martin 1987, Yahner and Scott 1988), especially when birds rather than mammals are the principal predators (Yahner et al. 1989). At the Barrens Grouse HMA, avian predators (e.g., American Crows and Blue Jays) rather than mammalian predators (e.g., raccoons) traditionally have had the major impact on artificial and natural avian nests (Yahner et al. 1989, Yahner 1991).

We have no evidence of temporal changes in abundance of mammalian predators at the Barrens Grouse HMA (Yahner and Morrell 1991). In contrast, limited data suggest that relative abundance of avian predators has declined subsequent to the third cutting cycle compared to the era between the second and third cycles. Both American Crows and Blue Jays are adapted to edge habitats (Whitcomb et al. 1981), and relative abundances are negatively correlated with the percentage of forest within 2 km of sampling units (Robbins et al. 1989). However, relative abundances of these two corvids are positively associated with size of forest stands (Robbins et al. 1989). Hence, despite increased fragmentation at the Barrens Grouse HMA with the third cutting cycle (Yahner 1992), relative abundances of crows and jays probably declined in the 75% area because only one-half of the uncut forest (plots C and D combined = 2 ha) present after the second cutting cycle remained after the third cycle (plot D only = 1 ha). As forest stands became smaller, nest-site availability was reduced, thereby conceivably affecting breeding abundance of both corvids (Stouffer and Caccamise 1991). We would expect nest predation by crows to be reduced with lower nest-site availability because predation is greater on nests within home ranges of breeding crows than outside home ranges (Sullivan and Dinsmore 1990). Moreover, smaller forest stands perhaps reduced both the availability of mast and the abundance of jays; jays are dependent on mast as food (Smith 1986) at the Barrens Grouse HMA.

Although we found no difference in rates of nest depredation with age of stand, distance of nest from edge, or time period (trial), we urge caution in interpreting our results. In previous studies, rates of depredation were significantly associated with age of plot or with trial (Yahner and Wright 1985, Yahner and Cypher 1987) when corvids, which represent efficient nest predators (Wray et al. 1982, Joern and Jackson 1983), were abundant. We concur with others (Bowman and Harris 1980, Picman 1988, Yahner and Morrell 1991) that effects of localized forest fragmentation, such as created by intensive habitat management for Ruffed Grouse, on avian nesting success must consider the dynamics of predator abundance to understand impacts on avian nesting success.

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