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Experimental Analysis of Nest Predation: Effects of Habitat and Nest Distribution

Charles D. Ardizzone

The College at Brockport

Christopher J. Norment

The College at Brockport, cnorment@brockport.edu

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ECOLOGY AND CONSERVATION OF GRASSLAND BIRDS OF THE WESTERN HEMISPHERE

PETER D. VICKERY AND JAMES R. HERKERT, EDITORS



Studies in Avian Biology No. 19

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Peter D. Vickery and James R. Herkert
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Cover photograph of Greater Rheas (*Rhea americana*) in the Pampas of Argentina by Juan Carlos Reboreda.

LIST OF AUTHORS

CHARLES D. ARDIZZONE
Department of Biological Sciences
State University of New York College at Brockport
Brockport, NY 14420
(present address: 1011 East Tudor Road
Anchorage, AK 99503)

ROBERT A. ASKINS
Department of Zoology
Connecticut College
New London, CT 06320

GIANFRANCO D. BASILI
Department of Wildlife Ecology
University of Wisconsin
Madison, WI 53706
(present address: Florida Audubon Society
1331 Palmetto Avenue
Winter Park, FL 32789)

BARRY C. BENNETT
Department of Environmental, Population, and
Organismic Biology
University of Colorado
Boulder, CO 80309-0334

LOUIS B. BEST
Department of Animal Ecology
Iowa State University
Ames, IA 50011

CARL E. BOCK
Department of Environmental, Population, and
Organismic Biology
University of Colorado
Boulder, CO 80309-0334

JANE H. BOCK
Department of Environmental, Population, and
Organismic Biology
University of Colorado
Boulder, CO 80309-0334

RANDALL B. BOONE
Department of Wildlife Ecology
Nutting Hall
University of Maine
Orono, ME 04469

ROBERTO B. CAVALCANTI
Departamento de Zoologia
Universidade de Brasília
70910-900 Brasília, D.F., Brazil

GERARDO CEBALLOS
Instituto de Ecología
Universidad Nacional Autónoma de México, C.U.
Apartado Postal 70-275
México, D.F., C.P. 04510
Mexico

STEPHEN K. DAVIS
Saskatchewan Wetland Conservation Corporation
202-2050 Cornwall Street
Regina, SK S4P 2K5
Canada

MARTHA J. DESMOND
Department of Forestry, Fisheries and Wildlife
University of Nebraska
Lincoln, NE 68583-0819
(present address: Caesar Kleberg Wildlife Research
Institute
Texas A&M University
Kingsville, TX 78363)

DAVID C. DUNCAN
Saskatchewan Wetland Conservation Corporation
202-2050 Cornwall Street
Regina, SK S4P 2K5
Canada

WILLIAM R. EVANS
Cornell Laboratory of Ornithology
159 Sapsucker Woods Road
Ithaca, NY 14850
(present address: P.O. Box 46
Mecklenberg, NY 14863)

BRICK M. FEVOLD
Department of Wildlife Ecology
University of Wisconsin
Madison, WI 53706

FABIÁN MARCELO GABELLI
Laboratorio de Biología del Comportamiento
Instituto de Biología y Medicina Experimental
Obligado 2490
1428 Buenos Aires, Argentina and
Facultad de Psicología
Universidad de Buenos Aires
Buenos Aires, Argentina

WILLIAM D. GLASS
Illinois Department of Natural Resources
Division of Natural Heritage
P. O. Box 88
Wilmington, IL 60481

ANDREW J. HANSEN
Fish & Wildlife Management Program
Biology Department
Montana State University
Bozeman, MT 59717

KATHLEEN HARTMAN
Department of Biological Sciences
State University of New York College at Brockport
Brockport, NY 14420

JAMES R. HERKERT
Illinois Endangered Species Protection Board
524 South Second Street
Springfield, IL 62701

C. STUART HOUSTON
853 University Drive
Saskatoon, SK S7N 0J8
Canada

MALCOLM L. HUNTER, JR.
Department of Wildlife Ecology
Nutting Hall
University of Maine
Orono, ME 04469

LAWRENCE D. IGL
Northern Prairie Wildlife Research Center
U.S. Geological Survey, Biological Resources
Division
8711 37th Street SE
Jamestown, ND 58401

M. ALAN JENKINS
George M. Sutton Avian Research Center
P.O. Box 2007
Bartlesville, OK 74005-2007

DOUGLAS H. JOHNSON
Northern Prairie Wildlife Research Center
U.S. Geological Survey, Biological Resources
Division
8711 37th Street SE
Jamestown, ND 58401

MALCOLM T. JONES
Department of Wildlife Ecology
Nutting Hall
University of Maine
Orono, ME 04469

STEVEN T. KNICK
USGS Forest and Rangeland Ecosystem Science
Center
Snake River Field Station
970 Lusk Street
Boise, ID 83706

FRITZ L. KNOPF
U.S. Geological Survey, Biological Resources
Division
4512 McMurry Avenue
Fort Collins, CO 80525-3400

ROLF R. KOFORD
Northern Prairie Wildlife Research Center
U.S. Geological Survey, Biological Resources
Division
8711 37th Street SE
Jamestown, ND 58401
(present address: Iowa Cooperative Fish and Wildlife
Research Unit
Science Hall II
Iowa State University
Ames, IA 50011)

T. BRUCE LAUBER
Department of Wildlife Ecology
Nutting Hall
University of Maine
Orono, ME 04469
(present address: Department of Natural Resources
Fernow Hall
Cornell University
Ithaca, NY 14853)

RURIK LIST
Department of Zoology, Oxford University
South Parks Road
Oxford OX1 3PS
United Kingdom

ELIZABETH M. MADDEN
Fish & Wildlife Management Program
Biology Department
Montana State University
Bozeman, MT 59717
(present address: J. Clark Salyer National Wildlife
Refuge
P.O. Box 66
Upham, ND 58789)

PATRICIA MANZANO-FISCHER
Department of Zoology, Oxford University
South Parks Road
Oxford OX1 3PS
United Kingdom
(present address: Apartado Postal 32-F
Toluca, México 50190
Mexico)

KATHY MARTIN
Centre for Applied Conservation Biology
Department of Forest Sciences
#270-2357 Main Mall
University of British Columbia
Vancouver, BC V6T 1Z4
Canada
(present address: Canadian Wildlife Service
5421 Robertson Road, R.R. 1
Delta, BC V4K 3N2
Canada)

DAVID K. MELLINGER
Cornell Laboratory of Ornithology
159 Sapsucker Woods Road
Ithaca, NY 14850
(present address: Monterey Bay Aquarium Research
Institute
7700 Sandholdt Road
Moss Landing, CA 95039-0628)

ANDREW J. MURPHY
North American Waterfowl Management Plan
c/o Ducks Unlimited Canada
#8, 5580-45th Street
Red Deer, AB T4N 1L1
Canada

KARI J. NELSON
Centre for Applied Conservation Biology
Department of Forest Sciences
#270-2357 Main Mall
University of British Columbia
Vancouver, BC V6T 1Z4
Canada
(present address: 1895 Sea Lion Crs.
Nanoose Bay, BC V9P 9J3
Canada)

CHRISTOPHER J. NORMENT
Department of Biological Sciences
State University of New York College at Brockport
Brockport, NY 14420

RAYMOND J. O'CONNOR
Department of Wildlife Ecology
Nutting Hall
University of Maine
Orono, ME 04469

LAURA K. PAINE
Department of Agronomy
University of Wisconsin
Madison, WI 53706

DUSTIN W. PERKINS
Department of Forestry and Wildlife Conservation
Holdsworth Natural Resource Center
University of Massachusetts
Amherst, MA 01003

BRUCE G. PETERJOHN
U.S. Geological Survey, Biological Resources
Division
Patuxent Wildlife Research Center
12100 Beech Forest Road
Laurel, MD 20708

KENNETH L. PETERSEN
Department of Environmental Studies
Dordt College
Sioux Center, IA 51250

A. TOWNSEND PETERSON
Natural History Museum
University of Kansas
Lawrence, KS 66045

DAVID R. C. PRESCOTT
Land Stewardship Centre of Canada
13 Mission Avenue
St. Albert, AB T8N 1H6
Canada
(present address: Alberta Conservation Association
P.O. Box 40027, Baker Centre Postal Outlet
Edmonton, AB T5J 4M9
Canada)

DAN L. REINKING
George M. Sutton Avian Research Center
P.O. Box 2007
Bartlesville, OK 74005-2007

MARK B. ROBBINS
Natural History Museum
University of Kansas
Lawrence, KS 66045

RONALD W. ROHRBAUGH, JR.
George M. Sutton Avian Research Center
P.O. Box 2007
Bartlesville, OK 74005-2007
(present address: Cornell Laboratory of Ornithology
159 Sapsucker Woods Road
Ithaca, NY 14850)

KENNETH V. ROSENBERG
Cornell Laboratory of Ornithology
159 Sapsucker Woods Road
Ithaca, NY 14850

JAY J. ROTELLA
Fish & Wildlife Management Program
Biology Department
Montana State University
Bozeman, MT 59717

JOHN T. ROTENBERRY
Natural Reserve System and Department of Biology
University of California
Riverside, CA 92521

JEFFERY R. RUPERT
U.S. Geological Survey, Biological Resources
Division
4512 McMurry Avenue
Fort Collins, CO 80525-3400

DAVID W. SAMPLE
Bureau of Research
Wisconsin Department of Natural Resources
Monona, WI 53716

JOHN R. SAUER
U.S. Geological Survey, Biological Resources
Division
Patuxent Wildlife Research Center
12100 Beech Forest Road
Laurel, MD 20708

JULIE A. SAVIDGE
Department of Forestry, Fisheries and Wildlife
University of Nebraska
Lincoln, NE 68583-0819

JOSEF K. SCHMUTZ
Department of Biology
University of Saskatchewan
112 Science Place
Saskatoon, SK S7N 5E2
Canada

STEVE K. SHERROD
George M. Sutton Avian Research Center
P.O. Box 2007
Bartlesville, OK 74005-2007

W. GREGORY SHRIVER
Department of Forestry and Wildlife Conservation
Holdsworth Natural Resource Center
University of Massachusetts
Amherst, MA 01003
(present address: College of Environmental Science
and Forestry
State University of New York
1 Forestry Drive
Syracuse, NY 13210)

JOSÉ MARIA CARDOSO DA SILVA
Universidade Federal de Pernambuco
Centro de Ciências Biológicas
Departamento de Zoologia
Av. Prof. Moraes Rego, 1235
50670-420 Recife, PE
Brazil

STANLEY A. TEMPLE
Department of Wildlife Ecology
University of Wisconsin
Madison, WI 53706

PABLO LUIS TUBARO
Laboratorio de Biología del Comportamiento
Instituto de Biología y Medicina Experimental
Obligado 2490
1428 Buenos Aires
Argentina

DANIEL J. UNDERSANDER
Department of Agronomy
University of Wisconsin
Madison, WI 53706

PETER D. VICKERY
Department of Wildlife Ecology
Nutting Hall
University of Maine
Orono, ME 04469
(present address: Center for Biological Conservation
Massachusetts Audubon Society
Lincoln, MA 01773 and
Department of Forestry and Wildlife Conservation
University of Massachusetts
Amherst, MA 01003)

JEFFREY V. WELLS
Cornell Laboratory of Ornithology
159 Sapsucker Woods Road
Ithaca, NY 14850
(present address: National Audubon Society
Cornell Laboratory of Ornithology
159 Sapsucker Woods Road
Ithaca, NY 14850)

MAIKEN WINTER
Department of Behavioral Physiology
University-Tübingen
72072 Tübingen
Germany
(present address: 611 Winston Court, Apt. #4
Ithaca, NY 14850-1953)

DONALD H. WOLFE
George M. Sutton Avian Research Center
P.O. Box 2007
Bartlesville, OK 74005-2007

EXPERIMENTAL ANALYSIS OF NEST PREDATION IN A NEW YORK GRASSLAND: EFFECTS OF HABITAT AND NEST DISTRIBUTION

CHARLES D. ARDIZZONE AND CHRISTOPHER J. NORMENT

Abstract. Depredation of artificial avian ground nests was studied in 1994 and 1995 on cool-season and warm-season grasslands in western New York State. The study examined the effects of habitat type and distance from forested edge on nest success in adjacent fields. Two experiments were conducted. The first examined the effects of nest distribution on nest success. Experimental predation rates were highest at the field-forest boundary, although there was no correlation between predation rate and distance from edge. Overall predation rates for cool-season grasslands differed significantly between years, with predation rates being higher during the 1995 field season. The second experiment examined the effects of dense nesting cover on nest success. Predation rates for nests in dense nesting cover varied among distance classes in 1995 but not in 1994; predation rates were also higher in 1995 than in 1994. Experimental rates of nest predation were similar in pasture/cool-season grasslands and warm-season grasslands in both years, suggesting that dense cover did not improve productivity of ground-nesting birds. Indirect evidence suggested that the primary predators along the forest-field boundaries were mammals, with birds and small mammals most frequently depredating nests away from the edge. This study suggests that dense nesting cover does not increase nesting success for small passerines on our study site.

ANÁLISIS EXPERIMENTAL DE DEPREDACIÓN DE NIDOS EN UN PASTIZAL EN NUEVA YORK: LOS EFECTOS DEL HÁBITAT Y DE LA DISTRIBUCIÓN DE NIDOS

Sinopsis. Se estudió la depredación de nidos avícolas artificiales en suelo durante 1994 y 1995 en pastizales de la estación fresca y de la estación cálida en el este del estado de Nueva York. El estudio examinó los efectos del tipo de hábitat y de la distancia desde el límite del bosque en el éxito de los nidos en campos adyacentes. Se hicieron dos experimentos. El primero revisó los efectos de la distribución de nidos en el éxito de los nidos. Las tasas experimentales de depredación fueron mayores en el límite del campo con el bosque, aunque no hubo correlación entre la tasa de depredación y la distancia del límite. Las tasas totales de depredación para los pastizales de estación fresca difirieron significativamente entre años, con las mayores tasas de depredación durante el período de investigación de 1995. El segundo experimento revisó los efectos de cobertura densa de los nidos en el éxito de los mismos. Las tasas de depredación para los nidos en la cobertura densa variaron en las diferentes clases de distancia en 1995 pero no en 1994; también las tasas de depredación fueron más altas en 1995 que en 1994. Las tasas experimentales de depredación de nidos fueron similares en prados/pastizales de estación fresca y pastizales de estación cálida en los dos años, lo que indica que la cobertura densa no mejoró la fertilidad de las aves que anidaron en el suelo. Evidencia indirecta indicó que los depredadores principales a lo largo del límite entre el campo y el bosque fueron mamíferos, y que aves y mamíferos pequeños depredaron los nidos fuera del límite con más frecuencia. Este estudio señala que la cobertura densa de nidos no incrementa el éxito de los nidos para las pequeñas aves paseriformes en el área de nuestro estudio.

Key Words: artificial nests; grassland birds; nest success; New York; predation.

Populations of several neotropical migrant songbirds have declined in many regions of North America since the mid- to late 1970s (Robbins et al. 1989). Significant negative trends have been noted for grassland and early successional bird species at regional and continental scales (Robbins et al. 1986, Hagan et al. 1992, Hussell et al. 1992, James et al. 1992, Herkert 1995). One of the most important factors contributing to the decline of grassland nesting birds is breeding-ground habitat loss (Herkert 1991, Warner 1994). This habitat loss has been attributed to changing land-use practices that have dramatically reduced the amount and quality of avail-

able grassland habitat, in part by increasing habitat fragmentation (Herkert 1991, Warner 1994).

Wildlife managers traditionally encouraged landscape fragmentation to maximize the amount of habitat interspersion and edge (Faaborg et al. 1993). Many biologists considered the edge between two adjacent habitat types to be a positive feature of the landscape for wildlife (Kremsater and Bunnell 1992), and wildlife refuge managers often created as much edge as possible with little concern for the effects of these actions on nongame birds (Noss 1983). More recently, wildlife biologists have challenged the idea that edge benefits most wildlife

and have begun reexamining the effects of edge on neotropical migrant landbirds (Reese and Ratti 1988, Yahner 1988).

Increased isolation and fragmentation of breeding habitats can increase nest parasitism and nest predation (Wilcove 1985, Terborgh 1992). Nest predation is a primary source of nest loss for many avian species, accounting for a majority of all losses across a wide diversity of species, habitats, and geographic locations (Ricklefs 1969; Martin 1992, 1993). Depredation of avian nests may vary with habitat (Andrén and Angelstam 1988, Picman 1988), extent of habitat fragmentation (Wilcove 1985, Yahner and Scott 1988), degree of concealment provided by vegetation (Bowman and Harris 1980, Sugden and Beyersbergen 1986), and distance from edge (Gates and Gysel 1978, Wilcove 1985). Because increased predation along edges may cause species to reproduce well below levels necessary to maintain adequate population levels (Wilcove 1985), a full understanding of edge effects is needed if bird populations are to be managed successfully (Reese and Ratti 1988, Yahner 1988, Yahner and Scott 1988). In a review of 14 artificial- and 7 natural-nest predation studies, Paton (1994) concluded that more data are needed on nest predation rates between 100 and 200 m of the field-forest ecotone and that artificial nests should be placed at smaller increments (20–25 m) to quantify threshold edge effects. Because fragmentation and loss of grassland habitat, and concurrent creation of edge, are ongoing processes in New England and New York State (U.S. Department of Agriculture 1936–1991, Bollinger and Gavin 1992), we undertook this study to gather data on how nest-predation rates are affected by proximity to field-forest boundaries in two grassland habitat types in New York.

METHODS

Field work was conducted at the Iroquois National Wildlife Refuge (NWR), administered by the U.S. Fish and Wildlife Service, and at adjacent New York State wildlife management areas, administered by the New York State Department of Conservation. Together these areas comprise approximately 8,000 ha and contain a mosaic of habitat types including pastures/cool-season grasslands, warm-season grasslands dominated by switchgrass (*Panicum* spp.), old fields, marshes, fallow fields, deciduous forests, and wetlands. Grasslands ranging in size from less than 1 ha to 98 ha occur in some upland portions of the refuge and adjacent state-owned lands. Although the primary management objective of Iroquois NWR is to provide optimum conditions for resting, feeding, and nesting waterfowl (Iroquois NWR 1990), grassland habitats in the area support breeding populations of Savannah Sparrows (*Passerculus sandwichensis*), Bobolinks (*Dolichonyx oryzivorus*), Eastern Meadowlarks (*Sturnella magna*),

and Northern Harriers (*Circus cyaneus*). Many potential nest predators occur on the refuge and adjacent state-owned lands. Potential mammalian nest predators include raccoons (*Procyon lotor*), weasels (*Mustela* spp.), red foxes (*Vulpes vulpes*), and striped skunks (*Mephitis mephitis*; Iroquois NWR 1990). Potential avian nest predators include Blue Jays (*Cyanocitta cristata*) and American Crows (*Corvus brachyrhynchos*; Iroquois NWR 1990).

In early June of 1994 and 1995 we conducted two experiments to determine how predation rates on artificial nests are affected by proximity to field-forest boundaries and habitat type. Our first experiment examined the relationship between distance from the forest edge and nest success. In 1994 and 1995 we placed 21 transects of 7 artificial nest cups each perpendicular to the forest-field boundaries in pastures and cool-season grasslands, which are planted with native and introduced cool-season grasses that generally produce the major portion of their growth in winter and early spring. These pastures/cool-season grasslands ranged in area from 33 to 98 ha. The transects were separated from each other by at least 100 m. Artificial nest cups were placed 0, 25, 50, 75, 100, 125, and 150 m from the edge. Since markers may guide predators to nests (Picozzi 1975), nest cups were not marked in any way; instead, a small section of flagging was placed 5 m to one side of the beginning of each transect to facilitate relocation. Artificial nest cups were commercial wicker canary (*Serinus* sp.) nest cups (10.5 cm wide, 5 cm deep), each containing one Common Quail (*Coturnix coturnix*) egg. All eggs were mottled to some degree. Nest cups were checked once, at the end of 15 d, which is approximately the combined egg-laying and incubation period of many small passerines. We considered nests depredated if an egg was destroyed or removed from the nest cup.

Our second experiment examined effects of dense nesting cover on nest success. At Iroquois NWR, dense nesting cover occurs in small (<8 ha) warm-season grasslands, planted primarily in switchgrass, which produces most or all of its growth in late spring or summer and is usually dormant in winter. Experimental protocol followed that used in the first experiment. Transects were placed perpendicular to boundaries between forests and adjacent warm-season grasslands, were marked in a similar manner as in the first experiment, and were separated from one another by 100 m. Artificial nest cups were placed at 25-m increments. The small size of available warm-season grasslands limited the number of nest cups placed in each field and the distance of nest cups from the edge; all nest cups thus were within 100 m of the field-forest edge. Nest cups contained one Common Quail egg and were checked at the end of the 15-d period. Because of the small size of the warm-season grasslands, comparisons between the different habitats could have been confounded by area effects. In an attempt to partially control for area effects, comparisons of between-habitat predation rates included only those nests located 50 m or less from edge. This included most (80%; $N = 122$) of the nests placed in cool-season grasslands.

In addition to conducting artificial nest experiments, we also conducted intensive nest searches to locate grassland bird nests, from which natural predation

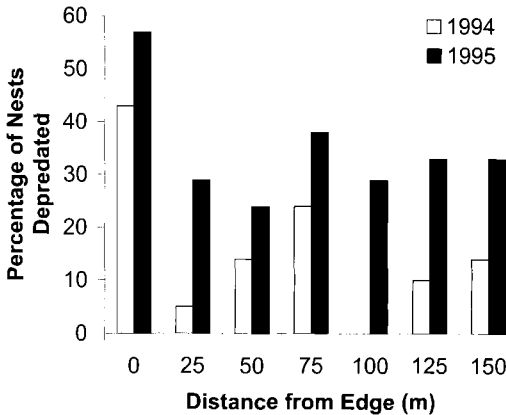


FIGURE 1. Nest-predation rates for artificial nests in pastures/cool-season grasslands at Iroquois NWR, Alabama, New York, 1994–1995. $N = 21$ at each distance for each year.

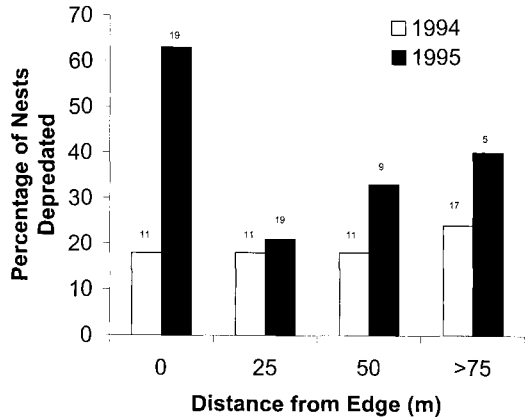


FIGURE 2. Nest-predation rates for artificial nests in warm-season grasslands at Iroquois NWR, Alabama, New York, 1994–1995. Sample sizes are indicated above bars.

rates could be compared to rates for artificial nests. Once located, each nest was marked with a numbered flag 5 m north of the nest. We revisited nests every 3–4 d until the nesting attempt ended. During each visit we recorded the number of eggs and/or nestlings in the nest and checked for the presence of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*). Natural nests were considered successful if they fledged at least one young.

After all nesting attempts were completed, we returned to each nest to record local habitat characteristics. We recorded the height of vegetation at the nest cup and measured the height of vegetation surrounding the nest, sampling at 1-m increments along 5-m transects extending outward from the nest cup in the four cardinal directions (north, south, east, and west). At each sampling point we recorded the maximum height of vegetation. We also took Robel-pole measurements in the four cardinal directions to help determine the density of vegetation surrounding the nest (Robel et al. 1970).

Between-year and between-habitat effects were analyzed using χ^2 tests. The percentage of nests depredated at each distance in pastures/cool-season grasslands was analyzed using Spearman's rank correlation coefficient to determine if nest distribution had any effect on predation rates. Significance level was set at $\alpha = 0.05$.

RESULTS

Results of the first experiment showed that predation rates were highest at forest-field boundaries in both years. In 1994, 43% of all nests located at the edge were destroyed, and in 1995, 57% of all nests at the edge were destroyed (Fig. 1). Although predation rates were highest where the two habitats met, distance from edge was not related to nest-predation rates in any consistent manner; however, small sample sizes may have limited the power to detect pat-

terns in the data. Predation rates for 1994 differed significantly ($\chi^2 = 16.24$, $df = 6$, $P = 0.0125$) among the different distances; however, there was no significant correlation between predation rate and distance ($r_s = -0.324$, $P > 0.05$). In 1995 predation rates did not differ significantly among distances ($\chi^2 = 4.311$, $df = 6$, $P = 0.635$), and there was no significant correlation between predation rate and distance ($r_s = -0.073$, $P > 0.05$). Overall predation rates in pastures/cool-season grasslands were significantly higher in 1995 than in 1994 ($\chi^2 = 10.59$, $df = 1$, $P = 0.001$; Fig. 1).

Results of the second experiment showed that in 1994 there was no significant distance effect in warm-season grasslands ($\chi^2 = 6.74$, $df = 3$, $P = 0.081$). In 1995, however, predation rates differed significantly among distances ($\chi^2 = 11.95$, $df = 3$, $P = 0.008$), being highest at field-forest boundaries. Overall predation rates in warm-season grasslands were significantly higher in 1995 than in 1994 ($\chi^2 = 5.01$, $df = 1$, $P = 0.025$; Fig. 2).

Artificial-nest predation rates were similar in warm-season grasslands and pastures/cool-season grasslands in 1994 and 1995 (Table 1). Overall predation rates for nests located 50 m or less from the edge did not differ significantly between warm- and cool-season grasslands in 1994 ($\chi^2 = 0.82$, $df = 1$, $P = 0.775$) and 1995 ($\chi^2 = 2.108$, $df = 1$, $P = 0.147$).

Predation rates for artificial nests and natural nests that we followed were similar (Table 1). For example, in 1994 predation rates for artificial nests were 16% in cool-season grasslands and 20% in warm-season grasslands, whereas

TABLE 1. PREDATION RATES ON ARTIFICIAL AND NATURAL NESTS IN GRASSLAND HABITATS AT IROQUOIS NWR, ALABAMA, NEW YORK, 1994–1995

Habitat/species	1994		1995		Totals	
	% depredated	N	% depredated	N	% depredated	N
Artificial nests						
Cool-season grasslands/pastures	16	147	35	147	25	294
Warm-season grasslands	20	50	40	52	30	102
Savannah Sparrow nests	19	26	24	25	21	52
Bobolink nests	33	24	60	10	41	34

33% of Bobolink nests and 19% of Savannah Sparrow nests were depredated.

DISCUSSION

Several studies have demonstrated that nest predation decreases as distance from the forested edge increases (Gates and Gysel 1978, Wilcove 1985, Paton 1994). In our study, however, there was no significant correlation between predation rate and distance from edge, although the highest predation rates were observed at forest edge. This may be explained in several ways. First, a forest-grassland edge may function as a biological barrier and may concentrate predator activity along the wooded edge (Bider 1968, Johnson and Temple 1990). Raccoons use edges as travel lanes, which may increase nest predation (Fritzell 1978). Secondly, passerine nests may be destroyed incidentally as predators search for other prey items that are concentrated along edges (Vickery et al. 1992).

Several studies have concluded that depredation of avian nests may vary with habitat (Møller 1987, Andrén and Angelstam 1988, Picman 1988). Rates of artificial-nest predation in our study, however, were very similar between grassland habitat types, suggesting that dense nesting cover in warm-season grasslands will not significantly improve the productivity of nesting passerines. Warm-season grasslands in the study area also support few grassland bird species and individuals (Norment et al. 1999).

Significant increases in predation rates occurred in 1995 for both habitat types. These in-

creases may be explained by the reduced density and height of vegetation in 1995 compared to 1994. Spring weather in western New York was cooler in 1995 than in 1994. There was also considerably less spring rainfall in 1995 than in 1994 (11.91 vs. 25.88 cm; SUNY Brockport Earth Science Dept., unpubl. data), leading to decreased vegetation growth. In our study area, most nest measurements related to height and density of vegetation were significantly smaller in 1995 than in 1994 (Table 2). Tall, dense vegetational cover may provide olfactory, visual, and physical barriers between predators and nests of ground-nesting birds (Bowman and Harris 1980, Redmond et al. 1982, Sugden and Beyersbergen 1986). Many studies have found that reduced vegetational cover increases rates of nest predation (e.g., Wray and Whitmore 1979, Bowman and Harris 1980, Peterson and Best 1987). Mankin and Warner (1992) found that rates of predation were strongly influenced by the level of nest concealment, regardless of the predator's search strategy. The lower degree of concealment provided by vegetation in 1995 in our study site may have allowed predators to find more nests (e.g., Bobolinks; Table 1). Also, the winter of 1994–1995 was very mild; total snowfall was 171 cm compared with 358 cm in the winter of 1993–1994 (SUNY Brockport Earth Science Dept., unpubl. data). This may have allowed an increase in the number of mammalian predators because of decreased winter mortality rates.

Most grassland habitats support a variety of

TABLE 2. BETWEEN-YEAR DIFFERENCE IN NEST-SITE CHARACTERISTICS AT IROQUOIS NWR, ALABAMA, NEW YORK, 1994–1995

Measurement	Bobolink			Savannah Sparrow		
	1994	1995	P ^a	1994	1995	P ^a
Robel pole (\bar{X})	5.675	3.71	0.000	4.78	3.99	0.044
Height of nest-site vegetation (cm; \bar{X})	54.10	43.30	0.035	44.80	46.40	0.700
Height of vegetation at nest (cm)	62.90	44.20	0.004	52.50	43.30	0.060
% of nests successful ^b	64.00	13.00		79.00	71.00	

^a 2-sample t-test.

^b Apparent nest success—nests fledging at least one young; percentages include nest abandonments.

predators that employ different foraging techniques and whose importance as nest predators may change annually (Gottfried and Thompson 1978, Vickery et al. 1992). In our study, many of the artificial nest cups located nearest the edge were moved or disturbed, most likely by relatively large mammalian predators such as striped skunks, raccoons, and opossums (*Didelphis virginiana*; Best 1978, Martin 1992). In contrast, most depredated nests away from the forest edge had not been disturbed and were missing only the egg, which suggests predation by snakes or birds (Best 1978, Picman 1988). Several depredated nests ($N = 5$) away from the field-forest boundary also contained punctured eggs, whereas others contained only eggshell fragments—damage most likely caused by small mammals or birds (Best 1978, Maxson and Oring 1978, Picman 1992).

Haskell (1995) suggested that artificial nest experiments using quail (*Coturnix*) eggs are inappropriate for investigating among-fragment differences in predation rates on nests of neotropical migrants because of the size differences between quail eggs and neotropical birds' eggs. Quail-egg experiments may underestimate predation rates because a quail egg's larger size partially excludes known small-mouthed mammalian egg predators (Haskell 1995). This may be true for nest-predation studies in forested sites; however, only a small percentage (0.2%) of our depredated artificial nests showed evidence of predation by small-mouthed mammals such as mice (*Peromyscus* spp.), and we saw little evidence of small-mouthed mammal predation on natural nests. Other authors (e.g., Angelstam 1986, Yahner and Voytko 1989) believe that in some situations artificial nests may actually be depredated at higher rates than natural nests because adult birds associated with natural nests conceal eggs while incubating and often defend nests against potential predators. Although results of artificial-nest predation experiments should not be generalized to predation rates on natural bird nests (Angelstam 1986, Roper 1992), artificial predation rates may provide an estimate of relative predation rates, which in turn may be useful in determining future management practices (Reitsma 1992, Paton 1994). In our study, predation rates for artificial and natural nests were similar.

Although dense nesting cover may be beneficial for nesting waterfowl in some cases (Clark and Nudds 1991), our study suggests that it does not appear to increase nesting success for small passerines at Iroquois NWR. Birds nesting in dense nesting cover at Iroquois NWR, including Song Sparrows (*Melospiza melodia*) and Swamp Sparrows (*M. georgiana*), suffer higher rates of

nest predation than do grassland birds nesting in cool-season grasslands (C. J. Normont, unpubl. data). In nests away from the immediate vicinity of the field-forest boundary, we found no consistent relationship between distance from edge and nest success.

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