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Effect of reducing the availability of magpie nest sites on duck nest success

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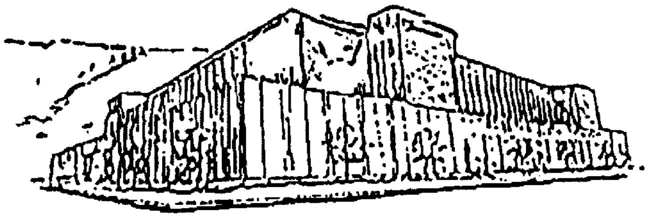

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EFFECT OF REDUCING THE AVAILABILITY OF MAGPIE NEST SITES ON DUCK NEST SUCCESS

By

Randell R. Meidinger

B.S., South Dakota State University, 1994

Presented in partial fulfillment of the
requirements for the degree of
Master of Science
The University of Montana
1998

Approved by

DJ Ball
Chairman, Board of Examiners

Dean, Graduate School

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Date

ABSTRACT

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Effect of Reducing the Availability of Magpie Nest Sites on Duck Nest Success

Director: Dr. I. J. Ball

Russian olive (*Elaeagnus angustifolia*) trees were removed from 347 ha of the Sterling Wildlife Management Area (SWMA) in southeastern Idaho during 1993-94, prior to my first field season in 1995, to determine whether duck nest success would increase when availability of nesting sites for black-billed magpies (*Pica pica*) was reduced. Species of nesting substrate and spatial distribution of magpie nests shifted on the treatment area when compared to 1993 pre-treatment data. Most magpie nests (91%) on the treatment area were built in big sage plants (*Artemisia tridentata*) compared to 92% built in Russian olives prior to tree removal. All magpie nests in the control area were built in Russian olive trees. I located and determined survival of duck nests located in treatment and control areas in 1995 (n = 91 vs. 147) and in 1996 (n = 166 vs. 134). Mallards had lower nest success than all other ducks in both 1995 (2.3% vs. 6.6%) and 1996 (8.0% vs. 21.0%). Nest success for mallards did not differ between treatment and control areas either in 1995 (5.2% vs. 1.2%) or in 1996 (11.6% vs. 4.8%), nor did it differ for non-mallards in 1995 (3.9% vs. 8.7%) or in 1996 (24.2% vs. 17.4%). Ducks nesting overwater experienced significantly higher nest success than ducks nesting in other habitat types during 1995 (18.4% vs. 4.0%) and 1996 (26.0% vs. 13.9%). Success of overwater nests was higher on treatment vs. control areas in 1995 (33.6% vs. 8.2%) but no difference was detected in 1996 (33.4% vs. 15.3%). Avian predators destroyed duck nests that were initiated earlier than mammalian-destroyed nests and were responsible for about 30% of all depredated nests. Proportion of duck nests destroyed by avian predators did not differ between treatment and control areas. Nearly 65% of depredated artificial nests were destroyed during daylight hours in 1995 and 54% of depredated nests were destroyed during daylight hours in 1996, suggesting that magpies destroyed most artificial nests. Based on results from my study, I believe removing Russian olive trees as nest sites for magpies alone will not be sufficient to increase duck nest success to the 30% objective level desired for the SWMA. However, more time may have to elapse before a significant increase in duck nest success is realized. Intensive removal of mammalian nest predators and increasing safety and attractiveness of overwater nest sites are options that may allow duck nest success to reach the desired level.

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INTRODUCTION

Declines were noted in breeding populations of several duck species (Johnson and Shaffer 1987, Caithamer et al. 1996) and in duck nest success in the prairie pothole region (Beauchamp et al. 1996) during recent decades. Although these declines presumably were associated with habitat degradation (Higgins 1977), low rates of nest success commonly occur in habitats managed specifically for duck production.

Low recruitment associated with high rates of nest predation and high predation rates on nesting hens may be associated with duck population declines (Sargeant 1972, Cowardin and Johnson 1979, Greenwood et al. 1995). Although upland-nesting ducks evolved with predators, composition and abundance of predator communities has changed as a result of human-altered landscapes and other human influences (Sargeant et al. 1993). Current predator communities are dominated by smaller predators, occurring at higher densities and occupying smaller home ranges, than those of the past (Cowardin et al. 1983, Sargeant et al. 1993). Consequently, upland-nesting ducks probably face higher rates of nest predation and nesting hen mortality than that with which they evolved.

One way humans have influenced changes in predator communities is by encouraging trees to grow in areas where they did not occur previously. This practice has created nesting habitat for black-billed magpies and American crows (Corvus brachyrhynchos) that historically were not abundant in certain duck nesting regions due to low availability of elevated nesting sites (Sargeant et al. 1993). One tree species of concern to wildlife managers in the western United States is Russian olive. This species was introduced into North America during colonial times, has escaped cultivation in 17 western states, and is considered a noxious weed in Utah (Christensen 1963). Russian olive trees provide food and shelter for some wildlife species, but also can displace native riparian vegetation (Olson and Knopf 1986) and ultimately cause changes in wildlife community composition. Because this tree species thrives adjacent to wetland and riparian areas where many ducks and other species, nest, and provides nest sites (which otherwise would be scarce) for black-billed magpies, colonization of duck nesting areas by Russian olives is of concern to wildlife managers.

Wetlands of the Sterling Wildlife Management Area (SWMA) in southeastern Idaho are attractive to breeding ducks, but low nest success (1.4-7.4%; Gazda 1994; D. Meints pers. comm.) severely limits recruitment. Gazda (1994) hypothesized that high nest predation rates at SWMA resulted partly from black-billed magpies that nest at high densities in Russian olive stands on the study area: he recommended that Russian olive trees be removed from part of the area and that duck nest success be monitored for change.

Objectives of my study were to:

1. document the distribution and success of magpie nests on the study area,
2. determine the relative importance of avian versus mammalian predation on duck nests, and
3. determine whether duck nest success increased when Russian olive trees (as potential nest sites for magpies) were removed.

My primary null hypothesis was that no difference would exist in duck nest success between treatment and control areas.

STUDY AREA

My study was conducted on the northern portion of the SWMA in Bingham County, southeastern Idaho. This 654 ha portion of the SWMA was delineated into a 347 ha treatment area and a 307 ha control area (Fig. 1). All Russian olive trees ≥ 1 m in height were cut down on the treatment area during 1993-94, prior to my field seasons in 1995 and 1996. Most of these trees were stacked into piles and burned although about 20% of the cut trees had not been stacked and burned before my initial field season. However, all of the remaining cut trees were burned before my second field season. Trees were not removed from the control area. A 400 m belt of private land immediately to the north and east of the American Game subunit was the only land bordering the treatment area that contained any notable numbers of mature Russian olive trees.

The SWMA is comprised of wetland, wet meadow, and upland areas. Predominant emergent plant species are hardstem bulrush (Scirpus acutus) and common cattail (Typha latifolia) in wetlands and Nebraska sedge (Carex nebraskensis) and Baltic rush (Juncus balticus) in wet meadows. The upland plant community includes Russian olive, cheatgrass (Bromus tectorum), Great Basin wildrye (Elymus cinereus), Canada thistle (Cirsium arvense), greasewood (Sarcobatus vermiculatus), big sagebrush, and rabbitbrush

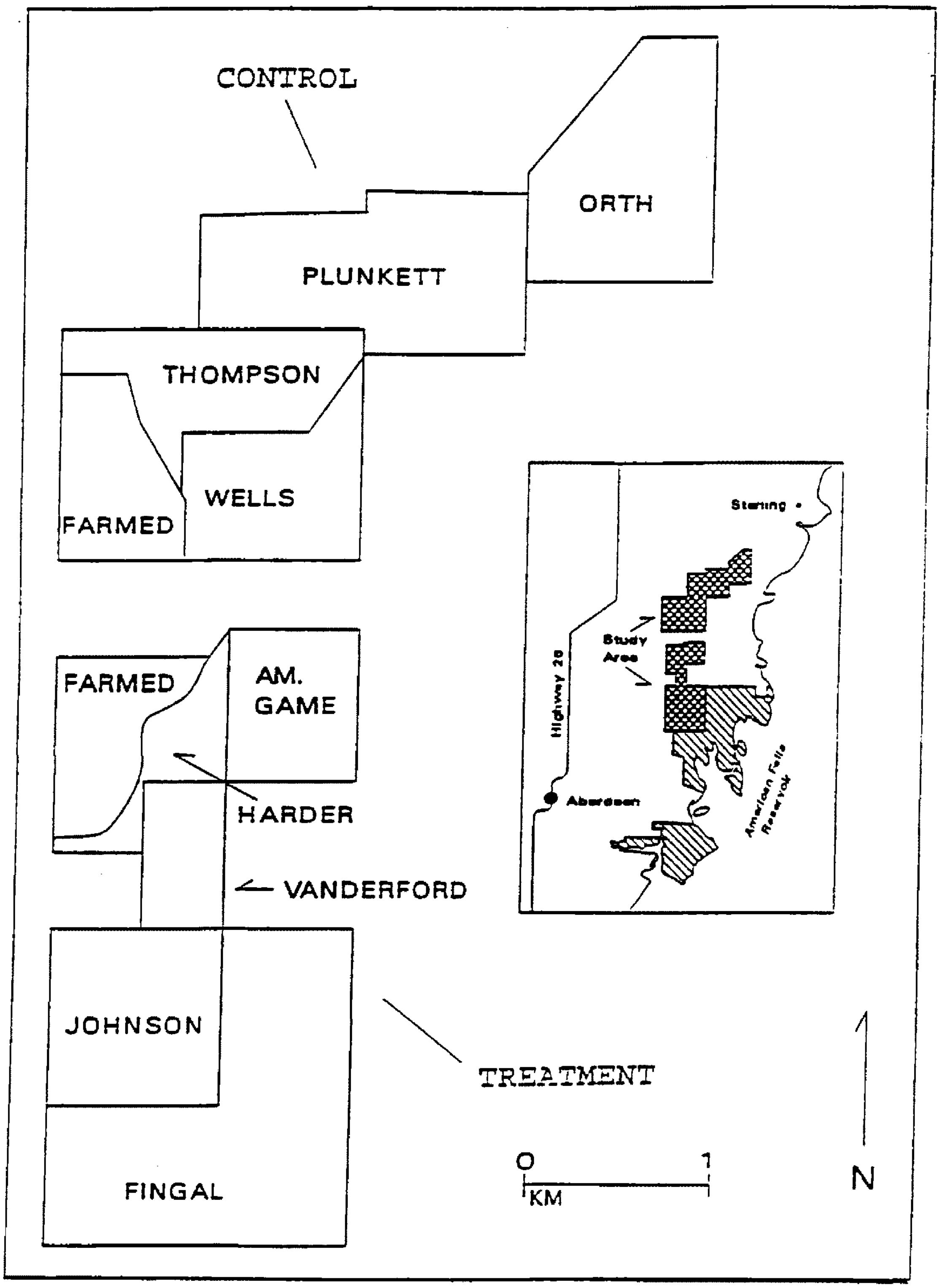

Figure 1. Study area depicting treatment and control area delineations (including SWMA subunit labels).

(Chrysothamnus nauseosus). Potential duck nest predators include black-billed magpies, American crows, ring-billed gulls (Larus delawarensis), California gulls (Larus californicus), striped skunks (Mephitis mephitis), raccoons (Procyon lotor), red foxes (Vulpes vulpes), and coyotes (Canis latrans).

The SWMA is bordered by the American Falls Reservoir on the southeast and by intensive irrigated agriculture and pasture on the remaining sides. Agricultural crops include potatoes, sugar beets, wheat, and alfalfa. The SWMA is located on the Upper Snake River Plain at an elevation of 1340 m amsl. Average annual precipitation is 22 cm, and average monthly high and low temperatures range from -6^0 C in January to 20^0 C in July (Natl. Climatic Data Cent. 1992).

METHODS

Magpie Nest Searches

Searches were conducted to locate all active magpie nests (i.e., those containing eggs or young) on the study area during late April and early May, the time of peak hatching of magpies in southern Idaho (Jones 1960). Trees containing active nests were marked inconspicuously to prevent duplicate counts, and locations were plotted on aerial photographs of the study site. All nests were revisited 1-3 times to determine fledging success (Brown 1957).

Breeding Pair Counts of Ducks

Breeding pair counts (Dzubin 1969) were conducted between mid-April and early June. Counts for early-nesting species [mallard (*Anas platyrhynchos*) and pintail(*A. acuta*)] were made between mid-April and early May, and counts for all other species were completed between mid-May and early June. Counts were made between 0700 and 1200 hr by approaching individual wetlands and recording the number, sex, and species of all ducks on each wetland. Only indicated pairs (i.e., lone drakes, each individual in a group of 5 or fewer drakes, or a paired drake and hen) were used for tabulation of breeding pairs (Appendix A).

Brood Counts of Ducks

Beginning in mid-June, all wetlands within the study area were visited weekly to count duck broods. Counts were made between 0600-1100 hr and 1800-2100 hr when broods were most active and thus most visible. Binoculars were used to identify species, age, (Gollop and Marshall 1954) and number of individuals in each group. Data were grouped by species and area, and potential multiple counts of the same brood were deleted. Productivity was estimated as number of broods per 100 indicated breeding pairs (Appendix A).

Duck Nest Searches

Large wet meadow areas were delineated into plots ranging in size from 8-15 ha, and all smaller (4-7 ha) tracts of wet meadow habitat were combined to form additional 8-15 ha plots. Overall, 14 wet meadow plots were searched for duck nests (7 treatment plots = 80 ha, and 7 control plots = 98 ha). Five plots (3 treatment plots = 11 ha, and 2 control plots = 8 ha) comprised of emergent wetland vegetation (cattail and bulrush)adjacent to wet meadow plots also were searched in 1995. An additional 4 plots (2 treatment plots = 13 ha, and 2 control plots = 7 ha) comprised of emergent wetland vegetation were searched during 1996 to increase sample size of overwater duck nests. Plots were searched alternating between treatment and control areas. Each plot was searched 3 times at approximately 21 day intervals between early May and mid-July.

Search techniques generally followed Klett et al. (1986). The primary search technique used in wet meadow habitat involved towing a 30 m cable-chain drag between 2, 4-wheeled all-terrain cycles. Flooded areas as well as those dominated by trees and brush were searched on foot with the aid of a labrador retriever (Sowls 1950) and by walking in a systematic zigzag pattern while swatting the vegetation with a switch until the entire plot was searched (Higgins et al. 1992). Nest searches were conducted between 0700 and 1300 hr to maximize the probability of locating nests, while minimizing chances of nest abandonment (Gloutney et al. 1993). Active duck nests found incidental to other activities on the study area also were monitored.

Incubation stage of eggs was determined by candling (Weller 1956). Location of each nest was marked with an inconspicuous, numbered willow switch 4 m from the nest. All nest locations were plotted on aerial photographs and visited every 7-10 days until fate was determined (successful, abandoned, infertile/addled, or destroyed). I considered a nest successful if evidence remaining in a nest bowl indicated that $\geq$ 1 egg had hatched. Nests abandoned due to investigator activity were excluded from calculations of nest success.

Nest success was calculated using a modified Mayfield technique (Mayfield 1961, Johnson 1979, Klett et al. 1986). Daily survival rate [DSR = (1 - number of failed nests/total exposure days)] was calculated for groups of nests and was used to estimate Mayfield nest success. Statistical differences in DSRs between treatment and control areas and between habitat types were tested with the program CONTRAST (Hines and Sauer 1989), using calculated DSRs and standard errors to generate a chi-square statistic to estimate the probability that DSRs differ between given samples. I considered differences significant if $P < 0.05$. I report nest success as DSR taken to the 35th power in the text of this thesis: sample sizes, exposure days, daily survival rates, and standard errors are presented in Appendix B.

Depredation of Duck Nests

A nest depredation form was completed for each nest that was destroyed. Information concerning disturbance in and near ($\leq$ 3 m) the nest bowl was reported. Evidence remaining at destroyed nests was used to ascertain what type of predator (avian or mammalian) had most likely destroyed a given nest (Reardon 1951, Sargeant et al. 1998). Depredation was attributed to an avian predator if one or more of the following criteria was met: > 10% of nest material was aerially displaced (i.e., resting loose on top of nearby vegetation) from the nest bowl, only trace amounts of shell fragments were found in or near the nest bowl, egg shells in or near the nest had small elliptical entry holes (≥ 75% of original surface intact), egg shells had multiple openings, or eggs in or around the nest contained a conspicuous (≥ 25% of original) amount of yolk and albumen.

Depredation was attributed to a mammalian predator if one or more of the following criteria was met: hair of predator was present, material from the nest bowl was pulled out on the ground, eggs were cached in or near the nest, digging occurred within 3 m of nest bowl, large shell fragments or crushed egg shells were present at the nest site, egg shells had < 75% of their original surface intact, egg shells had paired canine punctures, or egg shells contained little (< 25% of original) or no yolk or albumen. Presence of a dead hen or ducklings at a nest site was attributed to a mammalian or avian predator depending upon other evidence remaining at the nest site.

Vegetation at Duck Nest Sites

Duck nest sites were categorized into 4 major vegetation types: wet meadow areas - dominated by baltic rush and Russian thistle; upland habitat - dominated by big sage, greasewood, and cheatgrass; dry wetland sites - dominated by cattail and bulrush without standing water; and overwater wetland sites - dominated by cattail and bulrush with standing water (≥ 1 cm in depth) surrounding the nest.

Visual obstruction readings (cover, henceforth) were recorded as an index to vegetative height and density (Robel et al. 1970). Four measurements, 1 from each of the cardinal directions, were recorded from a height of 1 m and a distance of 4 m. Measurements were recorded to the nearest 0.5 dm at 100% visual obstruction, and cover was recorded as the mean of the 4 readings. Cover also was measured at distances of 4 m and 8 m in a random direction from each nest. Paired-samples t tests were used to test for differences in cover at 2 distances from nests. Independent-samples t tests were used to test for differences in nest initiation dates, cover at successful vs. destroyed nests, and cover at destroyed nests attributed to avian vs. mammalian predators. I considered differences significant if $P < 0.05$.

Artificial Nests with Timers

Artificial nests, each containing a timing device (Ball et al. 1994), were placed within the treatment and control areas to evaluate any difference in diurnal patterns of predation events. Location of these nests was determined by dividing the study area into 4 ha plots, then randomly choosing 6-12 of these plots (half each in treatment and control areas). The center point for each plot was located, and 1 artificial nest was constructed about 50 m from the center point in each of the cardinal directions (Gazda

1994). Specific nest sites were chosen to resemble actual duck nest sites located in corresponding vegetation types.

Each artificial nest was created by excavating a bowl-shaped depression in the soil, deep enough to bury the lower one third of the timer box. A brown-colored chicken egg was placed on the treadle of each timer, then vegetative material and duck down and contour feathers from terminated nests were placed around the nest to completely cover the timer box and about 50% of the egg. Two of the artificial nests on each plot were marked with an unflagged willow switch 4 m north of each nest during the 1995 field season, while the remaining 2 nests were not marked. Beginning in early May, 20-40 artificial nests were placed within the randomly chosen 4 ha plots for 10 days before being checked. This cycle was repeated every 10 days until late July.

During the 1996 field season, artificial nests with timers were constructed, with only 1 nest being constructed in each of 48 randomly selected 4 ha plots. Twenty-four nests were constructed in both the treatment and control areas beginning in early May. This procedure was repeated every 10 days until late July. Half of the 24 nests each in the treatment and control areas were randomly chosen to be visited 4 days after initial placement. During the second visit I lifted the egg and timer from the nest depression, verified the date and time on the clock, placed the timer and egg back into the depression, and re-covered the egg and timer (1-3 minutes were spent at each nest site). If a nest was destroyed between the first and second visit, information from the timer and nest site was recorded and the nest was considered terminated. All remaining nests were checked after 10 days to determine fate.

Nocturnal nest depredations (2200-0500 hr) were attributed to mammalian predators and diurnal depredations (0700-2000 hr) were attributed to avian predators. Dawn or dusk nest destructions (0501-0659 hr or 2001-2159 hr) were considered destroyed by unknown predators.

RESULTS

Habitat Alteration

About 20% of the Russian olive trees that were cut in 1994 remained at their original location during my 1995 field season. In addition, 12 of the Russian olive piles that had been burned had branches remaining that were large enough to support magpie nests. Seven magpie nests located in remnant unburned Russian olives were destroyed before any eggs were laid, to prevent magpie eggs or young from being destroyed when the piles were burned later in the season. All remaining trees were piled and burned prior to the onset of the 1996 field season.

Many of the tree stumps that remained after cutting began sprouting new branches during the following growing season. Hundreds of Russian olive saplings also were growing in sedge meadows on the treatment area. Some branches on remaining stumps have grown to nearly 2 m in height over 3 growing seasons. These provided elevated perch sites for magpies in 1996, and potentially could support magpie nests within a few years.

Magpie Nests

Total number of magpie nests (n = 103) did not vary among years (Table 1). Overall, magpie nests were less numerous on the treatment area than on the control area in

Table 1. Distribution and fledging success of magpie nests.

	1993[a]	1995[b]		1996	
	n	n	(% fledging)	n	(% fledging)
Control area					
Orth					
Plunkett	49	51	(76.5)	45	(68.9)
Thompson					
Wells	18	21	(57.1)	24	(41.7)
Total	67	72	(70.8)	69	(59.4)
Treatment area					
American Game					
Harder					
Vanderford	24	10	(40.0)	13	(76.9)
Johnson					
Fingal	12	21	(52.4)	21	(66.7)
Total	36	31	(48.4)	34	(70.6)
Total SWMA	103	103	(64.1)	103	(63.1)

[a] Data from Gazda (1994); fledging success not determined

[b] Destroyed nests (n = 7) located in tree piles scheduled for burning not included in totals

1995 and 1996, and a similar pattern was evident during 1993 before tree removal occurred (Gazda 1994); However, distribution of nests in the treatment area changed between 1993 and 1995. Fourteen fewer nests were found in American Game, Harder, and Vanderford SWMA subunits during 1995 than in 1993. Conversely, 9 more nests were located in the Fingal and Johnson subunits during 1995 than in 1993. Nest distribution was similar in 1995 and 1996 (Table 1). During each of my field seasons, about 6 active magpie nests were observed in Russian olive trees on private land bordering the treatment area immediately to the north and east of the American Game subunit.

Magpie nests on the treatment area were built in big sage (n = 56), willow (Salix sp.) (n = 5), greasewood (n = 3), and American elm tree (Ulmus americana) (n = 1). All magpie nests on the control area were located in Russian olive trees. Fledging success of nests in the treatment area was nominally lower than in the control area in 1995 but higher during 1996 (Table 1). Five of the unsuccessful magpie nests in 1995 were abandoned and 32 were destroyed by predators; 4 nests were abandoned in 1996 and 34 were destroyed by predators.

Density of Duck Nests

A lower density of nests in wet meadow and upland habitats was found in the treatment (n = 68) vs. control (n

= 124) areas in 1995 (0.9 vs. 1.3 nests/ha), but a higher density of nests was located in the treatment (n = 93) vs. control (n = 85) areas in 1996 (1.2 vs. 0.9 nests/ha) (Table 2). Density of duck nests discovered in dry wetland and overwater habitats was lower in the treatment (n = 35) vs. control (n = 36) areas in 1995 (3.2 vs. 4.5 nests/ha) and in 1996 (n = 85 vs 62) (3.5 vs. 4.1 nests/ha). For both years combined, nest density was over 3.5 times higher in dry wetland and overwater habitats than in wet meadow and upland habitats (3.8 vs. 1.0 nests/ha).

Duck Nest Success and Species Composition

Results in this section pertain to nests found in dry wetland (1995, n = 24, 1996, n = 48), upland (1995, n = 2, 1996, n = 8), and wet meadow habitats (1995, n = 169, 1996, n = 155). Overwater nests are considered in a later section. Nests in dry wetlands and wet meadow/upland areas were combined for nest success calculations because these habitat types did not differ in nest success in 1995 (0.8% vs. 4.6%, X^2 = 2.509, df = 1, P = 0.113) or in 1996 (11.5% vs. 14.6%, X^2 = 0.320, df = 1, P = 0.572).

Mallards constituted about half of nests found in 1995 and 1996. Mallards initiated nests earlier than other duck species in 1995 (15 May vs. 3 June, t = 7.38, df = 193, P < 0.001) and in 1996 (18 May vs. 1 June, t = 5.53, df = 209, P < 0.001).

Table 2. Area and fate of all duck nests discovered on SWMA.

	Treatment		Control		Total	
	% (n)		% (n)		% (n)	
Nests	1995	1996	1995	1996	1995	1996
Upland[a]	66.0 (68)	52.2 (93)	77.5 (124)	57.8 (85)	73.0 (192)	54.8 (178)
Wetland[b]	34.0 (35)	47.8 (85)	22.5 (36)	42.2 (62)	27.0 (71)	45.2 (147)
Total	9.2 (103)	54.8 (178)	60.8 (160)	45.2 (147)	100 (263)	100 (325)
Abandoned[c]	5.8 (6)	3.4 (6)	1.3 (2)	4.8 (7)	3.0 (8)	4.0 (13)
Deserted[d]	11.7 (12)	6.2 (11)	7.5 (12)	7.5 (11)	9.1 (24)	6.8 (22)
Successful	19.4 (20)	40.4 (72)	15.6 (25)	31.3 (46)	17.1 (45)	36.3 (118)
Depredated	63.1 (65)	50.0 (89)	75.6 (121)	56.5 (83)	70.7 (186)	52.9 (172)

[a] Includes nests found in wet meadow and upland habitats
[b] Includes nests found in dry wetland and overwater habitats
[c] Nests abandoned for unknown reasons or because of infertile or addled eggs
[d] Nests deserted due to investigator activity

Nest success of mallards was lower than that of other duck species in both 1995 (2.3% vs. 6.6%, $X^2 = 4.490$, df = 1, P = 0.034) and 1996 (8.0% vs. 21.0%, $X^2 = 7.364$, df = 1, P = 0.007) (Table 3). Consequently, mallards and other duck species were treated seperately in comparisons.

Mallard nests found in 1995 experienced lower nest success than those in 1996 (2.3% vs. 8.0%, $X^2 = 6.606$, df = 1, P = 0.010). Similarly, non-mallard nests found in 1995 experienced lower nest success than those in 1996 (6.6% vs. 21.0%, $X^2 = 9.693$, df = 1, P = 0.018).

Nest success of mallards did not differ between treatment and control areas in 1995 (5.2% vs. 1.2%, $X^2 = 3.406$, df = 1, P = 0.065) or in 1996 (11.6% vs. 4.8%, $X^2 = 2.109$, df = 1, P = 0.146). Similarly, nest success of other duck species did not differ between treatment and control areas in 1995 (3.9% vs. 8.7%, $X^2 = 1.311$, df = 1, P = 0.252) or 1996 (24.2% vs. 17.4%, $X^2 = 0.650$, df = 1, P = 0.420). Gazda (1994) similarly reported no difference in mallard nest success between treatment and control areas in the 2 years (1992 and 1993) prior to tree removal on the SWMA (Table 4). He did, however, find higher nest success for non-mallards in 1992 on the treatment vs. control areas, but found no difference in 1993 (Table 5).

Duck nests initiated before 1 June had higher success on the treatment area (n = 47, 5.9%) than the control area

Table 3. Duck nest success by species[a].

	Successful Nests/ Total Nests[b]		Mayfield % Nest Suc.	
Species	1995	1996	1995	1996
Mallard	15/107	29/103	2.4	8.0
Northern Shoveler	4/23	13/31	8.9	18.4
Gadwall	5/22	13/30	8.1	26.3
Cinnamon Teal[c]	2/20	8/22	7.9	9.8
Lesser Scaup	3/14	8/14	7.5	36.7
Northern Pintail	0/5	4/6	1.0	49.9
Redhead	0/3	1/3	5.4	12.4
Green Winged Teal	0/1	0/2	1.0	3.4
Total	29/195	76/211	4.0	13.9

[a] Includes all nests except those located over water

[b] Excludes nests abandoned due to investigator activity (n = 24 in 1995, and n = 19 in 1996)

[c] Includes blue-winged teal

Table 4. Recent Mayfield success and (daily survival rate) of mallard nests located in wet meadow habitat at SWMA.

Nests	1992[a]	1993[a]	1995	1996
Total	89	53	107	103
Treatment	49	20	39	54
Control	40	33	68	49
Success Treatment	10.3 (0.937)	0.2 (0.835)	5.2 (0.919)	11.6 (0.940)
Success Control	9.3 (0.934)	1.5 (0.887)	1.2 (0.882)	4.8 (0.917)
Success Overall	9.8 (0.936)	0.8 (0.871)	2.3 (0.898)	8.0 (0.931)
P value[b]	0.860	0.190	0.065	0.146

[a] Data from Gazda (1994)

[b] Probability that daily survival rate was similar between treatment and control area.

Table 5. Recent Mayfield success and (daily survival rate) of non-mallard duck nests located in wet meadow habitat at SWMA.

Nests	1992[a]	1993[a]	1995	1996
Total	75	82	88	108
Treatment	32	25	33	58
Control	43	57	55	50
Success Treatment	11.4 (0.940)	6.5 (0.925)	3.9 (0.912)	24.2 (0.960)
Success Control	2.2 (0.897)	4.4 (0.915)	8.7 (0.933)	17.4 (0.951)
Success Overall	4.9 (0.918)	5.0 (0.918)	6.6 (0.925)	21.0 (0.956)
P value[b]	0.048	0.620	0.252	0.420

[a] Data from Gazda (1994)

[b] Probability that daily survival rate was similar between treatment and control areas.

(n = 79, 1.0%) during 1995 (X^2 = 6.460, P = 0.0110) but showed no difference in 1996 (n = 62, 12.2% vs. n = 59, 7.9%, X^2 = 0.708, P = 0.400). However, success was lower for nests initiated on or after 1 June 1995 on the treatment area (n = 44, 2.5%) vs. the control area (n = 25, 13.7%) (X^2 = 4.028, P = 0.045), but no difference was realized between treatment (n = 50, 25.6%) and control areas (n = 40, 13.7%) in 1996 (X^2 = 1.813, P = 0.178). Overall, nest success was lower for early nests vs. late nests in 1995 (2.3% vs. 8.7%, X^2 = 7.562, P = 0.006) and 1996 (10.1% vs. 19.7%, X^2 = 3.969, P = 0.046).

Prior to tree removal, no difference in nest success between treatment and control areas was found for nests initiated before 1 June in 1992 (13.5% vs. 7.4%, X^2 = 1.345, P = 0.246) or in 1993 (0.3% vs. 1.2%, X^2 = 1.204, P = 0.273), nor for nests initiated on or after 1 June in 1992 (6.3% vs. 0.3%, X^2 = 3.521, P = 0.061) or in 1993 (11.3% vs. 6.7%, X^2 = 0.425, P = 0.515) (data from Gazda, 1994).

Depredation of Duck Nests

Avian predators were responsible for about 32% of depredated nests in 1995 and about 26% in 1996, with proportion of avian vs. mammalian predation being virtually identical between treatment and control areas. However, avian predators destroyed a higher percentage of duck nests initiated before 1 June than those initiated later in 1995 and 1996 (Table 6). Avian-destroyed nests were initiated earlier than mammalian-destroyed nests (19 May vs. 26 May, $t = -3.32$, $P = 0.001$) for both years combined.

Vegetative Cover at Duck Nests and Adjacent Sites

Cover measurements for 1995 ($n = 169$) and 1996 ($n = 155$) nests located in wet meadows were combined because no difference was found between years at the nest (2.7 dm vs. 2.6 dm, $df = 322$, $t = 1.17$, $P = 0.241$), 4 m from the nest (2.3 dm vs. 2.1 dm, $t = 1.95$, $P = 0.052$), and 8 m from the nest (2.3 dm vs. 2.1 dm, $t = 1.23$, $P = 0.219$). Measurements taken at nest sites were higher than those taken 4 m from nests (2.6 dm vs. 2.2 dm, $df = 322$, $t = 8.83$ $P < 0.001$) but did not differ between 4 m and 8 m (2.2 dm vs. 2.2 dm, $t = 0.33$, $P = 0.745$). Cover at successful nests ($n = 84$) in wet meadow habitat was greater than that of nests destroyed by predators ($n = 231$) (3.0 dm vs. 2.5 dm, $df = 313$, $t = 4.02$, $P < 0.001$). Also cover at nests destroyed by mammalian predators ($n = 158$, 2.6 dm) was significantly higher than at nests destroyed by avian predators ($n = 73$, 2.3 dm) ($df = 229$, $t = -2.52$, $P = 0.012$).

Overwater Duck Nests

Overwater nests constituted 18.1% of all nests found during 1995 (Table 7), with mallards and redheads (*Aythya americana*) accounting for 20 of the nests each. Nests

Table 6. Destruction of duck nests[a] attributed to avian versus mammalian predators on treatment and control areas by date of nest initiation[b].

	1995		1996		Total	
	% (n)		% (n)		% (n)	
	Early	Late	Early	Late	1995	1996
Avian	37.9 (47)	21.0 (13)	31.5 (34)	16.4 (10)	32.3 (60)	26.0 (44)
Mammalian	62.1 (77)	79.0 (49)	68.5 (74)	83.6 (51)	67.7 (126)	74.0 (125)
Total	100 (124)	100 (62)	100 (108)	100 (61)	100 (186)	100 (169)

[a] Following Sargeant et al. (1998).

[b] Early = initiated before 1 June; Late = initiated on or after 1 June.

Table 7. Area and fate of overwater duck nests discovered on SWMA.

	Treatment		Control		Total	
	% (n)		% (n)		% (n)	
Nests	1995	1996	1995	1996	1995	1996
	44.2	60.7	55.8	39.3	100	100
Nests[a]	(19)	(54)	(24)	(35)	(43)	(89)
	10.5	5.6	0.0	2.9	4.7	4.5
Abandoned[b]	(2)	(3)	(0)	(1)	(2)	(4)
	47.4	51.9	29.2	40.0	37.2	57.2
Successful	(9)	(28)	(7)	(14)	(16)	(42)
	42.1	42.6	70.8	57.1	58.1	48.3
Depredated	(8)	(23)	(17)	(20)	(25)	(43)
Mayfield Success	33.6	33.4	8.2	15.3	18.4	26.0

[a] Excluding nests deserted due to investigator disturbance (n = 1 in 1995, and n = 6 in 1996)

[b] Nests abandoned for unknown reasons

occurring overwater made up 29.7% of nests discovered in 1996, with mallards comprising 51 of the total and redheads 35. Cinnamon teal (Anas cyanoptera) (n = 3), ruddy duck (Oxyura jamaicensis) (n = 2), and lesser scaup (Aythya affinis) (n = 1), were the only other duck species found nesting overwater during either field season. Mallard and redhead nests located overwater were combined for nest success calculations because these species did not differ in nest success in 1995 (15.4% vs. 16.5%, $X^2 = 0.009$, $P = 0.923$) or in 1996 (27.4% vs. 25.8%, $X^2 = 0.024$, $P = 0.876$).

Nest success was higher for overwater nests (n = 43) than for other nests (n = 195) in 1995 (18.4% vs. 4.0%) ($X^2 = 13.638$, $P = 0.0002$) and in 1996 (26.0%, n = 89 vs. 13.9%, n = 211) ($X^2 = 5.743$, $P = 0.017$). Overwater nest success was higher on the treatment (n = 19) vs. control (n = 24) areas in 1995 (33.6% vs. 8.2%, $X^2 = 4.131$, $P = 0.042$) approached statistical significance in 1996 (33.4%, n = 54 vs. 15.3%, n = 35, $X^2 = 2.903$, $P = 0.088$).

Artificial Nests

Artificial nests in the treatment area had higher DSRs than those in the control area in 1995 (0.9243 vs. 0.8805, $X^2 = 7.843$, $P = 0.0051$). Conversely, during 1996 nests in the treatment area experienced lower DSRs than those in the control area (0.8853 vs. 0.9233, $X^2 = 10.089$, $P = 0.0015$). During 1995, the proportion of destroyed nests depredated during diurnal hours was similar in treatment and control areas (Table 8). This pattern of diurnal nest destruction also was evident during 1996. A slightly higher percentage of destroyed nests was depredated during nocturnal hours in the treatment area than the control area during 1995. Conversely, nocturnal depredations in 1996 were less common on the treatment than the control area.

Percentage of nests destroyed overall during 1995 and 1996 declined through the 10 day exposure periods (Fig. 2). The highest number of nest destructions occurred on the first day after artificial nests were placed in both 1995 and 1996. Overall, nests visited 4 days after construction experienced similar depredation patterns to those nests visited only once (i.e., during initial construction (Fig. 3)). Additionally, between the first and fourth days of exposure, (before any nests were revisited) nests eventually visited 4 days after construction had similar DSRs compared to those only visited during nest construction (0.8950 vs. 0.8623, $X^2 = 2.768$, $P = 0.096$). Also between the fifth and tenth days of exposure, nests visited after 4 days had similar DSRs compared to those visited only during initial construction (0.9550 vs. 0.9570, $X^2 = 0.051$, $P = 0.821$).

Nests marked with willows ($n = 119$) and nests without willows ($n = 118$) were destroyed at similar percentages in 1995 on treatment (68.9% vs. 65.0%) and control (50.0% vs. 53.4%) areas, and overall (59.7% vs. 59.3%).

Table 8. Spatial and temporal patterns of destruction in artificial nests with timers on SWMA.

Time of Depredation	Treatment area n/total depred. (%)		Control area n/total depred. (%)		Total n/total depred. (%)	
	1995	1996	1995	1996	1995	1996
Nocturnal[a]	10/60 (16.7)	15/131 (11.5)	8/81 (9.9)	23/98 (23.5)	18/141 (12.8)	38/229 (16.6)
Diurnal[b]	37/60 (61.7)	68/131 (51.9)	54/81 (66.7)	55/98 (56.1)	91/141 (64.5)	123/229 (53.7)
Dawn\Dusk[c]	3/60 (5.0)	20/131 (15.3)	4/81 (4.9)	8/98 (8.2)	7/141 (5.0)	28/229 (12.2)
Unknown[d]	10/60 (16.7)	28/131 (21.4)	15/81 (18.5)	12/98 (12.2)	25/141 (17.7)	40/229 (17.5)
Total[e]	60/116 (51.7)	131/193 (67.9)	81/121 (66.9)	98/193 (50.7)	141/237 (59.5)	229/386 (59.3)

[a] 2200-0500 hr
[b] 0700-2000 hr
[c] 0501-0659 hr and 2001-2159 hr
[d] timer malfunction (see appendix C)
[e] n depredated/n artificial nests

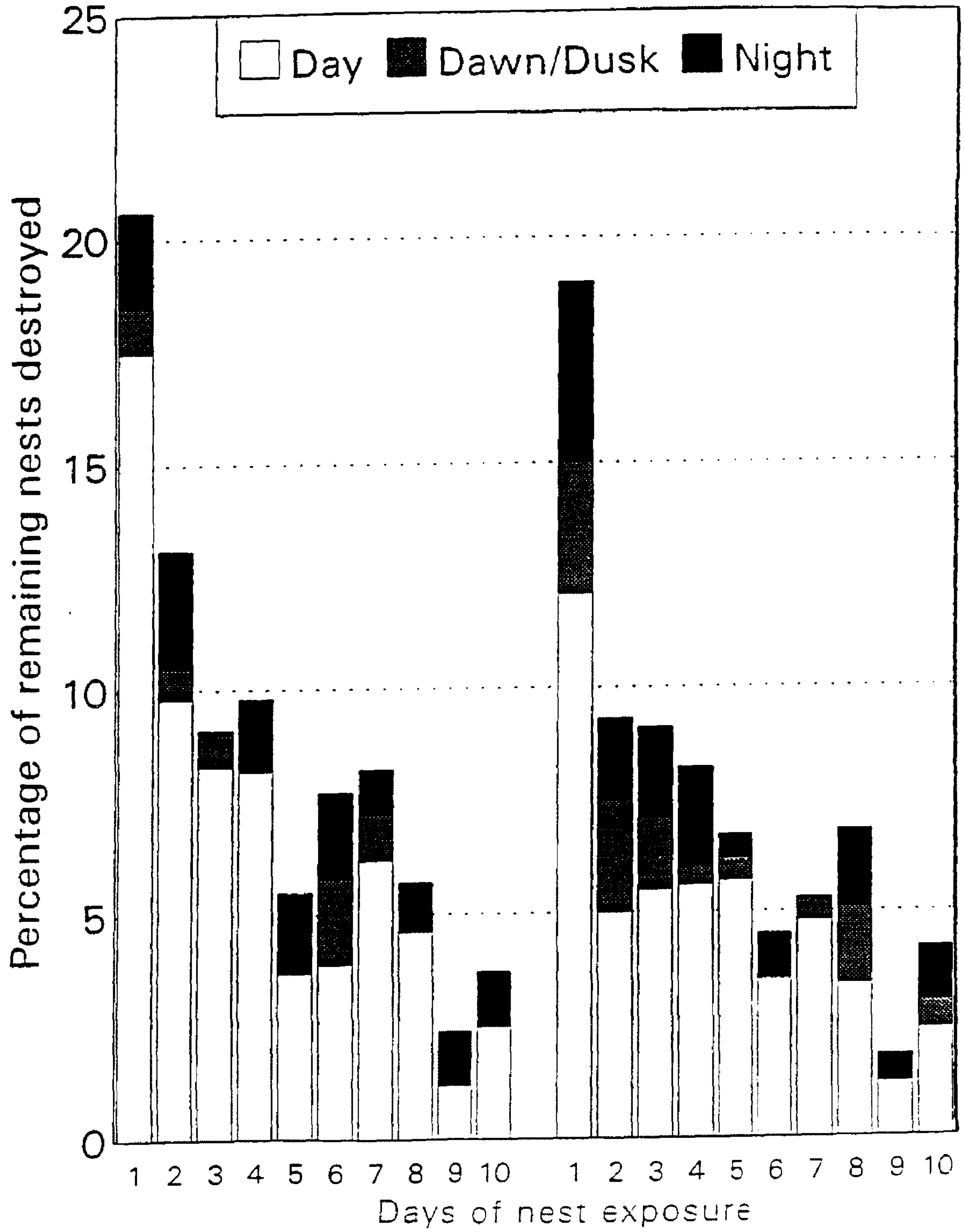

Figure 2. Artificial nest depredations by 24 hr period of nest exposure on SWMA.

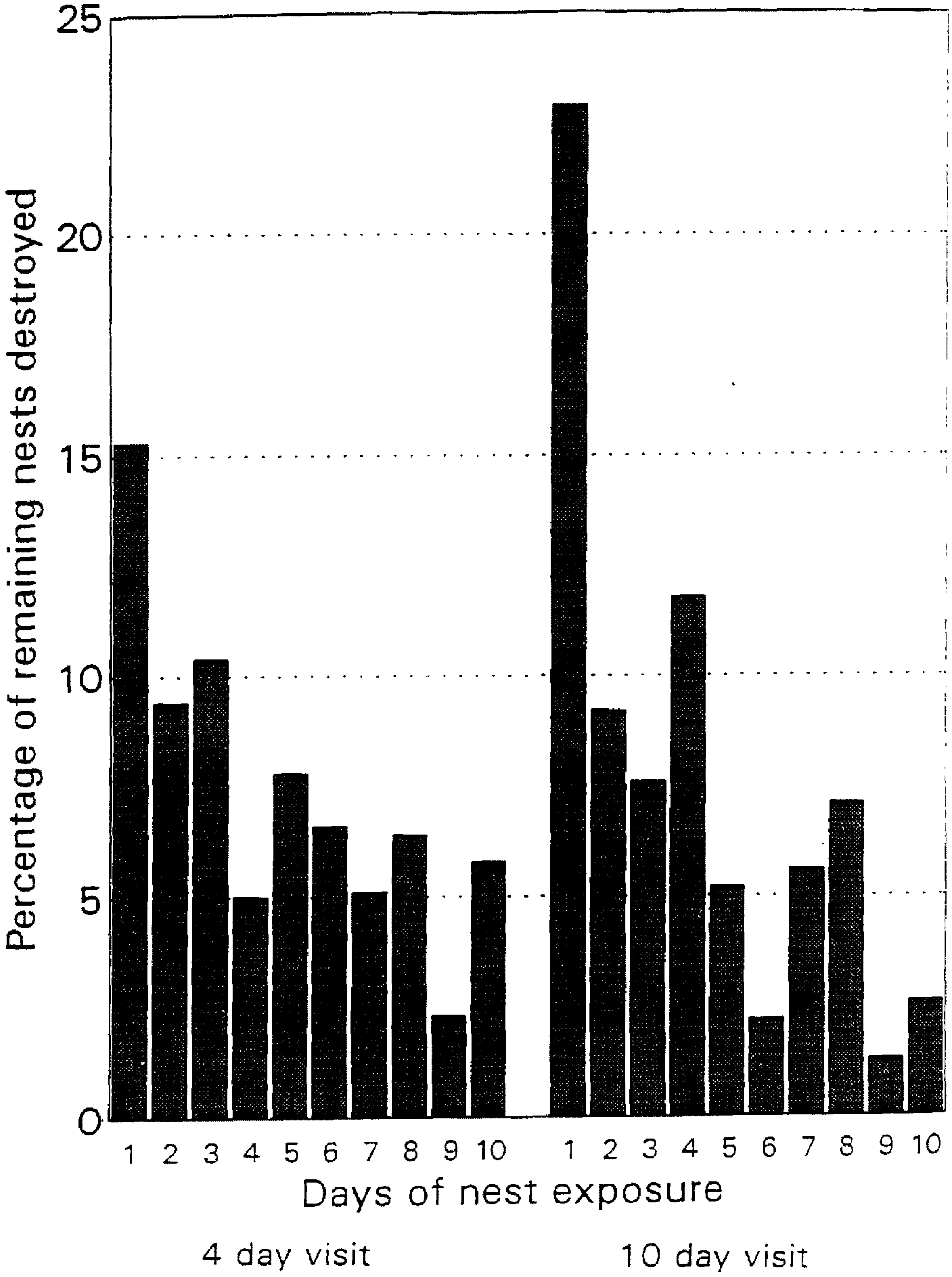

Figure 3. Percentage of artificial nests destroyed on SWMA during 1996, based on number of exposure days and investigator nest visits.

DISCUSSION

Spatial Distribution of Magpie Nests

Removing Russian olives did not have the desired effect of reducing the number of magpies nesting on the treatment area, although it did cause magpies to nest further from preferred duck nesting habitats (emergent wetlands and wet meadows). Spatial distribution of nests on the treatment area shifted, as did species of nesting substrate (from 92% Russian olive in 1993 to 91% big sage or greasewood in 1995-1996), but number of magpie nests was remarkably stable on both treatment and control areas. The shift in spatial distribution of nests primarily was the result of availability of alternative nest sites. The southern subunits of the treatment area (Johnson and Fingal) had larger and more numerous big sage plants than subunits in the northern portion of the treatment area (American Game, Harder, and Vanderford). Presumably, some of the magpies that formerly nested in Russian olive trees in the northern portion of the treatment area shifted their nesting efforts to Johnson and Fingal subunits after Russian olive were removed.

Habitat Alteration

Cutting trees without completely removing the branches and trunks from a location did not deter magpies from nesting in the area. Magpie nests were located in both individual cut trees, and in unburned branches of Russian olive piles. These nests were destroyed before any eggs were laid and were not included in total number of active magpie nests discovered due to the high probability of a pair renesting nearby. Magpies generally will renest only if a nest is destroyed before egg laying occurs because construction of a new nest takes a minimum of 2 weeks to accomplish (Birkhead, 1991). Complete removal or burning of trees is necessary to prevent magpies from nesting in branches of cut trees.

Density of Duck Nests

Density of duck nests in wet meadow habitat increased on the treatment area from 1995 to 1996 while nest density decreased over the same time period on the control area. The increase in density of nests on the treatment area could possibly be the result of magpies nesting farther from wet meadow areas and also could be the result of increased attractiveness of nesting ducks to the treatment area due to an increase in the density of vegetation where Russian olive trees once existed. However differences in water stability and grazing pressure between treatment and control areas varied considerably from 1995 to 1996 and the burning of some wet meadow nesting areas in 1995 also may have contributed to the differences of duck nest densities between areas and years.

Fate of Duck Nests and Species Composition

I could not detect statistically significant difference in duck nest success between treatment and control areas for ducks nesting in wet meadow habitat. Thus I failed to reject my primary null hypothesis that no difference in duck nest success would occur when Russian olives were removed. However, due to low sample size of some nest success comparisons and a moderately low P value (0.05), the power of my statistical tests was low, possibly resulting in a Type II error. Also, results may have shown greater differences had the treatment area lacked alternative magpie nest sites or if adjacent land did not contain trees that could support magpie nests. Magpies rarely nest on the ground (Birkhead 1991).

Moreover, mammalian predators were responsible for over 70% of all nest depredations, with no difference in the ratio of mammalian- to avian-destroyed nests occurring between treatment and control areas during either field season. However, both avian and mammalian predators could have visited a single destroyed nest and left confounding evidence at a nest site. Thus accurate predator identification from evidence remaining at a depredated nest site is subjective and caution should be used when interpreting these results (Trevor et al. 1991, Sargeant et al. 1998). Nonetheless, my results suggest that magpies have comparably less influence on duck nest success at SWMA than do mammalian predators.

Magpies are a more important predator of nests early than later in the season (Brown 1957, O'Halloran 1961), as are American crows (Johnson et al. 1989). Similarly, I found that more duck nests destroyed by avian predators were depredated early than late in the nesting season. Most magpies fledge during early June in southern Idaho. Before then, adult magpies forage for food within an approximate 400 m radius of their nest (Reese and Kadlec 1985). Once young birds fledge, however, adults lead young from nest sites to areas where better foraging opportunities exist (Buitron 1988, Birkhead 1991). Most destruction of late duck nests on the SWMA potentially could be attributed to mammals after magpies leave their nesting areas.

Mallards were the most common nesting duck on SWMA, but, nest success for mallards was lower than that of other ducks. Mallards generally are the first to initiate nests each season and also are persistent at renesting (Bellrose 1976). The lower nest success on SWMA of early-initiated nests (mostly mallards) in addition to my data that magpies destroyed a higher percentage of duck nests early in the season, suggest that magpies are partly responsible, for the overall lower nest success of mallards compared to other ducks nesting on SWMA.

Vegetative Cover at Sites of Duck Nests

Successful nests were located at more densely vegetated sites than unsuccessful nests. Dense vegetation may better conceal nests from avian predators, which primarily hunt by sight, but probably does not offer much added protection from mammalian predators, which primarily hunt by scent (Clark and Nudds 1991). Likewise in my study, nests destroyed by avian predators had less vegetative cover than those destroyed by mammals, and successful nests had more vegetative cover than those destroyed by mammals. However, vegetation height and density generally increase through the nesting season, and duck nests depredated by avian predators were more commonly destroyed early in the season. Also, nests initiated later in the season were more successful than nests initiated early. Thus, the differences in vegetative cover measurements could partially be explained by the increase in vegetation height and density as the nesting season progressed. Vegetation data were not separated and tested for differences across time due to inadequate sample sizes.

Ducks on SWMA selected for nest sites that had higher average cover measurements than vegetation measurements taken 4 m from nests. Additionally, readings taken at a distance of 4 m from nests were similar to those measured 8 m from nest bowls. Ducks were apparently selecting for dense cover at a scale < 4 m in radius.

Overwater Duck Nests

Overwater nests were more successful than those located in other habitat types in both 1995 and 1996, and this pattern is common (Krapu et al. 1979, Arnold et al. 1993). Differences in nest success between habitats may exist due to predator communities varying in composition and density between habitat types. Water is a barrier to certain mammalian predator species and habitats containing water may deter certain predators from searching for food within such a habitat type (Sargeant and Arnold 1984). Nonetheless, wetlands also may attract other predator species (Fritzell 1978). Unlike duck nests in other habitats of SWMA, no difference was detected in success of overwater nesting ducks during 1995 and 1996, possibly indicating that predator communities did not change in overwater habitat between years.

However, overwater nest success was higher in the treatment area than the control area, suggesting that different species or densities of overwater nest predators existed between these 2 areas. Also, higher success of overwater duck nests on the treatment area could have been the result of magpies nesting farther from wetland areas on the treatment area. However limited data were collected from overwater duck nests before Russian olive tree removal, so it is unknown if overwater nest success was higher on treatment vs. control areas prior to tree removal.

Another possible explanation for the difference of overwater nest success on treatment vs. control areas is the contrast in wetland structure between the 2 areas. Most nests on the treatment area were found in large wetlands characterized by dense stands of cattail and bulrush throughout the basins, whereas most nests on the control area were found in large wetlands characterized by dense stands of cattail and bulrush ringing the otherwise openwater basins. Predators theoretically would have been less likely to find and destroy nests in the type of wetlands in the treatment area vs. the type of wetlands in the control area, resulting in higher success of overwater nests on the treatment area.

Artificial Nests

Artificial nests with timers did not support results that were found for real duck nests when data from treatment and control areas were compared. Artificial nests in the treatment area had higher DSRs than those in the control area in 1995, however, the reverse was true in 1996. Comparably, I found no difference in DSRs between treatment and control areas during either 1995 or 1996 for duck nests. Also, about 15% of depredated artificial nests were destroyed during nocturnal hours (considered mammalian-caused), whereas over 70% of depredated duck nest were destroyed by mammalian predators. Mammalian predators were commonly observed during daylight hours, suggesting that some diurnal depredations of artificial nests may have been caused by mammals. Nevertheless, my results suggest that artificial nests may be poor indicators of patterns and predator types on real nests. But, additionally, they may mean that my classification of predator type on real duck nests was inaccurate and that magpies may have been responsible for more nest destruction than I suggest.

Nevertheless, Dwernychuk and Boag (1972) reported depredation rate of artificial nests was different than that of natural duck nests. Thus, results from artificial and actual duck nests are not directly comparable. Furthermore, artificial nests are more likely to be destroyed by avian predators and natural nests more likely to be destroyed by mammalian predators where the 2 different predator types coexist (Atwell 1959, Ruff 1963, Willebrand and Marcstrom 1988). The absence of an attending hen at artificial nests may be the main cause for such differences in nest destruction patterns of real and artificial nests.

Picozzi (1975) found that conspicuously marked artificial nests were more likely to be destroyed by crows than unmarked nests. However, marked and unmarked nests were destroyed at similar percentages in my study, indicating that predators were not using willow switches employed for marking duck nests as cues to locate nests before they depredated them.

Depredations of artificial nests during both field seasons showed a general decreasing trend throughout the 10 day exposure periods, with the highest percentage of nests being destroyed on the first day of exposure. Jones and Hungerford (1972) suggested a similar pattern for artificial nests in their study concerning magpie nest predation, possibly a result of differences of nest concealment and decreasing density of nests throughout the exposure period. Predators also could have used human cues (e.g., human trails and scent, or direct visual observations) to locate nests shortly after they were built. However, nests I visited twice during the 10 day exposure periods experienced similar survival after the second visit when compared to nests that were only visited during initial construction. This suggests that human visitation to nests did not increase the likelihood of a nest being destroyed by a predator. Esler and Grand (1993) similarly reported that multiple visits to nests did not increase probability of nest destruction if intervals between visits were $\geq$ 7 days.

MANAGEMENT RECOMMENDATIONS

Removal of Russian olive trees as nesting sites for black-billed magpies appears unlikely to increase duck nest success to the 30% objective level desired by the Idaho Department of Fish and Game for the SWMA. However, some of my results (i.e., a general increasing trend in duck nest success and nest density on the treatment area) indicate that removal of Russian olive trees had a positive effect on duck production on the SWMA. My study was conducted during the first few years after Russian olive tree removal, and lower magpie densities and significantly higher duck nest success may eventually result.

Nonetheless, magpies are more adaptable in their selection of nest sites than was anticipated when removal of Russian olive trees was proposed. In order for passive management of nest predation by magpies to have a chance to succeed, removal of nest substrate would need to be broadened to include the largest willow, greasewood, and sagebrush plants on the area. Removal of Russian olives from surrounding private land also may be necessary. Yet, reduction of magpies may still have minimal influence on nest success of ducks on the SWMA. Clark et al. (1995) reported that complete removal of American crows had no detectable effect on duck nest success and that removal of a single predator species from a diverse predator community has minimal impact on duck nest success. Additionally, preventing reestablishment of Russian olive trees on the SWMA will be difficult and labor-intensive given the close proximity of seed banks on surrounding private land and the sprouting of Russian olive tree stumps. To prevent sprouting of Russian olive tree stumps, the stumps should be chemically treated after being cut to prevent regrowth. In addition, newly sprouting trees also should be eliminated by mowing or burning of sedge meadows every 2 or 3 years. However, such treatment is likely to reduce density of duck nests the following spring (Kirsch et al. 1978, Renner et al. 1995, Kruse and Bowen 1996).

I attributed approximately 70% of all nest predation to mammals in this study. These losses were heaviest later in the season and were in relatively dense cover. Intensive removal of skunks, red fox, and possibly raccoons should be considered at SWMA if attaining substantially higher duck nest success remains a priority. Such removal has proven effective in some situations (Balser et al. 1968, Duebbert and Kantrud 1974, Duebbert and Lokemoen 1980, Greenwood 1986, Forman 1993) although costs and social issues must be considered.

One partial solution to low duck nest success at SWMA would be to increase the attractiveness and safety of overwater nest sites. Ducks that nested overwater on SWMA experienced higher nest success than those nesting elsewhere. Similar results were reported by Krapu et al. (1979) and Arnold et al. (1993). Density of duck nests found in dry and flooded emergent wetland vegetation was about 3.5 times higher than density of nests in wet meadow and upland areas on SWMA. To exploit this nesting behavior, water levels should be raised and stabilized before ducks begin nesting in early to mid-April. If water levels are raised early in the season, ducks that otherwise would nest in dry emergent wetland vegetation, and suffer similar low success as ducks nesting in wet meadow habitat, may nest overwater. Although water level management may increase nest success of mallards, redheads, and ruddy ducks, other duck species on the SWMA seldom nest overwater and nest success of these species would not directly increase from improvement of overwater nest sites.

Success of overwater duck nests on the treatment area was slightly above the 30% objective level for the SWMA, and when combined with all other nests on the treatment area, overall success of duck nests on the treatment area approached the desired 30% goal (Appendix C). The comparably higher nest success of overwater nests on the treatment vs. control areas possibly could have been the result of magpies nesting farther from overwater nesting habitat. The higher nest success also may be attributed to a change in the composition and density of other overwater predator populations due to removal of Russian olive trees. If all potential magpie nest sites on the control area were removed within 400 m of prime overwater nesting habitat, nest success similar to that experienced on the treatment area might be realized on the control area. However structure of vegetation within most wetland basins where overwater nests were found differed considerably between treatment and control areas. Accordingly, factors other than the proximity of magpie nest sites to wetlands may have had a greater influence on the difference in overwater nest success between the 2 areas.

Another general approach to the problem of low duck nest success would be to erect electric fences around SWMA areas that have exhibited high duck nest densities. Lokemoen et al. (1982) reported that electric fences built to reduce mammalian predation on duck nests was effective, and cost after initial fence construction was minimal. Electric fences however, do not deter avian predators from entering predator exclosures and removal of magpie nest substrate within 400 m of fenced areas would be necessary to potentially limit the number of magpies entering the fenced area.

Although I recommend that some level of Russian olive control continue on SWMA as a general attempt to protect the ecological integrity of the area, I suspect that more intensive management will be necessary if the goal of 30% duck nest success is to be attained.

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Appendix A. Number and percent [N(%)] of breeding duck pairs[a], broods, and broods per 100 pairs counted on SWMA.

	Pairs		Broods		Broods/100 pairs	
Species	1995	1996	1995	1996[b]	1995	1996
Mallard	149(30)	133(32)	27(27)	28(26)	18	21
Gadwall	85(17)	66(16)	25(25)	20(18)	29	30
Redhead	78(16)	79(19)	13(13)	25(23)	17	32
Cinnamon Teal[c]	72(15)	59(14)	11(11)	11(10)	15	19
Northern Shoveler	45 (9)	38 (9)	11(11)	11(10)	24	29
Lesser Scaup	41 (8)	27 (6)	11(11)	11(10)	27	41
Northern Pintail	11 (2)	13 (3)	1 (1)	3 (3)	9	23
Green Winged Teal	8 (2)	3 (1)	0 (0)	0 (0)	0	0
Total	489(99)	418(100)	99(99)	109(100)	20	26

[a] Ruddy ducks were excluded due to difficulties in counting
[b] Two week shorter field season, thus, 2 fewer brood counts completed than in 1995
[c] Includes blue-winged teal pairs (1995, n = 14, 1996, n = 5)

Appendix B. Number of nests (n), exposure days (days), unsuccessful nests[a] (failed), abandoned[b] (Ab), daily survival rates (DSR), and standard errors (SE) by duck species.

1995[c]

Species	n	Days	Failed	Ab	DSR	SE
Mallard	120	899.0	92	13	0.8977	0.0101
Northern Shoveler	25	276.5	19	2	0.9313	0.0152
Gadwall	27	245.5	17	5	0.9308	0.0162
Cinnamon Teal[d]	21	250.0	18	1	0.9280	0.0163
Lesser Scaup	15	154.0	11	1	0.9286	0.0208
Northern Pintail	6	21.5	5	1	0.7674	0.0911
Redhead	3	37.5	3	0	0.9200	0.0443
Green Winged Teal	2	6.5	1	1	0.8462	0.1415
Total	219	1890.5	166	24	0.9122	0.0065

[a] Includes depredated, infertile, addled, and nests abandoned for unknown reasons

[b] Nests abandoned due to investigator disturbance

[c] Excluding overwater nests

[d] Includes blue winged teal

1995 OVERWATER NESTS

Species	n	Days	Failed	Ab	DSR	SE
Mallard	20	268.5	14	0	0.9479	0.0136
Redhead	21	239.0	12	1	0.9498	0.0141
Cinnamon Teal	1	21.0	0	0	1.0000	0.0000
Lesser Scaup	1	31.0	1	0	0.9677	0.0317
Ruddy Duck	1	13.0	0	0	1.0000	0.0000
Total	44	572.5	27	1	0.9528	0.0089

Appendix B. (Continued)

1996[a]

Species	n	Days	Failed	Ab	DSR	SE
Mallard	109	1064.5	74	6	0.9305	0.0078
Northern Shoveler	35	371.0	18	4	0.9515	0.0112
Gadwall	31	454.0	17	1	0.9626	0.0089
Cinnamon Teal[b]	26	212.0	14	4	0.9340	0.0171
Lesser Scaup	18	212.5	6	4	0.9718	0.0114
Northern Pintail	6	93.0	2	0	0.9785	0.0150
Redhead	3	34.5	2	0	0.9420	0.0398
Green Winged Teal	2	20.5	2	0	0.9024	0.0655
Total	230	2462.0	135	19	0.9452	0.0046

[a] Excluding overwater nests
[b] Includes blue winged teal

1996 OVERWATER NESTS

Species	n	Days	Failed	Ab	DSR	SE
Mallard	55	688.0	25	4	0.9637	0.0071
Redhead	36	526.0	20	1	0.9620	0.0083
Cinnamon Teal	2	24.0	2	0	0.9167	0.0564
Lesser Scaup	1	0.0	0	1	0.0000	0.0000
Ruddy Duck	1	7.0	0	0	1.0000	0.0000
Total	95	1245.0	47	6	0.9622	0.0054

Appendix C. Mayfield success of duck nests by habitat, year and area.

	1995			1996		
Habitat	Treat. (n)	Con. (n)	P[a]	Treat. (n)	Con. (n)	P[a]
Upland[b]	4.5 (72)	3.7 (123)	0.692	17.5 (112)	10.2 (99)	0.121
Overwater[c]	33.6 (19)	8.2 (24)	0.042	33.4 (54)	15.3 (35)	0.088
Total[d]	8.6 (91)	4.3 (147)	0.089	22.4 (166)	11.4 (134)	0.015

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[a] Probability that nest success between treatment and control areas was similar

[b] Includes nests located in upland, wet meadow, and dry wetland habitats

[c] Includes only nests located over water

[d] Includes nests located in all habitat types on the SWMA

Appendix D. Cause of timer malfunctions at destroyed nests.

Timer Malfunction	1995 n	1995 (%)	1996 n	1996 (%)	Total n	Total (%)
Treadle remained depressed	9	(36.0)	19	(47.5)	28	(43.1)
Clock reset	1	(4.0)	14	(35.0)	15	(23.1)
Clock got wet	8	(32.0)	1	(2.5)	9	(13.8)
Solder bond on wire broken	5	(20.0)	4	(10.0)	9	(13.8)
Timer lost	2	(8.0)	2	(5.0)	4	(6.2)
Total	25	(100)	40	(100)	65	(100)