5-1989

Aspects of Mammalian Predation on Upland Nesting Waterfowl in Central North Dakota

John Thompson Trevor

Follow this and additional works at: https://commons.und.edu/theses

Part of the Psychology Commons

Recommended Citation
https://commons.und.edu/theses/836

This Thesis is brought to you for free and open access by the Theses, Dissertations, and Senior Projects at UND Scholarly Commons. It has been accepted for inclusion in Theses and Dissertations by an authorized administrator of UND Scholarly Commons. For more information, please contact zeinebyousif@library.und.edu.
ASPECTS OF MAMMALIAN PREDATION ON UPLAND NESTING WATERFOWL
IN CENTRAL NORTH DAKOTA

by
John Thompson Trevor
Bachelor of Arts, University of New Hampshire, 1986

A Thesis
Submitted to the Graduate Faculty
of the
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Science
Grand Forks, North Dakota
May
1989
This Thesis submitted by John Thompson Trevor in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota has been read by the Faculty Advisory Committee under whom the work has been done, and is hereby approved.

(Chairperson)

This Thesis meets the standards for appearance and conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

Dean of the Graduate School
Permission

Title Aspects of Mammalian Predation on Upland Nesting Waterfowl in Central North Dakota

Department Biology

Degree Masters of Science

In presenting this thesis in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Library of this University shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my thesis work or, in his absence, by the Chairman of the Department or the Dean of the Graduate School. It is understood that any copying or publication or other use of this thesis or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of North Dakota in any scholarly use which may be made of any material in my thesis.

Signature

Date 1/20/88
## TABLE OF CONTENTS

- **LIST OF ILLUSTRATIONS**: vi
- **LIST OF TABLES**: viii
- **ACKNOWLEDGMENTS**: ix
- **ABSTRACT**: xi
- **INTRODUCTION**: 1
- **STUDY AREA**: 5
- **METHODS**: 11
  - I. Artificial Nests: 11
  - II. Hair Analysis: 15
  - III. Predator Census: 16
  - IV. Analyses: 17
- **RESULTS**: 20
  - I. Nest Survival: 20
    - A) Overall: 20
    - B) Effect of Density: 20
    - C) Effect of Predator Control: 34
    - D) Effect of Distance to Roads, Dens, or Other Artificial Nests: 34
    - E) Effect of Haircatchers: 38
  - II. Hair Analysis: 38
  - III. Type and Location of Egg Remains: 38
  - IV. Predator Census: 54
- **DISCUSSION AND CONCLUSIONS**: 64
  - I. Nest Survival: 64
    - A) Differences in Nest Survival Between Years: 64
B) Differences in Nest Survival Between Experimental Trials..........................67

C) Effect of Nest Density on Nest Survival...68

D) Effect of Predator Control on Nest Survival........................................70

E) Effect of Roads, Dens, and Other Artificial Nests on Nest Survival...........73

F) Conclusions: Nest Survival..................73

II. Identifying Predator Species by Egg Remains...74

A) Differences Between Years......................74

B) Differences Between Predator Species......75

C) Conclusions: Identifying Predator Species By Egg Remains...................77

APPENDICES..........................................................79

APPENDIX A. Scent-station index results ..........80

APPENDIX B. Number and type of active predator dens on study plots...............81

APPENDIX C. Summary of nightlighting data..........82

REFERENCES CITED..................................................83
LIST OF ILLUSTRATIONS

Figure 1. Map of study area, showing specific study fields used, in 1987 and 1988.................6

Figure 2. A comparison of the probability of survival of nests located in the Corps areas for 1987 versus 1988.................................21

Figure 3. A comparison of the probability of survival of nests, located in the Corps areas, among experimental trials in each plot for 1987 and 1988..............................23

Figure 4. A comparison of the probability of survival of nests located in the Wolf Creek Management Area plot and the Mallard Island plot, between experimental trials, in 1987 and 1988.................................25

Figure 5. A comparison of the probability of survival for each experimental trial of nests located in the high versus low density plots, 1987.................................................29

Figure 6. A comparison of the probability of survival of nests located in the high versus low density plots, 1988.................................31

Figure 7. A comparison of the probability of survival between the Wolf Creek Management Area (WOLF) plot (no predator control) and the Mallard Island (M.I.) plot (predator control).................................35

Figure 8. The overall percentage of depredated eggs found in each egg remain category for all depredated nests in 1987 and 1988.................41

Figure 9. The overall percentage of depredated eggs found at each location for all depredated nests in 1987 and 1988.................................43

Figure 10. A comparison of the overall percentage of depredated eggs found in each egg remain category for 1987 versus 1988.........................45

Figure 11. A comparison of the overall percentage of depredated eggs found at each location for 1987 versus 1988.................................47
Figure 12. A comparison of the percentage of depredated eggs found in each egg remain category for skunks versus foxes...........50

Figure 13. A comparison of the percentage of depredated eggs found at each location for skunks and foxes.........................52

Figure 14. A comparison of the percentage of depredated eggs found in each egg remain category for nests in which a hair sample was and was not collected.......................55

Figure 15. A comparison of the percentage of depredated eggs found at each location for nests in which a hair sample was and was not collected..............................57

Figure 16. A comparison of the number of scats collected at random from study areas for 1987 and 1988.................................59
LIST OF TABLES

Table 1. Spring and summer climatological data for Garrison North Dakota, 1987 and 1988........10
Table 2. Number and density of artificial nests used, including initiation dates, for each experimental trial during 1987 and 1988......12
Table 3. Comparison of the probability of survival ± SE for nests of the first, second, and third experimental trials in 1987 and 1988...27
Table 4. Mean values for Robel Reading, highest height of the green vegetation, and the highest height of the residual vegetation measured in dm for 1987 and 1988.................28
Table 5. Comparison of the probability of survival ± SE for nests located in high versus low density plots in the Corps land area for 1987 and 1988..............................33
Table 6. Comparison of the probability of survival ± SE for nests located on the Wolf Creek Management Area mainland plot and the Mallard Island plot for 1988................37
Table 7. Number and type of hair samples collected from haircatchers for 1987 and 1988............39
Table 8. Scat collection data for red fox (Vulpes vulpes) for 1987 and 1988.................61
Table 9. Scat collection data for striped skunk (Mephitis mephitis) for 1987 and 1988........62
Table 10. Scent-station index results for 1987..........80
Table 11. Number and type of active predator dens recorded for all study plots for 1987 and 1988.................................81
Table 12. Summary of nightlighting data for Corps Area plots and Wolf Creek Management Area plot for 1987 and 1988.........................82
I would like to thank my advisor, Dr. Robert Seabloom for all his assistance and patience, especially during the preparation of this thesis. His encouragement throughout the duration of this study is truly appreciated. I would also like to acknowledge the other members of my committee, Dr. Richard Crawford and Dr. William Wrenn, for their valuable comments and advice throughout the preparation of this manuscript.

This study was funded by the University of North Dakota, Department of Biology and Graduate School, and supported by a grant to the Institute for Ecological Studies from the North Dakota Game and Fish Department under Project W-67-R. A scholarship from the North Dakota Chapter of the Wildlife Society was used to purchase research supplies.

I acknowledge the personnel of the Riverdale office of the North Dakota Game and Fish Department, especially George Enyeart, the U.S. Army Corps of Engineers, and the Audubon National Wildlife Refuge for their logistical support.

I would like to express my sincere gratitude to the entire staff (both past and present) of the Institute of Ecological Studies, especially Dr. Rodney Sayler, Director, for all his help in planning this study, and his continued support. A warm thanks to Mark Willms who provided helpful guidance in the field and someone to talk to on those rare
rainy nights. I would also like to thank John Steiner, Noreen Walsh, Cathy Nigg, Neil Wilken, Terry Kostinec, and Mike Havlik who provided a great deal of friendship while in the field.

I would like acknowledge the graduate students, who provided me with years of companionship and encouragement. I would especially like to thank John Carroll and Bill Jensen, who besides being close friends provided priceless statistical guidance and advice. Also a special thanks to Paul Pickett and Val Schawaroch for all the laughs they provided.

I would like to give a very special thanks to my wife, Cheri, for her relentless support, patience, and encouragement. Rocks will melt if sufficiently heated.

This thesis is dedicated to my parents, Jacqueline and Edward, who stood by me and supported all my endeavors, even something as crazy as biology.
ABSTRACT

The impact of mammalian predation on upland nesting waterfowl was studied in central North Dakota during the summers of 1987 and 1988. Survival of artificial nests was examined in relation to nest density, vegetation cover, distance from roads, active predator dens, and other artificial nests in a plot. Survival of artificial nests was also compared between an area with predator control and one without predator control.

Artificial waterfowl nests located in high density plots had a significantly lower probability of survival than nests located in low density plots. Although there were significant differences in vegetation height and density between years, the probability of survival of nests in dense vs. sparse vegetative cover was the same. There was also no relationship between nest survival and distance to roads, active predator dens, or other artificial waterfowl nests. The probability of survival of nests located in the predator control plot was significantly greater than nests located in the plot without predator control for the first experimental trial but not the second.

Striped skunks (*Mephitis mephitis*) and red fox (*Vulpes vulpes*) were the 2 most important nest predators on artificial waterfowl nests. The majority of eggs depredated by both fox and skunk were missing (75% and 36%,
respectively). Of the remaining 64% of remains found at destroyed nests attributed to skunks, crushed egg remains were the most common type found. Fox left only 25% of all depredated eggs at the nest, but again crushed eggs were prevalent. The majority of egg remains left by skunks were in or adjacent to the nest bowl, while most remains from foxes were found 0.5-2 m from the nest bowl. Although many researchers document nest predators from descriptions in the literature, conflicting reports for the same predator are often found. In this study, the type and location of egg remains attributable to fox and skunk overlapped approximately 30%.

As nesting habitat decreases, waterfowl are forced to nest in smaller suitable areas at increased densities. The results of this study show that nests at higher densities had a significantly lower probability of survival than nests at lower densities, regardless of nesting cover, or distance to roads, active predator dens, or other artificial nests.
INTRODUCTION

Predation has long been known to be a primary factor limiting waterfowl nesting success, particularly in areas with pcor nesting cover and abundant predators (Burgess et al. 1965, Byers 1974, Duebbert and Kantrud 1974, Hill 1984, Cowardin et al. 1985). However, the impact of individual species of predators on waterfowl nesting success remains poorly understood. Only recently have studies begun to examine the role of individual predator species. Nevertheless, it is very difficult to isolate individual predators from a system, and examine solely their role in a natural setting.

Identification of nest predators is very difficult, and often inaccurate. Usually, only avian versus mammalian predation can be distinguished. Documentation of the condition of egg remains at nests depredated by mammals has been provided by Darrow (1938), Sooter (1946), Sowls (1948), Reardon (1951), Einarsen (1956), and Davis (1959). These accounts, however, are sometimes contradictory regarding a predator's method of eating eggs, or the resulting condition of the egg shell remains. Davis (1959:139) stated that "invariably the end of the egg is opened as if had hatched", while Darrow (1938), Sowls (1948), Reardon (1951), and Einarsen (1956) stated that egg shells are eventually crushed by skunks, but their method of entry into the egg varies from opening it with their front paws, boring into it
primary nest predators are avian (Dwernychuk and Boag 1972, Jones and Hungerford 1972, Sugden and Beyersbergen 1987). However, when dealing with mammalian predators, predator control can make a significant difference in improving nesting success (Balser et al. 1968, Chesness et al. 1968, Sargeant and Arnold 1984). In order for predator control to be effective and cost efficient, the primary nest predators present and their abundance must be taken into consideration. Another potentially important point is the effect of nest density on hatching success. Although little experimental work has been done to compare the effect of density on nest success, studies by Göransson et al. (1975), and Sugden and Beyersbergen (1986) showed that nests in high density areas were subjected to more predation than nests in low density areas. In both of these studies, however, the primary predators were avian. If one is trying to optimize waterfowl productivity at the lowest cost, it is important to know if nest density and nest predation are interrelated, and whether the cost of predator control offsets any productivity advantage in high density nesting areas.

Therefore, the objectives of this study were as follows:

1) To identify mammalian nest predators and compare the type of egg remains left by each species.

2) To determine factors responsible for survival of
with their nose, or crushing it in their mouth. Generalizations about the egg remains and the method of eating eggs by predators are based on relatively small sample sizes, and often do not take into account different egg sizes of the various ground nesting birds involved in these studies.

Wildlife managers attempt to increase nesting success by decreasing predation with the primary management tool of predator removal. Predator control has been implemented in some nesting areas, and reports of its effectiveness vary. Chesness et al. (1968) and Balser et al. (1968) both noted that predator control resulted in increased nesting success of pheasants and waterfowl, respectively, while Duebbert and Kantrud (1974) found habitat quality to be more important than predator reduction for higher nesting success in controlled versus natural areas. Schranck (1972) discovered that increased density of nesting cover and predator control were both important in increasing nesting success. Recently, such tools as electric fences and exclosure fences have been used to exclude all predators from nesting areas (Lokemoen et al. 1982, Nol and Brooks 1982). All predator control methods, however, are time consuming and expensive, and they must be maintained for the duration of the nesting season in order to enhance nesting success. In addition the effectiveness of each method varies with the predator species involved. Nesting cover is important when the
artificial waterfowl nests including:
  a) density of nests in an area;
  b) nest vegetation cover;
  c) distance to roads and nests;
  d) distance to active predator dens.
3) To compare nest survival between a nesting island with predator control, and a similar mainland nesting area without predator control.
STUDY AREA

This study was conducted in the vicinity of Coleharbor, T147N R83W, in McLean County, North Dakota (Fig. 1). I used 3 study sites in the Wolf Creek Area which is located on the eastern shore of Lake Sakakawea. The Wolf Creek Area is owned by the United States Army Corps of Engineers, but 2 of these sites, plots 2 and 3, are operated by the North Dakota Game and Fish Department as wildlife management areas (Fig. 1).

Mallard Island, used only in 1988, is an 11 km² island that was created in 1955 when the Garrison Reservoir was formed. The island is approximately 56% cooperatively farmed (including shared food plots for wildlife), and the rest of the island consists of planted grass/legume, native shortgrass prairie, shelterbelts, wetlands, and beaches (Sutherland 1987). Management practices include tree plantings, grass/legume cover plantings, burning, and predator control. The island is used intensively by nesting waterfowl and pheasants, primarily because of the high quality nesting habitat and relative isolation from mainland predators. With such a unique opportunity for study, the North Dakota Game and Fish Department in conjunction with the Institute of Ecological Studies and University of North Dakota Biology Department, began a series of studies in 1982 on the population ecology of the pheasants (Phasianus colchicus), waterfowl, avian, and mammalian predators on the
Figure 1. Map of study area, showing specific study fields used, in 1987 and 1988. 1a = high density plot, Corps land area; 1b = low density plot, Corps land area; 2 = Wolf Creek Wildlife Management Area mainland plot; 3 = Mallard Island plot.
island. These studies included home range and habitat use by pheasants, waterfowl nesting ecology and brood survival, and predation ecology of northern harriers.

The land operated by the Army Corps of Engineers (Corps land), 1A and 1B, was divided into 2 study plots which were separated by a gravel access road (Fig. 1). Plot 1A was 5.75 ha, while plot 1B was 23.00 ha. In the areas operated by the North Dakota Game and Fish Department, a 5.60 ha plot was used on both the Wolf Creek Wildlife Management Area (Wolf land, Area 2), and on Mallard Island (M.I., Area 3).

Land use in this area of North Dakota is dominated by agriculture, and wheat, barley, and sunflowers are the major crops planted. Fields of dense nesting cover (DNC) for wildlife were found primarily on management areas. The grass/legume species that make up these DNC fields, include brome (*Bromus* spp.), alfalfa (*Medicago* spp.), Kentucky bluegrass (*Poa* spp.), and wheatgrass (*Agropyron* spp.) (Duebbert et al. 1981). All 4 study plots were located in dense nesting cover (DNC) fields.

The area is used extensively as waterfowl nesting habitat, primarily by mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), pintail (*Anas acuta*), blue-winged teal (*Anas discors*), northern shoveler (*Anas clypeata*), lesser scaup (*Aythya affinis*), and redhead (*Aythya americana*), both on the mainland and nearby islands (Sayler 1983). Other common nesting birds include Canada geese (*Branta*
canadensis), ring-necked pheasants (Phasianus colchicus), gray partridge (Perdix perdix), and mourning doves (Zenaida macroura).

The primary mammalian predators occurring in this area are striped skunks (Mephitis mephitis), raccoons (Procyon lotor), red fox (Vulpes vulpes), mink (Mustela vison), coyotes (Canis latrans), badgers (Taxidea taxus), and Franklin's ground squirrels (Spermophilus franklinii) (Fritzell 1978, Greenwood 1981, Sargeant and Arnold 1984, Sargeant et al. 1984, Sargeant et al. 1987).

Other abundant mammals include white-tailed deer (Odocoileus virginianus), voles (Microtus spp.), deer mice (Peromyscus maniculatus), ground squirrels (Spermophilus tridecemlineatus and S. richardsonii), eastern cottontails (Sylvilagus floridanus), and white-tailed jackrabbits (Lepus townsendii) (Sutherland 1987).

During the period of this study, climatological data taken from Garrison, North Dakota, indicate that the average monthly temperature was warmer than average in both 1987 and 1988 (Table 1). However, in 1988, the average monthly temperature for the summer months was appreciably greater than average. Total monthly precipitation data indicate that 1987 was wetter than normal while 1988 was dryer than normal (Table 1).

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean Temperature (°C)</th>
<th>Total Precipitation (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>-5.0</td>
<td>-2.8</td>
</tr>
<tr>
<td>April</td>
<td>4.6</td>
<td>9.8</td>
</tr>
<tr>
<td>May</td>
<td>11.8</td>
<td>14.9</td>
</tr>
<tr>
<td>June</td>
<td>17.1</td>
<td>19.7</td>
</tr>
<tr>
<td>July</td>
<td>20.5</td>
<td>20.4</td>
</tr>
</tbody>
</table>
METHODS

I. Artificial Nests

Artificial waterfowl nests were randomly placed at 2 different densities in adjacent study plots. The total area of each study plot was determined with a steel tape measure. Random numbers for both the x and y axes were used to obtain coordinates for placement of all artificial nests. These coordinates ranged from 0 to the maximum measurement of the axis of the study plot in which the nest was to be placed. Nest densities were determined by dividing the total number of nests placed in a plot by the total area of the study plot. Densities to be used for artificial nests were determined from the literature and previous studies on Mallard Island (Duebbert and Lokemoen 1976, Giroux 1981, Duebbert et al. 1983, Sayler 1983, Sayler 1986). Densities on Mallard Island were much higher than those on mainland areas. Mallard Island nest densities of 5.2 nests/ha were used here for the "high density" areas, while mainland nest densities of 1.3 nests/ha were used for the "low density" areas. Several experimental trials using the same plots and densities were performed over the entire summer. Number and densities of artificial nests, along with initiation dates of the experimental trials, appear in Table 2.

Each nest contained 5 chicken eggs. These eggs were placed in boiling water for 2 minutes in order to solidify the whites, allowing the egg to remain unspoiled for a
Table 2. Number and density of artificial nests used, including initiation dates for each experimental trial during 1987 and 1988.

<table>
<thead>
<tr>
<th>Area</th>
<th>Year</th>
<th>Trial</th>
<th># of Nests</th>
<th>Density (nests/ha)</th>
<th>Initiation Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>1987</td>
<td>1</td>
<td>30</td>
<td>5.22</td>
<td>18 May</td>
</tr>
<tr>
<td>1B</td>
<td>1987</td>
<td>1</td>
<td>30</td>
<td>1.30</td>
<td>19 May</td>
</tr>
<tr>
<td>1A</td>
<td>1987</td>
<td>2</td>
<td>25</td>
<td>5.71</td>
<td>17 June</td>
</tr>
<tr>
<td>1B</td>
<td>1987</td>
<td>2</td>
<td>25</td>
<td>1.28</td>
<td>18 June</td>
</tr>
<tr>
<td>2</td>
<td>1987</td>
<td>1</td>
<td>40</td>
<td>5.10</td>
<td>30 May</td>
</tr>
<tr>
<td>2</td>
<td>1987</td>
<td>2</td>
<td>40</td>
<td>5.10</td>
<td>8 July</td>
</tr>
<tr>
<td>1A</td>
<td>1988</td>
<td>1</td>
<td>30</td>
<td>5.22</td>
<td>16 May</td>
</tr>
<tr>
<td>1B</td>
<td>1988</td>
<td>1</td>
<td>30</td>
<td>1.30</td>
<td>15 May</td>
</tr>
<tr>
<td>1A</td>
<td>1988</td>
<td>2</td>
<td>30</td>
<td>5.22</td>
<td>13 June</td>
</tr>
<tr>
<td>1B</td>
<td>1988</td>
<td>2</td>
<td>30</td>
<td>1.30</td>
<td>15 June</td>
</tr>
<tr>
<td>1A</td>
<td>1988</td>
<td>3</td>
<td>30</td>
<td>5.22</td>
<td>14 July</td>
</tr>
<tr>
<td>1B</td>
<td>1988</td>
<td>3</td>
<td>30</td>
<td>1.30</td>
<td>13 July</td>
</tr>
<tr>
<td>2</td>
<td>1988</td>
<td>1</td>
<td>30</td>
<td>5.35</td>
<td>3 June</td>
</tr>
<tr>
<td>2</td>
<td>1988</td>
<td>2</td>
<td>30</td>
<td>5.35</td>
<td>8 July</td>
</tr>
<tr>
<td>3</td>
<td>1988</td>
<td>1</td>
<td>30</td>
<td>5.35</td>
<td>1 June</td>
</tr>
<tr>
<td>3</td>
<td>1988</td>
<td>2</td>
<td>30</td>
<td>5.35</td>
<td>26 June</td>
</tr>
</tbody>
</table>

1 Area 1A = high density plot of the Corps area.
2 Area 1B = low density plot of the Corps area.
3 Area 2 = Wolf Creek Management Area mainland plot.
4 Area 3 = Mallard Island plot.
longer period of time. Nests were set out in the morning at the appropriate random coordinates. I wore gloves to minimize the presence of human scent when placing eggs into the nest bowl. For each nest, a nest bowl was dug out by removing the ground vegetation and creating a shallow depression approximately 15 cm in diameter. Vegetation density was measured at each nest by using a Robel pole, and measuring the visibility obstruction of the vegetation within 1 m² of the nest bowl (Robel et al. 1970). Highest heights of the green and residual vegetation were also taken at this time. The major grass/legume species were recorded in the 1 m² area surrounding the nest bowl, using visual estimates to determine the most abundant species. Nests were marked by willow stakes labelled with a piece of orange flagging, and placed 3 m north of each nest.

Haircatchers, adapted from Baker (1980), were placed immediately around the nest bowl. Two types were used; a rod shape in 1987, and a dome type in 1988. The rod shape haircatchers were constructed by attaching a large-tooth serrated hacksaw blade to an 46 cm long threaded steel rod. At first only 2 rod shaped haircatchers were placed with each nest, but in subsequent trials 3 or 4 were used per nest. These were bent so they could be placed around the base of the nest bowl and yet be attached to the top of each other. The dome type haircatchers were constructed from a roll of sheet metal. Strips, 4 to 5 cm in diameter and 50
cm long, were cut from the roll, and then serrations were cut on each side. These haircatchers had a small hole at each end of the strip for a spike, so they could be secured into the ground. With each end nailed into the ground the haircatcher assumed a dome appearance over the nest. These haircatchers were spray painted green after the first trial to test whether the original silver color attracted predators. In the third experimental trials for the high and low density plots, and the second trials for Wolf Creek Wildlife Management Area and Mallard Island plots, green and silver haircatchers were randomly placed with each nest. I believe that the silver appearance might have been more visible from above, thereby attracting more avian predators, or that the sun might reflect off them and attract diurnal predators. Finally, matted vegetation near each nest was returned to its original appearance in order to reduce visual attraction of predators to the nest.

After placement, nests were checked bi-weekly, weather permitting. An entire area was examined at each visit. During each nest check I recorded whether or not the nest had been depredated. If depredation had occurred, the following additional information was recorded: description of egg remains, position of egg remains in or around the nest, and condition of the nest bowl and surrounding vegetation. Each depredated nest was then surveyed for hair samples on the haircatcher and in and around the nest bowl.
Any hair samples collected were immediately sealed in plastic bags, labelled, and stored for later analysis. Regular nest examinations were continued until all nests in a plot were depredated, or sufficient time had passed for the average incubation period of a dabbling duck, about 23-25 days (Bellrose 1980).

Several trials were carried out in each plot during the season, with a period of 1-2 weeks between trials. New nest coordinates were randomly generated for each trial.

II. Hair Analysis

Hairs collected during 1987 and 1988 were prepared according to Carter and Dilworth (1971) to reveal their external cuticular pattern. Slides were first sprayed with a thin layer of clear enamel, then the hair was placed on it with the tip extending over the edge of the slide for easy removal. The slides were left overnight to dry, and then the hairs were removed and replaced in their collecting bags. These slides were analyzed by comparing the cuticular pattern from base to tip, to published references (Adjoran and Kolensky 1969, Moore et al. 1974) and my reference slides from known specimens. If hairs could not be positively identified the mammalian predator responsible for depredating those nests was classified as unknown.
III. Predator Census

To determine the relative abundance of nest predators in the different study plots, several methods were used. In 1987, scent-stations were set up in plots 1A and 1B on the Corp's land, according to Conner et al. (1983). These were baited with the putrefied remains of a large mammal. Each scent-station consisted of a central stake with a wire mesh bait container attached to the top, surrounded by 4 stakes with 3 layers of barbed wire running around the perimeter at approximately 30 cm intervals from the ground. The interior of the scent-station, approximately 1.5 m$^2$, was cleared of all vegetation and the soil was loosened with a metal rake to reveal tracks more easily. The scent-stations were rebaited when the bait became dry and odorless, about once a week. Scent-stations were checked intermittently for signs of predator visitation, including tracks, scats, and hair on the barbed wire.

Other indices of relative abundance were also used. First, the number and position of active dens in a particular study plot was recorded during nest placement and checks. The occupant was determined by hair and scat samples collected from the den openings. Only active dens were counted, since mammals often use many dens for short periods of time (Shirer and Fitch 1970). Second, scats were counted and collected during each nest check. Since nests were placed randomly, and scats were only collected in the
plot when carrying out nest checks, the survey for scats was therefore a random survey of the study plots. Scats were also collected along the access roads immediately adjacent to each study plot.

In 1988 on Mallard Island, a series of 7 conibear traps were set over artificial nests containing 4 chicken eggs. Each trap was set so the trigger extended over the eggs. Nests were lined with down to resemble natural nests, and placed with a bowl marker and nest marker, as with all natural nests found on Mallard Island. These nest traps were set on 26 June and checked weekly.

IV. Analyses

The Kaplan-Meier product-limit method for estimating survival was used to analyze nest success (Kaplan and Meier 1958). Kaplan-Meier estimates and nest survival distributions for all areas were calculated using the Statistical Analysis System (SAS), specifically the PHGLM procedure (SAS Institute Inc. 1986). This procedure uses the Cox's proportional hazards linear regression model, using a stepwise backward elimination procedure to determine significant dependent variables entered in the model. For those dependent variables not entering the model a single degree-of-freedom global chi-square statistic is calculated. Censored and uncensored observations are used to calculate a probability of survival over a period of time. Censored
observations are those known to be alive until a certain
time when their fate cannot be determined, while uncensored
observations are those with a known fate, (death), after a
certain period of time. For this study, successful nests
are censored observations, and depredated nests are
uncensored. However, since nests were not checked daily,
the exact date of nest depredation was unknown. Therefore,
to obtain nest destruction dates, I averaged the number of
days between the previous nest check, and the day the nest
was found depredated.

Survival models could then be made using the number of
days surviving as the dependent variable, and inputting
independent variables from the data set. These models then
compared probability of survival for each category within
every independent variable, and recorded any significant
differences between these categories. In this way
comparisons could be made between years, areas, fields, etc.

Survival curves were then made by plotting the
probability of survival for nests on the y-axis, and the
number of exposure days on the x-axis. These curves were
compared by the SURVTEST procedure (SAS Institute Inc.
1986), which tests for differences between the curves. A
significant difference in these curves is interpreted as a
significant difference in the probability of survival
between nests within a particular variable. For example, if
the variable "year" was used, the SURVTEST procedure would
test the difference between the 1987 and 1983 nest survival curves. In this way individual nest survival comparisons were made for years, areas, fields, and trials. For a more detailed discussion of the Kaplan-Meier product-limit method see Kurzejeski et al. (1987).

Means for Robel readings, highest height of green, and residual vegetation were derived by the univariate procedure outlined by SAS Institute Inc. (1985), and t-tests were used to test for differences. Correlations and frequencies for all variables were produced using the CORR and FREQ procedures, respectively (SAS Institute Inc. 1985). I used G-tests to test for differences in the distributions of egg remain types and locations between years, different predator species, and nests with and without hair samples. Significance of all statistical tests and comparisons are reported at the 95% probability level (0.05 alpha level), unless otherwise indicated.
RESULTS

I. Nest Survival

A) Overall

The probability of survival (PS) for all nests in 1987 (PS=0.1566) was significantly greater than the probability of survival for nests in 1988 (PS=0.1096) (Fig. 2). Overall, there was a significant difference in the probability of survival between experimental trials performed in an area (Figs. 3, 4; Table 3). In 7 comparisons of the results for each experimental trial done in a particular plot, 3 were significantly different (Figs. 3, 4; Table 3). No other variables entered into the overall survival model were significant. These nonsignificant variables were cover type, Robel reading, and highest height of the green and residual vegetation.

The mean Robel reading and highest height of the green vegetation were significantly greater in 1987 than 1988, while the mean highest height of the residual vegetation was not different between years (Table 4).

B) Effect of Density

Overall, for 1987 and 1988, the probability of survival was significantly lower for nests located in high versus low density plots (Figs. 5, 6; Table 5). Although in all cases nest survival tended to be higher in the low density plots than high density plots, in 1987 there was a significant
Figure 2. A comparison of the probability of survival of nests located in the Corps areas for 1987 versus 1988. Results from the first and second experimental trials are shown. A = high density plot, trial 1; B = low density plot, trial 1; C = high density plot, trial 2; D = low density plot, trial 2.
Figure 3. A comparison of the probability of survival of nests, located in the Corps areas, among experimental trials in each plot for 1987 and 1988. A = high density plot, 1987; B = low density plot, 1987; C = high density plot, 1988; D = low density plot, 1988.
Figure 4. A comparison of the probability of survival of nests located in the Wolf Creek Management Area plot and the Mallard Island plot, between experimental trials, in 1987 and 1988. A = Wolf Creek Management Area plot, 1987; B = Wolf Creek Management Area plot, 1988; C = Mallard Island plot, 1988.
Table 3. Comparison of the probability of survival ± SE for nests of the first, second and third experimental trials, in 1987 and 1988. Numbers in parentheses represent the last day in which a nest was still active in that area.

<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>1A</td>
<td>$0.0648 \pm 0.0114$ (21)$^a$</td>
<td>$0.0770 \pm 0.0148$ (15)$^a$</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>$0.1641 \pm 0.0279$ (23)$^a$</td>
<td>$0.4317 \pm 0.0651$ (7)$^a$</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>$0.1187 \pm 0.0178$ (19)</td>
<td>$0.0831 \pm 0.0126$ (12)</td>
<td>----</td>
</tr>
<tr>
<td>88</td>
<td>1A</td>
<td>$0.1791 \pm 0.0296$ (6)</td>
<td>$0.0938 \pm 0.0163$ (6)</td>
<td>$0.0385 \pm 0.0069$ (6)</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>$0.0884 \pm 0.0154$ (12)</td>
<td>$0.2094 \pm 0.0340$ (6)</td>
<td>$0.0101 \pm 0.0018$ (12)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>$0.3784 \pm 0.0545$ (2)</td>
<td>$0.0938 \pm 0.0163$ (6)</td>
<td>----</td>
</tr>
<tr>
<td>88</td>
<td>3</td>
<td>$0.0039 \pm 0.0007$ (25)$^a$</td>
<td>$0.0005 \pm 0.0001$ (22)$^a$</td>
<td>----</td>
</tr>
</tbody>
</table>

$^a$ The probability of survival of the study plots within each trial is significantly different ($P < 0.05$).
Table 4. Mean values for Robel reading, highest height of the green vegetation, and the highest height of the residual vegetation measured in dm for 1987 and 1988. Comparisons of vegetation parameters between years with the same letters are significantly different ($P < 0.05$).

<table>
<thead>
<tr>
<th></th>
<th>Mean Robel reading</th>
<th>Mean Highest Height of Green</th>
<th>Mean Highest Height of Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall (n=488)</td>
<td>2.090</td>
<td>5.034</td>
<td>6.388</td>
</tr>
<tr>
<td>1987 (n=188)</td>
<td>2.926&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.084&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.657</td>
</tr>
<tr>
<td>1988 (n=300)</td>
<td>1.566&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.378&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.219</td>
</tr>
</tbody>
</table>
Figure 5. A comparison of the probability of survival for each experimental trial of nests located in the high versus low density plots, 1987. A = results from the first experimental trial; B = results from the second experimental trial.
Figure 6. A comparison of the probability of survival of nests located in the high versus low density plots, 1988. A = results from the first experimental trial; B = results from the second experimental trial; C = results from the third experimental trial.
Table 5. Comparison of the probability of survival ± SE for nests located in high versus low density plots in the Corps land area for 1987 and 1988. Numbers in parentheses represent the last day in which a nest was still active in that area.

<table>
<thead>
<tr>
<th>Year</th>
<th>Trial</th>
<th>High Density</th>
<th>Low Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>1</td>
<td>0.0648 ± 0.0114 (21)\textsuperscript{a}</td>
<td>0.1641 ± 0.0279 (23)\textsuperscript{a}</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>0.0770 ± 0.0148 (15)</td>
<td>0.4317 ± 0.0651 (7)</td>
</tr>
<tr>
<td>88</td>
<td>1</td>
<td>0.1791 ± 0.0296 (6)</td>
<td>0.0884 ± 0.0154 (12)</td>
</tr>
<tr>
<td>88</td>
<td>2</td>
<td>0.0938 ± 0.0163 (6)</td>
<td>0.2094 ± 0.0340 (6)</td>
</tr>
<tr>
<td>88</td>
<td>3</td>
<td>0.0385 ± 0.0069 (6)\textsuperscript{a}</td>
<td>0.0101 ± 0.0018 (12)\textsuperscript{a}</td>
</tr>
</tbody>
</table>

\textsuperscript{a} The probability of survival of the study plots within each trial is significantly different (P < 0.05).
difference between plots only in experimental trial 1 (Fig. 5, Table 5), and in 1988, only in trial 3 (Fig. 6, Table 5).

C) Effect of Predator Control

In 1988, plots on Mallard Island and Wolf Creek Wildlife Management Area mainland were compared to determine the effects of predator control on nest survival. The probability of nest survival was significantly greater for nests located on the Mallard Island plot (predator control) than on the Wolf Creek Wildlife Management Area mainland plot (no predator control) for the first experimental trial, but not for the second trial (Fig. 7, Table 6).

D) Effect of Distance to Roads, Dens, or Other Artificial Nests

None of these distance variables could be used in a survival model because of low global chi-square values (distance to roads $X^2=1.20$, df=1, $P=0.27$, distance to dens $X^2=0.04$, df=1, $P=0.83$, distance to nearest artificial nest $X^2=0.43$, df=1, $P=0.2$). Therefore, there were no significant differences in the probability of survival of nests and the distance to access roads, the distance to the nearest nest, or the distance to active predator dens.
Figure 7. A comparison of the probability of survival between the Wolf Creek Management Area (WOLF) plot (no predator control) and the Mallard Island (M.I.) plot (predator control). A = results from the first experimental trial; B = results from the second experimental trial.
Table 6. Comparison of probability of survival ± SE for nests located on the Wolf Creek Management Area mainland plot and the Mallard Island plot for 1988. Numbers in parentheses represent the last day in which a nest was still active in that area.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Mallard Island</th>
<th>Wolf Creek Management Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00386 ± 0.00070 (25)^a</td>
<td>0.3784 ± 0.05447 (2)^a</td>
</tr>
<tr>
<td>2</td>
<td>0.00477 ± 0.00009 (22)</td>
<td>0.0938 ± 0.01630 (6)</td>
</tr>
</tbody>
</table>

^a The probability of survival of the study plots within each trial is significantly different (P < 0.05).
E) Effect of Haircatchers

Similar to the distance variables, the haircatcher color variable could not be used in a survival model because of a low global chi-square value \( (X^2=0.06, \, df=1, \, P=0.81) \). Again, there was no significant difference in the probability of survival between nests with silver colored haircatchers and nests with green-painted haircatchers.

II. Hair Analysis

Hair samples were found at 32.1% of all depredated nests. However, in 1988, 37.6% of all depredated nests had a hair sample, while in 1987 only 23.7% had hairs. The number of depredated nests with a hair sample collected was significantly different between years \( (G=12.45, \, df=1, \, P=0.0) \).

Of 152 hair samples collected, those of striped skunks and red fox were the most numerous (Table 7). Skunk hairs were the most prevalent in both years, while red fox hairs were numerous only in 1988. All other predators had a low incidence of hairs found at nests (Table 7).

III. Type and location of Egg Remains

A total of 2450 eggs were placed in nests during this study; 940 eggs were used in 1987, whereas 1500 eggs were used in 1988. Egg type remains were recorded for 1106 eggs, of which, more than 85% were crushed or broken into 1/2-
Table 7. Number and type of hair samples collected from haircatchers for 1987 and 1988. Percentages are shown in parentheses.

<table>
<thead>
<tr>
<th>Predator Species</th>
<th>1987</th>
<th>1988</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Striped Skunk</td>
<td>23 (69.7)</td>
<td>60 (50.4)</td>
<td>83 (51.6)</td>
</tr>
<tr>
<td>Red Fox</td>
<td>1 (3.0)</td>
<td>37 (31.1)</td>
<td>38 (23.6)</td>
</tr>
<tr>
<td>Unknown (large)</td>
<td>6 (18.2)</td>
<td>17 (14.3)</td>
<td>23 (14.3)</td>
</tr>
<tr>
<td>Vole (Microtus spp.)</td>
<td>2 (6.1)</td>
<td>1 (0.8)</td>
<td>3 (1.9)</td>
</tr>
<tr>
<td>Unknown small mammal</td>
<td>0 (0.0)</td>
<td>2 (1.7)</td>
<td>2 (1.2)</td>
</tr>
<tr>
<td>Ground Squirrel (Spermophilus spp.)</td>
<td>1 (3.0)</td>
<td>1 (0.8)</td>
<td>2 (1.2)</td>
</tr>
<tr>
<td>Raccoon</td>
<td>0 (0.0)</td>
<td>1 (0.8)</td>
<td>1 (0.6)</td>
</tr>
</tbody>
</table>
1/4-sized pieces. The remaining eggs were in 3/4-sized pieces or only punctured with small holes (Fig. 8). Egg shell locations were recorded for 1104 eggs, 39.0% of which were located in the nest bowl, 18.1% were on the edge of the nest bowl, 34.5% were 0.5 to 1 m from the nest bowl, 7.6% were 1 to 2 m from the nest bowl, and 0.8% were 2 to 3 m from the nest bowl (Fig. 9). Of the 2450 eggs placed, 1170 eggs were removed from nests in which no egg remains were found. Of these, 11 were later found cached.

There was a significant difference in the distributions of egg remain types, including missing eggs (G=654.57, df=4, P<0.0001), and location of egg remains (G=20.94, df=4, P<0.0001) between years. In 1987, the majority of egg remains were left at nests and were in 1/2- to 1/4-sized pieces, or crushed, while in 1988, the majority of eggs were missing (Fig. 10). However, the location of egg remains at depredated nests in 1987 and 1988 was very similar (Fig. 11).

The condition of the nest bowl was recorded at 567 visits to depredated nests in 1987 and 1988. It was found to be undisturbed at 91.2% of the visits, lightly disturbed at 1.1%, and heavily disturbed at 7.7% of the visits.

A comparison of the nest and egg remains for the different mammalian predators was restricted to skunks and foxes, because of the limited number of hair samples collected from all other mammalian predators (Table 7).
Figure 8. The overall percentage of depredated eggs found in each egg remain category for all depredated nests in 1987 and 1988. PUNC = eggs with small puncture holes; 3/4 = eggs with 3/4 of the shell remaining intact; 1/2 = eggs with 1/2 to 1/4 of the shell intact; CRUSH = eggs that were crushed; MISS = eggs that were missing.
Figure 9. The overall percentage of depredated eggs found at each location for all depredated nests in 1987 and 1988. BOWL = egg remains found in the nest bowl; EDGE = egg remains found on edge, or just outside (< 0.5 M) of the nest bowl; 0.5-1 M = egg remains found from 0.5 to 1 m of the nest bowl; 1-2 M = egg remains found from 1 to 2 m of the nest bowl; 2-3 M = egg remains found from 2 to 3 m of the nest bowl.
Figure 10. A comparison of the overall percentage of depredated eggs found in each egg remain category for 1987 versus 1988. PUNC = eggs with small puncture holes; 3/4 = eggs with 3/4 of the shell remaining intact; 1/2 = eggs with 1/2 to 1/4 of the shell intact; CRUSH = eggs that were crushed; MISS = eggs that were missing.
Figure 11. A comparison of the overall percentage of depredated eggs found at each location for 1987 versus 1988. BOWL = egg remains found in the nest bowl; EDGE = egg remains found on edge, or just outside (< 0.5 M) of the nest bowl; 0.5-1 M = egg remains found from 0.5 to 1 m of the nest bowl; 1-2 M = egg remains found from 1 to 2 m of the nest bowl; 2-3 M = egg remains found from 2 to 3 m of the nest bowl.
LOCATION OF EGG REMAINS

PERCENT OF EGGS

1987

1988

LOCATION OF EGG REMAINS

BOWL
EDGE
0.5-1 M
1-2 M
2-3 M
The distributions of the types of egg remains for skunks and fox were significantly different ($G=72.14$, $df=4$, $P<0.0001$). Skunks had 0.9% punctured egg remains, 6.5% 3/4-sized egg remains, 22.8% 1/2- to 1/4-sized egg remains, 33.4% crushed egg remains, and 36.4% missing egg remains (Fig. 12). Fox had 0.0% punctured egg remains, 0.6% 3/4-sized egg remains, 5.7% 1/2- to 1/4-sized egg remains, 19.8% crushed egg remains, and 74.0% missing egg remains (Fig. 12). The category with highest percent of egg remains for both skunks and fox was missing eggs, with 36% and 75%, respectively (Fig. 12). Of the remaining 64% of egg remains found at destroyed nests attributed to skunks, crushed egg remains were the most common type found. Fox left only 25% of all depredated eggs at the nest, but again crushed eggs were prevalent (Fig. 12).

The distribution of the locations of egg remains was significantly different for skunks and fox, ($G=30.18$, $df=3$, $P<0.0001$). Skunks left 40.6% of eggs in the nest bowl, 27.4% on the edge of the bowl, 25.4% from 0.5 to 1 m of the nest bowl, and 6.6% from 1 to 2 m of the nest bowl (Fig. 13). Fox left 19.6% of eggs in the nest bowl, 8.7% on the edge of the nest bowl, 41.3% from 0.5 to 1 m of the nest bowl, and 30.4% from 1 to 2 m of the nest bowl (Fig. 13).

The distribution of types of egg remains for depredated nests in which hair samples were and were not collected were not significantly different, ($G=3.13$, $df=4$, $P=0.5$)
Figure 12. A comparison of the percentage of depredated eggs found in each egg remain category for skunks versus foxes. PUNC = eggs with small puncture holes; 3/4 = eggs with 3/4 of the shell remaining intact; 1/2 = eggs with 1/2 to 1/4 of the shell intact; CRUSH = eggs that were crushed; MISS = eggs that were missing.
Figure 13. A comparison of the percentage of depredated
eggs found at each location for skunks and
foxes. BOWL = egg remains found in the nest
bowl; EDGE = egg remains found on edge, or
just outside (< 0.5 M) of the nest bowl.
0.5-1 M = egg remains found from 0.5 to 1 m of
the nest bowl; 1-2 M = egg remains found from
1 to 2 m of the nest bowl.
(Fig. 14). Similarly, the distribution of location of egg remains for depredated nests in which hair samples were and were not collected was also not significantly different, ($G=4.25$, $df=4$, $P=0.5$) (Fig. 15).

IV. Predator Census

In 1987, sign was recorded at only 6 out of 24 visits to scent-stations (Appendix A). Because of the labor intensive nature of scent-stations and the lack of visitation by predators this census method was discontinued.

Collections of scats in all areas showed a dramatic increase in visitation by fox in 1988 over 1987 (Fig. 16, Table 8). Also, in 1988, 96 adult and juvenile fox scats were collected at a fox den located on the Wolf Creek Management Area. Skunk scat collections showed a fairly uniform distribution between years and areas, except for the Wolf Creek Management Area in 1987, in which there was a high number of skunk scats collected (Fig. 16, Table 9). Scats found at dens were not included in these tabulations. Other predator scats included mink, raccoon, and badger, but these were not frequently found. Comparisons between years and areas were not made since so few scats were collected.

Data on numbers of active dens in the areas showed an increase in the utilization by fox in 1988 over 1987 (Appendix B). These data also showed an increased use of the Wolf Creek Management area by skunks in 1987. The
Figure 14. A comparison of the percentage of depredated eggs found in each egg remain category for nests in which a hair sample was and was not collected. PUNC = eggs with small puncture holes; 3/4 = eggs with 3/4 of the shell remaining intact; 1/2 = eggs with 1/2 to 1/4 of the shell intact; CRUSH = eggs that were crushed; MISS = eggs that were missing. These percentages are based on 783 eggs found at nests with a hair sample and 1481 eggs found at nests without a hair sample.
Figure 15. A comparison of the percentage of depredated eggs found at each location for nests in which a hair sample was and was not collected. BOWL = egg remains found in the nest bowl; EDGE = egg remains found on edge, or just outside (< 0.5 M) of the nest bowl. 0.5-1 M = egg remains found from 0.5 to 1 m of the nest bowl; 1-2 M = egg remains found from 1 to 2 m of the nest bowl. These percentages are based on 783 eggs found at nests with a hair sample and 1481 eggs found at nests without a hair sample.
LOCATION OF EGG REMAINS

PERCENT OF EGGS

HAIR

NO HAIR

LOCATION OF EGG REMAINS

BOWL

EDGE

0.5-1 M

1-2 M
Figure 16. A comparison of the number of cats collected at random from study areas for 1987 and 1988. A = results from 1987; B = results from 1988; CORPS 1A = the high density plot in the Corps area; CORPS 1B = the low density plot in the Corps area; WOLF 2 = the Wolf Creek Management Area plot.
NUMBER OF SCATS COLLECTED

A

- SKUNK
- FOX
- OTHER

CORPS 1A | CORPS 1B | WOLF 2
---|---|---
CORPS 1A | CORPS 1B | WOLF 2

STUDY AREAS

<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
<th>Trial</th>
<th>Number of Visits</th>
<th>Total # of Scats Collected</th>
<th>Mean # of Scats/Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>1A</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>87</td>
<td>1A</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>0.75</td>
</tr>
<tr>
<td>87</td>
<td>1B</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>0.17</td>
</tr>
<tr>
<td>88</td>
<td>1A</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>1.17</td>
</tr>
<tr>
<td>88</td>
<td>1A</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>88</td>
<td>1A</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>88</td>
<td>1B</td>
<td>1</td>
<td>4</td>
<td>13</td>
<td>3.25</td>
</tr>
<tr>
<td>88</td>
<td>1B</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>1.50</td>
</tr>
<tr>
<td>88</td>
<td>1B</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>0.20</td>
</tr>
<tr>
<td>88</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>88</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

1 High density plot, Corps Area.
2 Low density plot, Corps Area.
3 Wolf Creek Management Area.

<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
<th>Trial</th>
<th>Number of Visits</th>
<th>Total # of Scats Collected</th>
<th>Mean # of Scats/Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>1A</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>0.75</td>
</tr>
<tr>
<td>87</td>
<td>1A</td>
<td>2</td>
<td>4</td>
<td>9</td>
<td>2.25</td>
</tr>
<tr>
<td>87</td>
<td>1B</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>87</td>
<td>1B</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>12</td>
<td>2.40</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>18</td>
<td>3.00</td>
</tr>
<tr>
<td>88</td>
<td>1A</td>
<td>1</td>
<td>6</td>
<td>10</td>
<td>1.67</td>
</tr>
<tr>
<td>88</td>
<td>1A</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1.00</td>
</tr>
<tr>
<td>88</td>
<td>1A</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>0.50</td>
</tr>
<tr>
<td>88</td>
<td>1B</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>1.25</td>
</tr>
<tr>
<td>88</td>
<td>1B</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>1.50</td>
</tr>
<tr>
<td>88</td>
<td>1B</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>88</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>88</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>2.50</td>
</tr>
</tbody>
</table>

1 High density plot, Corps Area.
2 Low density plot, Corps Area.
3 Wolf Creek Management Area.
increased utilization by fox in 1988 could also be seen through field observations made both during the day and at night. During the course of examining and recording nest depredations, fox were observed in the Corps study area only in 1988, but not in 1987. In the nightlighting data, fox were also only observed in 1988 (Appendix C).

In 1988, 2 juvenile magpies (M. Willms pers. comm.) were caught on Mallard Island by the conibear traps set out over artificial nests. Two other nest traps had missing eggs but were not triggered.
DISCUSSION AND CONCLUSIONS

I. Nest Survival

A) Differences in Nest Survival Between Years

Artificial waterfowl nests had a significantly greater probability of survival in 1987 than in 1988. This may be due to any one or combination of the following factors. There was a significantly greater density of vegetation around nests in 1987 than in 1988 (Table 3). Mean Robel reading (a measure of the visual obstruction of the nest vegetation) in 1987 was almost double that of 1988, and mean height of the tallest green vegetation at nests was also significantly greater in 1987. Both of these differences in nesting cover between years could be attributed to the drought conditions of 1988 (Table 1). Numerous studies including those by Duebbert (1969), Bengston (1972), Giroux (1981), Livezey (1981), Hill (1984), Cowardin et al. (1985), and Crabtree et al. (1989) have noted that nests found in taller, denser vegetation have higher nesting success than those in sparse cover. Vegetative cover protects nests in several ways. It may act as a visual barrier to avian predators (Odin 1957, Dwernychuk and Boag 1972, Jones and Hungerford 1972, Sugden and Beyersbergen 1986), and also may provide a barrier to travel and scent for mammals (Elton 1939, Schrank 1972, Duebbert and Kantrud 1974, Duebbert and Lokomoen 1976, Livezey 1981).

There was a greater abundance of predators on the study
areas in 1988, compared to 1987. Based on the results of the random scat collections, active den counts, daily observations, nightlighting observations, and hair sample collections, it is apparent that fox utilization of the high and low density plots in the Corps area greatly increased from 1987 to 1988. These predator abundance data also show a decrease in skunk utilization of the Wolf Creek Wildlife Management Area plot from 1987 to 1988, and a slight increase in skunk utilization of the high and low density plots in the Corps area from 1987 to 1988. Numerous studies of predator control support the idea that increased predator abundance results in decreased nesting success (Balser et al. 1968, Chesness et al. 1968, Duebbert and Kantrud 1974, Duebbert and Lokemoen 1980, Sargeant and Arnold 1984, Sayler 1987). In addition, Angelstam (1986) found that avian and mammalian predators destroyed more nests as the number and density of predators increased.

Finally, because of the extremely hot and dry weather conditions in 1988, the number of natural waterfowl nests in the area was greatly reduced (Sayler 1988). Spring water levels are known to regulate waterfowl nesting, both in their initial and subsequent renesting efforts (Derksen and Eldridge 1980, Giroux 1981, Krapu et al. 1983, Cowardin et al. 1985). Krapu et al. (1983) examined reproductive effort of waterfowl in relation to variable spring water conditions over a 20-year period, and found that the number of
waterfowl nesting during drought years was low, and also
that renesting was relatively rare during dry years. With
this reduced availability of natural waterfowl nests in
1988, the amount of alternative prey in the form of natural
nests was reduced. In addition, numbers of small mammals
(primarily microtines) would be expected to be lower in 1988
than 1987, due to reduced water availability in 1988 (R.
Seabloom pers. comm.). Without adequate data on small
mammal populations, however, the extent of this suggested
decline in availability is unknown. Errington (1937)
compared red fox food habits from a normal year to that of a
drought year and found that red fox consumed fewer small
mammals in the drought year. However, this could either
reflect a decreased availability of small mammals, or an
increased susceptibility of other prey items. Crabtree and
Wolfe (1988) found that increased amounts of alternate prey
reduced skunk predation on waterfowl nests. Darrow (1945),
Byers (1974) and Weller (1979) found correlations between
nesting success and the abundance of alternate small mammal
prey. As a consequence of the drought, the availability of
all alternate prey items was apparently lower in 1988 than
1987. Therefore, the lower survival of artificial nests in
1988 could be attributable to increased predator use in the
study areas, decreased vegetative cover at nests, and/or
decreased availability of alternative prey in 1988.
B) Differences in Nest Survival Between Experimental Trials

Overall, there was a significant difference in the probability of survival between nests located in the first, second or third (if applicable) trial (Figs. 3, 4, Table 2). Generally, the highest probability of survival was found in the first trial for that area. It is possible that predators were attracted to the haircatchers, and learned to detect them. Baker (1978), however, noted no difference in predation between nests with and without haircatchers, and in the present study there was no difference between silver-colored versus camouflaged (green) haircatchers. Alternatively, predation may have increased seasonally if avian predators learned to search for nests (Picozzi 1975), or mammalian predators returned to areas where nests were first found, or predators were attracted to the areas by the presence of human disturbance.

There is considerable debate as to whether predators are attracted or unaffected by human visitation of waterfowl nests. Gottfried and Thompson (1978), Liveze (1980), and Götmark and Åhlund (1984) found that human disturbance did not significantly increase predation rates on nests. However, Vacca and Handel (1988) found that investigators did attract predators to the study area. Götmark and Åhlund (1984) and Vacca and Handel (1988) noted that simulated nests with exposed eggs experienced higher predation rates.
than those covered with down. This leads to questions regarding the validity of using artificial nests, and how results compare to natural waterfowl nests. Some recent studies show a difference between artificial and natural nests (Dwernychuk and Boag 1972, Byers 1974, Storaas 1988, Willerbrand and Marcstrom 1988), while others found no differences (Gottfried and Thompson 1978, Boag et al. 1984, Yahner and Voytko 1989). Willerbrand and Marcstrom (1988), in a comparative study of artificial and natural nests, determined that most natural nests were destroyed by mammalian predators, whereas artificial nests were destroyed primarily by birds. They postulated that artificial nests lack the scent of the hen and thus are less apt to be found by mammals. Hammond and Forward (1956), however, found no difference in predation between artificial nests given hen scent and those not given hen scent. In my study however, the amount of avian predation on artificial nests was low, except on Mallard Island where predator control was being carried out. Predation on artificial and natural waterfowl nests on Mallard Island was similar. Both types of nests suffered high nest loss and the depredated eggs of both were usually missing (Sayler 1988).

C) Effect of Nest Density on Nest Survival

One of the primary objectives of this study was to determine the responses of mammalian predators to various
densities of nests in an area. Overall, nests located in the high density plots had a significantly lower probability of survival than nests in low density plots. In all trials, nests in the high density plot tended to have a lower probability of survival than nests in the low density plot. Search intensity of predators is expected to increase as the frequency of finding nests increases. As a result, the number of nests found and destroyed by predators should be higher in areas with a high density of nests. Martin (1988) reported that red squirrels (Tamiasciurus hudsonicus) and gray-neck chipmunks (Tamias cinereicollis) increased their search intensity in an area which contained nests at higher densities, but Boag et al. (1984) found that predation was independent of nest density. Göransson et al. (1975) and Sugden and Beyersbergen (1986) noted that nests located at higher densities were subject to higher predation rates, although both studies dealt with avian, as opposed to mammalian predators. Seasonal changes in the foraging pattern of mammalian predators could also be a factor influencing nest survival between high and low density plots. Food habits of waterfowl nest predators are known to change throughout the season as certain types of prey become abundant and others become scarce (Sargeant 1978, Greenwood 1981, Bowyer et al. 1983, Arnold and Fritzell 1987). Skunks are known to forage in a widely searching mode in the spring and early summer when prey is unpredictably located, and
then change to a sit and wait mode as prey becomes abundant and localized (Huey and Pianka 1981, Crabtree and Broome 1985, Crabtree and Wolfe 1988). These findings are supported by food habits studies, which reveal that skunks are primarily insectivorous in late June and July (Wade-Smith and Verts 1982, J. Trevor pers. obs.). Once again, the number of nests found by wide ranging predators does increase as the density of nests increases.

D) Effect of Predator Control on Nest Survival

Predator control on Mallard Island was deemed effective for the first experimental trial but not the second, in terms of nest survival (Fig. 7, Table 5). Predator control has been found to increase nesting success in at least some studies (Balser et al. 1968, Chesness et al. 1968, Duebbert and Kantrud 1974, Duebbert and Lokemoen 1980, Sayler 1987). However, the predator control program for Mallard Island in 1988 was not as successful as in previous years, primarily due to low lake levels, which allowed easier access of predators to the island (Sayler 1988).

There are several explanations for the difference in survival observed only in the first experimental trial, but not the second. The first involved the nature of the predators in both areas. On the Wolf Creek Management Area plot there was an active fox den located in the center of the study plot during the first experimental trial (Appendix
At this time no nests in the plot survived longer than 2 days. Conversely, no active fox dens were found on the Wolf Creek Management Area plot during the second experimental trial. There was a significant difference in nest survival between the Mallard Island plot (with predator control) and the Wolf Creek Management Area plot (without predator control) in the first experimental trial but not the second. The change in fox utilization of the Wolf Creek Management Area plot, solely may have affected nest survival rates between the two areas. There was, however, no significant difference in nest survival between the first and second experimental trials on the Wolf Creek Management Area plot (Fig. 4, Table 2). Skunk utilization of this area increased during the second trial, and may have compensated for the absence of fox (Table 8). Greenwood (1986) showed that in areas where different species of nest predators were abundant, the effect of removing skunks alone was negated by compensatory predation from the other predators. This compensatory predation by other predators may have negated any effect of the reduced fox utilization during the second trial on the Wolf Creek Management Area plot.

Alternatively, on Mallard Island avian predation may have increased to compensate for the lack of mammalian predators. From the conibear nest trap data, the primary predator on Mallard Island was the black-billed magpie. These birds were noticeable around the study plot, and they
nested along the shelterbelts of the island. It is possible that magpies developed a search image for artificial nests, so that predation rates for the second experimental trial were higher. Picozzi (1975) noted that corvids are capable of developing a search image for dummy nests. Other studies have found that avian predators are more likely to locate nests with exposed eggs, particularly nests with minimal overhead cover (Dwernychuk and Boag 1972, Jones and Hungerford 1972, Götmark and Ahlund 1984, Vacca and Handell 1988). Results from the Mallard Island plot support the idea of increased magpie predation, since the probability of survival for nests in the first experimental trial was significantly greater than for the second trial (Fig. 4, Table 2). In addition, no difference was found in nest survival between nests with heavy versus poor cover on the Mallard Island plot. This suggests that magpies were learning to search for nests as opposed to opportunistically taking nests that they could see.

The results of this study show that predator control is not necessarily a simple management tool. Nature of the predator complex, quality of nesting cover, and cost of the control program, are just a few of the many variables that must be considered before implementing an effective predator control program.
E) Effect of Roads, Dens, and Other Artificial Nests on Nest Survival

Nest survival was also examined in relation to a number of other variables, including roads, active predator dens, and other artificial nests, but in no case were there any significant effects. On the Wolf Creek Management Area plot there was one experimental trial with active predator dens and one trial without in both 1987 and 1988, but not a significant difference in nest survival between trials. The most probable reason is the extremely high predation rate in this study, especially in 1988. To compare nest survival, a number of nests must survive, but few nests survived for a sufficient amount of time to compare variables such as distance to landmarks. Other studies have also made these comparisons. Cowardin et al. (1985) did not note a relationship between nest success and the distance from roads, while Livezey (1980) found no trend between nesting success and the distance from vehicle tracks in nesting fields. Hill (1984) observed that both mallard and tufted duck (Aythya fuligula) nests located near another nest were more susceptible to predation, but he attributed this susceptibility to increased density.

F) Conclusions: Nest Survival

As nesting habitat continues to be destroyed, waterfowl have been forced to nest on smaller and smaller suitable
nesting areas at increased densities (Aus 1969, Whitsell 1970). In order to maximize production of waterfowl on these small areas, however, wildlife managers must carefully consider the resident predators and their responses to an increased density of nests. The results of my study show that without predator control, increasing the density of nests in an area decreases nest survival regardless of the vegetation density around nests, distance of nests to roads, distance of nests to other nests, and distance of nests to active predator dens. Although predator control is an accepted tool to increase nesting success of waterfowl, it did not always increase nest survival in this study, primarily because of increased predation by avian predators. The compensatory nature of the predators in the area and specific environmental conditions making the predator control areas accessible, resulted in similar survival of nests located on Mallard Island (predator control) and the Wolf Creek Management Area plot.

II. Identifying Predator Species by Egg Remains

A) Differences Between Years

The distribution of the types and locations of egg remains was significantly different between years (Figs. 10, 11). Notably, the proportion of "missing eggs" greatly increased in 1988. This can be directly attributed to the increased utilization of these study areas by red fox, as
evidenced by the number of scats collected, number of active dens, nocturnal and diurnal observations, and the number of hairs collected at depredated nests in 1988 compared to 1987 (Tables 7, 8, Appendices B, C). More direct evidence is from the type of egg remains found at nests depredated by fox. "Missing eggs" made up about 75% of all depredated eggs attributable to fox (Fig. 12). From this comparison of egg remains between years, it is clear that egg remains found at depredated nests depend to a great extent on the predator species complex in an area, and this may change from one year to the next. Wildlife managers should be more aware of changes in predator species abundance before trying to determine the identity of nest predators.

B) Differences Between Predator Species

Identification of nest predators by the method of nest destruction and appearance of eggshell remains is unreliable, due to individual variation among predators and, as noted earlier, inconsistent published descriptions of egg remains. In order to relate types of egg remains to specific nest predators, positive identifications of the nest predators must be made. In this study, haircatchers adapted from Baker (1980) provided hair samples for positive identification of mammalian predators, and ample data were collected to compare 2 primary nest predators, skunk and fox. These 2 species shared approximately 30% overlap in
the types and locations of egg remains (Figs. 12, 13). Descriptions in the literature of the egg remains for skunk and fox differ. Eggs destroyed by skunks are most often crushed and left in the nest bowl, whereas those depredated by fox are usually missing, or taken some distance from the nest and left in 1/2- to 3/4-sized pieces (Darrow 1938, Sowls 1948, Rearden 1951, Einarsen 1956, Davis 1959). These studies generally described only one type of egg remain for a predator species. In my study, the highest egg remains category for skunks was missing eggs, while other types of remains expected after reading the literature, such as crushed eggs and 1/2- to 1/4-sized eggs, were also prevalent. For fox, the highest percent egg remains was also missing eggs, but with much greater representation than that for skunks. "Missing eggs" were expected to be common in fox predation, but it is interesting that of egg remains actually left by fox at nests, crushed eggs were the most prevalent. Previous studies have reported that skunks leave egg remains in or just outside the nest bowl, while fox leave egg remains far from nests. Results from my study generally support this generalization; however, both skunk and fox left egg remains at each of the 4 location categories (Fig. 13).

In the present study, different types of egg remains were recorded for the same predator species, probably indicating variation within individuals of a species (Fig.
This variation in the condition of egg remains may be due to the age of the predator. Young fox, for example, might be more prone to eating eggs at the nest instead of removing them, because they are inexperienced at depredating nests (A. Sargeant pers. comm.). Alternatively, such variability may have been due to a bias in the haircatcher technique. A nest could have been depredated by a predator which left no hair, and subsequently hair might have been left at the nest while another predator species examined the depredated nest. It is possible that 2 different predator species destroyed the same nest between my nest visits. However, there were no instances where hairs from different predator species were found at the same depredated nest. If either situation occurred frequently, one would expect some instances of multiple species identification. Finally, the distributions of the types and locations of egg remains for depredated nests in which a hair sample was and was not collected were not significantly different (Figs. 14, 15). This result supports the statement that data collected from depredated nests were an accurate representation of all depredations in the study areas.

C) Conclusions: Identifying Predator Species by Egg Remains

If wildlife managers determine nest predators solely on the basis of characteristic sign left by predators, they could easily assign different predators to the same nest
depending on which reference they used. Even in recent studies these references are the only means used to identify predators. From the obvious contradictions in the literature regarding accounts of sign left by nest predators, and from the results of this study, it should be clear that nest predators can not, and should not, be determined solely on the basis of the type and location of egg remains left at depredated nests.
APPENDICES
APPENDIX A

Table 10. Scent-station index results for 1987.

<table>
<thead>
<tr>
<th>Date</th>
<th>Scent Post&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/15/87</td>
<td>1</td>
<td>Skunk tracks</td>
</tr>
<tr>
<td>6/22/87</td>
<td>1</td>
<td>No sign</td>
</tr>
<tr>
<td>6/25/87</td>
<td>1</td>
<td>No sign</td>
</tr>
<tr>
<td>7/6/87</td>
<td>1</td>
<td>No sign</td>
</tr>
<tr>
<td>7/7/87</td>
<td>1</td>
<td>No sign</td>
</tr>
<tr>
<td>7/12/87</td>
<td>1</td>
<td>No sign</td>
</tr>
<tr>
<td>7/14/87</td>
<td>1</td>
<td>Skunk scat and tracks</td>
</tr>
<tr>
<td>7/15/87</td>
<td>1</td>
<td>No sign</td>
</tr>
<tr>
<td>7/20/87</td>
<td>1</td>
<td>No sign</td>
</tr>
<tr>
<td>7/23/87</td>
<td>1</td>
<td>Fox tracks</td>
</tr>
<tr>
<td>6/15/87</td>
<td>2</td>
<td>No sign</td>
</tr>
<tr>
<td>6/22/87</td>
<td>2</td>
<td>No sign</td>
</tr>
<tr>
<td>6/27/87</td>
<td>2</td>
<td>No sign</td>
</tr>
<tr>
<td>7/6/87</td>
<td>2</td>
<td>Container chewed; hair samples</td>
</tr>
<tr>
<td>7/7/87</td>
<td>2</td>
<td>No sign</td>
</tr>
<tr>
<td>7/12/87</td>
<td>2</td>
<td>No sign</td>
</tr>
<tr>
<td>7/14/87</td>
<td>2</td>
<td>Unknown scat</td>
</tr>
<tr>
<td>7/15/87</td>
<td>2</td>
<td>Skunk tracks</td>
</tr>
<tr>
<td>7/20/87</td>
<td>2</td>
<td>No sign</td>
</tr>
<tr>
<td>7/23/87</td>
<td>2</td>
<td>No sign</td>
</tr>
<tr>
<td>6/13/87</td>
<td>3</td>
<td>No sign</td>
</tr>
<tr>
<td>6/17/87</td>
<td>3</td>
<td>No sign</td>
</tr>
<tr>
<td>6/22/87</td>
<td>3</td>
<td>No sign</td>
</tr>
<tr>
<td>6/25/87</td>
<td>3</td>
<td>No sign</td>
</tr>
</tbody>
</table>

<sup>1</sup>Scent post 1 = scent post located in the high density plot of Corps Area.

Scent post 2 = scent post located in the low density plot of Corps Area.

Scent post 3 = scent post located on the Mallard Island plot.
APPENDIX B

Table 11. Number and type of active predator dens recorded for all study plots for 1987 and 1988.

<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
<th>Date</th>
<th>Trial</th>
<th>Den Type and Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>1A</td>
<td>6/2</td>
<td>1</td>
<td>Skunk den; scats collected</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>7/8</td>
<td>2</td>
<td>2 Skunk dens; scats collected</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>7/16</td>
<td>2</td>
<td>Skunk den; scats collected</td>
</tr>
<tr>
<td>88</td>
<td>2</td>
<td>6/3</td>
<td>1</td>
<td>Fox den; pups at opening; scats collected</td>
</tr>
<tr>
<td>88</td>
<td>2</td>
<td>7/8</td>
<td>2</td>
<td>3 Skunk dens; scats collected</td>
</tr>
</tbody>
</table>

1 High density plot, Corps Area.

2 Wolf Creek Management Area plot.

<table>
<thead>
<tr>
<th>Year</th>
<th>Date</th>
<th>Area</th>
<th>Total Observation</th>
<th>Time (in hours)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>5/20</td>
<td>1</td>
<td>No sightings</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>5/29</td>
<td>1</td>
<td>No sightings</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>6/5</td>
<td>1</td>
<td>No sightings</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>6/12</td>
<td>1</td>
<td>No sightings</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>6/28</td>
<td>1</td>
<td>No sightings</td>
<td>2.15</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>7/14</td>
<td>1</td>
<td>Skunk sighted on road</td>
<td>3.25</td>
<td>No sightings</td>
</tr>
<tr>
<td>88</td>
<td>5/25</td>
<td>1</td>
<td>No sightings</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>6/7</td>
<td>1</td>
<td>Skunk sighted along highway edge near study plot 1A</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>6/18</td>
<td>1</td>
<td>No sightings</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>5/24</td>
<td>2</td>
<td>3 skunks sighted in sunflower field next to study plot.</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>5/25</td>
<td>2</td>
<td>No sightings</td>
<td>4.50</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>5/28</td>
<td>2</td>
<td>No sightings</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>5/30</td>
<td>2</td>
<td>Skunk sighted on road</td>
<td>2.00</td>
<td>No sighting</td>
</tr>
<tr>
<td>87</td>
<td>6/6</td>
<td>2</td>
<td>Fox sighted on refuge access road.</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>6/10</td>
<td>2</td>
<td>Fox sighted on refuge access road.</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>6/13</td>
<td>2</td>
<td>No sightings</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>6/21</td>
<td>2</td>
<td>No sightings</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>7/15</td>
<td>2</td>
<td>No sightings</td>
<td>4.00</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>7/20</td>
<td>2</td>
<td>No sightings</td>
<td>2.50</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>7/22</td>
<td>2</td>
<td>No sightings</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>5/23</td>
<td>2</td>
<td>Raccoon sighted along wetland edge; fox sighted along road</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>6/7</td>
<td>2</td>
<td>Skunk on road</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>6/15</td>
<td>2</td>
<td>No sightings</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>6/21</td>
<td>2</td>
<td>No sightings</td>
<td>2.00</td>
<td></td>
</tr>
</tbody>
</table>

1 High and low density plots, in the Corps Area.
2 Wolf Creek Management Area plot.
References Cited


Sowls, L.K. 1948. The fraklin's ground squirrel, Citellus franklinii (Sabine), and its relationship to nesting ducks. J. Mammal. 29:113-137.


