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Influence of Supplemental Food for Striped Skunks on Duck Nest Success in the Prairie Pothole Region of North Dakota

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INFLUENCE OF SUPPLEMENTAL FOOD FOR STRIPED SKUNKS ON DUCK NEST SUCCESS IN THE PRAIRIE POTHOLE REGION OF NORTH DAKOTA

by

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This thesis, submitted by Donovan G. Pietruszewski 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.

Richard D. Crawford
(Chairperson)

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

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ABSTRACT

Predation on clutches of upland nesting ducks has been implicated as a major cause of low duck production in the Prairie Pothole Region. Management techniques that reduce predation rates and are socially acceptable are of interest to wildlife managers. This thesis examines differences in nest success of upland nesting ducks in areas where supplemental food was provided (treatment areas) for striped skunks (Mephitis mephitis) compared to areas where supplemental food was not provided (control areas). Differences in nest success between areas occupied by red foxes (Vulpes vulpes) and coyotes (Canis latrans) were also examined. The study was conducted from 1993-94 on 24 study areas (Waterfowl Production Areas, North Dakota Game and Fish Wildlife Management Areas, portions of Audubon National Wildlife Refuge and a site on Falkirk Mining Company property) located in North Dakota. Overall nest success (Mayfield estimates) averaged 41% on 12 treatment areas and 29% on 12 control areas. Overall nest success averaged 57% on 6 coyote-dominated areas and 20% on 18 red fox-dominated areas.

Average proportion of depredated nests assigned to striped skunks was lower on treatment areas (11%) than on control areas (24%). Average proportion of depredated nests assigned to red fox was higher on red fox-dominated areas (32%) than on coyote-dominated areas (6%). Average proportions of depredated nests assigned to badger (Taxidea taxus) and red fox were similar between treatment and control areas. Average proportions of depredated nests assigned to striped skunk and badger were similar between red fox-dominated areas and coyote-dominated areas.

Assessment of predator activity in the food plots suggested high use by striped skunks and Franklin's ground squirrels (1994 only) and low use by other mammalian predators. No difference was found in the density of residual vegetation between treatment and control areas. Implications of the results of this study for the management of increased duck nest success are discussed.

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INTRODUCTION

The Prairie Pothole Region of North America encompasses approximately 770,000 km^2 of grassland and aspen parkland in the north central United States and south central portion of Canada (Mann 1974, Kantrud et al. 1989, Sargeant et al. 1993). This region is characterized by millions of fertile wetlands (Mann 1974) ideal for duck production. Although the Prairie Pothole Region makes up approximately 10% of the Continent's duck nesting grounds, it produces between 50% and 70% of the Continent's ducks (Smith et al. 1964, Leitch and Danielson 1979). For this reason, factors that affect duck production and recruitment in this Region are of interest to North American waterfowl managers.

Prior to settlement, the Prairie Pothole Region was covered by large expanses of grasslands interspersed by wetlands. Agricultural practices during the past 100 years have drastically altered this landscape. Currently, nearly all the land is farmed or grazed by livestock; in some areas over 80% of the upland is cultivated annually

(Higgins 1977).

Factors implicated in contributing to low duck production in the Prairie Pothole Region include: 1) habitat degradation (Higgins 1977, Duebbert and Kantrud 1974, Cowardin et al. 1985, Klett et al. 1988); 2) nutrition (Krapu and Swanson 1975, Krapu 1981, Duncan 1987, Eldridge and Krapu 1988); and 3) nest success (Balser et al. 1968, Sargeant and Arnold 1984, Greenwood 1986, Johnson et al. 1987, Sargeant et al. 1993, Greenwood et al. 1995). Of these factors, low nest success caused by mammalian predation may be the most influential factor limiting duck recruitment and subsequent population growth (Cowardin and Johnson 1979, Klett et al. 1988, Sargeant and Raveling 1992, Greenwood et al. 1995).

Threshold levels of nest success suggested as necessary for population stability in ducks are 15% for mallards (Anas platyrhynchos) (Cowardin et al. 1985) and northern pintails (A. acuta) and 20% for several other upland nesting ducks (Klett et al. 1988). Research in the Prairie Pothole Region has shown that nest success rates for dabbling ducks often are below these threshold levels and that predation is the principal cause for these low levels (Johnson et al. 1987, Klett et al. 1988, Greenwood et al. 1995).

Cowardin et al. (1985) reported that predation was responsible for 70% of the unsuccessful mallard nests in a North Dakota study. Greenwood et al. (1995) concluded that 77% of all nest initiations failed due to predation in the Prairie Pothole Region of Canada, as did Klett et al. (1988) in a summary of several studies for 5 dabbling duck species in North Dakota, South Dakota and Minnesota. Stoudt (1971) and Sovada et al. (1995) reported that predation accounted for > 90% of the nest failures in their respective studies.

Species having the greatest impact on upland nesting ducks in the Prairie Pothole Region are striped skunk (*Mephitis mephitis*), red fox (*Vulpes vulpes*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), badger (*Taxidea taxus*), long-tailed weasel (*Mustela frenata*), Franklin's ground squirrel (*Spermophilus franklinii*), American crow (*Corvus brachyrhynchos*), and black-billed magpie (*Pica pica*) (Stoudt 1971, Jones and Hungerford 1972, Greenwood 1981, 1986, Sargeant and Arnold 1984, Sargeant et al. 1987b, Fleskes 1988, Johnson et al. 1989, Sargeant et al. 1993). Of these species, the red fox and striped skunk have been implicated as having the greatest impact on nesting ducks and their clutches (Duebbert and Lokemoen 1976, Sargeant et al. 1984, Greenwood 1986, Crabtree and Wolfe 1988).

Crabtree and Wolfe (1988) reported that striped skunks were responsible for about 66% of all nests destroyed by predators in a study conducted on Bear River Migratory Bird Refuge in Utah. Johnson et al. (1989) reported activity indices of striped skunks were positively related to predation on late nests. When striped skunks were removed from duck nesting areas, Greenwood (1986) showed a 10 percentage point increase in duck nest success. Trevor (1989) concluded that striped skunks preyed more heavily on eggs of artificial nests than any other single predator species.

In the last few decades several techniques have been successfully used to reduce the impacts of predators on duck nests (Balser et al. 1968, Duebbert and Kantrud 1974, Duebbert and Lokemoen 1980), although some of the techniques have been legally restricted (e.g., ban on strychnine laced baits, Presidential Executive Order 11643). Furthermore, concerns over the ethics of predator destruction (McCabe and Kozicky 1972) have become increasingly important for sociological reasons.

Crabtree and Wolfe (1988) demonstrated that providing striped skunks with an artificial buffer food consisting of carp (Cyprinus carpio) and commercial mink (Mustela vision) chow significantly increased duck nest success on treatment areas in June. They noted a change in foraging behavior by striped skunks as a result of introduced and natural prey items. In May and June, the skunks foraged in a "widely-searching" mode (Huey and Pianka 1981), which is adapted for exploiting immobile, unpredictably located prey items. A type of mode they concluded was conducive to finding nests. In July, with the increase in natural buffer prey, skunks shifted to a "sit-and-wait" mode, adapted for exploiting predictably located and mobile prey (Huey and Pianka 1981). Crabtree and Wolfe (1988) concluded that both introduced and naturally occurring buffer prey directly affected predation on waterfowl nests by skunks. Early in the nesting season, the introduced food provided a buffer which diverted skunks away from nesting habitats. Later in the nesting season, the availability of naturally occurring alternate prey reduced the amount of time skunks spent in a widely-searching mode. Crabtree and Wolfe (1988) also noted that skunks did not specifically search for nests, but it was rather a chance encounter that depended upon the distribution, type and abundance of alternate prey. Vickery et al. (1992) demonstrated a positive correlation between activity of skunks foraging for invertebrates and nest predation of grassland birds in Maine. In a later study, Crabtree et al. (1989) reported a significant increase in nest success as a result of a 80% decrease of striped skunk foraging activity in nesting habitats due to an abundance of alternate prey.

Because striped skunks are major predators of upland-nesting duck eggs, providing this predator with an alternate food source when naturally occurring prey items are scarce should favor increased duck production. Wildlife managers are interested in predator control methods that are acceptable to the public, that have a broad application, and provide significant positive results. Predator control methods that do not involve killing or removing predators are socially appealing, and might provide more acceptable approaches that could be applied to localized areas of high predation.

The purpose of this research was to determine if providing an artificial food source for striped skunks during the nesting season would affect success of ducks nesting in upland habitats managed for waterfowl production in the Prairie Pothole Region and, if so, the magnitude of the effect.

Several potentially confounding factors that could influence this study were also evaluated. These factors include principal canid species occupying the area, residual vegetation density that could affect nest site selection or availability of natural alternate prey, the composition and relative abundance of other egg predators, the predators responsible for clutch depredation, and the predator species utilizing the artificial food source. These factors were assessed to verify whether conditions were similar between areas occupied by fox or coyotes where food was to be placed and if conditions were similar between study areas that would have artificial food distributed and those that would not.

STUDY AREA

This study was conducted in 1993 and 1994 on 24 study areas in the Missouri Coteau and Drift Plain physiographic regions in North Dakota (Stewart 1975, Kantrud et al. 1989; Fig. 1). The Missouri Coteau is moderate to steeply rolling glacial moraine and outwash plains. The Drift Plain is relatively flat to moderately rolling. Both physiographic regions contain numerous wetland basins interspersed with Conservation Reserve Program land (Bjerke 1991), pastures, hayfields, cultivated land, and federal and state property managed for wildlife. Much of the cultivated land in the locations of this study was used for cereal grain and row crop production. The climate of North Dakota is continental characterized by warm summers and cold winters. Snow melt is generally complete by mid-late April. Total annual precipitation at study locations was 57 cm in 1993 and 59 cm in 1994 (U. S. Dept. of Commerce 1993, 1994).

Study areas were in McLean County in 1993 and in Stutsman County in 1994 (Fig.1). Drought impacted much of

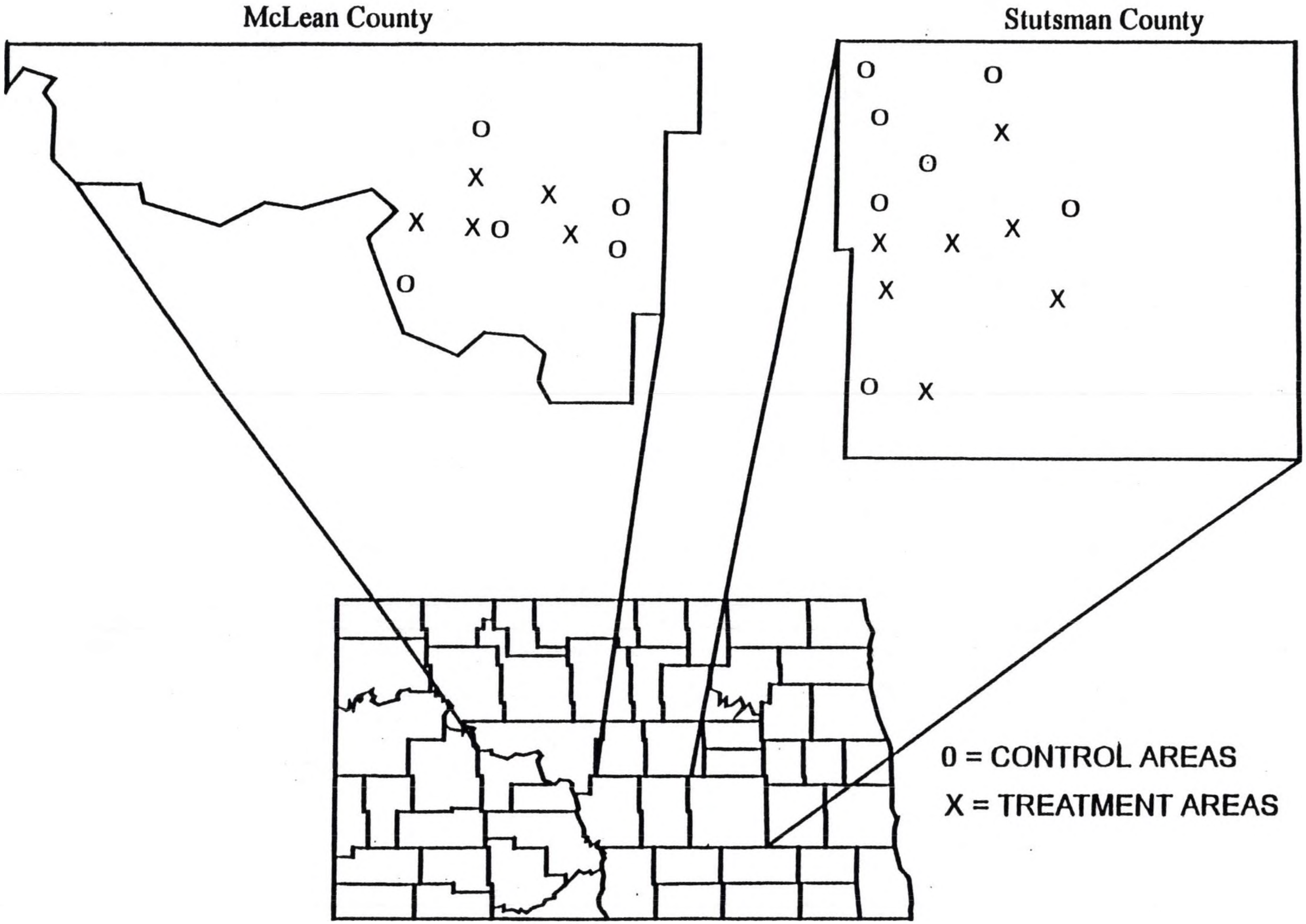

Figure 1. Locations of treatment and control study areas in McLean (1993) and Stutsman (1994) counties, North Dakota.

North Dakota in 1992 (Sovada et al. 1995) and these localities were selected primarily because I believed sufficient wetlands contained water to attract breeding ducks needed for the evaluation. In 1993 10 areas were selected for study; 3 fields on Audubon National Wildlife Refuge and 1 on Lake Nettie National Wildlife Refuge, 3 on Wildlife Development Areas (WDA's) or portions thereof, 2 on North Dakota Game and Fish Department Wildlife Management Areas (WMA's) or portions thereof and 1 on Falkirk Mining Company property(Appendix 1). In 1994, 14 fields on Waterfowl Production Areas (WPA's) or portions of WPA's were selected as study areas (Appendix 1). Each area contained 35-83 ha of upland and was managed for nesting ducks or other wildlife.

METHODS

Study Area Selection

A goal each year was to have $\geq$10 study areas with an equal number of treatment areas and control areas. A treatment area was an area where supplemental food was provided. A control was an area where supplemental food was not provided. Prior to each field season, a pool of candidate areas was established from which study areas would be chosen. A candidate area was a contiguous block of land at least 65 ha in size, with a minimum of 30 ha of upland nesting cover; certain other criteria also were necessary. The nesting cover on each candidate area had to consist of native grasses and/or planted cover established before 1989. Each candidate area would also have to be 6.5 km from the nearest adjacent candidate area to ensure independence in treatments. This distance is thought to exceed the home range diameter of most striped skunks during spring and early summer (A. B. Sargeant and R. J. Greenwood, Northern Prairie Science Center, Jamestown, ND, unpubl. data). The minimum distance was waived when the areas were separated by a body of water thought sufficient to restrict skunk movements (e.g., deep canal). No grazing, burning or other vegetation manipulation was allowed on the study areas during the evaluation year. Also, no predator removal could be practiced within 8 km of a study area during the evaluation year. Information provided by local wildlife managers, and from visits to potential candidate areas aided in selection.

After a pool of candidate areas was established, a preliminary survey was conducted on each area to determine principal canid (fox, coyote) occupancy. Sovada et al. (1995) demonstrated that the presence of red foxes or coyotes can strongly influence nest success of ducks. Determination of canid occupancy consisted primarily of track surveys (Sargeant et al. 1993) conducted in early-mid April. Study areas with tracks almost exclusively from one of the two canids in or on its periphery were classified as occupied by that canid (i.e. red fox area or coyote area). Information provided by local residents, wildlife managers and biologists was also utilized when possible.

The study areas were blocked by principal canid; treatment and control areas were randomly selected from the pool of candidate areas within the respective block. The goal was to have an equal proportion of areas occupied by red foxes and coyotes as treatments and controls during each field season.

Each year, two systematic track surveys were conducted in late April-early May and late May-early June to confirm principal canid occupancy of each study area as determined by the preliminary track survey. Track survey methods and criteria described by Sovada et al. (1995) were used. For an area to be classified as a coyote area, I had to observe coyote tracks on $\geq$10% of plots and fox tracks on $\leq$10% of plots. For an area to be classified as a fox, I had to observe fox tracks dispersed throughout the area and on $\geq$20% of plots, and coyote tracks on $\leq$10% of plots. I attempted to survey for tracks in suitable substrate on $\geq$10 200 m^2 plots per study area. Allowances were made for occasional use of an area by a canid species other than the determined principal canid because of interspecific territory overlap and the amount of use the overlapping areas receive by each canid (Sargeant et al. 1987a, Harrison et al. 1989). Supplemental information about canids on each study area also was used to confirm canid occupancy determinations. Such information included observations of all canids on or within 0.8 km of each study area and observations of canid tracks on the study areas at times other than systematic track surveys. The final canid classification of a study area each year was based on all information acquired from that study area that year.

Food Distribution

In 1993, two food plots measuring approximately 50 x 200 m each were established on opposite ends of each treatment area. Sites for food plots were selected to provide the greatest distance possible between food plots on individual areas; sites were required to be accessible by vehicle. In 1994, one food plot measuring approximately 50 x 300 m was established on one end of each treatment area; other criteria for site selection were the same as in 1993. Food plots were not closer than 100 m from an improved road with public access or 400 m from an occupied residence.

During 16 April-15 July 1993 and 20 April-13 July 1994, a mixture of chopped fish offal (R and R Feeds, Ottertail, MN) and oil sunflower seeds was distributed on the food plots. Primarily walleye (Stizostedion vitreum), sauger (Stizostedion canadense), and several species of Salmonids were included in the chopped fish offal. An earlier study (R. J. Greenwood, Northern Prairie Science Center, Jamestown, ND, unpubl. data) demonstrated that chopped fish offal and oil sunflower seeds were readily consumed by striped skunks.

The fish offal and oil sunflower seeds (hereafter called food mixture) were mixed at a 10:1 ratio (offal:seeds) by weight. The food mixture was distributed twice weekly (every 3-4 days) on each treatment area. Approximately 100 kg was used per application in 1993 and 90 kg in 1994. In 1993, the food mixture was divided between food plots at each end of each treatment area. In 1994 each food plot received the total amount of food mixture per visit. The food mixture was distributed between 0700-1200 h by throwing it by shovel from a tank in the back of a pickup truck. It was spread widely at each food plot to increase its availability to skunks.

During both years, the food mixture was placed in the heaviest tall grass and brush cover in each food plot in an attempt to conceal it from gulls (Larus spp.) that found it on some treatment areas within a few days after it was first distributed. Other methods were also used to deter gulls from the food mixture. In 1993, monofilament fishing line also was suspended approximately 1 m over a 30 x 50 m area of all food plots in an attempt to deter gulls; some food was thrown under the monofilament mesh and in surrounding areas of the food plot during each visit.

Similar techniques have been used to deter gulls from various areas by Blokpoel (1984) and Ostergaard (1981). An owl decoy also was suspended over the monofilament line as an added deterrent. In 1994, I attempted to deter gulls from the food plots during early June-mid July using shell crackers fired from a 12 gauge shotgun. The shell crackers were fired over the gulls observed during daylight hours in or near the food plots. Similar techniques have been used to frighten gulls from airports and garbage dumps (Solman 1994). Gulls were hazed at times of food distribution and periodically between food distributions when field personnel were near food plots with gulls in them.

I constructed 8-10 1-m^2 track plots in the food plots on each treatment area to provide substrate for monitoring use of food plots by striped skunks and other mammals. Track plots were made by removing the sod layer in a 1-m^2 area and replacing it with sifted soil. Track plots were raked smooth during each visit and observed for presence of tracks before food was placed during the next visit. Track plots were constructed 18-19 May 1993 and 12-18 May 1994. Tracks present in the track plots or in other suitable substrates were recorded each time the food mixture was distributed. If tracks were present but unidentifiable they were recorded as unidentified.

Assessment of Duck Nest Success

Nest Searches. Three searches for duck nests were conducted at 3-week intervals each year in the upland portion of each study area from early May through June (Appendix 2). Searches were made using 4-wheel drive jeeps towing a chain-drag (Higgins 1977, Klett et al. 1986). Study areas were searched in the same order during each search period. A fourth nest search would be conducted, if necessary, to increase sample size of nests on individual study areas.

We recorded information about nests as described by Klett et al. (1986). Data recorded upon locating a nest were date, duck species, location, type of vegetation within 1 m, habitat class (e.g. grassland, planted cover, scrubland), number of eggs, and incubation stage (Weller 1956). Duck species were identified when the female flushed from the nest. Each nest was marked with an individually numbered willow (*Salix* sp.) stick (1-1.5 m tall) with a small piece of pink plastic flagging attached. Markers were placed upright 4 m north of the nest for easy relocation. Nest locations were plotted on aerial photographs.

Nests were revisited every 6-10 days in 1993 and approximately every 21 days in 1994 until $\geq$1 egg hatched or the nest was totally destroyed or abandoned. Upon each revisit, we verified species identity and recorded the number of eggs, incubation stage, and full clutch size if known. During the final visit we recorded fate, and if the nest was successful, the number of eggs that hatched.

A nest was considered successful if $\geq$1 egg hatched, as determined by the presence of shell membranes (Klett et al. 1986) or ducklings in the nest bowl. A nest was considered unsuccessful if eggs were totally destroyed or it was abandoned due to predator influences as described by Greenwood et al. (1995). If a nest failed to hatch, suspected cause of failure (e.g., predators, abandonment, farm equipment) was determined. Evidence of predation (egg shells, digging, etc.) within 3 m of a nest destroyed by a predator was recorded (Sargeant et al., In Press). Nests that appeared to have been abandoned due to investigator influences were not used in analyses (Greenwood et al. 1995).

<u>Nest Success</u>. Daily survival rates (DSR's) of nests were estimated by the Mayfield method (Mayfield 1961) as modified by Johnson (1979). Data from nests of all species were combined to increase the sample sizes for estimation of DSR's for each study area, because sample sizes for individual species were too small to analyze separately.

The variance of an estimated DSR is inversely proportional to the number of exposure days (Johnson 1979). Exposure days are the number of days an active nest is observed and vulnerable to destruction by predators or other factors. Daily survival rates were converted to nest success rates for ease of interpretation by raising them to the 34^{th} power, which represents the average laying interval plus incubation period (days) for the duck species in this evaluation (Klett et al. 1986, 1988). I used nest success rates to measure the effect of supplemental food on striped skunks because it is the most important determinant of recruitment rates of upland nesting ducks (Cowardin and Johnson 1979, Johnson et al. 1992) and it can be relatively accurately measured.

The difference in the number of exposure days among study areas may influence the precision of daily survival rates. I used the method of weighted least-squares, with the weight equal to the number of exposure days (Snedecor and Cochran 1980) to improve balance for small numbers of exposure days in some study areas. Weighted DSR's were used to estimate parameters for analysis of variance (ANOVA) models. Confidence intervals, using the method described by Johnson (1979), were computed using the standard errors generated by the least-squares means statement of the GLM procedure (SAS Institute, Inc. 1990).

Analysis of Daily Survival Rates. I used a 3-way (treatment x canid x year) factorial treatment structure with a randomized design to analyze daily survival rates of all duck species among treatment and control areas. The design was randomized except that treatment and canid classes could not be assigned randomly to individual study areas. I examined effects on DSR's due to treatment, canid influence, year, and their interactions with a 3-way analysis of variance (ANOVA; least-squares means estimate, GLM Proc., SAS Institute, Inc. 1990). Statistical significance is defined at $P \leq 0.05$ for all analyses. Variation expressed as standard error (SE) and confidence intervals (CI) (95%) are reported.

Assessment of Nest Depredations

Procedures developed by Northern Prairie Science Center were used to collect and quantify evidence found ≤ 3 m from each depredated nest. This data was used to assign a predator species likely responsible for the depredation. Caution must be used, however, in interpreting the results of this analysis because of the variability of evidence left by individual predators species and the overlapping similarity in evidence left by individuals of different predator species (Sargeant et al. In Press). Evidence at nests depredated by common mammalian predator species examined in this study may differ in amount of whole eggs or eggshells, nest bowl disturbance, contents left in eggshells, and local ground disturbance (Sooter 1946, Rearden 1951, Sargeant et al. In Press). A hierarchial stepwise approach was used to estimate the proportion of nests destroyed by striped skunks, badgers and red foxes based on evidence found at depredated nests that contained $\geq$6 eggs (large-clutch nest) within 21 days of the previous visit or day destroyed. In each step, depredated nests not containing evidence unique to that left by a particular predator species were removed, until only the depredated nests with evidence meeting the correct criteria were left. I assumed that all depredated nests used in these analyses were independent, and I have ignored that several nests may be assigned multiple predator species because certain evidence may not be clearly unique to one predator (i.e. if a nest was assigned both badger and striped skunk in the badger analysis, the nest was included as destroyed by badger and in the striped skunk analysis it was included as destroyed by striped skunk). I used a weighted least-squares approached with categorical data modeling procedures of SAS(CATMOD PROC, SAS Institute Inc. 1987) and chi-square analyses to test for differences in the proportions of depredated nests assigned to each predator species between treatment and control areas, coyote and red fox areas, years, and all interactions. I excluded raccoons from the analyses because raccoons seldom use upland habitats where ducks nests are found (Fritzell 1978) and because similarities in evidence left at destroyed nests between raccoons and striped skunks confounded interpretations.

Assessment of Striped Skunks and Other Predators

Observations, systematic track surveys, and live trapping were used to document presence of mammalian predator species known or suspected to prey on duck eggs (Reardon 1951, Sargeant and Arnold 1984, Sargeant et al. 1993, Sargeant et al., In Press). Besides coyote and red fox, other species of concern were striped skunk, raccoon, badger, Franklin's ground squirrel, long-tailed weasel, American crow, and black-billed magpie.

Observation methods followed those of Sargeant et al. (1993). Field personnel recorded daily the number of hours ($\geq$0.5) spent on each study area and the number of places (150 m diameter area) each person observed a predator species. Any predator known to have been seen in $\geq$1 place was recorded as in only 1 place. Predators were only recorded once if the same individual was known to have been observed in the same place several times in one day. We recorded observations from 3 May-15 July in 1993 and from 2 May-15 July in 1994. Results are reported as the average number of places each predator was observed per hour.

Tracks of mid-sized mammalian predators were recorded when systematic track surveys were conducted for canid species. Results are reported as the percentage of all plots (both surveys summed) where tracks of each species were found.

Live traps were set to document presence of mid-sized mammalian predators on all study areas each year; methods were similar to those used by Greenwood (1986). Trapping was conducted over 4 consecutive 24-hr periods during the last 2 weeks of July with the treatment areas being trapped first each year. The food mixture was used for bait.

In 1993, 4 single door wire-mesh live traps (23 x 23 x 66 cm; 2.5-cm^2 mesh) were spaced approximately 20 m apart in or near the food plots on the treatment areas and on each end of each control area. Traps were set before 1200 h the first day and checked and reset before 1200 h each day thereafter. Traps were not moved from their original placement.

In 1994, 10 single door wire-mesh live traps (25 x 31 x 81 cm; 2.5-cm^2 mesh), hereafter called large traps, were used for mid-sized mammalian predators and 10 live traps (23 x 23 x 66; 2.5-cm^2 mesh), hereafter called small traps, were modified for use on Franklin's ground squirrels. Presence of Franklin's ground squirrels was assessed in 1994 because evidence suggested they were common in this vicinity of study areas (Greenwood 1986, Choromanski-Norris et al. 1989, Sovada 1993). Trapping methods were modified from Greenwood (1986) and Choromanski-Norris et al. (1989). Separate trapping efforts were conducted for mid-size predators and Franklin's ground squirrels due to the effectiveness of each trap size in relation to the predator and the nocturnal and diurnal nature of these animals (Jones et al. 1983, Choromanski-Norris et al. 1989). On treatment areas, 5 pairs of traps (one large trap and one small trap) were set in and near the food plot and 5 pairs were set in dense cover throughout the treatment area. On control areas, 10 pairs of traps were set in dense cover throughout the study area.

The large traps were set between 1600-2100 h while the small traps were being checked. The small traps were set between 0700-1100 when the large traps were being checked. The large traps remained closed while the small traps were set and vice versa.

All striped skunks captured were anesthetized with Ketamine HCl (Beck 1976); weight, sex, age (adult, juvenile) and general physical condition were recorded. All striped skunks and Franklin's ground squirrels were ear-tagged to permit future identification of individuals. Other animals captured were marked with paint. All animals were released at the site of capture when traps were checked. Data are reported as capture rates for each study area (i.e. number of each species captured divided by the number of trap days [one trap set for 1 day]).

All survey information including food plot observation data and any incidental information collected through the field season was combined to summarize occurrence of predator species on each study area (Sovada 1993). Log-odds maximum likelihood analyses (Agresti 1990) using chi-square statistics were used to compare the odds of detecting each predator species on treatment and control areas. A constant of 0.5 was added to each frequency to accommodate for values of 0. I analyzed only those predator species that were potentially important to the results of this study. Uncommon, rarely detected, or avian species were not evaluated.

Assessment of Residual Vegetation Density

Density of residual vegetation was measured in treatment and control areas during late April or early May each year. Methods were similar to Robel et al. (1970) and Higgins and Barker (1982). Transects were established for each study area using aerial photographs. Four height-density measurements were taken at the 4 principal directions at each station approximately every 180 m (200 steps); this was sufficient to effectively sample an entire study area. The measurements from each station were averaged then combined to provide a study area average. A 2-way ANOVA was used to determine if average height-density values varied between treatment and control areas and between years.

RESULTS

Of the 24 study areas 10 of the treatment areas and 8 of the control areas were fox-dominated; the remainder (6) were coyote-dominated (Table 1, Appendix 3). I found 1046 duck nests of which 1008 met the criteria to be used in analyses (Table 2, Appendix 4). In 1993, 267 nests were found of 7 duck species on 570 ha of upland for an average of 0.47 nests/ha (Appendix 4). On treatment and control areas combined, 33% of nests were gadwall, 22% blue-winged teal, 18% mallard, 13% northern shoveler, 10% northern pintail, and 5% other species (Fig. 2, Table 2). In 1994, 741 nests of 9 duck species were found on 760 ha of upland for an average of 0.98 nests/ha (Appendix 4). On treatment and control areas combined, 40% of the nests were blue-winged teal, 20% mallard, 19% gadwall, 11% northern shoveler, 7% northern pintail, and 3% other species (Fig. 2, Table 2).

A total of 302 nest failures occurred on treatment areas over the 2 years of investigation of which 91% (276) of the failures was attributed to predation and 9% (26) was

Table 1. Number of nests used to estimate daily survival rates and nest success rates with 95% confidence intervals (CI) for each study area in North Dakota (1993-94).

Study area	Number of nests	Nest success (%)	CI[a]
TREATMENT AREAS			
1993			
Refuge Headquarters (F)[b]	27	5	2-17
West Bay (C)[c]	72	84	74-96
George's Point (F)	14	48	25-92
Lake Nettie NWR (F)	28	13	5-31
Turtle Lake (F)	28	67	48-93
Least square mean[d]		46	27-77
1994			
Dammel (F)	31	23	12-46
Zimmerman WPA (F)	62	43	30-61
Zimmerman FmHA (F)	57	36	23-57
Gaier (F)	80	16	10-27
Hertal (C)	79	47	35-63
Seekin (F)	25	15	6-37
Roosevelt (F)	106	29	21-41
Least square mean[d]		36	23-56
Least square mean[d] (1993-94)		41	29-57
CONTROL AREAS			
1993			
East Bay (C)	20	84	65-100
NE Plot (F)	13	10	2-41
Lake Williams N. (C)	39	55	38-79
Lake Williams S. (F)	17	13	4-42
Falkirk Mine (C)	9	28	8-98
Least square mean[d]		36	23-56

(Continued)

Table 1. (Continued)

Study area	Number of nests	Nest success (%)	CI[a]
1994			
Crystal Springs (F)	26	34	18-63
Mud Lake (C)	81	45	33-60
Smith-Bingham (F)	29	43	26-72
Kutz (F)	28	16	7-36
Tischner (F)	41	8	3-19
Thiesen (F)	36	34	20-56
Mount Moriah (F)	60	18	10-30
Least square mean[d]		31	20-49
Least square mean[d] (1993-94)		29	18-47

[a] 95% CI computed, using methods described by Johnson (1979).

[b] F = fox dominated area.

[c] C = coyote dominated area.

[d] Least square means estimated, using GLM procedure statement (SAS Institute, Inc. 1990).

Table 2. Number of study areas (n) and number of duck nests by species used to estimate daily survival rates on treatment and control areas in North Dakota (1993-94).

Species	Treatment areas 1993 (5)	Treatment areas 1994 (7)	Control areas 1993 (5)	Control areas 1994 (7)	Total
Mallard	28	81	19	66	194
Northern pintail	16	33	10	17	76
Gadwall[a]	57	76	30	65	228
Blue-winged teal	39	182	21	116	358
Northern shoveler[b]	19	57	15	28	119
Other[c]	10	11	3	9	33
Total	169	440	98	301	1008

[a] Anas strepera

[b] A. clypeata

[c] American widgeon (A. americana), green-winged teal (A. crecca), lesser scaup (Aythya affinis), and redhead (A. americana) combined.

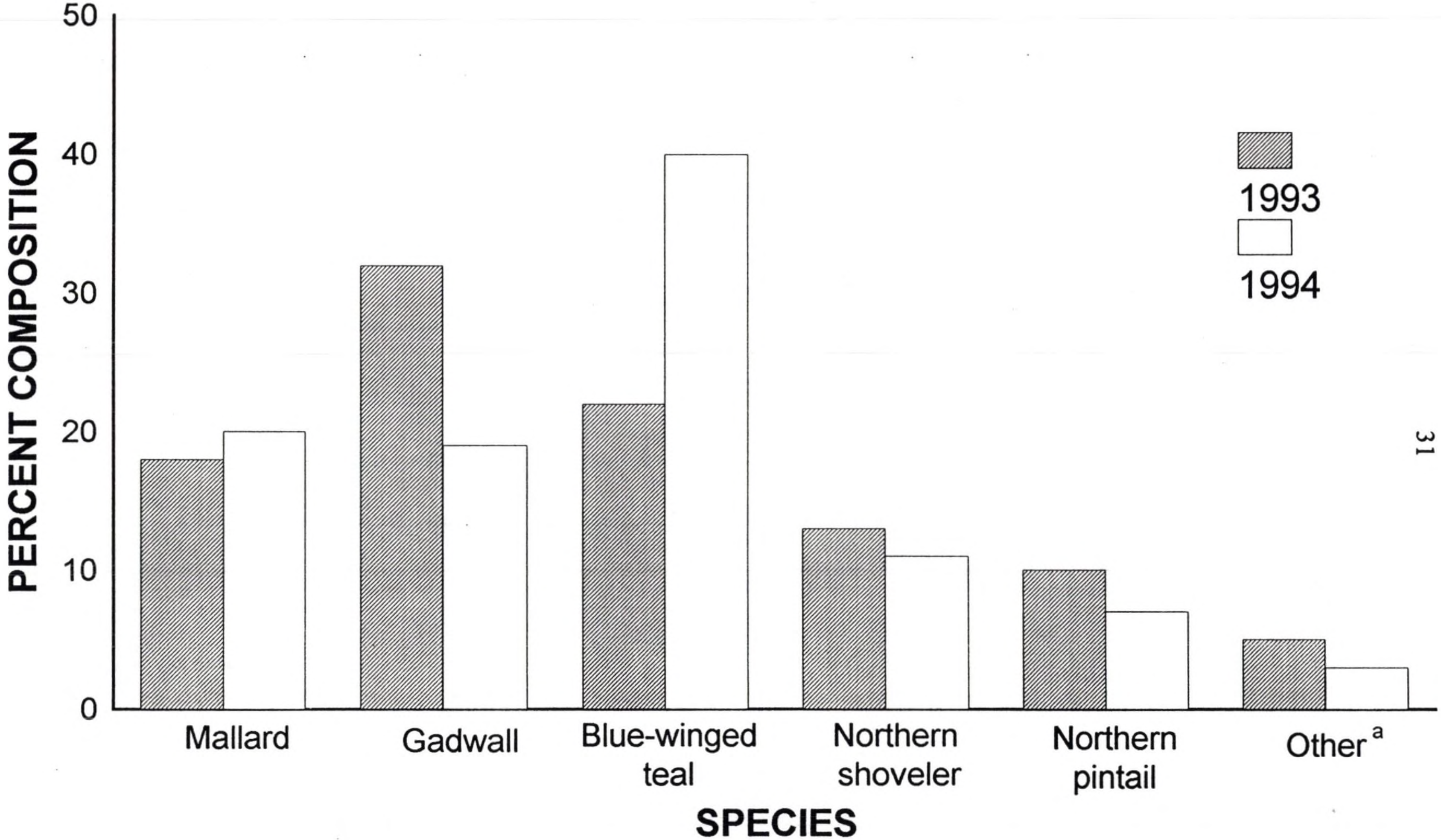

Figure 2. Percent composition of duck nests by species found on study areas in North Dakota (1993-94).
[a] American widgeon, green-winged teal, lesser scaup and redhead combined.

attributed to abandonment without evidence of predation. On control areas, 213 nest failures occurred, of which 94% (201) was attributed to predation and 6% (12) was attributed to abandonment without evidence of predation. One nest was destroyed by farm machinery on a control area.

Nest Data

Nest Success Estimates. The nest success rate on treatment areas averaged 41% (29-57%) and on control areas averaged 29% (18-47%) (Fig. 3, Table 1). There was considerable variability in nest success rates among treatment areas (5-84%) and among control areas (8-84%) (Table 1). The nest success rate on coyote-dominated areas averaged 57% (40-82%) and on red fox-dominated areas, averaged 20% (13-32%) for both years combined (Fig. 4, Table 1). There was also considerable variability in nest success rates among coyote areas (28-84%) and among fox areas (5-67%) (Table 1).

Analyses of Daily Survival Rates. Three-way ANOVA (treatment x canid x year) showed no difference in daily survival rates of all duck species combined among years for main effect of treatment (2 levels - treatment and control; $P = 0.27$). Average DSR tended to be higher on treatment

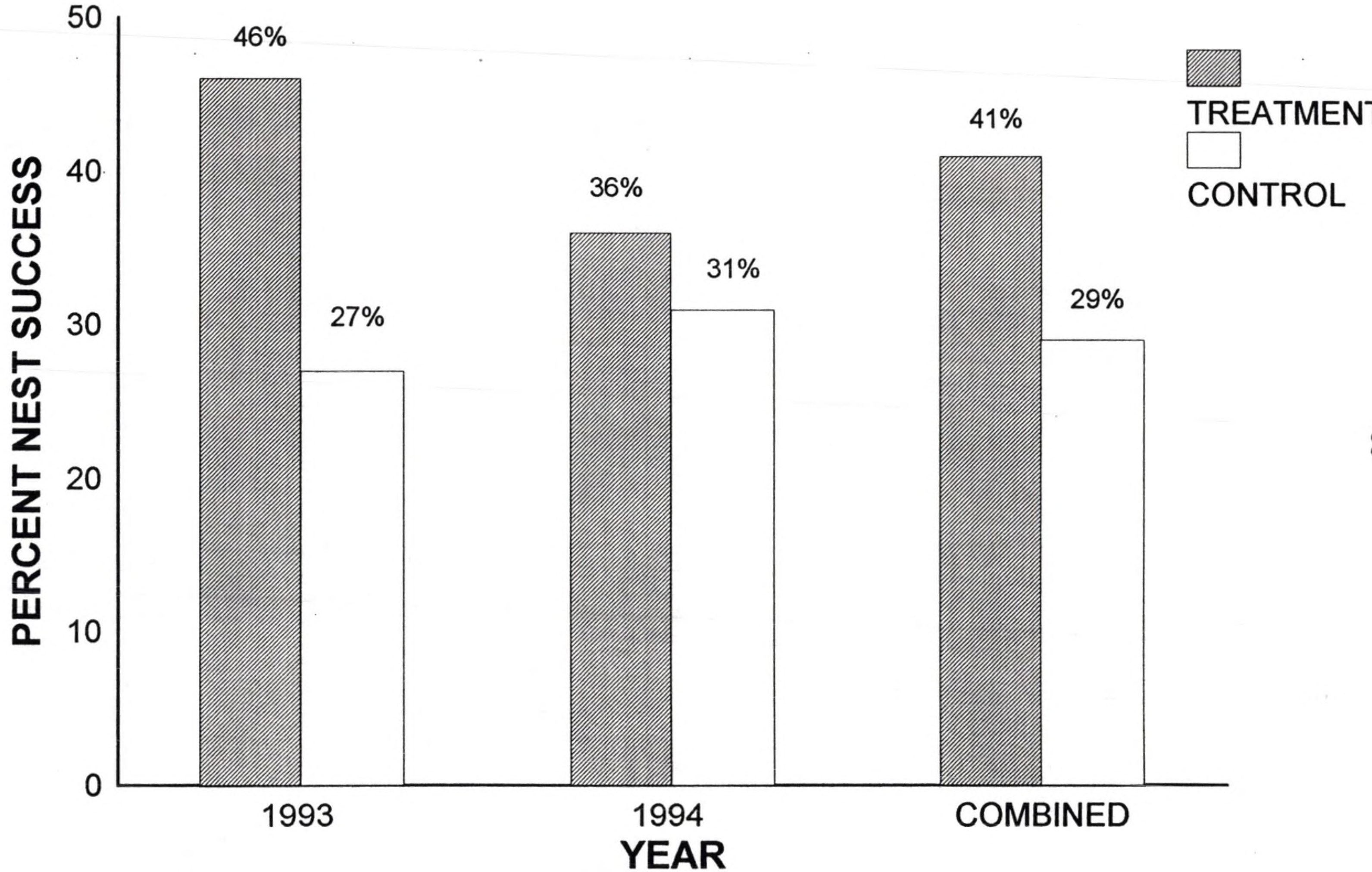

Figure 3. Percent nest success rates for treatment and control study areas in North Dakota (1993-94).

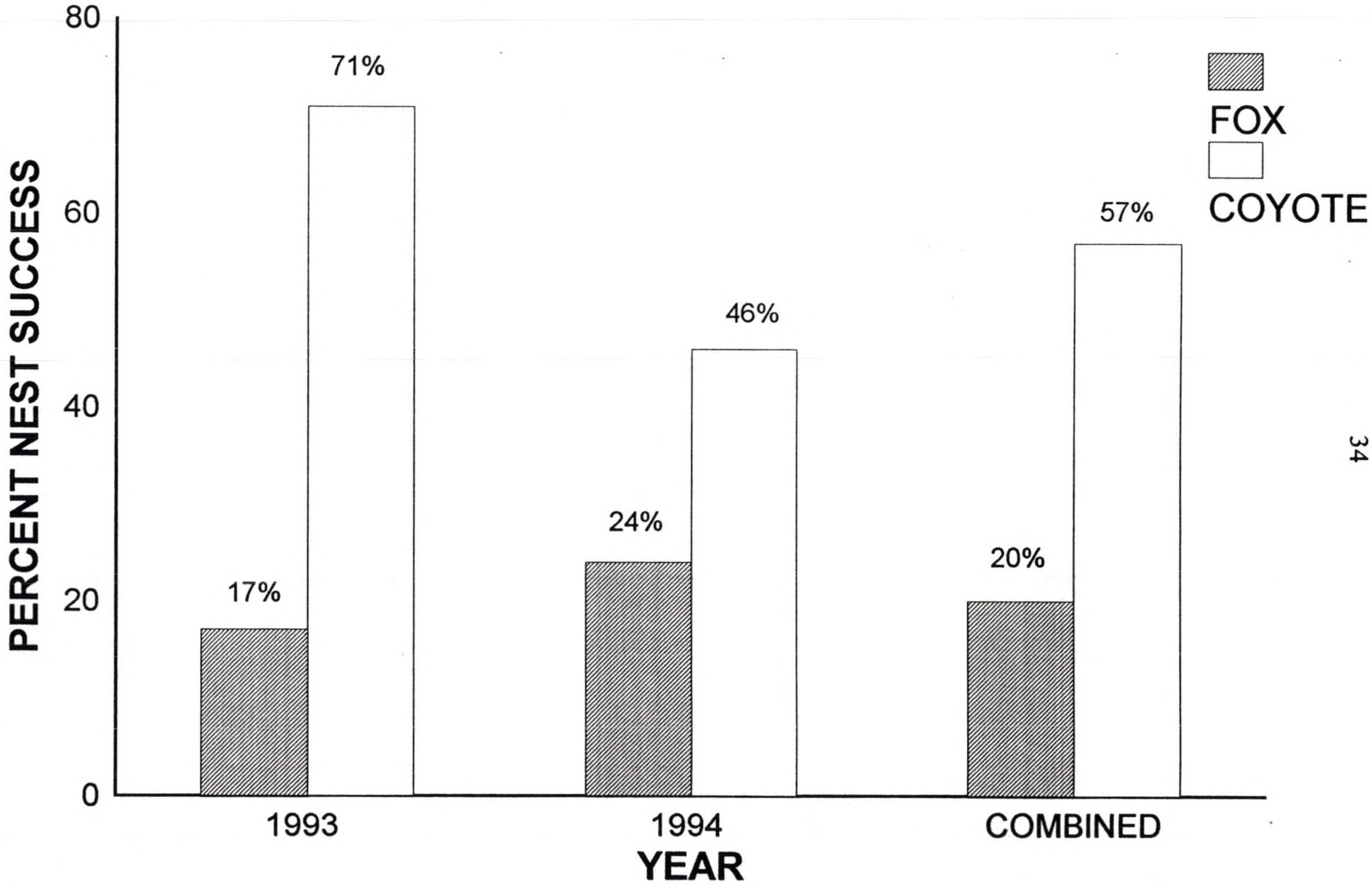

Figure 4. Percent nest success rates for coyote and fox dominated study areas in North Dakota (1993-94).

areas (0.973, SE = 0.005) than on control areas (0.964, SE = 0.007) although not significantly different. There was significant difference in daily survival rates between coyote- and fox-dominated areas ($P = 0.003$). Average daily survival rate was higher on coyote areas (0.984, SE = 0.006) than red fox areas (0.954, SE = 0.006). The effect of year and all interactions were not significant ($P \geq 0.20$) (Table 3).

Nest Depredations

A total of 325 large-clutch nests was used for estimating the average proportion of depredated nests assigned to striped skunk, red fox and badger on treatment and control areas, red fox and coyote areas, and years (Table 4). The proportion of all depredated large-clutch nests that were assigned to striped skunks was less for treatment areas (0.11) than for control areas (0.24) ($P = 0.05$) and marginally less for coyote areas (0.11) than for red fox areas (0.24) ($P = 0.06$). The proportion of all depredated large-clutch nests that were assigned to red foxes was less for coyote areas (0.06) than for red fox areas (0.32) ($P = 0.001$). There were no differences in the proportion of all depredated large-clutch nests that were

Table 3. ANOVA results for treatment, canid and year effect and all interactions on daily survival rates of duck nests in North Dakota (1993-94).

Source	df	*F*	*P*
Treatment	1,16	1.32	0.27
Canid	1,16	12.13	0.003
Year	1,16	0.02	0.88
Treatment x year	1,16	0.51	0.49
Treatment x canid	1,16	0.20	0.66
Year x canid	1,16	1.83	0.20
Treatment x year x canid	1,16	0.04	0.85

Table 4. Results of chi-square analyses for weighted least-squares mean proportions of all large-clutch nests[a] destroyed by striped skunks, red foxes, and badgers on treatment and control areas, red fox and coyote areas, and years in North Dakota (1993-94).

		Predator Species								
		Striped Skunk			Red Fox			Badger		
Study areas	Number destroyed large clutch nests	Average proportion	X^2	*P*	Average proportion	X^2	*P*	Average proportion	X^2	*P*
Control	122	0.24	3.83	0.05	0.18	0.47	0.49	0.31	0.15	0.70
Treatment	203	0.11			0.21			0.28		
Red Fox	263	0.24	3.43	0.06	0.32	28.93	0.001	0.27	0.52	0.47
Coyote	62	0.11			0.06			0.32		
1993	87	0.19	0.20	0.65	0.21	0.63	0.43	0.19	10.09	0.001
1994	238	0.16			0.17			0.41		

[a] Nest with $\geq$6 eggs depredated within 21 days of previous visit.

assigned to red foxes and badgers on treatment and control areas and to badgers on red fox and coyote areas (Table 4). The proportion of all depredated large-clutch nests that were assigned to badger was less for 1993 (0.19) than for 1994 (0.41) ($P = 0.001$). There were no differences in the proportion of all depredated large-clutch nests that were assigned to striped skunk and red foxes between years (Table 4). All 2-way and 3-way interactions were not significant ($P > 0.27$).

Canid Occupancy of Study Areas

During the initial track survey in 1993, 3 treatment areas and 3 controls were designated as fox-dominated areas. Two treatment areas and 2 controls were designated as coyote-dominated areas. One treatment area, Turtle Lake, was later classified as a fox area when more information was collected throughout the season. Coyote tracks had been found on Turtle Lake during the preliminary track survey and on 38% of the plots (Appendix 3) during the first systematic track survey. No coyote tracks were found during the second systematic track survey or incidently thereafter. Exception to the established criteria for classifying dominant canid occupancy was allowed for two other areas. Lake Nettie NWR was classified as a fox area despite 20% of the plots having coyote tracks. This exception was allowed because no coyote tracks were found during subsequent evaluations on Lake Nettie NWR; observations of red fox tracks continued. Coyote tracks observed during the first systematic survey occurred on the shoreline of Lake Nettie presumably from a single visit by this species. East Bay was the other exception allowed. This area was classified as coyote-dominated despite fox tracks being found on 26% of the plots. The exception was allowed for the same reasons as Lake Nettie, where 80% of the fox tracks found were along a shoreline presumably from a single visit. Continued observations of coyote tracks, a sighting of a coyote near the area, and no other observations of fox tracks supported the classification of coyote for this area.

In 1994, during the initial track survey, 1 treatment and 1 control area were designated as coyote-dominated areas; the remaining study areas were designated as fox-dominated (Appendix 3). The initial canid classifications remained consistent and were confirmed by the two systematic track surveys. No exceptions to the established criteria were necessary during this year.

Food Distribution

A total of approximately 13,000 kg and 16,000 kg of the food mixture was distributed in 1993 and 1994, respectively. Each food plot in 1993 received about 1,300 kg of the food mixture and 2,300 kg per food plot was distributed in 1994.

Predator Activity in the Food Plots. Information about striped skunks and other predators visiting the food plots was largely descriptive, but provided some insight about their activity at each food plot. The percent of observation days (not affected by rain) when striped skunk, red fox, and other mammalian predator tracks (raccoon, badger) were found in the food plots was calculated for the food distribution period following the installation of the track plots (Table 5). Striped skunk and red fox tracks were the most common tracks found in the food plots. Striped skunk tracks were found on an average of 35 and 38% of the visits in 1993 and 1994, respectively. Red fox were found on 9 and 35% of visits in 1993 and 1994, respectively. It was not uncommon to find striped skunk and occasionally red fox tracks on >1 track plot per visit and on several occasions more than 1 set of striped skunk tracks were found in a single track plot.

Raccoon and badger tracks were uncommon in the food

Table 5. Percent of observation days when striped skunks, red fox, and other[a] predator tracks were found in the food plots after construction of track plots in North Dakota (1993-94).

		Observation days with tracks (%)		
Treatment Areas	Number of oberservation days[b]	Striped skunks	Red fox	other[a]
1993				
Refuge Headquarters	17	35	18	0
West Bay	16	6	0	0
George's Point	14	64	14	7
Lake Nettie NWR	15	40	13	7
Turtle Lake	17	29	0	6
mean		35	9	4
(sd)		(20.9)	(8.4)	(3.7)
1994				
Dammel	13	46	23	0
Zimmerman WPA	12	33	17	0
Zimmerman FmHA	16	69	31	0
Gaier	12	17	25	0
Hertal	12	33	33	0
Seekin	16	25	81[c]	13
Roosevelt	14	43	36	7
mean		38	35	3
(sd)		(16.9)	(21.2)	(5.2)

[a] Raccoon and badger tracks combined.

[b] Excluding observation days where tracks were destroyed by rain.

[c] A fox rearing den was located <150 m from the food plots

plots. Raccoon and badger tracks combined were only detected on 4 and 3% of the visits in 1993 and 1994, respectively (Table 5). In 1994, following a late April blizzard that resulted in most food plots with >60% snow cover, I found 71% of the food plots with striped skunk tracks and 57% with red fox tracks. In these snow covered food plots, there were several places where the predators had dug through the snow to reach the covered food. These findings occurred 9 days after the distribution of supplemental food was initiated.

During both years, dig marks were common in the food plots throughout the food mixture distribution period. Bite marks also were observed in the food mixture that was partially frozen early in the distribution period. Scat, presumed from striped skunk, was observed on 1 occasion in the food plots and contained a large proportion of fish remains (scales, bones) and oil sunflower seeds.

In 1993, 3 active striped skunk dens were established on 3 separate food plots during the food distribution period. In 1994, 2 active skunk dens were established in the food plots on 2 separate treatment areas.

Ring-billed gulls (Larus delawarensis) and occasionally California gulls (Larus californicus) were observed at food plots on 45% and 42% of all occasions when

I distributed the food mixture in 1993 and 1994 respectively. Although measures taken to exclude gulls were marginally successful, sufficient quantities of the food mixture remained for striped skunks and other predators in protected and hidden areas of the food plots. A great horned owl (Bubo virginianus) decoy, positioned so as to move with the wind, displaced the gulls for a short period, but they returned upon becoming accustomed to the plastic decoy. Monofilament fishing line over a portion of the food plot accompanied by a great horned owl decoy proved most successful in 1993. The combination excluded gulls from the protected portion of the food mixture 100% of the time, although gulls fed in the remainder of the food plot. Shell crackers used in 1994 also were marginally successful in displacing the gulls. Franklin's ground squirrels were not observed in food plots during 1993 but were occasionally observed or heard in food plots during 1994.

Predator Occupancy of Study Areas

Predator Community. Information obtained about predators other than canids was also descriptive, but provided some insight about the predator community in the vicinity of each study area and the relative use of each study area by individual species. A summary of observation, livetrapping, and track survey data for detecting the presence of mammalian and avian predators of duck eggs on individual study areas revealed no marked differences in the composition of predator communities, other than canid occupancy (Table 6).

Striped skunks, raccoons, badgers, and Franklin's ground squirrels were non-canid predator species commonly detected on study areas. Maximum likelihood analyses indicated no differences in the odds of detecting the presence of each predator species on treatment versus control areas (Table 7). Long-tailed weasels, American crows, and black-billed magpies were uncommon on study areas (Table 6, Appendix 6).

Livetrapping. The most common predator species livetrapped on study areas were striped skunks and Franklin's ground squirrels. Skunks were captured on 70 and 57% of the study areas in 1993 and 1994, respectively. Franklin's ground squirrels were captured on 10 and 86% of the study areas in 1993 and 1994, respectively. Thirty-one skunks were captured on the treatment areas in 1993, for an average capture rate of 0.182 skunks/trap day. Six striped skunks were captured on control areas for an average capture rate of 0.037 skunks/trap day (Appendix 6). In

Table 6. Evidence of occurrence of mammalian predator species on study areas from observations by investigators[a], detection of tracks[b,c], and capture[d] of individuals during livetrapping in North Dakota (1993-94).

Study Area	Striped skunk	Badger	Mink	Raccoon	Red Fox	Coyote	Franklin's ground squirrel	Long-tailed weasel
TREATMENT AREAS								
1993								
Refuge Headquarters	oTPC	T	T	T	TP			
West Bay	Tp			tp	t	T		
George's Point	TPC	p	t	T	TP	T	C	
Lake Nettie	TPC	Tp		T	TP	T		
Turtle Lake	TPC	tp		T	Tp	T		
1994								
Dammel	TPC			T	TP		OoC	C
Zimmerman WPA	TP	T		T	TP		oC	
Zimmerman FmHA	oTPC	T		T	TP		oC	
Gaier	TPC	t		Tp	TP	t	Oo	
Hertal	TP	O		T	TP	Tp	OC	
Seekin	TP	T		T	TP			
Roosevelt	TP	T		TP	TP		C	

(Continued)

Table 6. (Continued)

Study Area	Striped skunk	Badger	Mink	Raccoon	Red Fox	Coyote	Franklin's ground squirrel	Long-tailed weasel
CONTROL AREAS								
1993								
East Bay					T	T		
NE Plot	TC	T		TC				
Lake Williams N.	TC	t		T		T		
Lake Williams S.	T	t		TC	T			
Falkirk Mine	TC			T	T	T		
1994	TPC	tp		T	Tp	T		
Crystal Springs	TC			T	OT		OC	
Mud Lake	TC			T	t	T	OC	
Smith-Bingham	T	t		T	T	T	OC	
Kutz	TC			TC	OT		C	
Tischner	TC	T		T	TC	t	C	
Thiesen	T	tC		T	OT	Tp	OC	
Mount Moriah	TC			T	T		C	

[a] Observations are reported as O = observed on study area during nest search or other activity and o = observed in food plot during food distribution.

(Continued)

Table 6. (Continued)

[b] Presence of tracks is reported as T = tracks observed on > 1 plot and t = tracks observed on 1 plot during systematic track surveys.

[c] Presence of tracks reported as P = tracks observed on > 1 visit and p = tracks observed on 1 visit during food distribution.

[d] Capture of individual species during livetrapping is reported as C = $\geq$ 1 individual.

Table 7. Results of Log-odds maximum likelihood chi-square analyses to test for variation in the presence of common predator species detected on treatment and control study areas in North Dakota (1993-94).

Predator	% Areas presence detected		P^a
	Treatment	Control	
Skunk	100	92	0.48
Badger	83	58	0.21
Raccoon	100	92	0.48
Franklin's ground squirrel	42	42	0.99

[a] Chi-square conducted using frequency of areas where predator species were detected.

1994, 13 striped skunks were captured on treatment areas for an average capture rate of 0.046 skunks/trap day and 10 skunks were captured on control areas for an average capture rate of 0.036 skunks/trap day. In 1994, 100% of the skunks livetrapped on the treatment areas were captured in the food plots.

Only 1 Franklin's ground squirrel was caught on the treatment areas in 1993 and none were caught on the control areas. There was no separate trapping effort conducted for Franklin's ground squirrels during 1993, although the live traps used were capable of retaining this species if the opportunity existed. In 1994, 46 Franklin's ground squirrels were captured on 5 of 7 treatment areas for a total average capture rate of 0.164 ground squirrels/trap day. Twenty-three Franklin's ground squirrels were captured on control areas for an average capture rate of 0.082 ground squirrels/trap day (Appendix 6). Of the 46 Franklin's ground squirrels captured on the treatment areas in 1994, 72% were caught in the food plots.

<u>Systematic Track Surveys</u>. Percentage of plots with striped skunk tracks ranged from 8 to 43% on treatment areas and 0 to 48% on control areas. For raccoons, the percentage of plots with tracks ranged form 4 to 68% on treatment areas and 0 to 57% on control areas. Percentage

of plots with badger tracks ranged from 0 to 12% on treatment areas and 0 to 10% on control areas (Appendix 3). Percent of plots with tracks provides a relative index to the intensity of use by a predator on an area. However, the ability to find and recognize tracks was affected by the variability in tracking conditions among areas.

Residual Vegetation Density.

The least-squares mean height-density measurements on control areas (1.23 dm) tended to be higher than on treatment areas (1.15 dm), although analysis indicated no significant difference ($P = 0.22$) (Table 8). There was a significant difference in the least-squares mean height-density measurements between 1993 (1.31 dm) and 1994 (1.07 dm) ($P < 0.001$). This may have been partially attributed to compaction resulting from heavy snow falls (224 cm) in the winter of 1992-93. Analyses indicated no interaction between treatment and year ($P = 0.99$).

Table 8. Results of analysis of variance for Robel residual vegetation densities among treatment and control areas and years in North Dakota (1993-94).

Source	df	*F*	*P*
Treatment	1,20	1.57	0.22
Year	1,20	16.36	<0.001
Treatment x year	1,20	0.00	0.99

DISCUSSION

Effects of Supplemental Food on Duck Nest Success

Mean nest success was 29% on control areas and 41% on areas where supplemental food was provided for striped skunks. Although nest success tended to be higher on treatment areas, results did not differ significantly and were highly variable among areas. High variability may have reduced my ability to detect a difference. Under less variable conditions, the 12 percentage point gap in nest success may be important since it is at a level sufficient to increase duck nest success in most situations above the 15-20% suggested threshold levels for population stability of several dabbling duck species (Cowardin et al. 1985, Klett et al. 1988).

My results do not support those reported by Crabtree and Wolfe (1988) for a similar study with striped skunks in Utah. These investigators reported an increase in nest success during June in areas where alternate food was provided for striped skunks, despite indications of possible compensatory response by other predators. Those authors reported that introduced foods did not have an effect on striped skunk depredation during July, even though nest success increased significantly on both treatment and control areas from that observed in June. Crabtree and Wolfe (1988) attributed this difference to the skunk's change in foraging activity, which was adapted to utilizing a sudden abundance of mobile invertebrate prey. Striped skunks become almost exclusively insectivorous during times of year when invertebrate prey numbers are high (Verts 1967). Although I did not analyze for differences between early and late season nests, one can surmise that any significant effect observed early in the nesting season would produce overall results that were favorable for the entire season. Greenwood et al. (1995) indicated that predation rates tended to decrease as the nesting season progressed. This would be especially true if buffer prey species were abundant. Buffer prey has been shown to influence predation rates on birds and their clutches (Larson 1960, Rusch et al. 1972, Pehrsson 1985, Summers 1986). Byers (1974) reported a significant correlation between blue-winged teal nest success and abundance of small mammals.

I found that average nest success rates on coyote-dominated areas were significantly higher than on red fox-dominated areas. The 37 percentage point difference in nest success is especially important since it is approximately twice the value of the threshold level of nest success needed for population stability of several prairie nesting duck species (Cowardin et al. 1985, Klett et al. 1988).

These results support those reported by Sovada et al. (1995) on the significant positive effects of coyotes on duck nest success. Although the difference I found was more than double the value discovered by Sovada et al. (1995), a relatively small sample of coyote-dominated areas may have influenced results. Sovada et al. (1995) noted that not all areas dominated by coyotes experience high nest success rates, or conversely, that areas dominated by foxes experience low nest success. I detected a nest success rate of 43% on one fox-dominated control area (Smith-Bingham). A weak negative correlation was reported between daily predation rates of duck nests and the abundance of coyotes and a strong positive correlation has been reported between daily predation rates and abundance of red fox (Johnson et al. 1989). Differences in predator communities, especially the canid component, have been suggested for regional differences in nest success rates in portions of North Dakota, South Dakota, and Minnesota

(Klett et al. 1988).

Red fox and coyotes are territorial canids, when in sympatric populations, coyotes will exclude foxes (Sargeant et al. 1987a, Sargeant et al. 1993). Although both coyotes and red foxes prey on nesting hens and their clutches (Sooter 1946, Keith 1961, Sargeant 1972, Johnson and Sargeant 1977), the coyote is considered to be less detrimental to duck production than red fox (Johnson et al. 1989).

I found that the proportion of all depredated nests assigned as likely destroyed by striped skunks was significantly less on treatment areas (11%) than on control areas (24%). I believe the difference in proportions of depredations assigned to skunks in treatment areas is due to the presence of supplemental food. Evidence suggested that skunks responded to the food mixture. Skunks utilized the supplemental food within a week of distribution and use remained constant throughout the distribution period. This was evident because of the amount of tracks, dig marks, and partially consumed supplemental food that was found in the food plots. Skunk tracks were found in food plots on more than 35% of the visits that were not affected by rain. However, I believe that assessment of the use of food plots may be conservative, since natural tracking substrate in the food plots was limited and the constructed track plots represented <1% of the total surface area. On several occasions skunk tracks were observed in more than one track plot per food plot, despite the small amount of tracking substrate. This would suggest that the skunk's foraging activity was concentrated on the food plots.

Skunks also excavated new dens in or near food plots during the distribution period on several treatment areas, possibly to locate themselves closer to an abundant food source. Crabtree and Wolfe (1988) reported that introduced food provided a buffer that diverted skunks from nesting habitats. They also reported a change in skunk foraging activity in the latter part of the season that resulted in less use of introduced food and more use of natural prey. Crabtree and Wolfe (1988) and Vickery et al. (1992) concluded that skunks did not actively search for bird nests, but depredation was incidental while skunks searched for other prey items such as invertebrates. With this in mind, one can conclude that the supplemental food source I provided elicited a behavior that caused the skunks to actively forage in the localized area of the food plot, significantly reducing a chance encounter of finding a nest, thus decreasing skunk depredation rates.

The average proportion of all depredated nests assigned to skunks was marginally less on coyote areas than on fox areas. Johnson et al.(1989) found a weak negative relation between indices to abundance of striped skunks and coyotes, suggesting coyotes may regulate skunk numbers. I found that capture rates and proportions of plots with skunk tracks tended to be slightly lower on coyote areas than on red fox areas. Sovada (1993) also reported that the activity of skunks was slightly lower on coyote areas than on red fox areas. Baker (1978) suggested that the exclusion of coyotes caused an increase in skunks and raccoons which resulted in lower nest success rates of wild turkey (Meleagris gallopavo). One cannot rule out the possibility that coyotes may regulate skunk numbers, thus reducing skunk depredation and further enhancing duck nest success.

No differences were found in the proportion of depredated nests that were assigned to fox and badger between treatment and control areas. I estimated that red foxes destroyed 18% of the nests on control areas and 21% on treatment areas. Fox tracks were rarely observed in food plots in 1993, but were found nearly as often as skunk tracks in 1994. This finding may be inflated due to the increased fox activity associated with a rearing den located <150 m from a food plot on one study (Seekin).

Sargeant et al. (1986) reported that commercial sunflower seeds were found in 75% of the red fox stomachs examined during winter and that sunflower seeds made up about half of the stomach's contents. On one occasion I observed red fox pups consuming the supplemental food mixture.

Although red foxes were attracted to the food plots and likely consumed portions of the supplemental food, no decrease in depredation rate on duck nests by red foxes was observed. During the pup rearing season, fox bring large quantities of prey to the den and adult ducks comprised approximately one-fourth of the prey biomass (Sargeant et al. 1984). The supplemental food I provided was not likely to be transported to den sites. Sargeant et al. (1984) suggested it may be more efficient for foxes to utilize large prey items, such as ducks, when feeding pups.

Badgers were attributed to destroying 31% of usable nests on control areas and 28% on treatment areas. This was unexpected since survey information suggested badger activity was low on all areas. Sovada (1993) also reported low badger activity on her study areas. Badgers have been implicated as predators of duck nests (Sargeant and Arnold 1984), but little is known about the actual magnitude of their impact on nest success. In past research the badger was not considered an important predator of duck nests (e.g. Keith 1961, Stoudt 1971).

Badgers accounted for a significantly higher proportion of depredations in 1994 (41%) than in 1993 (19%). This may be attributed to a higher badger population on the area studied in 1994. Although the data do not support this, badgers are secretive, solitary animals and their presence can often go unnoticed. Sargeant et al. (1993) reported that badger abundance varies geographically. In 1994 badgers were attributed to destroying more nests than skunks and foxes combined. There was little evidence that suggested badgers utilized the supplemental food that was provided.

I detected a significantly lower proportion of useable nests that failed due to fox depredation on coyote areas than on fox areas. This indicates that my assignments of canid occupancy to study areas were correct. Coyotes exclude fox from their territories, thus reducing the possibility of fox depredation on duck nests (Sargeant et al. 1987a, Harrison et al. 1989, Sovada et al. 1995).

Although the rate of depredation by skunks decreased on treatment areas, no significant increase in nest success was observed. Crabtree and Wolfe (1988) indicated that the presence of introduced food reduced predation rates of skunks, but overall predation rates were not affected.

They suggested that compensatory responses by other predators were responsible. Greenwood (1986) also suggested that the positive effects of skunk removal on some areas was negated by the presence of Franklin's ground squirrels. I did not observe an increase in proportions of nests destroyed by fox or badger on treatment areas where skunk predation rates were affected. This would suggest no compensatory response by either of these species.

Depredation by Franklin's ground squirrels, however, may have compensated for reduced skunk depredation resulting from supplemental feeding. I found that nest success was 19 percentage points higher on treatment areas in 1993, but only 5 percentage points higher in 1994. Franklin's ground squirrels were essentially absent in 1993, but abundant in 1994. The average capture rates I observed on control areas (0.082) were similar to those reported by Greenwood (1986). Although, average capture rates on treatment areas (0.164) were twice that observed on controls, Franklin's ground squirrels likely were attracted to the treatment areas because of the supplemental food. On several occasions they were observed or heard in the food plots.

Locally, Franklin's ground squirrels can be an important predator of duck eggs (Sowls 1948, Sargeant et al. 1987b). They often depredate clutches, one egg at a time, and may take several days (up to 5 days for a clutch of 6) to depredate a whole clutch (Sargeant et al. 1987b). Nests with eggs missing before they hatch or are destroyed are indicators of Franklin's ground squirrel depredation (Sargeant et al. In Press). I was not able to ascertain if any of the nests I discovered showed indications of Franklin's ground squirrel depredation because of the length of time between visits. Nests were visited about every 21 days in 1994. This is more than a sufficient time for a Franklin's ground squirrel to completely depredate a nest.

Franklin's ground squirrels travel extensively in habitats used by nesting ducks (Choromanski-Norris 1983), but there is little evidence to suggest they actively search for nests. Depredation of eggs by Franklin's ground squirrels may be a result of chance encounters. Sargeant et al. (1987b) stated that depredation of eggs usually began immediately after the nest was discovered by Franklin's ground squirrels, but they did not suggest that the nests were the primary target. The food mixture was apparently attractive to Franklin's ground squirrels and may have resulted in them frequently traveling through a treatment area, possibly discovering nests in their paths.

There were no other obvious differences that would explain the variability in average nest success rates found between years on treatment and control areas. Excluding the canid component, analyses of the composition of predator communities showed no differences. Similar predator communities were commonly found on treatment and control areas each year, with the exception of Franklin's ground squirrels. Other variables, such as the density of residual vegetation, did not differ between treatments and controls. Densities were different between years, but this was likely due to the compaction of unusually heavy snow falls in the winter of 1992-93. Evidence from several studies (Duebbert 1969, Duebbert and Kantrud 1974, Crabtree et al. 1989) indicates that the density of nesting cover or the amount of residual cover can elicit positive influences on nest success. In light of the differences in residual vegetation density, higher nest success should have been favored in 1994, but no difference was found between years.

Raccoons were detected on all study areas, however, their influence on nests was likely low. Sargeant et al. (In Press) reported that raccoons had a minor influence on nest depredation rates. Fritzell (1978) showed that raccoons seldom used upland habitats where ducks nest. Raccoon tracks were seldom observed in the food plots, suggesting that their use of these food plots in upland habitats was low. American crows and black-billed magpies had little influence on results of this study because they were rarely observed on study areas. Both are important predators of duck eggs in much of the Prairie Pothole Region of Canada (Johnson et al. 1989, Sargeant et al. 1993). Although large gulls were common during both years and extensively consumed portions of the food mixture at food plots, they were seldom detected on the ground other than at the location of the food plots. Large gulls are known predators of duck eggs (Anderson 1965), but their responses to duck eggs are weak and they probably destroy few upland duck nests (Sargeant et al. In Press).

Conclusion and Implications

Two factors should be considered when interpreting the results of this study. First, the study was conducted at a time when there was substantially more grassland habitat than the previous decade, due to the implementation of the Conservation Reserve Program (CRP)(Bjerke 1991). Many study areas were located adjacent to large CRP fields. Additional grassland helps to reduce the concentration of duck nests, which may reduce the efficiency of predators discovering nests. Increased cover also provides more habitat, which is conducive to the production of some buffer prey items (i.e. small mammals, invertebrates), likely resulting in an overall larger prey base.

A second factor is that this study was conducted during a period of greatly improved water conditions resulting in record high numbers of breeding ducks (Caithamer et al. 1994). Improved water conditions not only encourages nesting, but also increases renesting attempts (Krapu et al. 1983, Cowardin et al. 1985). The average nest success rates I found were markedly higher than those normally reported for the region (Klett et al. 1988). Reynolds et al. (1994) and Renner et al. (1995) also reported higher than normal nest success rates during the same period in this region. High numbers of breeding waterfowl coupled to the presence of buffer prey species may have provided predators with more food than they could functionally consume, resulting in an overall reduced proportion of depredations on duck nests. Newton (1993:149) states "If for some reason prey numbers continue to rise, there comes a point when predators can increase their kill rate no further. This happens because there are limits to both the amounts that individual predators can eat and to the numbers of predators that can live in a given area (for example because of interference or social intolerance). The numbers of prey that are taken then remains constant so that, if prey numbers continue to rise, a progressively smaller proportion is taken. The relationship then switches from density-dependent (regulatory) to inversely density-dependent (nonregulatory)." I believe that ducks may have increased the prey base enough to act as buffers on nests of their own kind. An inverse density-dependant relationship on the predation of female red grouse (Lagopus lagopus scoticus) primarily by peregrine falcons (Falco perengrinus)was reported by Hudson (1992).

Although I did not detect an increase in duck nest success from providing supplemental food, food placement did appear to decrease depredations caused by skunks. Possible compensatory responses by other predators, such as Franklin's ground squirrels, may have negated any beneficial effects. Buffering effects caused by high breeding duck numbers added to the existing alternate prey base may have been responsible for the high overall nest success rates that were observed. Coyote dominated areas proved to be beneficial to nesting ducks as indicated by Sovada et al. (1995). The marginally less depredation by skunks found on coyote areas may suggest that coyotes influence skunk activity or numbers, thus, coyotes may benefit ducks by reducing the influences of red foxes and striped skunks on duck nest success.

Under the conditions of my study, provision of an alternate food source did not appear to be an effective management technique for increasing duck nest success. Beneficial effects of this nonlethal method to reduce depredation on duck nests apparently were negated by compensatory responses by other predators and/or the effects of abundant naturally occurring prey items. Alternate prey density and their effects on predation may vary year to year and from predator community to predator community. The positive influences of providing supplemental foods tended to be greater in 1993 when Franklin's ground squirrels were absent. However, this technique may prove to be beneficial in situations with specific predator communities and in years or areas where there are low amounts of naturally occurring buffer prey.

Provisions of supplemental food only in coyote-dominated areas, may increase the usefulness of this technique. In those areas, striped skunk depredation may be reduced to levels sufficient enough to significantly increase nest success rates. This is one reason that it is important for investigators to consider the predator community when evaluating duck nest success. The composition of a predator community may change from area to adjacent area or from year to year within any given area (Sargeant et al. 1993). This technique applied to coyote areas coupled by harvest management to maintain moderate coyote densities may prove to be a cost effective and socially acceptable method to control depredation of duck eggs and significantly increase nest success.

Striped skunks and red foxes are known to be important predators of duck eggs, but little is known about the relationship between badgers and their impact on duck nests. The results I found suggest that in certain areas badgers may have a greater impact on duck nest success than either striped skunks or red foxes. However, this study was not designed to evaluate the influences of badger depredation on duck eggs, it may stimulate further research into the relationship between this potentially destructive predator and upland nesting ducks.

Large gulls were attracted to the supplemental food mixture that was provided. Gulls were persistent in their attempts to feed and at times several hundred were concentrated in the vicinity of the food plots. This technique may prove applicable to reducing gull depredation on eggs of piping plovers (<u>Charadrius melodus</u>), American white pelicans (<u>Pelecanus erythrorhynchos</u>), or other birds that nest in areas with high gull concentrations. Further research is needed to determine the exact effects it may have on large gulls and their relationship with ground nesting birds.

Introduction of a supplemental food source may provide means of reducing depredation rates by striped skunks on duck nests even if naturally occurring buffer prey items are abundant. Besides economic and logistical constraints, such a management technique must consider the possibility of numerical responses by predators (i.e. increased fecundity or immigration). I did not measure fecundity, but observed no immigration with the possible exception of Franklin's ground squirrels.

The results of this study were obtained from two field seasons in different geographical locations of the Prairie Pothole Region of North Dakota. Evaluation on individual treatment and control areas was not replicated. The predator community and natural prey densities may vary from year to year and from location to location thus limiting the application of my results. However, the predator-prey relationships and destruction attributed to individual predator species revealed in this study may serve as a template for future investigations. The results of this study suggest that, in some situations, alternatives to less socially acceptable predator control methods may be advantageous. Considering the problems associated with predator removal, research directed at refining techniques involving introduced foods and the possible implementation of canid management is encouraged.

APPENDICES

Appendix 1. Year of evaluation, names, legal description, and amount of upland searched for each study area in North Dakota (1993-94).

Study area	Legal description: Township	Range	Section(s)[a]	Upland searched (ha)
TREATMENT AREAS				
1993				
Refuge Headquarters[b]	147	83	4	68
West Bay[b]	147	82	7	83
George's Point WMA[c]	148	82	17,18	47
Lake Nettie NWR	148	81	28	59
Turtle Lake WDA[d]	147	80	24	62
1994				
Dammel WPA[e]	139	69	24	48
Zimmerman WPA	140	69	22	33
Zimmerman FmHA WPA	140	67	15	57
Gaier WPA	141	67	26	64
Seekin WPA	141	69	24	35
Hertal WPA	141	68	36	52
Roosevelt WPA	143	67	28	70
CONTROL AREAS				
1993				
East Bay[b]	147	82	8	45
NE Plot WMA	149	82	36	49
Lake Williams N. WDA	147	80	23,24	47
Lake Williams S. WDA	147	80	34	35
Falkirk Mine[f]	146	83	35	75
1994				
Crystal Springs WPA	139	69	7	68
Mud Lake WPA	141	68	6	67

(Continued)

Appendix 1. (Continued)

Study area	Legal description			Upland searched (ha)
	Township	Range	Section(s)[a]	
Smith-Bingham	141	66	4	60
Kutz	142	68	9	47
Tischner	143	69	22	47
Thiesen	144	69	15	55
Mount Moriah	144	67	21	58

[a] Section(s) in which study areas were located.

[b] Audubon National Wildlife Refuge (NWR)

[c] North Dakota Game and Fish Wildlife Management Area

[d] Garrison Diversion Wildlife Development Area

[e] Federal Waterfowl Production Area

[f] Falkirk Mining Company land

Appendix 2. Dates of nest searches on study areas in North Dakota (1993-94).

Study area	Dates of nest searches			
TREATMENT AREAS				
1993				
Refuge Headquarters	4 May	25 May	15 June	
West Bay	3 May	24 May	14 June	
George's Point	5 May	26 May	16 June	6 July[a]
Lake Nettie NWR	10 May	28 May	18 June	
Turtle Lake	6 May	27 May	19 June	
1994				
Dammel	3 May	24 May	14 June	
Zimmerman WPA	3 May	25 May	15 June	
Zimmerman FmHA	6 May	28 May	18 June	
Gaier	7 May	29 May	19 June	
Seekin	4 May	26 May	16 June	
Hertal	5 May	27 May	17 June	
Roosevelt	10 May	1 June	22 June	
CONTROL AREAS				
1993				
East Bay	14 May	3 June	23 June	
NE Plot	5 May	26 May	17 June	6 July[a]
Lake Williams N.	11 May	29 May	21 June	
Lake Williams S.	12 May	1 June	20 June	8 July[a]
Falkirk Mine	13 May	2 June	22 June	7 July[a]
1994				
Crystal Springs	2 May	23 May	13 June	
Mud Lake	9 May	31 May	21 June	
Smith-Bingham	14 May	5 June	26 June	

(Continued)

Appendix 2. (Continued)

Study area	Dates of nest searches		
Kutz	8 May	30 May	20 June
Tischner	11 May	2 June	23 June
Thiesen	12 May	3 June	24 June
Mount Moriah	13 May	4 June	25 June

[a] Additional nest search conducted to increase nest sample size.

Appendix 3. Number of plots searched during systematic track surveys (April-May-June) and percentage of plots where tracks were detected on study areas for each species in North Dakota (1993-94).

Study area	Number plots searched	Plots with tracks (%)				
		Coyote	Red Fox	Striped Skunk	Raccoon	Badger
TREATMENT AREAS						
1993						
Refuge Headquarters (F)[a]	26	0	69	35	4	0
West Bay (C)[b]	24	67	4	8	4	0
George's Point (F)	23	4	52	17	51	0
Lake Nettie NWR (F)	25	20	64	16	52	12
Turtle Lake (F)	23	22	61	35	13	4
1994						
Dammel (F)	22	0	64	18	64	0
Zimmerman WPA (F)	26	0	50	39	27	8
Zimmerman FmHA (F)	21	5	24	24	62	0
Gaier (F)	19	5	74	21	63	5
Seekin (F)	21	0	86	43	10	10
Hertal (C)	27	44	11	22	59	0
Roosevelt (F)	19	0	53	37	68	11

(Continued)

Appendix 3. (Continued)

Study area	Number plots searched	Plots with tracks (%)				
		Coyote	Red Fox	Striped Skunk	Raccoon	Badger
CONTROL AREAS						
1993						
East Bay (C)	19	84	26	0	0	0
NE Plot (F)	21	0	76	48	57	10
Lake Williams N. (C)	18	72	0	28	17	6
Lake Williams S. (F)	20	0	75	15	30	5
Falkirk Mine (C)	25	84	12	36	24	0
1994						
Crystal Springs (F)	19	0	74	16	21	0
Mud Lake (C)[c]	15	20	7	40	53	0
Smith-Bingham(F)[c]	23	9	44	22	35	4
Kutz (F)	21	0	33	43	40	0
Tischner (F)	25	4	56	32	40	8
Thiesen (F)	25	0	68	20	52	4
Mount Moriah (F)	12	0	33	17	42	0

[a] F = fox dominated area.

[b] C = coyote dominated area.

[c] Includes a 3rd systematic survey conducted in early July.

Appendix 4. Density of duck nests that were found and that hatched on study areas in North Dakota (1993-94).

Study area	Number nest found[a]	Area Searched (ha)	Nest per ha[b]	Number hatched nests	Hatched nests per ha[c]
TREATMENT AREAS					
1993					
Refuge Headquarters	27	68	0.40	33	0.04
West Bay	75	83	0.90	65	0.78
George's Point	15	47	0.32	9	0.19
Lake Nettie NWR	33	59	0.56	7	0.12
Turtle Lake	30	62	0.48	22	0.35
1994					
Dammel	33	48	0.69	13	0.27
Zimmerman WPA	64	33	1.94	39	1.18
Zimmerman FmHA	58	57	1.02	33	0.58
Gaier	84	64	1.31	28	0.44
Seekin	80	52	1.54	53	1.02
Hertal	28	35	0.80	8	0.23
Roosevelt	110	70	1.57	53	0.76
CONTROLS					
1993					
East Bay	21	45	0.47	18	0.40
NE Plot	13	49	0.27	3	0.06
Lake Williams N.	42	47	0.89	28	0.60
Lake Williams S.	17	35	0.49	5	0.14
Falkirk Mine	9	75	0.12	5	0.07
1994					
Crystal Springs	27	68	0.40	14	0.21
Mud Lake	82	67	1.22	50	0.75

(Continued)

Appendix 4. (Continued)

Study area	Number nest found[a]	Area Searched (ha)	Nest per ha[b]	Number hatched nests	Hatched nests per ha[c]
Smith-Bingham	29	60	0.40	14	0.21
Kutz	28	47	0.60	8	0.17
Tischner	41	47	0.87	9	0.19
Thiesen	38	55	0.69	18	0.33
Mt. Moriah	62	58	1.07	22	0.38

[a] All nest found including those not included in daily survival rate analysis because of observer influenced fate or nonviable clutch.

[b] Density of nests = number of nests found on a study area divided by ha searched for nests.

[c] Density of hatched nests = number of hatched nests on a study area divided by ha searched for nests.

Appendix 5. Mean number of places[a] per hour (observation rate) where 1 or more mammalian or avian predators were seen on study area in North Dakota (1993-94).

		Observation rate							
Study Area	Hours[b]	Coyote	Red Fox	Striped skunk	Raccoon	Badger	Franklin's Ground Squirrel	A. Crow/ Black-billed magpie	Large gulls
TREATMENT AREAS									
1993									
Refuge Headquarters	58	0	0	0	0	0	0	0.017	0.724
West Bay	96	0	0	0	0	0	0	0	0.531
George's Point	48	0	0	0	0	0	0	0	0.792
Lake Nettie NWR	62	0	0	0	0	0	0	0	0.645
Turtle Lake	56	0	0	0	0	0	0	0	0.607
1994									
Dammel	45	0	0	0	0	0	0.022	0	0.222
Zimmerman WPA	51	0	0	0	0	0	0	0	1.275
Zimmerman FmHA	44	0	0	0	0	0	0.045	0	1.909
Gaier	57	0	0	0	0	0	0.018	0.018	0.737
Hertal	49	0	0	0	0	0.061	0.020	0	1.694
Seekin	30	0	0	0	0	0	0	0	1.833
Roosevelt	77	0	0	0	0	0	0	0	0.468

Continued

Appendix 5. (Continued)

Study Area	Hours[b]	Observation rate: Coyote	Red Fox	Striped skunk	Raccoon	Badger	Franklin's Ground Squirrel	A. Crow/ Black-billed magpie	Large gulls
CONTROL AREAS									
1993									
East Bay	40	0	0	0	0	0	0	0	0.375
NE Plot	35	0	0	0	0	0	0	0	0.257
Lake Williams N.	45	0	0	0	0	0	0	0	0.133
Lake Williams S.	35	0	0	0	0	0	0	0	0.057
Falkirk Mine	55	0	0	0	0	0	0	0	0.018
1994									
Crystal Springs	33	0	0.030	0	0	0	0.061	0	0.333
Mud Lake	61	0	0	0	0	0	0.049	0	0.639
Smith-Bingham	51	0	0	0	0	0	0.078	0	0.294
Kutz	22	0	0.136	0	0	0	0	0.045	0.545
Tischner	35	0	0	0	0	0	0	0	0.486
Thiesen	36	0	0.167	0	0	0	0.028	0	0.250
Mount Moriah	65	0	0	0	0	0	0	0	0.154

[a] A place is defined as a 0.4 ha aera (Sargeant et al. 1993).

[b] Total hour spent on study area by investigators during activities other than supplemental food distribution.

Appendix 6. Number of trap-days[a] and capture rates[b] of mid-sized mammalian predators of duck eggs and Franklin's ground squirrels on study areas in North Dakota (1993-94).

Study Area	Trap-days	Capture rate					
		Red Fox	Striped skunk	Raccoon	Badger	Franklin's ground squirrel	Long-tailed weasel
TREATMENT AREAS							
1993							
Refuge Headquarters	32	0	0.406	0	0	0	0
West Bay	32	0	0	0	0	0	0
George's Point	42	0	0.333	0	0	0.024	0
Lake Nettie	32	0	0.063	0	0	0	0
Turtle Lake	32	0	0.063	0	0	0	0
1994							
Dammel	40	0	0.125	0	0	0.250	0.025
Zimmerman WPA	40	0	0	0	0	0.350	0
Zimmerman FmHA	40	0	0.150	0.050	0	0.050	0
Gaier	40	0	0.050	0	0	0	0
Hertal	40	0	0.050	0	0	0.150	0
Seekin	40	0	0	0	0	0	0
Roosevelt	40	0	0	0	0	0.350	0

(Continued)

Appendix 6. (Continued)

Study Area	Trap-days	Capture rate					
		Red Fox	Striped skunk	Raccoon	Badger	Franklin's ground squirrel	Long-tailed weasel
CONTROL AREAS							
1993							
East Bay	32	0	0	0	0	0	0
NE Plot	32	0	0.031	0.031	0	0	0
Lake Williams N.	32	0	0.031	0	0	0	0
Lake Williams S.	32	0	0	0.031	0	0	0
Falkirk Mine	32	0	0.125	0	0	0	0
1994							
Crystal Springs	40	0	0.025	0	0	0.075	0
Mud Lake	40	0	0.125	0	0	0.050	0
Smith-Bingham	40	0	0	0	0	0.025	0
Kutz	40	0	0.025	0.025	0	0.200	0
Tischner	40	0.025	0.025	0	0	0.100	0
Thiesen	40	0	0	0	0.025	0.075	0
Mt. Moriah	40	0	0.050	0	0	0.050	0

[a] Trap-days are the sum of the number of traps set each day of trapping on a study area.

[b] Capture rate is the number of individuals captured divided by total trap-days.

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