AN ABSTRACT OF THE THESIS OF

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Title: Nest Site Selection on Flint Hills Impoundments by Canada Geese (Branta canadensis)

Abstract approved: Carl W. Prophet

Twenty-four habitat variables considered important to the selection of a nest site by Canada Geese were evaluated at 59 impoundments (n = 55 stockponds, n = 4 watershed lakes) in northern Greenwood County, Kansas, during the 1989 and 1990 nesting seasons. Impoundments with nesting pairs present, termed "occupied," were compared to impoundments without nesting pairs present, termed "vacant."

Eleven pairs of Canada Geese during 1989 and 27 pairs during 1990 produced broods. Twenty-four nests during 1989 and 26 nests during 1990 were located on artificial structures.

Occupied impoundment size was significantly larger than vacant impoundment size during both 1989 and 1990 when watershed lakes were included in the analysis ($P < 0.05$). When watershed lakes were removed from analysis, occupied impoundment size was not significantly larger than vacant impoundment size during 1989, however, occupied impoundment size was significantly larger than vacant impoundment size during 1990.

Analysis of 18 habitat variables by stepwise discriminant function analysis indicated that brood use of an impoundment, presence of an artificial structure, impoundment fenced to exclude livestock, and the average distance to the nearest three vacant impoundments explained 49% of the variation between occupied and vacant impoundments during 1989. During 1990, the presence of an artificial structure, brood use of an impoundment, impoundment size, and the percent of shoreline having shrubs explained 41% of the variation between impoundment classes.

Thirty-eight vacant impoundments (97.4%) and eight occupied impoundments (13.8%) were correctly classified by discriminant function analysis during 1989; 12 occupied impoundments were misclassified as vacant impoundments. During 1990, 38 vacant impoundments (100%) and 21 occupied impoundments (100%) were correctly classified.

Brood use of occupied and vacant impoundments was significantly different during both years. Climatic conditions, previous nesting success, presence of an artificial structure, and brood use of an impoundment appeared to be important factors influencing nest site selection by Canada Geese.

NEST SITE SELECTION ON FLINT HILLS IMPOUNDMENTS BY CANADA GEESE, *Branta canadensis*

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Approved for Major Department

Faye N. Vowell
Approved for Graduate Council

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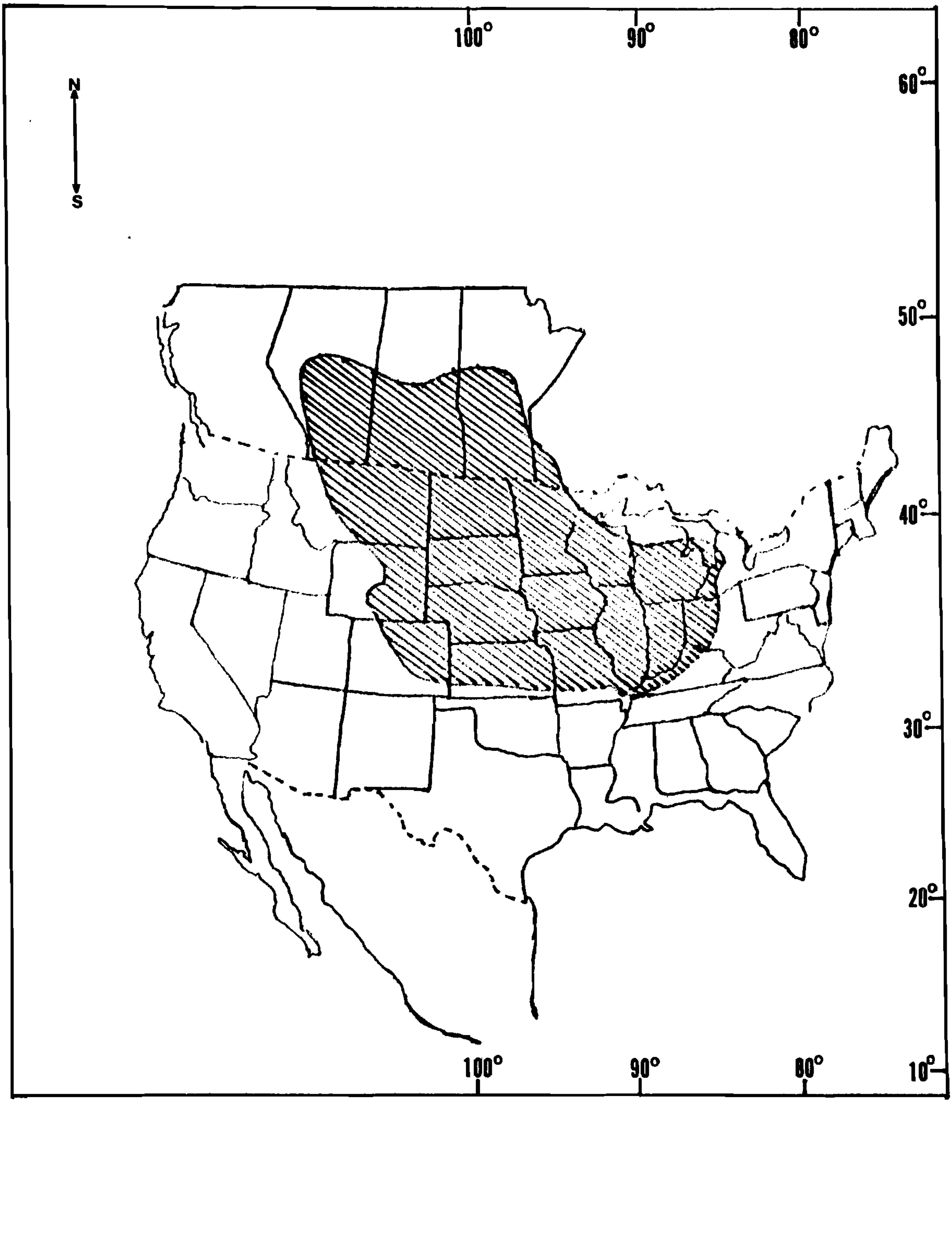
INTRODUCTION

The Canada Goose (Branta canadensis) has been subdivided into numerous subspecies based on differences in body size, plumage, weight, and distribution on wintering and nesting grounds. Bellrose (1976) recognized 11 subspecies, while Johnsgard (1978) described 12 subspecies. Regardless of the actual number of subspecies that have existed, the Giant Canada Goose (B. c. maxima) was perhaps the only subspecies that nested in Kansas (Hanson 1965).

Historical Range of the Giant Canada Goose

The historical range of the Giant Canada Goose probably included the tall grass and mixed grass prairies of the United States and Canada, as well as the parkland region of Canada (Hanson 1965, see Figure 1). Johnsgard (1978) concluded this subspecies originally nested from Manitoba south into Kansas, Missouri, Arkansas, and Tennessee. Also, Hanson (1965) believed that the Giant Canada Goose nested along rivers in Kansas before it became extinct, in Kansas, during the early 1900s. He stated that Cheyenne Bottoms in Barton County and McPherson Bottoms in western McPherson County may have been important nesting grounds for this subspecies prior to the arrival of settlers in Kansas. As agricultural activity in the area increased, McPherson Bottoms disappeared; but Cheyenne Bottoms continued to be an important nesting, breeding, and stopover point.

Records of nesting by Giant Canada Geese in other parts of North America during the late 1800s and early 1900s were gure 1. Historical range of the Giant Canada Goose (shaded area, adapted from: Hanson 1965).


100°
90°
80°
N
S
60°
50°
40°
30°
20°
10°

also incomplete. According to Cooper (1978), the disappearance of nesting Giant Canada Geese in southern Manitoba probably occurred during the period of rapid settlement from 1870 to 1900.

By the mid-1930s the Giant Canada Goose was believed extinct throughout its entire range in North America (Hanson 1965). However, surviving members of this subspecies were discovered in a city park in Rochester, Minnesota, during January 1962. Biologists of the Minnesota Department of Conservation and the U.S. Fish and Wildlife Service noticed differences in size, weight, and plumages among Canada Geese that they captured during banding operations; and they concluded that some of the captured birds were Giant Canada Geese (Hanson 1965).

Introduction Program in Kansas

In 1980, the KDWP initiated a program to restore nesting populations of Canada Geese in eastern Kansas. Adult Canada Geese that were used in the program were obtained mainly from Colorado and Wisconsin. However, Gerald Horak (KDWP, pers. comm.) stated that these geese may not have been purebred Giant Canada Geese, but rather a mixture of several different subspecies of Canada Geese. Therefore, in my study no attempt was made to distinguish between the separate subspecies. These birds were wing-clipped and held at the Mined Land Wildlife Area in Cherokee County and at facilities near Cheney, El Dorado, Fall River, Melvern, and Glen Elder reservoirs. After one year, these birds were released. Other adult geese were pinioned and held in goose pens at various sites across the state, including Cedar Bluff Reservoir, Marais Des Cygnes Wildlife Area, and at facilities near Pratt (Gerald Horak, pers. comm.). Goslings produced by these captive adult geese were removed from the pens before they could fly, at ages 8-9 weeks, and then released at selected sites within the Flint Hills. It was hoped that after sexual maturity the goslings would return to the same area where they learned to fly and attempt to nest (Brakhage 1965).

Objectives of Study

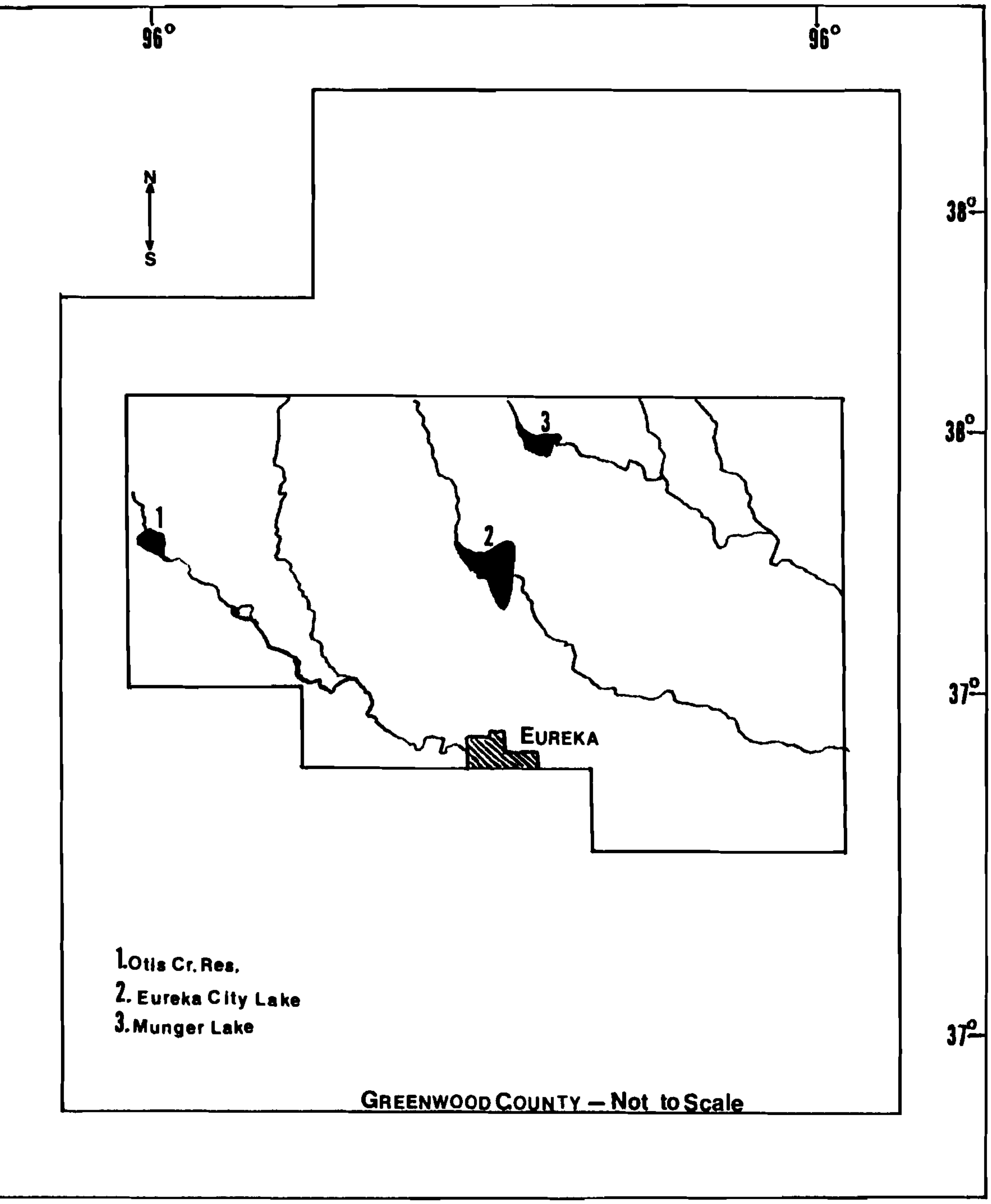
Because little was known about the nesting behavior of Canada Geese in Kansas (Hanson 1965), a study of the nesting of this species in the Flint Hills was conducted. The primary objectives of the study were to determine whether impoundments used as nesting sites shared certain common features and to determine if it were possible to distinguish between impoundments which were suitable and which were unsuitable for nesting. Knowledge of the preferred nesting habitat of the Canada Goose may be used during future efforts to restore and manage this species in the Flint Hills of Kansas.

DESCRIPTION OF STUDY AREA

The study was conducted in an area of approximately 374 km^2 in northern Greenwood County, Kansas, during the Springs of 1989 and 1990 (see Figure 2). This site was selected for study because KDWP personnel had initially released the majority of the Canada Geese adult and goslings in this area.

Fortner et al. (1982) described the soils of the area as deep to moderately deep, gently sloping to moderately sloping with a clay subsoil. The Clime-Sogn-Martin soils complex, with a slope range of 0 to 30% and the Eram-Labette-Kenoma soil complex, with a slope range of 0 to 8%, made up 75% of the soil types found in Greenwood County. Impoundments in Greenwood County had a clay substrate overlying a limestone bedrock that was usually less than 100 cm below ground level. These shallow soils were easily eroded causing siltation of impoundments.

The major land use in this area was livestock grazing, with some crop production on the more suitable soil types. Dominant native grasses of this region included big bluestem (*Andropogon gerardi*), little bluestem (*Andropogon scoparius*), indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and sideoats grama (*Bouteloua curtipendula*). Smooth brome (*Bromus inermis*) and tall fescue (*Festuca arundinacea*) were domestic grasses that were introduced for early and late season grazing and haying gure 2. Location of the study area (outlined in black) in northern Greenwood County, Kansas, during 1989 and 1990.


96°
96°
38°
38°
37°
37°
N
S
1
2
3
EUREKA
1. Otis Cr. Res.
2. Eureka City Lake
3. Munger Lake
GREENWOOD COUNTY — Not to Scale

purposes; however, they accounted for only seven percent of the pasture acreage in Greenwood County (Fortner et al. 1982).

Vegetation types that were found along the shoreline of the study impoundments included aquatic macrophytes, shrubs, trees, or domestic or native grasses. Aquatic vegetation included cattails (Typha sp.), barnyardgrass (Echinochloa crusgalli), sedge (Carex sp.), curly dock (Rumex crispus), and smartweed (Polygonum sp.). Shrub species included aromatic sumac (Rhus aromatica), smooth sumac (Rhus glabra), wild plum (Prunus americana), and rose (Rosa sp.). Common tree species included cottonwood (Populus deltoides), red cedar (Juniperus virginiana), mulberry (Morus sp.), and willow (Salix sp.).

METHODS

Selection of the study impoundments began 24 March 1989 and continued through 31 May 1989. After permission was received from area landowners and operators, impoundments were visited to determine if they were used for nesting sites by Canada Geese. The impoundments that were visited were divided into two classes; occupied and vacant. Impoundments where a ground nest was found or where an artificial nest structure was used were classed as occupied, even if the nest was later abandoned or destroyed. If there was no evidence of nesting activity at an impoundment, it was designated vacant. Each impoundment that was visited was assigned an identification number for future reference (see Table 1). An aerial survey of the study area was conducted on 13 April 1989 to identify those impoundments that were occupied by Canada Geese.

Habitat Characteristics

Twenty-four habitat variables that were assumed to influence the selection of a nesting site by Canada Geese were selected for evaluation at each study impoundment. Variables that were chosen were based on previous nesting studies of Giant Canada Geese (Hamilton 1978, Bultsma et al. 1979, Poly 1979, and Stiefel 1980), on other waterfowl species (Lokemoen 1973, Mack and Flake 1980, Rumble and Flake 1983, Lokemoen, Duebbert, and Sharp 1984, and Belanger and Couture 1988) and on numerous discussions with Gerald Horak (KDWP). These variables were summarized in Table 2.

Table 1. Identification number, legal description, and location of the study impoundments.

Impoundment:	Township:	Legal Description:
BAN-12-1	BACHELOR NORTH	W1/2E1/2SW1/4 Sec.12,T25S, R11E.
BAN-12-4	BACHELOR NORTH	W1/2E1/2SW1/4 Sec.12,T25S, R11E.
BAN-12-5	BACHELOR NORTH	NW1/4NW1/4SW1/4 Sec.12,T25S, R11E.
BAN-14-1	BACHELOR NORTH	NE1/4NE1/4 Sec.14,T25S, R11E.
BAN-17-1	BACHELOR NORTH	S1/2N1/2N1/2S1/2SW1/4 Sec.17,T25S,R11E.
BAN-17-2	BACHELOR NORTH	SE1/4N1/2SW1/4 Sec.17,T25S, R11E.
BAN-17-3	BACHELOR NORTH	NE1/4S1/2SW1/4 Sec.17,T25S, R11E.
BAN-17-4	BACHELOR NORTH	SW1/4SW1/4NE1/4 Sec.17,T25S, R11E.
BAN-17-5	BACHELOR NORTH	S1/2S1/2SW1/4 Sec.17,T25S, R11E.
BAS-5-1	BACHELOR SOUTH	SW1/4SW1/4NW1/4 Sec.5,T26S, R11E.
BAS-5-2	BACHELOR SOUTH	N1/2S1/2NW1/4 Sec.5,T26S, R11E.
BAS-5-3	BACHELOR SOUTH	NW1/4NW1/4SW1/4 Sec.5,T26S, R11E.
BAS-5-4	BACHELOR SOUTH	NW1/4NW1/4SW1/4 Sec.5,T26S, R11E.
BAS-5-5	BACHELOR SOUTH	E1/2SW1/4 Sec.5,T26S, R11E.
BAS-6-1	BACHELOR SOUTH	S1/2S1/2NW1/4S1/2S1/2NE1/4 Sec.6,T26S, R11E.
BAS-6-2	BACHELOR SOUTH	E1/2NW1/4W1/2NE1/4 Sec.6,T26S, R11E.
BAS-6-3	BACHELOR SOUTH	NE1/4SW1/4 Sec.6,T26S, R11E.
EUN-2-2	EUREKA NORTH	S1/2NE1/4 Sec.2,T25S, R10E.
EUN-3-1	EUREKA NORTH	NE1/4NW1/4 Sec.3,T25S, R10E.
EUN-4-1	EUREKA NORTH	N1/2S1/2NW1/4 Sec.4,T25S, R10E.
EUN-4-2	EUREKA NORTH	W1/2E1/2SE1/4 Sec.4,T25S, R10E.
EUN-5-1	EUREKA NORTH	NE1/4SW1/4 Sec.5, T25S, R10E.
EUN-5-2	EUREKA NORTH	SW1/4SW1/4 Sec.5, T25S, R10E.
EUN-5-3	EUREKA NORTH	W1/2SE1/4 Sec.5, T25S, R10E.
EUN-5-4	EUREKA NORTH	SW1/4NE1/4 Sec.5, T25S, R10E.
EUN-7-1	EUREKA NORTH	W1/2NE1/4 Sec.7, T25S, R10E.
EUN-7-2	EUREKA NORTH	W1/2NE1/4 Sec.7, T25S, R10E.
EUN-7-3	EUREKA NORTH	E1/2NW1/4 Sec.7, T25S, R10E.
EUN-7-4	EUREKA NORTH	E1/2NW1/4 Sec.7, T25S, R10E.
JAW-34-1	JANESVILLE WEST	S1/2S1/2SE1/4 Sec.34,T24S, R10E.
JAW-34-2	JANESVILLE WEST	S1/2SW1/4 Sec.34,T24S, R10E.
JAW-34-3	JANESVILLE WEST	W1/2S1/2NE1/4 Sec.34,T24S, R10E.
JAW-34-4	JANESVILLE WEST	N1/2S1/2SE1/4 Sec.34,T24S, R10E.
JAW-34-5	JANESVILLE WEST	SE1/4NE1/4 Sec.34,T24S, R10E.
JAW-34-6	JANESVILLE WEST	NE1/4NE1/4NE1/4 Sec.34,T24S, R10E.
JAW-34-7	JANESVILLE WEST	N1/2S1/2NE1/4 Sec.34,T24S, R10E.
JAW-34-8	JANESVILLE WEST	NW1/4SW1/4 Sec.34,T24S, R10E.
SSE-3-1	SOUTH SALEM EAST	E1/2W1/2W1/2E1/2 Sec.3, T25S, R9E.
SSE-3-2	SOUTH SALEM EAST	NW1/4NW1/4SE1/4 Sec.3, T25S, R9E.
SSE-3-3	SOUTH SALEM EAST	E1/2N1/2SE1/4 Sec.3, T25S, R9E.
SSE-3-4	SOUTH SALEM EAST	SW1/4N1/2SE1/4 Sec.3, T25S, R9E.
SSE-3-6	SOUTH SALEM EAST	SW1/4SW1/4 Sec.3, T25S, R9E.
SSE-10-1	SOUTH SALEM EAST	NW1/4NW1/4 Sec.10, T25S, R9E.
SSE-10-2	SOUTH SALEM EAST	SE1/4SE1/4NW1/4 Sec.10, T25S, R9E.
SSE-10-3	SOUTH SALEM EAST	SE1/4NE1/4 Sec.10, T25S, R9E.
SSE-10-4	SOUTH SALEM EAST	SE1/4SE1/4 Sec.10, T25S, R9E.
SSE-11-1	SOUTH SALEM EAST	SW1/4SW1/4 Sec.11, T25S, R9E.
SSE-14-1	SOUTH SALEM EAST	NW1/4 Sec.14, T25S, R9E.
SSE-22-1	SOUTH SALEM EAST	NW1/4NW1/4SE1/4 Sec.22, T25S, R9E.
SSE-23-1	SOUTH SALEM EAST	E1/2NW1/4 Sec.23, T25S, R9E.
SSE-27-1	SOUTH SALEM EAST	E1/2W1/2S1/2NE1/4 Sec.27, T25S, R9E.
SSE-27-2	SOUTH SALEM EAST	W1/2E1/2S1/2NE1/4 Sec.27, T25S, R9E.
SSE-33-1	SOUTH SALEM EAST	NW1/4SE1/4 Sec.33, T24S, R10E.
SSE-33-2	SOUTH SALEM EAST	N1/2S1/2SE1/4 Sec.33, T24S, R10E.
SSE-33-3	SOUTH SALEM EAST	SW1/4SE1/4 Sec.33, T24S, R10E.
SSW-28-1	SOUTH SALEM WEST	S1/2NE1/4N1/2SE1/4 Sec.28, T24S, R9E.
SSW-28-2	SOUTH SALEM WEST	SW1/4SW1/4NE1/4 Sec.28, T24S, R9E.
SSW-28-3	SOUTH SALEM WEST	W1/2SE1/4 Sec.28, T24S, R9E.
SSW-29-1	SOUTH SALEM WEST	N1/2S1/2SE1/4 Sec.29, T24S, R9E.

Table 2. The 24 habitat variables selected for study during 1989 and 1990.

Label:	Variable Description:
IMSIZE	Impoundment Size
IMTYPE	Impoundment Type
SHII	Shoreline Irregularity Index
SSL	Slope of Surrounding Land
PSHLEX	Percent of Shoreline Exposed or Dry
ISPR	Presence of Natural or Man Made Islands
AGI	Age of Impoundment
PSHLEV	Percent of Shoreline Emergent Vegetation
PSHLSV	Percent of Shoreline Shrub Vegetation
PSHLWV	Percent of Shoreline Trees
LAUA	Landuse of Area
CUCT	Cultivated Crop Type
NIW1.6 km	Number of Impoundments Within 1.6 km Radius of each Study Impoundment
IDSRS	Impoundment Distance to Release Site
DISN3I	Distance to Nearest 3 Vacant Impoundments
DISNF	Distance to Nearest Farmstead
DISNCC	Distance to Nearest Cultivated Crop
NNPI	Number of Nesting Pairs on Impoundment
PRW	Presence of Other Waterfowl
IMBROOD	Impoundment Use by Broods
GNP	Ground Nest Present
PRAN	Presence of Artificial Nest Structure
ART	Artificial Nest Structure Type
IMFENCE	Impoundment Fenced to Exclude Livestock

Physical data recorded at each impoundment included size (IMSIZE), type (IMTYPE), shoreline development (SHII), slope of the surrounding land (SSL), percent of the shoreline exposed (PSHLEX), presence of islands (ISPR), and age of the impoundment (AGI). Shoreline development was determined according to Wetzel (1975). The percent of shoreline exposed was determined using a standard measuring wheel. This value was then subtracted from the impoundment size value estimated from Agricultural Stabilization and Conservation Services aerial photographs, using a planimeter. The resultant value expressed the percentage of an impoundment as exposed or dry. The age of impoundments was estimated from discussions with area landowners and operators and the Greenwood County Soil Conservation Service.

Vegetational data included the percent of the shoreline having vegetation classified as emergent macrophytes (PSHLEV), shrubs (PSHLSV), trees (PSHLWV), or as bareground, or domestic or native grasses. The values for these variables were estimated either visually or from aerial photographs.

Land use categories (LAUA) surrounding, or near, an impoundment were rangeland, pasture, and cultivated cropland (Mack and Flake 1980). The cultivated crop type (CCUT), such as wheat, milo, alfalfa or soybeans, were determined visually.

Variables that characterized the degree of isolation or the availability of impoundments, included the number of impoundments within a 1.6-km radius (Rumble and Flake 1983) of each study impoundment (NIW1.6 km), the distance to the nearest release site (IDSRS), and the average distance to the nearest three vacant impoundments (DISN3I). The values for these variables were estimated from aerial photographs. The distance to the nearest farmstead (DISNF) and the distance to the nearest cultivated field (DISNCC) were also estimated from aerial photographs.

Variables that characterized the use of impoundments by nesting pairs of Canada Geese and other waterfowl included the number of nesting pairs present on an impoundment (NNPI), the presence of waterfowl other than the nesting pair (PRW), brood use of an impoundment (IMBROOD), and the presence of at least one ground nesting pair (GNP). The presence of an artificial nest structure (PRAN) and the artificial nest structure type (ART) were observed and recorded. The variable (IMFENCE) impoundment fenced to exclude livestock was included to see if the presence of livestock negatively influenced the presence of a nesting pair (Stiefel 1980), or if fenced impoundments where the vegetation surrounding the impoundment was not grazed by livestock, or burned, or mowed negatively influenced the presence of a nesting pair (Gerald Horak, pers. comm.).

Nest sites at occupied impoundments were examined for the presence of either eggs or goose down. Usually, clutch size and distance from the nest structure to water were recorded during the initial visits to reduce the number of times a nest site was visited. This procedure reduced the probability of the adults deserting the nest because of frequent disturbance (Poly 1979). Impoundments were visited weekly (weather permitting) during the nesting season until all habitat variables were measured or evaluated. When the opportunity arose, initial brood size was recorded; however, individual broods were not followed closely throughout the summer.

Weather data for Eureka, Kansas (closest reporting weather site) were obtained from the National Oceanic and Atmospheric Administration (NOAA) Climatological Data for Kansas (1988, 1989, 1990). Weather data pertaining to the 20-yr precipitation and temperature averages were obtained from Fortner et al. (1982).

Statistical Analyses

All data were recorded in a dBASE III PLUS file (ASHTON-TATE 1985) and later converted to a SAS-program file (SAS Institute 1979) for the statistical analyses. Basic statistics (mean, standard deviation, standard error, minimum, maximum) and Pearson product correlation coefficients were calculated for each variable using SAS (SAS Institute 1979). Pearson product correlation coefficients represented associations between variables. The higher the absolute value of the correlation coefficient value between two variables the greater the association between those two variables. Negative coefficient values represented negative associations between two variables.

An *F*-max. test was used to see if the variances of occupied and vacant impoundments were equal. If the variances were equal a standard *t*-test was used to determine if the means of occupied and vacant impoundments were significantly different. If the variances were unequal then an approximation to the *t*-test was used (Behrens-Fisher problem, in SAS; SAS Institute 1979) to determine if the means of occupied and vacant impoundments were significantly different. After initial analysis of the habitat variables by *t*-tests, all the data pertaining to watershed lakes were removed from the analysis to determine if inclusion of the watershed lakes influenced the results of the *t*-tests.

Stepwise discriminant function analysis was used to measure the discriminating power of each variable. In this test, dependent variables were not continuous but were separated into classes (Mack and Flake 1980). At each step in the procedure the variable with the highest *F*-statistic was entered into the analysis, and this stepwise selection continued until no more variables were entered ($P < 0.05$). The resulting list of variables "best explained" the differences between occupied and vacant impoundments.

Discriminant function was used to analyze the data set. The first part of the discriminant function analysis was a classification technique used to measure how well the variables separated the two classes of impoundments: occupied and vacant impoundments. The program gave each impoundment a classification score based on the value of each recorded variable. Each impoundment received a classification score for each of the two classes, and then it was assigned to the class for which it obtained the highest score. The percent of impoundments that were correctly classified indicated the usefulness of the selected habitat variables for the prediction of impoundments used or not used by nesting Canada Geese. After initial testing of the 24 habitat variables by discriminant function analysis and stepwise, 18 habitat variables that produced similar results to the original 24 variables were used to compare occupied and vacant impoundments.

RESULTS

1989 and 1990 Nesting Seasons

Nesting by Canada Geese within the area began on or near 1 April in 1989 and on or near 19 March in 1990. First reported hatching of goslings was 30 April in 1989 and 16 April in 1990, 14 days earlier than the first hatching in 1989. Latest known hatching dates of goslings were 17 May in 1989 and 5 May in 1990.

Nesting conditions during 1989 were poor because of previous and existing weather conditions. Temperatures fluctuated from above to below normal during the latter parts of March and early April (see Table 3). Precipitation falling during 1988 and early 1989 was below normal, and caused water levels to fall in most impoundments, thereby reducing their surface areas. The distance from a nest structure to the nearest point of water averaged seven m (min. = 0, max. = 100 m).

Nesting conditions during 1990 were considerably better than 1989. Early warm temperatures during February and March, moderate temperature fluctuations, and slightly above normal low temperatures may have contributed to improved nesting success. No known desertion of nests occurred. In addition, normal to above normal rainfall during the summer and fall of 1989, and early spring 1990 kept impoundments nearly full, to running over. Unlike the spring of 1989, when most nest structures were surrounded by dry ground, in 1990 nearly all nest structures were surrounded by water.

Nesting Success

During 1989, 20 impoundments were occupied by at least one pair of Canada Geese, compared to 21 impoundments being occupied during 1990. Thirty-nine impoundments were vacant during 1989 compared to 38 during 1990. Fourteen impoundments occupied during 1989 were nested on again during 1990 (see Table 4). Twenty occupied and nine vacant impoundments were used by the geese for brood rearing during 1989, compared to 21 occupied impoundments and 17 vacant impoundments being used during 1990.

Usually, only one nesting pair was present at each impoundment. However, during 1989 two of the stockponds were occupied by two pairs, and one watershed lake was inhabited by five pairs of nesting geese. During 1990, three stockponds were inhabited by two pairs, and one watershed lake was inhabited by four pairs of Canada Geese. The four watershed lakes during 1989 and three watershed lakes during 1990 were occupied by one or more nesting pairs of Canada Geese; one watershed lake was not nested on during 1990. Waterfowl other than the nesting pair were observed on 13 occupied and seven vacant impoundments during 1989, and on 15 occupied and 22 vacant impoundments during 1990.

Table 4. Use of the study impoundments by Canada Geese during the 1989 and 1990 nesting seasons.

Impoundment:	1989		1990	
	Occupied	Vacant	Occupied	Vacant
BAN-12-1	X			X
BAN-12-4		X		X
BAN-12-5		X		X
BAN-14-1*		X		X
BAN-17-1	X		X	
BAN-17-2		X		X
BAN-17-3	X		X	
BAN-17-4		X		X
BAN-17-5		X		X
BAS-5-1	X		X	
BAS-5-2	X		X	
BAS-5-3		X		
BAS-5-4		X		X
BAS-5-5*		X	X	
BAS-6-1	X			X
BAS-6-2		X		X
BAS-6-3		X		X
EUN-2-2	X		X	
EUN-3-1	X		X	
EUN-4-1	X		X	
EUN-4-2	X		X	
EUN-5-1		X		X
EUN-5-2		X		X
EUN-5-3		X	X	
EUN-5-4		X		X
EUN-7-1		X		X
EUN-7-2	X			X
EUN-7-3		X		X
EUN-7-4		X		X
JAW-34-1[1]	X			X
JAW-34-2*	X		X	
JAW-34-3	X		X	
JAW-34-4		X		X
JAW-34-5		X		X
JAW-34-6		X		X
JAW-34-7		X		X
JAW-34-8		X		X
SSE-3-1		X		X
SSE-3-2		X		X
SSE-3-3	X		X	
SSE-3-4		X		X
SSE-3-6		X		X
SSE-10-1	X			X
SSE-10-2		X	X	
SSE-10-3		X	X	
SSE-10-4	X		X	
SSE-11-1		X		X
SSE-14-1		X		X
SSE-22-1*		X		X
SSE-23-1	X		X	
SSE-27-1		X	X	
SSE-27-2		X		X
SSE-33-1	X		X	
SSE-33-2		X	X	
SSE-33-3		X		X
SSW-28-1		X		X
SSW-28-2	X			X
SSW-28-3		X		X
SSW-29-1		X	X	

* - Watershed lakes.

1 - Nest structure rusted out and fell apart after the 1989 season.

During 1989, 11 (42%) of 26 pairs of Canada Geese, produced broods; 10 broods were fledged from artificial structures, and one brood was produced from a ground nest. A successful nest was identified as a nest from which at least one or more goslings was produced. Of 15 unsuccessful nests (58%), 11 were deserted for unknown reasons; two nests were deserted after human disturbance, and two nests were destroyed by predators. Initial brood size for the 11 broods averaged 4.5 goslings (min. = 1, max. = 6).

During 1990, 27 pairs of Canada Geese produced broods; 26 broods were incubated on artificial nest structures, and one brood was produced from a ground nest. Initial brood size for 11 of the 27 broods averaged 5.1 goslings (min. = 1, max. = 7).

Artificial Nest Structure Use

During 1989, 24 pairs of Canada Geese nested on artificial structures, compared to 26 pairs nesting on artificial structures during 1990. Nest structures were located on 35 impoundments during 1989 and on 34 impoundments during 1990. Two watershed lakes and two stockponds each had at least two nest structures on them; one watershed lake had seven nest structures on it, and one watershed lake did not have any nest structures on it. The three types of nest structures commonly used in the area were floating nest structure, barrel-type tub nest structure, and tire-type tub nest structure.

Numerous artificial structures within the area were not properly maintained during both years of the study. For example, the bottoms on several of the barrel type nest structures were completely rusted through. The supporting poles of some nest structures were leaning and the tops of the nest structures were almost touching the surface of the water. One floating structure that was used in 1989 was either damaged or destroyed by weather and unusable in 1990. The bottom of one barrel-type nest structure used during 1989 had completely rusted out, making it unusable in 1990. Also, the nesting material in some nest structures was not replaced during both years of the study.

Habitat Characteristics

Fifty-nine impoundments (n = 55 stockponds, n = 4 watershed lakes) were identified and studied during 1989 and 1990. During 1989, the average surface area of 16 occupied stockponds was 0.439 ha, compared to an average of 0.323 ha for 39 vacant stockponds. The average surface area of four occupied watershed lakes was 4.063 ha (min. = 0.615, max. = 5.83 ha); there were no vacant watershed lakes. However, the surface area of one of the watershed lakes was reduced because of drought conditions (see Table 5). The percent of the shoreline exposed on 59 impoundments averaged 51% (min. = 1, max. = 87%).

Table 5. Impoundment surface areas during 1989 and 1990.

Impoundment:	1989 (ha)	1990 (ha)	1990 D_L[1]
BAN-12-1	0.32	1.29	1.20
BAN-12-4	0.04	0.19	1.03
BAN-12-5	0.12	0.19	1.03
BAN-14-1	0.40	0.91	1.19
BAN-17-1*	4.92	7.44	1.58
BAN-17-2	0.26	0.26	1.11
BAN-17-3	0.19	0.77	1.29
BAN-17-4	0.06	0.39	1.45
BAN-17-5	0.08	0.19	1.00
BAS-5-1	0.32	0.52	1.26
BAS-5-2	0.89	1.10	2.38
BAS-5-3	0.39	0.39	2.55
BAS-5-4	1.23	1.23	1.64
BAS-5-5	2.01	2.01	1.28
BAS-6-1*	5.83	5.83	2.63
BAS-6-2	0.52	0.52	1.89
BAS-6-3	0.48	0.78	1.54
EUN-2-2	0.52	1.15	1.39
EUN-3-1	0.72	0.72	1.00
EUN-4-1	0.75	1.15	1.42
EUN-4-2	0.14	0.16	1.34
EUN-5-1	0.10	0.58	1.34
EUN-5-2	0.24	0.72	1.40
EUN-5-3	0.94	0.94	1.05
EUN-5-4	1.09	1.30	1.04
EUN-7-1	0.45	1.15	1.42
EUN-7-2	0.12	0.61	1.29
EUN-7-3	0.87	1.22	1.07
EUN-7-4	0.03	0.08	1.99
JAW-34-1	0.07	0.20	1.26
JAW-34-2	0.16	0.43	1.03
JAW-34-3*	0.61	3.17	1.61
JAW-34-4	0.06	0.29	1.00
JAW-34-5	0.16	0.58	1.11
JAW-34-6	0.06	0.07	1.00
JAW-34-7	0.08	0.29	1.00
JAW-34-8	0.04	0.15	1.00
SSE-3-1	0.06	0.29	1.26
SSE-3-2	0.12	0.43	1.03
SSE-3-3	0.91	1.87	1.00
SSE-3-4	0.16	0.43	1.03
SSE-3-6	0.01	0.22	1.78
SSE-10-1	0.07	0.10	1.89
SSE-10-2	0.07	0.10	1.00
SSE-10-3	0.58	0.58	2.01
SSE-10-4	0.81	1.15	1.26
SSE-11-1	0.07	0.07	2.52
SSE-14-1	0.24	0.58	1.34
SSE-22-1	0.04	0.07	1.26
SSE-23-1*	4.89	5.76	1.69
SSE-27-1	0.48	0.72	1.00
SSE-27-2	0.12	0.43	1.29
SSE-33-1	0.26	0.30	1.60
SSE-33-2	0.30	0.72	1.00
SSE-33-3	0.06	0.07	1.26
SSW-28-1	0.14	0.43	1.03
SSW-28-2	1.44	1.44	1.13
SSW-28-3	0.79	1.87	1.23
SSW-29-1	0.36	1.30	1.19

* - Watershed lakes.
[1] - Values for the 1989 were not determined because of drought conditions.

During 1990, the average surface area of 18 occupied stockponds was 0.963 ha, compared to an average of 0.554 ha for 37 vacant stockponds. The average surface area of three watershed lakes was 5.46 ha (min. = 3.17, max. = 7.44 ha), compared to 5.83 ha for one vacant watershed lake (see Table 5). The percent of the shoreline exposed on 59 impoundments averaged 2.5% (min. = 0, max. = 74%).

Forty-nine impoundments (83%) were located in gently rolling rangeland during 1989 and 1990. Seven impoundments were located in steep-sloped rangeland; three impoundments were located in flat to slightly rolling rangeland. Eighteen occupied impoundments (90%) and 37 vacant impoundments (95%) were located in rangeland. Of the 59 impoundments, 29 were located near fields planted to grain sorghum; 14 of those impoundments were occupied and 15 were vacant.

All impoundments were estimated to be approximately 10 years of age, or older. In addition, some of the impoundments were thought to be 40 - 60 years old (Charles Wiggins, pers. comm.). This variable was removed from analysis by SAS (SAS Institute 1979) because it was a "constant" variable. No natural or man made islands were found on the study impoundments. This variable was also removed from analysis by SAS (SAS Institute 1979). The results of other habitat variables that were not summarized in the results section were listed in Table 6.

Table 6. Results of habitat variables evaluated during the study (see Table 2 for definition of the variables).

	1989				1990			
Variable:	Occupied	Vacant	min.	max.	Occupied	Vacant	min.	max.
PSHLEV	42%[1]	61%[1]	1%	100%	63%	52%	1%	100%
PSHLSV	3%	3%	0%	40%	2%	4%	0%	40%
PSHLWV	28%	14%	0%	88%	22%	17%	0%	88%
NIW1.6 km	4.3	4.1	0	8	4.3	4.0	0	8
DISN3I	0.6 km	0.5	0.2	1.9	0.6	0.5	0.2	1.9
IMSIZE (stockponds)	0.44 ha	0.32	0.03	1.23	0.96*	0.55*	0.07	2.22
IMSIZE (w/shed lakes)	4.1 ha	---	0.61	5.83	5.5	5.6	3.2	7.44
IDSRS	2.0 km	2.4	0	6.4	2.2	2.3	0	> 6.4
DISNF	0.5 km	0.7	0.1	2.5	0.6	0.7	0.1	2.5
DISNCC	0.9 km	1.2	0.1	3.3	1.2	1.1	0.1	2.1
IMFENCE	3	0	---	---	2	1	---	---
SHII	---	---	---	---	1.33	1.38	1.00	2.63
IMBROOD	20*	9	---	---	21*	17	---	---
ISPR	0	0	---	---	0	0	---	---
PRW	13	7	---	---	15	22	---	---
PRAN	19	16	1	7	20	14	1	7

1 - Aquatic vegetation was measured at 13 occupied and 16 vacant impoundments during 1989.

* - Indicated significant differences ($P < 0.05$) between occupied and vacant impoundments.

Analysis of Habitat

During 1989, the average occupied impoundment size (0.439 ha, n = 16) was not significantly different from the average vacant impoundment size (0.323 ha, n = 39) when the four watershed lakes were removed from the analysis ($\underline{t}$ = -1.198, $\underline{df}$ = 53.0, $\underline{P}$ > 0.05, see Table 7). However, the average occupied impoundment size (1.16 ha, n = 20) was significantly different from the average vacant impoundment size (0.323 ha, n = 39) when the four watershed lakes were included in the analysis ($\underline{t}$ = -2.098, $\underline{df}$ = 19.7, $\underline{P}$ < 0.05). The percent of the shoreline having aquatic macrophytes along vacant impoundments (61%, n = 16) was significantly different from occupied impoundments (42%, n = 13) when the watershed lakes were removed from the analysis ($\underline{t}$ = 2.221, $\underline{df}$ = 23.0, $\underline{P}$ > 0.05). In addition, brood use of occupied impoundments was significantly different from brood use of vacant impoundments when watershed lakes were included ($\underline{t}$ = -4.681, $\underline{df}$ = 53.0, $\underline{P}$ > 0.05), and removed ($\underline{t}$ = -8.447, $\underline{df}$ = 57.0, $\underline{P}$ > 0.05) from the analysis.

During 1990, the average occupied impoundment size (0.964 ha, n = 18) was significantly different from the average vacant impoundment size (0.554 ha, n = 37) when the four watershed lakes were removed from the analysis ($\underline{t}$ = -2.600, $\underline{df}$ = 27.0, $\underline{P}$ > 0.05, see Table 8). In addition, the average occupied impoundment size (1.60 ha, n = 21) was significantly different from the average vacant

Table 7. Results of 1989 habitat variables using *t*-tests* (see Table 2 for definition of variables).

Variable:	n	DF	T	Prob > |T|
Watershed lakes included				
IMSIZE	59	19.7	-2.0972	0.0491
PSHLEV	29	27.0	1.9453	0.0622
IMBROOD	59	57.0	-8.447	0.0000
Watershed lakes removed				
IMSIZE	55	53.0	-1.198	0.2361
PSHLEV	25	23.0	2.226	0.0365
IMBROOD	55	53.0	-4.681	0.0000

* - Variables reported based on significant differences of unequal ($P < 0.05$) or equal ($P > 0.05$) variances.

Table 8. Results of 1990 habitat variables using *t*-tests* (see Table 2 for definition of variables).

Variable:	n	DF	T	Prob > |T|
Watershed lakes included				
IMSIZE	59	26.3	-2.125	0.0431
IMBROOD	59	54.6	-5.044	0.0001
Watershed lakes removed				
IMSIZE	55	53.0	-2.852	0.0062
IMBROOD	55	53.0	-4.853	0.0001

* - Variables reported based on significant differences of unequal ($P < 0.05$) or equal ($P > 0.05$) variances.

impoundment size (0.693 ha, n = 38) when watershed lakes were included in the analysis (t = -2.125, df = 26.3, P < 0.05). Brood use of occupied impoundments was significantly different from brood use of vacant impoundments when watershed lakes were included (t = -4.853, df = 53.0, P < 0.05) and removed (t = -5.044, df = 54.6, P < 0.05) from the analysis.

Analysis of 18 of the habitat variables by stepwise discriminant function indicated that brood use of an impoundment, presence of an artificial nest structure, impoundment fenced to exclude livestock, and distance to the nearest three vacant impoundments, were correlated with impoundment use by nesting pairs of Canada Geese (R^2 = 0.486, Wilks' Lambda = 0.514, P > 0.0001, see Table 9). This analysis showed that 49% of the variation between occupied and vacant impoundments was best explained by these four variables. However, a significant portion of the variation (51%) between impoundment classes was not explained. Brood use of an impoundment and presence of an artificial nest structure explained 39% of the variation between impoundment classes. The remaining two variables explained an additional 10% of the variation.

During 1990, the presence of an artificial nest structure, brood use of an impoundment, impoundment size, and percent of shoreline with shrub vegetation along it, were correlated with impoundment use by nesting pairs of

Table 9. The contribution of 18 variables used to distinguish between impoundment classes during the 1989 nesting season using stepwise discriminant function analysis (see Table 2 for definition of variables).

Variable:	Partial R^2	F - Statistic	Prob > F	Wilks' Lambda	Prob < Lambda	ASCC[1]	Prob > ASCC
IMBROOD	0.34	28.444	0.0001	0.663	0.0001	0.337	0.0001
PRAN	0.08	4.904	0.0309	0.609	0.0001	0.391	0.0001
IMFENCE	0.12	6.545	0.0134	0.543	0.0001	0.457	0.0001
DISN3I	0.05	2.970	0.0907	0.514	0.0001	0.486	0.0001
CUCT	0.04	2.104	0.1529	a[2]	a	a	a
SHII	0.02	1.173	0.2839	a	a	a	a
DISNF	0.02	1.083	0.3029	a	a	a	a
IMTYPE	0.02	0.986	0.3253	a	a	a	a
SSL	0.01	0.793	0.3773	a	a	a	a
PSHLWV	0.01	0.785	0.3796	a	a	a	a
PSHLEX	0.01	0.684	0.4119	a	a	a	a
PSHLSV	0.01	0.571	0.4534	a	a	a	a
IMSIZE	0.01	0.522	0.4732	a	a	a	a
PRW	0.01	0.390	0.5351	a	a	a	a
NIW1.6KM	0.00	0.264	0.6094	a	a	a	a
DISNCC	0.00	0.225	0.6372	a	a	a	a
LAUA	0.00	0.192	0.6633	a	a	a	a
IDSRS	0.00	0.048	0.8277	a	a	a	a

[1] - Average Squared Canonical Correlation.

a[2] - Values were not calculated by stepwise because they were not entered into the equation.

Canada Geese ($\underline{R}^2$ = 0.407, Wilks' Lambda = 0.592, $\underline{P}$ > 0.0001, see Table 10). This analysis showed that approximately 41% of the variation between occupied and vacant impoundments was best explained by these four variables. However, a significant portion of the variation (59%) between impoundment classes was not explained. Presence of an artificial structure, and brood use of an impoundment explained approximately 34% of the variation between impoundment classes. The remaining two variables explained an additional seven percent of the variation.

During 1989, analysis of the 18 habitat variables by discriminant function correctly classified eight (13.8%) occupied impoundments (see Table 11). Twelve occupied impoundments were misclassified as vacant impoundments. Thirty-eight vacant impoundments (97.4%) were correctly classified. One vacant impoundment was removed from analysis by SAS (SAS Institute 1979) because of missing data. Discriminant function analysis was able to correctly classify occupied and vacant impoundments an average of 80% (n = 46) of the time. During 1990, discriminant function analysis correctly classified 21 occupied impoundments (100%) and 38 vacant impoundments (100%, see Table 11).

Several of the habitat variables were significantly correlated with each other ($\underline{P}$ < 0.05, see Tables 12 and 13). Impoundment size was correlated with the percent of the shoreline supporting trees during 1989 ($\underline{r}$ = 0.502) and

Table 10. The contribution of 18 variables used to distinguish between impoundment classes during the 1990 nesting season using stepwise discriminant function analysis (see Table 2 for definition of variables).

Variable:	Partial R^2	F - Statistic	Prob > F	Wilks' Lambda	Prob < Lambda	ASCC[1]	Prob > ASCC
PRAN	0.24	18.418	0.0001	0.756	0.0001	0.244	0.0001
IMBROOD	0.13	8.792	0.0044	0.653	0.0001	0.347	0.0001
IMSIZE	0.05	3.240	0.0773	0.617	0.0001	0.383	0.0001
PSHLSV	0.04	2.235	0.1407	0.592	0.0001	0.408	0.0001
PSHLEX	0.02	1.312	0.2571	a[2]	a	a	a
PRW	0.02	1.196	0.2790	a	a	a	a
SSL	0.02	0.936	0.3377	a	a	a	a
DISN3I	0.01	0.459	0.5010	a	a	a	a
DISNCC	0.01	0.379	0.5409	a	a	a	a
NIW1.6KM	0.00	0.268	0.6071	a	a	a	a
CUCT	0.00	0.141	0.7091	a	a	a	a
IMFENCE	0.00	0.073	0.7875	a	a	a	a
DISNF	0.00	0.055	0.8148	a	a	a	a
SHII	0.00	0.050	0.8231	a	a	a	a
IDSRS	0.00	0.033	0.8563	a	a	a	a
IMTYPE	0.00	0.015	0.9044	a	a	a	a
PSHLWV	0.00	0.004	0.9524	a	a	a	a
LAUA	0.00	0.000	0.9986	a	a	a	a

[1] - Average Squared Canonical Correlation.

a[2] - Values were not calculated by stepwise because they were not entered into the equation.

Table 11. Presence or absence of Canada Geese on impoundments as predicted by discriminant function analysis, and based on 18 habitat variables during the 1989 and 1990 nesting seasons.

	Vacant		Occupied	
	1989	1990	1989	1990
Vacant:	38*	38	0	0
Occupied:	12	0	8	21
Total:	50 (86.2%)	38 (100%)	8 (13.8%)	21 (100%)
Prior Prob.:	0.5000		0.5000	

* - One vacant impoundment ommited from analysis by SAS (SAS Institute 1979).

Table 12. Results of 1989 Pearson product correlation coefficients for 18 habitat variables (see Table 2 for definition of variables).

Variable:	DISNF	DISNCC	IMSIZE	PSHLEX	PSHLWV	NIW1.6km	SHII	IMTYPE	LAUA	PRAN	SSL	CCUT	IMFENCE	PRW	DISN31	IDSRS	PSHLSV	IMBROOD
DISNF	1.000	0.426	-0.059	0.097	-0.282	-0.215	-0.278	-0.093	-0.277	0.283	0.503	-0.028	-0.157	-0.258	0.068	0.007	-0.276	-0.227
DISNCC	0.426	1.000	0.105	-0.087	0.179	-0.006	0.170	-0.061	-0.264	0.180	0.402	-0.009	0.129	-0.247	0.182	-0.060	0.170	-0.104
IMSIZE	-0.059	0.105	1.000	0.017	0.502*	-0.093	0.282*	0.737*	0.139	-0.010	0.042	-0.003	0.617	0.082	0.084	-0.121	0.243	0.084
PSHLEX	0.097	-0.087	0.017	1.000	-0.107	-0.031	-0.148	0.000	-0.059	0.049	-0.049	-0.102	-0.223	0.008	-0.028	-0.175	-0.105	0.009
PSHLWV	-0.282	0.179	0.502	-0.107	1.000	0.229	0.385*	0.450*	0.041	0.017	0.002	0.176	0.456	0.107	-0.091	-0.127	0.720	0.166
NIW1.6km	-0.215	-0.006	-0.093	-0.031	0.229	1.000	0.082	-0.240	-0.099	-0.073	-0.026	0.119	0.104	0.140	-0.313	-0.401	0.302	0.326
SHII	-0.278	0.170	0.282	-0.148	0.385	0.082	1.000	0.140	-0.025	-0.209	0.094	0.062	0.478	0.045	0.001	-0.010	0.507	0.234
IMTYPE	-0.093	-0.061	0.737	0.000	0.450	-0.240	0.140	1.000	0.349	0.043	-0.240	-0.069	0.361	0.042	0.100	-0.070	0.195	0.022
LAUA	-0.277	-0.264	0.139	-0.059	0.041	-0.099	-0.025	0.349	1.000	-0.171	-0.388	-0.135	-0.054	0.104	0.511	0.081	0.000	-0.060
PRAN	0.283	0.180	-0.010	0.049	0.017	-0.073	-0.209	0.043	-0.171	1.000	0.041	0.000	-0.037	0.063	-0.141	0.058	-0.049	0.169
SSL	0.503	0.402	0.042	-0.049	0.002	-0.026	0.094	-0.240	-0.388	0.041	1.000	0.025	0.230	0.155	-0.372	0.983	-0.125	-0.102
CCUT	-0.028	-0.009	-0.003	-0.102	0.176	0.119	0.062	-0.069	-0.035	0.000	0.025	1.000	0.093	-0.093	-0.118	-0.081	-0.156	0.273
IMFENCE	-0.157	0.129	0.617*	-0.023	0.456*	0.104	0.478*	0.361*	-0.054	-0.037	0.230	0.093	1.000	0.105	-0.102	-0.199	0.560	0.072
PRW	-0.258	-0.247	0.082	0.008	0.107	0.140	0.045	0.042	0.104	0.063	0.155	-0.093	0.105	1.000	0.029	0.278	0.170	-0.072
DISN3I	0.068	0.182	0.084	-0.028	-0.091	-0.313*	0.000	0.100	0.511*	-0.141	-0.107	-0.118	-0.102	0.029	1.000	0.274	0.130	-0.107
IDSRS	0.007	-0.061	-0.121	-0.175	-0.127	-0.401*	-0.010	-0.070	0.081	0.058	0.983	-0.081	-0.199	0.278	0.274	1.000	0.105	-0.493
PSHLSV	-0.276	0.170	0.243	-0.105	0.720	0.302*	0.507*	0.196	0.000	-0.049	-0.125	-0.156	0.560	0.170	0.130	0.105	1.000	0.067
IMBROOD	-0.227	-0.104	0.084	0.009	0.166	0.326*	0.234	0.022	-0.060	0.169	0.000	0.273	0.072	-0.072	-0.107	-0.493	0.067	1.000

* - Indicates significant correlation between habitat variables ($\underline{P}$ < 0.05).

Table 13. Results of 1990 Pearson product correlation coefficients for 18 habitat variables (see Table 2 for definition of variables).

Variable:	DISNF	DISNCC	IMSIZE	PSHLEX	PSHLWV	NIW1.6km	SHII	IMTYPE	LAUA	PRAN	SSL	CCUT	IMFENCE	PRW	DISN31	IDSRS	PSHLSV	IMBROOD
DISNF	1.000	0.409	0.089	0.211	-0.259	-0.225	-0.256	-0.106	-0.272	0.361	0.484	-0.031	-0.108	-0.286	0.088	-0.013	-0.286	-0.217
DISNCC	0.409	1.000	0.167	-0.087	0.217	0.008	0.219	0.009	-0.248	0.129	0.397	0.008	0.177	-0.130	0.205	-0.076	0.181	-0.462
IMSIZE	-0.089	0.167	1.000	-0.264*	0.527*	-0.128	0.390*	0.810*	0.149	-0.162	0.055	-0.063	0.653	0.210	0.050	-0.030	0.278	0.027
PSHLEX	0.211	-0.087	-0.264	1.000	-0.334*	-0.084	0.506*	-0.037	0.119	0.273	-0.012	-0.101	-0.181	-0.065	0.092	-0.105	-0.390	0.029
PSHLWV	-0.259	0.217	0.527	-0.334	1.000	0.208	0.416*	0.462*	0.013	-0.165	0.018	0.148	0.419	0.196	-0.135	-0.110	0.720	0.012
NIW1.6km	-0.225	0.008	-0.128	-0.084	0.208	1.000	0.145	-0.051	-0.104	-0.106	-0.015	0.106	0.079	-0.052	-0.349	-0.40	0.303	0.119
SHII	-0.256	0.219	0.390	-0.506	0.416	0.145	1.000	0.325*	-0.028	-0.378	0.145	0.118	0.479	0.165	0.017	0.025	0.583	-0.015
IMTYPE	-0.106	0.009	0.810	-0.037	0.462*	-0.051	0.325	1.000	0.174	-0.100	0.000	-0.169	0.490	0.268	0.001	-0.122	0.242	0.072
LAUA	-0.272	-0.248	0.149	-0.119	0.013	-0.104	-0.028	0.174	1.000	-0.108	-0.371	-0.141	-0.098	0.215	0.499	0.092	0.005	-0.063
PRAN	0.361	0.129	-0.162	0.273	-0.165	-0.106	-0.378*	-0.100	-0.108	1.000	0.020	-0.145	-0.318	-0.034	-0.005	-0.002	-0.222	0.181
SSL	0.484*	0.397*	0.055	-0.012	0.018	-0.015	0.145	0.000	-0.371*	0.020	1.000	0.021	0.202	0.015	0.033	-0.100	-0.013	-0.121
CCUT	-0.031	0.008	-0.063	-0.101	0.148	0.106	0.118	-0.169	-0.141	-0.145	0.021	1.000	0.000	-0.098	-0.137	0.014	0.199	-0.139
IMFENCE	-0.108	0.177	0.653*	-0.181	0.419*	0.079	0.479*	0.490*	-0.098	-0.318	0.202	0.000	1.000	0.225	-0.085	-0.054	0.256	0.060
PRW	-0.286*	-0.130	0.210	-0.065	0.196	-0.052	0.165	0.268*	0.215	-0.034	0.015	-0.098	0.225	1.000	0.103	-0.104	0.105	0.279
DISN3I	0.088	0.205	0.050	0.092	-0.135	-0.349*	0.017	0.001	0.499*	-0.005	0.033	-0.137	-0.085	0.103	1.000	0.087	-0.165	-0.218
IDSRS	-0.013	-0.076	-0.030	-0.105	-0.110	-0.405*	-0.025	-0.122	0.092	-0.002	-0.100	0.014	-0.054	-0.104	0.087	1.000	-0.107	-0.105
PSHLSV	-0.286	0.182	0.278*	-0.390*	0.720*	0.303	0.583*	0.242	0.005	-0.222	-0.013	0.199	0.256	0.105	-0.165	-0.107	1.000	-0.132
IMBROOD	-0.217	-0.462	0.027	0.029	0.012	0.119	-0.015	0.072	-0.063	0.181	-0.121	-0.139	0.060	0.279	-0.218	-0.105	-0.132	1.000

* - Indicates significant correlation between habitat variables ($\underline{P} < 0.05$).

1990 ($\underline{r}$ = 0.527). Impoundment type was correlated with the percent of the shoreline supporting trees during 1989 ($\underline{r}$ = 0.450) and 1990 ($\underline{r}$ = 0.462). Brood use of an impoundment was correlated with the number of impoundments within 1.6-km radius of each study impoundment during 1989 ($\underline{r}$ = 0.326), however, it was not significantly correlated with any other variable during 1989 or 1990.

DISCUSSION

Nest Site Selection

In my study, the majority of Canada Geese nested on artificial structures. I believed that the selection of the nest site included the selection of; 1) a particular impoundment or area as a nest site, and 2) the nest site type based on previous nesting success or imprinting as goslings on the nest structure or nest site.

Canada Geese usually returned to the same area to nest year after year (Brakhage 1965), however, there is more of a tendency for females, than males, to return to their natal home when they begin nesting (Johnsgard 1978). MacInnes (1962) suggested that pairs returned to nest in the same area but that they may not use the same nest. If a pair nested on the impoundment the previous year and were successful at producing a brood then they would probably return and nest at this same impoundment, but they may not use the same nest site. Several of the impoundments within the study area had more than one nest structure on them; however, usually the same nest structure was used each year. Studies by MacInnes (1962) and Cooper (1978) showed that Giant Canada Geese pairs usually did not nest in the same site year after year. Hanson (1965) believed that it was the rule rather than the exception for *B. c. interior* to return to the same nesting site.

Canada Geese successful at producing a brood on an artificial structure one year may be more likely to nest on a structure the following year. Cooper (1978) reported that 73% of the Giant Canada Geese at Marshy Point nested on the same type of structure each year; also older, used, structures were used more often than newer structures. I observed that most of the artificial structures used were of the tub type. Also, Canada Geese were observed more often on artificial structures used the previous year compared to structures not used the previous year. I also believed that older nest structures, or those used the previous year(s), were used by early nesting Canada Geese. Nest structures not selected by the early nesting Canada Geese were used more by younger pairs.

Studies by Hanson (1965) and Stoudt (1971) showed that Canada Geese and other waterfowl species had a tendency to nest on or near the same body of water where they learned to fly. I believed that this was part of the imprinting process that goslings experience. If the nest site that the goslings had imprinted on was an artificial structure then they would more likely return and nest on an artificial structure. Conversely, had the goslings imprinted on a ground nest site then they would be more likely to return and nest on the ground. For example, during 1989 I observed a pair of Canada Geese nesting on the ground on an impoundment outside the study area (located along K-99

Highway). Again, in 1990 I observed a pair nesting on the ground at this same impoundment, but the nest site was different. It was possible that I observed the same pair nesting both years and that previous nesting success and imprinting influenced the selection of the nest site. Cooper (1978) concluded that nesting success apparently influenced the distance from the old nest site to the new nest site. He also found that the average distance between nests, nest concealment, distance to and height above open water, and the visibility of the surrounding habitat strongly influenced the selection of the nest site by the female Giant Canada Goose. Bellrose (1976) concluded that prerequisites to the selection of the nest site included cover for the nest and an exposed view for the incubating bird.

Nesting Success

The lower nesting success rate (42%) that I found in 1989, in comparison to 1990, was caused by desertion and predation. Two nests were deserted after disturbance by humans, while 11 nests were deserted for unknown reasons, and two nests were destroyed by predators. However, I assumed that desertion was influenced by several factors: 1) periods of above normal high and below normal low temperatures combined with unusually dry weather prior to and during the egg-laying and incubation periods, 2) disturbance by humans or livestock, or 3) an observed lack of suitable nesting material in the nest structure. It was possible that the lack of nest material in some of the artificial structures increased the chances of freezing or overheating of the eggs during 1989. Inspection of a nest deserted during 1989 revealed four unhatched eggs surrounded only by the down from the female Canada Goose. Conversely, during 1990 absent nesting material did not appear to influence nesting success. It was possible that improved weather conditions contributed to the higher nesting success. The aerial survey flown 13 April 1989 revealed numerous artificial nest structures located in Butler and Greenwood Counties that did not have nest material in them. The results of my study were comparable to that of other researchers like Szymczak (1975) who reported nesting success rates ranging from 0 to 100% for Giant Canada Geese in the Fort Collins-Loveland, Colorado area. Cooper (1978) reported nesting success rates varying from 65 to 82% for Giant Canada Geese at Marshy Point, Manitoba, from 1969 through 1971. Stiefel (1980) studied nesting Giant Canada Geese in western South Dakota and he indicated a success rate of 78%.

Despite the fact that only two ground nests were observed in 1989 and one in 1990 management of the vegetative cover along impoundments was important to the success of ground nesting Canada Geese. In both 1989 and 1990 ground nests located in dense vegetation were successful, while the ground nest located in short vegetation in 1989 was unsuccessful. Poly (1979) found that dense vegetation near the nest resulted in a low desertion rate. Cooper (1978) concluded that the female Giant Canada Goose selected her nest site where vegetation would screen the nest.

Artificial Nest Structure Use

The majority of Canada Geese during 1989 and 1990 nested on artificial structures. Mackey et al. (1988) reported a nesting success rate of 85%, from 1983 through 1987, for Canada Geese nesting in Montana using artificial structures located in trees. He also found that the nesting population increased when artificial structures were provided for them.

During 1989, 13 pairs of Canada Geese that nested on artificial structures deserted their nests. Cooper (1978) reported that nests on artificial structures, at Marshy Point, were deserted more often than nests located on natural sites. Perhaps artificial structures placed in open areas were subjected to more disturbance than nests or structures that were well concealed. However, Cooper (1978) also believed that the high nesting success rate at Marshy Point was due to the nest sites being located such that disturbance, predation, and flooding were reduced.

Most nest sites were located on artificial structures, either in open water or on exposed mudflats during both years of study, therefore, vegetative cover near the nest seemed of little importance. Cooper (1978) concluded that the female Giant Canada Goose selected a nest site with high visibility and with little or no concealment only when surrounded by water or surrounded by a haystack. Hamilton (1978) reported nesting success rates of 65% for nests located in exposed sites compared to 35% for nests located in concealed sites. In my study, success rates for exposed sites (artificial structures), were 42% in 1989 and 100% in 1990 compared to 50% in 1989 and 100% in 1990 for concealed sites (ground nests).

Many of the artificial structures not used by Canada Geese in the area were unsuitable as nest sites. Likewise, some of those used in 1989 were no longer suitable nest sites in 1990. Cooper (1978) suggested that the physical condition of a nest structure influenced its use by nesting Giant Canada Geese; structures lacking stability were often rejected. This may be one of the reasons why numerous nest structures were unused.

Brood Use of Impoundments

Brood use of occupied and vacant impoundments was significantly different during both 1989 and 1990. Broods were observed more often on previously occupied impoundments than vacant impoundments, and some impoundments were frequented more than others. Watershed lakes, for various reasons (i.e., larger surface area, more food or cover), usually attracted the most broods. In addition, brood use of an impoundment and the number of impoundments within 1.6 km were correlated with each other (r = 0.326). Broods were more often associated with impoundments in close proximity to other impoundments. This observation supported results reported by Rumble and Flake (1983) that indicated that the number of natural pond basins within a 1.6 km radius of a study pond was positively associated with use by duck broods. Stiefel (1980) found that several Giant Canada Goose pairs and their broods usually used a common stockpond, and that overland travel of 1.6 to 4.8 km occurred within three to seven days after hatching. Hamilton (1978) reported that brood movement was minimal under optimal habitat conditions, however, brood movement became more extensive when conditions were poor. In my study brood travel was not negatively influenced by the drought conditions (1989) because brood travel occurred during improved habitat conditions (1990) as well. I concluded that this was the case for adults and broods located in areas where watershed lakes were absent. However, broods that were hatched on watershed lakes had a tendency to stay there all summer.

Brood use of impoundments was dependent on numerous influential variables of which food and cover were probably the most important. Also, I believed that brood use was limited for impoundments whose surface areas were reduced.

Numerous impoundments that had no shrub or tree cover along the shoreline were unused during both years of the study.

Habitat Characteristics

The smaller impoundment surface areas of 1989 were caused by the drought conditions that were prevalent during 1988 and early 1989. Impoundment surface areas were approximately one-half of their normal size. In addition, occupied and vacant impoundment sizes were smaller than the minimum impoundment size of 0.61 ha recommended by Lokemoen (1973) to maximize waterfowl use of an impoundment in the Northern High Plains. However, during 1990 conditions were different because above normal precipitation during the summer and fall of 1989 filled impoundments to within two percent of their normal surface areas. The average impoundment surface area reported in my study was also smaller than the reported mean size of 1.6 ha for stockponds used by Giant Canada Geese, and 0.6 ha for stockponds not used by Giant Canada Geese in South Dakota (Stiefel 1980).

Although, occupied impoundment size was significantly larger than vacant impoundment size during 1990, I do not think that impoundment size alone was an indicator of impoundment use by Canada Geese, because Canada Geese nested on impoundments ranging in size from less than 0.5 to 7.44 ha during both years of the study.

Several of the habitat variables were significantly correlated with each other. Impoundment size was correlated with percent of shoreline supporting trees during 1989 and 1990 (see Tables 12 and 13). As impoundment size increased the presence of trees along the shoreline increased. The lack of difference between the 1989 and 1990 coefficient values was probably due to the lack of change in the percent of shoreline having trees. Impoundment type was also correlated with percent of shoreline supporting trees during 1989 and 1990. An example of this was watershed lakes that were fenced to exclude livestock. Livestock had a tendency to graze or trample vegetation along the shoreline of impoundments, thus limiting tree or shrub growth.

Because numerous broods were observed on watershed lakes I concluded that trees and shrubs along the shoreline of watershed lakes helped hide the young goslings from predators. Conversely, Rumble and Flake (1983) found that the occurrence of trees along the shoreline or an impoundment was associated with reduced use of the impoundment by duck broods. Also, in my study I found that adult Canada Geese, at impoundments where trees or shrubs were limited or absent, often took their broods to the middle of an impoundment when disturbed.

Impoundment size was correlated with shoreline development during 1989 and 1990 (see Tables 12 and 13), yet, because of the drought, an index of approximately 1.00

would have more accurately reflected the shoreline development of most impoundments during 1989. In comparison to most stockponds, watershed lakes had a more irregular shoreline, providing more food and cover for adult geese and broods. Mack and Flake (1980) reported that shoreline length and surface water area were both indicative of impoundment size, however, shoreline length predicted brood occurrence better than actual impoundment size. This may have been the reason some adult geese took their broods to the watershed lakes soon after hatching.

Analysis of Habitat

Analysis of the 18 habitat variables by stepwise discriminant function produced somewhat different results between years. The two variables that explained the most variation between use of occupied and vacant impoundments by Canada Geese during both nesting seasons were brood use of an impoundment and presence of an artificial structure. Other important variables included impoundment fenced to exclude livestock and the average distance to the nearest 3 vacant impoundments during 1989 or impoundment size and percent of shoreline supporting shrubs during 1990. I believed that the features influencing Canada Geese to select an impoundment as a nest site included: 1) the impoundment area provided food and cover for the nesting pair and brood, and 2) an artificial structure (in good condition) was present.

The drought-reduced impoundment surface areas forced the adult geese and broods to move to impoundments that provided more food and cover. During 1990 when impoundments were full, the variables impoundment size and percent of shoreline with shrubs were more important than IMFENCE and DISN3I (see Table 2). Also, during 1990, when water levels were higher the vegetation along the shoreline possibly provided escape cover for the broods. Shoreline vegetation was missing along many ponds during 1989; this would explain why some impoundments were unused during both years of the study. Numerous vacant impoundments that were not used by Canada Geese had no trees or shrub cover along their shorelines. Until the breeding population within the area became large enough to force nesting on these vacant impoundments or shrubs or trees become established along the shorelines, nesting or use of these impoundments by adult geese and broods probably will not occur.

Analysis of the 18 habitat variables by discriminant function resulted in an overall average of 80% and 100% of the impoundments being correctly classified during 1989 and 1990, respectively. However, the 80% average reported for 1989 was misleading because only eight occupied impoundments were correctly classified as being occupied. It was apparent that discriminant function had difficulty in distinguishing between occupied and vacant impoundments, because 12 occupied impoundments were misclassified as vacant impoundments. Eleven of the 12 misclassified impoundments were stockponds. I assumed that the misclassification was caused by the occupied impoundments having a smaller surface area comparable to that of the vacant impoundments, although, the surface area of the watershed lake that was misclassified was 85% of normal. If the impoundments were misclassified because of their size, then the occupied watershed lake whose surface area was reduced because of the drought should have been misclassified. During 1990, using the same habitat variables, discriminant function accurately distinguished between occupied and vacant impoundments. It was important to note that impoundment surface areas were significantly larger, enabling discriminant function to correctly classify impoundments. It was possible that drought years produced results that made it hard to discern between impoundment classes, while years when good habitat conditions were present, enabled discriminant function to distinguish between the two classes. The results of my study were similar to those reported by Stiefel (1980) who, was able predict the presence and absence of Giant Canada Geese on stockponds in South Dakota 83.3% and 97.6% of the time, respectively. Mack and Flake (1980) studying duck brood use of stockponds in South Dakota were able to classify 90% of their study ponds correctly as either brood or nonbrood stockponds.

MANAGEMENT

The results from both years of the study indicated that nest structures were important to the selection of an impoundment as a nest site. If the structures were not important the geese would have never used them. I believed that the program would have been more successful had the structures been maintained and kept filled with nesting material. If the KDWP did not have the manpower to maintain the structures then they should have looked to other organizations such as Ducks Unlimited for help.

There were many impoundments in the Flint Hills that could provide suitable nesting habitat for Canada geese if nest structures were provided and maintained. The absence of maintenance was apparent during both years of my study. Nest structures were either leaning over in the water, were submerged under water, were rusting out, or had little or no nest material in them. The nest structures I saw in good condition were maintained by the area ranchers, primarily by Mr. Charles Wiggins.

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