Productivity and nest site selection of Canada geese in northwestern Iowa

by

Thomas Alan Nigus

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ABSTRACT

Productivity, gosling habitat use and survival, and nest site selection of giant Canada geese in northwestern Iowa were studied in 1977 and 1978. The arrival of geese on the breeding grounds in March coincided with the first open water in smaller wetlands. Initial laying dates (25 March 1977 and 26 March 1978) were probably influenced by photoperiod, timing of arrival at the breeding grounds, and ice conditions. The density of successful pairs in 1978 averaged 0.12 pairs/ha of wetland in the principal study area. Pair density was highest in Class IV-2 or hemi-marsh wetlands. The large mean clutch size of 6.01 eggs for 185 nests suggested that the majority of the breeding population was fairly old. Most nests hatched 10-20 May both years of the study. Of the 211 nests found during the study, 166 (79%) hatched. Nesting success was similar among 6 wetland types in northwestern Iowa. Nesting success was greater ($P < 0.01$) in artificial nest structures than in natural nest sites. Desertion was the main cause of nest failure each year. Of the 1,126 eggs laid in 205 nests, 862 (77%) hatched. Hatching success of 1,002 eggs in 167 clutches incubated full term was 86 percent. Fewer geese renested in 1977 than in 1978, possibly because reduced water levels in 1977 made nest sites unattractive. The mean initial brood size for 165 nests was 5.32 goslings.

Mudflat shorelines, pasture-like uplands, and man-made islands were used by goslings for foraging, loafing, and roosting. Many areas were used by goslings both years. Gosling survival was 73-90+ percent with weather being the major mortality factor.

Due to a scarcity of muskrat houses and reduced water levels, most geese nested in artificial nest structures. During the study, 26 percent of the artificial nest structures investigated received use. Highest percent use (51%) of artificial nest structures occurred in Class IV-2 or hemi-marsh wetlands. Discriminant function analysis was used to determine what factors were important in distinguishing used from unused artificial nest structures for each of 3 structure types.

Future management of this flock should include maintaining wetlands in the hemi-marsh condition, maintaining uplands traditionally used by broods in pasture-like conditions, and continuing the use of artificial nest structures. Guidelines for the placement of 3 types of artificial nest structures were determined from the discriminant function analysis.

INTRODUCTION

In recent years, many state and federal wildlife agencies have attempted to establish local breeding populations of Canada geese (*Branta canadensis*) (Nelson 1963, Dill and Lee 1970). The objective of these programs has been to increase the number of geese available for the enjoyment of the general public. These programs have had varied success.

The most popular and successful subspecies used in these projects has been the giant Canada goose (*B. c. maxima*). Prior to settlement, the breeding range of the giant subspecies was the tallgrass prairies of the north central states and southern Canada (Hanson 1965). Loss of habitat and unrestricted hunting severely reduced the numbers of giants so that this subspecies once was thought to be extinct (Delacour 1954), but in 1962 it was rediscovered (Hanson 1965). Thus, most of the establishment projects have returned the giant Canada goose to its former range.

In Iowa, wild giant Canada geese were extirpated by 1906 (Ron Howing, Iowa Conservation Commission, Estherville, personal communication, 1978). The Iowa Conservation Commission began a restoration program in northwestern Iowa in 1964. Details of the restoration procedures are summarized in Bishop and Howing (1972) and Bishop (1978).

Successful management of a Canada goose breeding population requires data on productivity and habitat requirements. This information has been gathered for numerous populations (Dow 1943, Craighead and Craighead 1949, Naylor 1953, Geis 1956, Klopman 1958, MacInnes 1962, Brakhage 1965, Sherwood 1966, Hanson and Eberhardt 1971, Zicus 1974, Mickelson 1975, Szymczak 1975, Hilley 1976, Raveling and Lumsden 1977, Sayler 1977, Cooper 1978, and several others), but little information on the productivity or nesting habitat requirements of the Iowa Canada goose population is available.

The objectives of this study were to 1) determine the nesting success and other reproductive parameters for giant Canada geese in northwestern Iowa, 2) estimate gosling survival and describe gosling habitat use, and 3) determine what factors affect the selection and use of artificial nest structures.

STUDY AREA

This study was conducted in 1977 and 1978 on several state-owned wetlands in Clay, Emmet, and Palo Alto Counties in northwestern Iowa (Fig. 1). From 1975 to 1977, a severe drought in this region reduced water levels and increased vegetation in many wetlands. All wetlands were described using the classification system of Stewart and Kantrud (1971).

The principal study area was a 21 km^2 complex of permanent and semi-permanent lakes and marshes interspersed with state- and privately-owned uplands and woodlands centered around Ingham and High Lakes (Fig. 2). This area, in Emmet County, contains 11 wetlands totaling 673 ha (Table 1).

Additional information was obtained from 5 other wetlands in the 3 county area (Fig. 1, Table 1). Wetlands in Clay and Palo Alto Counties have been described by Bennett (1938), Hayden (1943), and Low (1945).

Artificial nest structures have been placed in most of the wetlands investigated (Table 1). These structures are of 3 basic types: 1) a basket or barrel elevated by a single pipe, 2) a barrel fastened to a small raft, and 3) man-made islands (Fig. 3). Structures are maintained and receive fresh nesting material annually.

Fig. 1. Map of the general study area in northwestern Iowa (insert shows the location of Clay, Emmet, and Palo Alto Counties). A) West Swan Lake, B) Principal Study Area, C) Burr Oak Lake, D) Twelve Mile Lake, E) Dewey's Pasture, F) Mud Lake, G) Trumbull Lake, H) Round Lake, I) Lost Island Lake, J) Barringer's Slough, K) Fallow Marsh, L) Virgin Lake, M) Five Island Lake

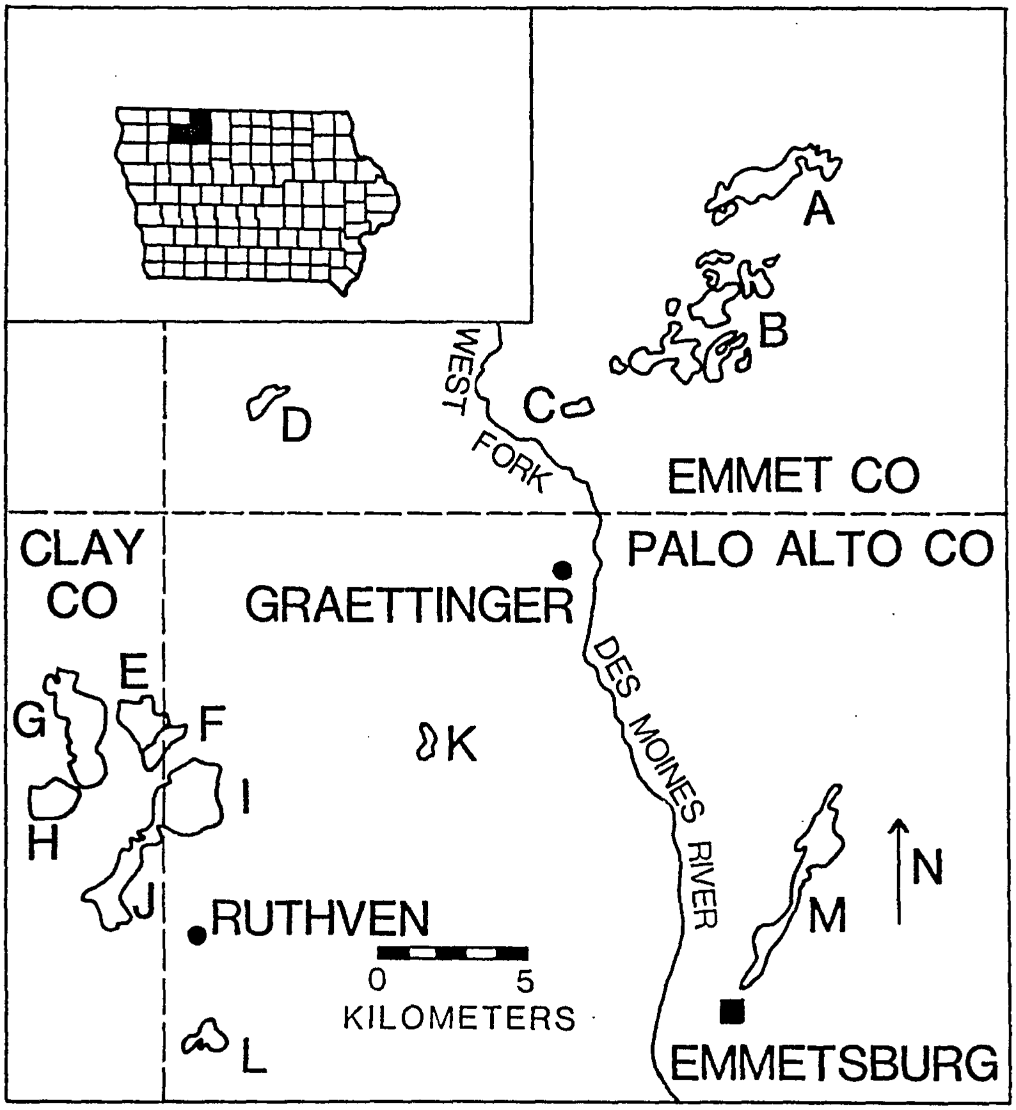
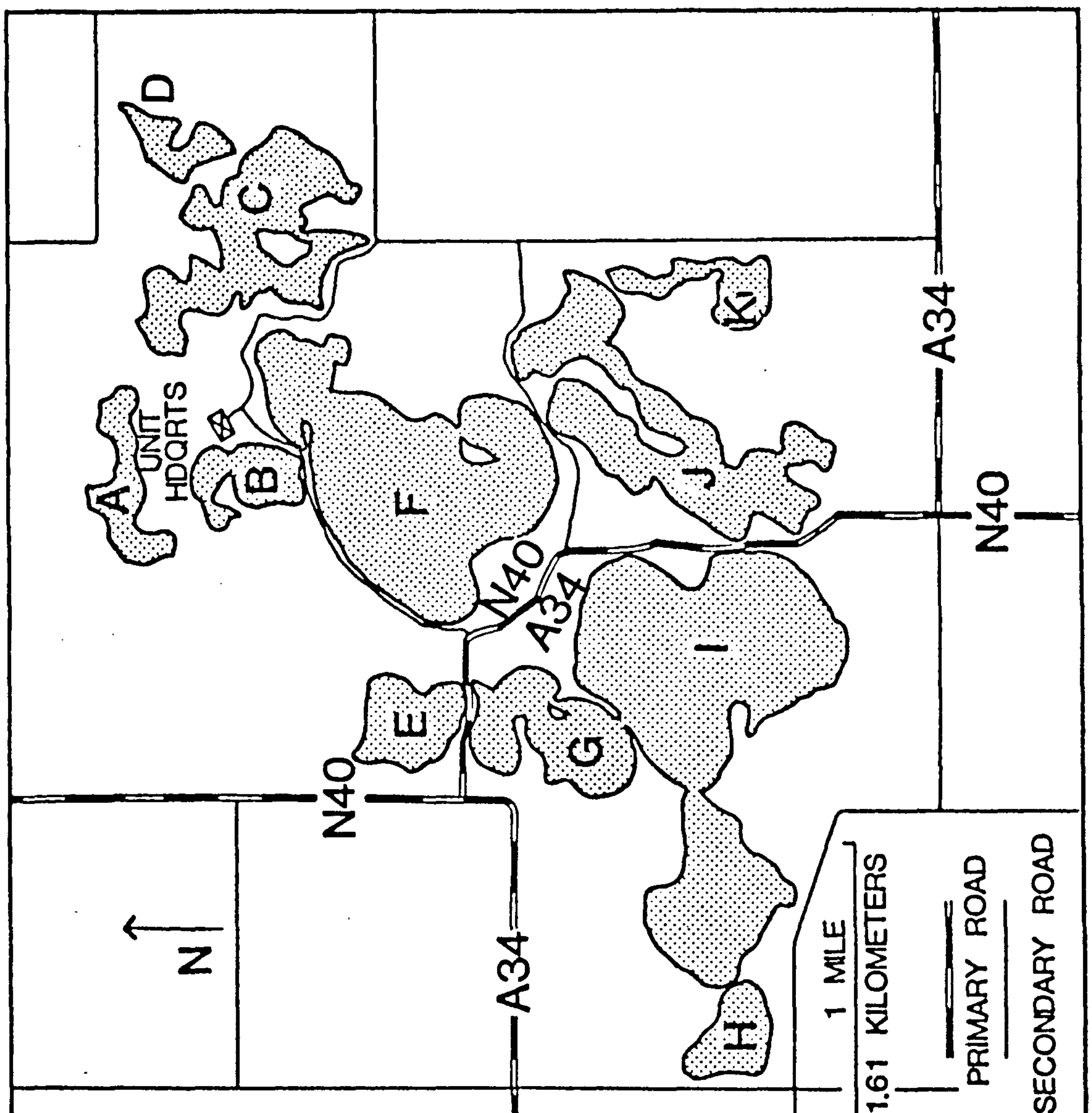

A
B
C
D
WEST FORK
EMMET CO
PALO ALTO CO
CLAY CO
GRAETTINGER
DES MOINES RIVER
E
F
G
H
I
J
K
L
M
N
RUTHVEN
0 5
KILOMETERS
EMMETSBURG

Fig. 2. Map of the principal study area, the Ingham and High Lakes area of northwestern Iowa. A) North Slough, B) Goose Pen Slough, C) East Slough, D) Snipe Meadow, E) North of grade, F) Ingham Lake, G) Torreson's Slough, H) McQuowen's Slough, I) High Lake, J) Cunningham Slough, K) Jensen Slough



N
A
UNIT
HDQRTS
B
C
D
E
F
G
H
I
J
K
N40
A34
1 MILE
1.61 KILOMETERS
PRIMARY ROAD
SECONDARY ROAD

Fig. 3. Three types of artificial nest structures placed in wetlands in northwestern Iowa. A) elevated barrel, B) floating barrel, C) man-made island

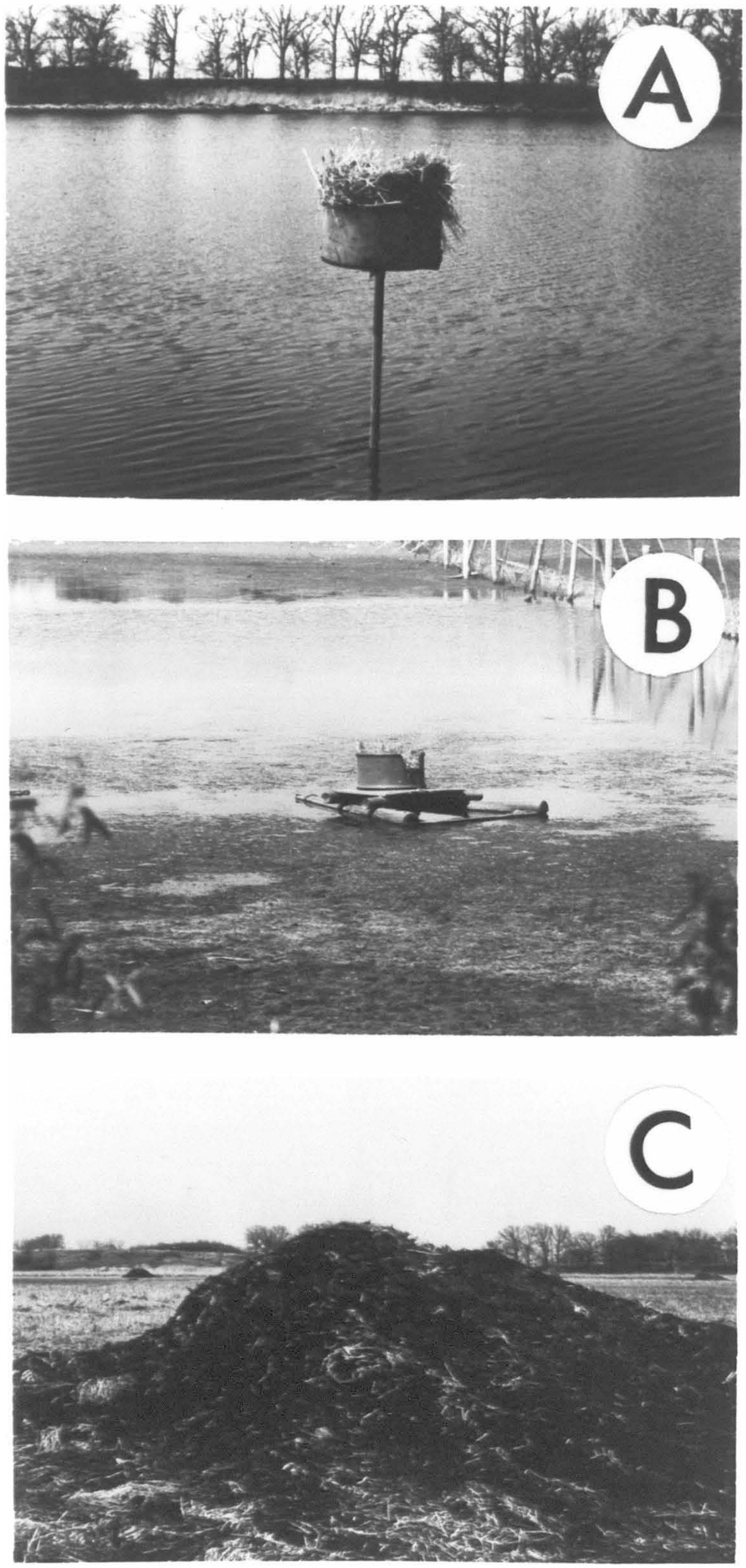

A
B
C

Table 1. Characteristics of wetlands studied in the 3 county area

Wetland name	Size (ha)	Wetland class[a]	Cover type[a]
Principal study area			
Cunningham Slough	92	IV	3
East Slough	72	IV	1
Goose Pen Slough	19	IV	3
High Lake	185	V	4
Ingham Lake	170	V	4
Jensen Slough	25	IV	2
McQuowen's Slough	19	IV	3
North Slough	17	IV	2
North of grade	22	V	4
Snipe Meadow	12	IV	1
Torreson's Slough	40	IV	3
Additional areas			
Dewey's Pasture[b]	180	III and IV	1-3
Fallow Marsh	65	IV	1
Twelve Mile Lake	117	V	4
Virgin Lake[b]	91	V	4
West Swan Lake	424	V	2-3

[a]Wetland classification according to Stewart and Kantrud (1971).

[b]These areas did not contain artificial nest structures.

METHODS

In both years, nesting studies began in late March. In 1977, only Cunningham Slough, East Slough, Ingham Lake, and North Slough were searched for nests. In 1978, all wetlands listed in Table 1 were searched for nests. All artificial nest structures (ANS) in each wetland were inspected for usage several times during the nesting season. Use of an ANS was indicated by the presence of at least 1 egg or small amounts of down. Wetlands were also searched for natural nest sites (NNS). Virtually all NNS in each wetland were found.

Each nest was visited 3 times during the nesting season. Initial laying date was estimated by floating incubated eggs (Westerkov 1950) and by using a laying rate of 1.5 days/egg (Kossack 1950, Brakhage 1965). The floatation technique was accurate prior to 10 days of incubation. Clutch size was recorded as complete once incubation had begun. Hatching date was estimated using an incubation period of 28 days (Kossack 1950, Brakhage 1965). Shortly after the estimated hatching date, nests were visited the last time and nesting and hatching success was determined. Time spent at a nest was minimized to reduce desertion and avoid attracting predators. Nests were not visited on extremely windy, cold, or rainy days. Air temperature data for the nesting season were obtained from the U.S. Weather Bureau at Spencer, Iowa, 40 km southwest of the principal study area.

Survival of goslings to banding age (5-7 weeks) was estimated by comparing the number of goslings hatched with the number observed just prior to banding. In 1977 and 1978, survival was estimated for goslings hatched in the principal study area. In 1978, 2 isolated wetlands, Fallow Marsh and Virgin Lake, were included for additional data on gosling survival.

In 1978 during the first visit to each ANS on the principal study area, 10 factors were measured on and around the structure (Table 2). Two additional characteristics of the wetlands were determined later for analysis (Table 2). A multivariate analysis of variance of these factors was used to determine if there were differences between used and unused ANS for each of 3 structure types. Stepwise discriminant function analysis (Health Sciences Computing Facility, University of California-Los Angeles, Biomedical Data Package; BMDP-1977) was used to rank factors important for distinguishing between used and unused ANS for each structure type. Green (1971) has discussed the statistical theory and ecological application of discriminant function analysis.

Chi-square and t-tests were used to test for significant differences among various productivity data. Probabilities of less than 0.05 were considered significant for all statistical tests.

Table 2. Factors used for analysis of artificial nest structure (ANS) usage, 1978

1. Wetland class (IV or V)[a]
2. Wetland cover class (1, 2, 3, or 4)[a]
3. Use (used - 0, unused - 1)
4. Wetland area (ha)
5. Cover class of surrounding vegetation (0 to 25% - 1, 26 to 50% - 2, 51 to 75% - 3, 76 to 100% - 4)
6. Occurrence (0) or lack (1) of water surrounding structure
7. Height of nest material above water (cm)
8. Distance to open water (m)
9. Distance to nearest shoreline (m)
10. Distance to permanent water (m)
11. Density of successful pairs in wetland (pairs/ha)
12. Density of artificial nest structures in wetland (ANS/ha)

[a]After Stewart and Kantrud (1971).

RESULTS

Nesting Season and Productivity

Arrival

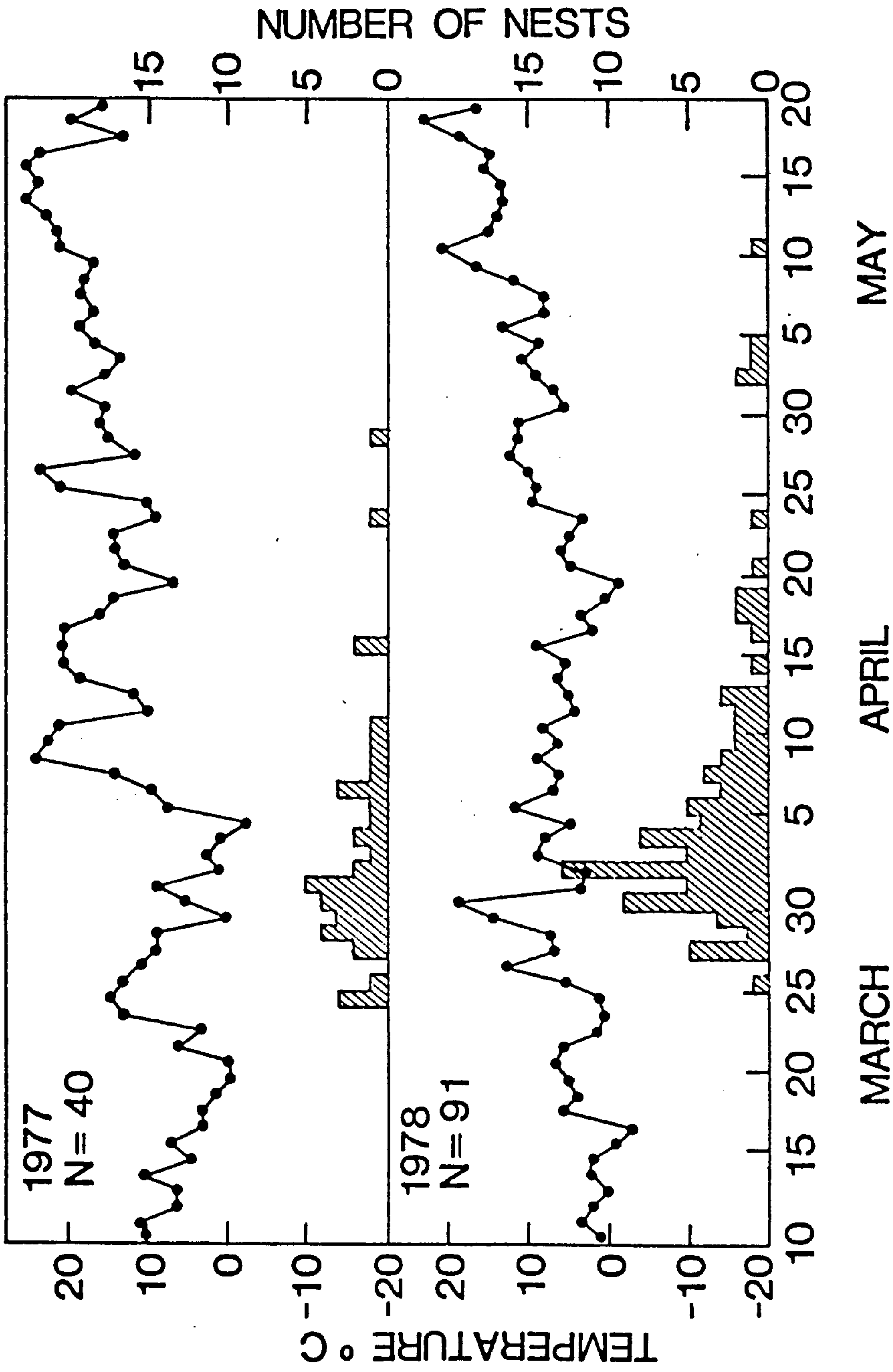
Giant Canada geese first returned to the study area in early March 1977 and on 15 March 1978 (Larry Kropf, Iowa Conservation Commission, Wallingford, personal communication, 1978). Upon arrival both years, there was no snow covering the ground and all wetlands were icebound except for those with medium to dense stands of emergent vegetation. Mean daily air temperatures during the first half of March were higher in 1977 than in 1978 (Fig. 4). Numbers of returning geese peaked during the week following arrival.

Nest initiation

During the first 2 weeks following arrival, pairs of geese explored wetlands for possible nest sites. Nests were initiated first in shallow wetlands with medium to dense vegetation as these wetlands were the first to become free of ice. The last wetlands in which nests were initiated were deep-water, permanent lakes. In both years, the permanent lakes were free of ice by 3 April.

Initial laying dates were determined for 40 nests in 1977 and 91 nests in 1978 (Fig. 4). The first egg was laid on 25 March 1977 and 26 March 1978 respectively. The peak of initial egg laying for each season was 1 April 1977 and 2 April 1978. These peaks were at least 23 and 18 days following first arrival for 1977 and 1978 respectively. The last initial laying date for each season was 29 April 1977 and

Fig. 4. Mean daily air temperature and Canada goose initial laying dates, northwestern Iowa, 1977-1978


NUMBER OF NESTS
TEMPERATURE ° C
1977
N = 40
1978
N = 91
MARCH
APRIL
MAY

11 May 1978.

The onset of laying was not directly related to mean daily air temperature (Fig. 4). Prior to the onset of laying, snow and ice conditions were similar for both years.

Pair density

It was not possible to determine the density of pairs competing for nest sites in each wetland. The pair density thus was estimated from the number of successful nests in each wetland in the principal study area in 1978. This estimate avoids the bias of renesting pairs, but it does not account for pairs that failed to renest.

The overall pair density for the principal study area was 0.12 pairs/ha of wetland. The pair densities of the 11 wetlands ranged from 0.01 to 0.90 pairs/ha. The cover classes, in order of decreasing pair density, were 2, 1, 3, and 4 (Table 3).

Clutch size

Clutch size was determined from eggs found in completed clutches (Table 4). The most frequent clutch sizes, in order of decreasing frequency, were 6, 7, and 5 eggs (Table 4). The mean clutch size and range for the entire study were 6.01 eggs and 2-9 eggs, respectively.

Mean clutch size was higher in nests in ANS than in NNS (Table 4) but not significantly higher ($P > 0.20$). Clutch size decreased with later initial laying dates in both years (Figs. 5 and 6). In 1977, clutch size declined 0.15 eggs/day. This decline was 0.06 eggs/day in 1978. For both years, the mean clutch size for the first half of all clutches initiated was greater than the mean for the second half

Table 3. Density of successful pairs in the wetlands of the principal study area in 1978

Wetland cover class[a]	Wetland name	Number of pairs		Pair density (pairs/ha)
1	East Slough	16		0.22
	Snipe Meadow	2		0.17
	Total	18	Average	0.21
2	Jensen Slough	13		0.52
	North Slough	15		0.90
	Total	28	Average	0.66
3	Cunningham Slough	13		0.14
	Goose Pen Slough	11		0.57
	McQuowen's Slough	3		0.15
	Torreson's Slough	3		0.07
	Total	30	Average	0.18
4	High Lake	2		0.01
	Ingham Lake	4		0.02
	North of grade	2		0.09
	Total	8	Average	0.02
1-4	Principal study area	84	Average	0.12

[a]After Stewart and Kantrud (1971).

Table 4. Distribution of clutch sizes for completed clutches found in artificial nest structures (ANS) and natural nest sites (NNS) in 1977 and 1978

		1977		
		ANS	NNS	Total
Clutch size	2	--	--	--
	3	1	--	1
	4	2	1	3
	5	6	2	8
	6	14	1	15
	7	12	2	14
	8	3	--	3
	9	--	--	--
Total nests		38	6	44
Mean clutch size		6.13	5.67	6.07
Standard deviation		1.12	1.21	1.13
S.E.M.		±.18	±.49	±.17
Range		3-8	4-7	3-8

1978			Combined		
ANS	NNS	Total	ANS	NNS	Total
2	--	2	2	--	2
3	1	4	4	1	5
6	1	7	8	2	10
28	3	31	34	5	39
44	2	46	58	3	61
39	2	41	51	4	55
7	--	7	10	--	10
2	1	3	2	1	3
131	10	141	169	16	185
6.02	5.70	5.99	6.04	5.69	6.01
1.23	1.70	1.26	1.20	1.49	1.23
±.11	±.54	±.11	±.09	±.37	±.09
2-9	3-9	2-9	2-9	3-9	2-9

Fig. 5. Clutch size in relation to initial laying date, 1977. Mean clutch sizes are shown for 2-day periods. Number of clutches is in parentheses

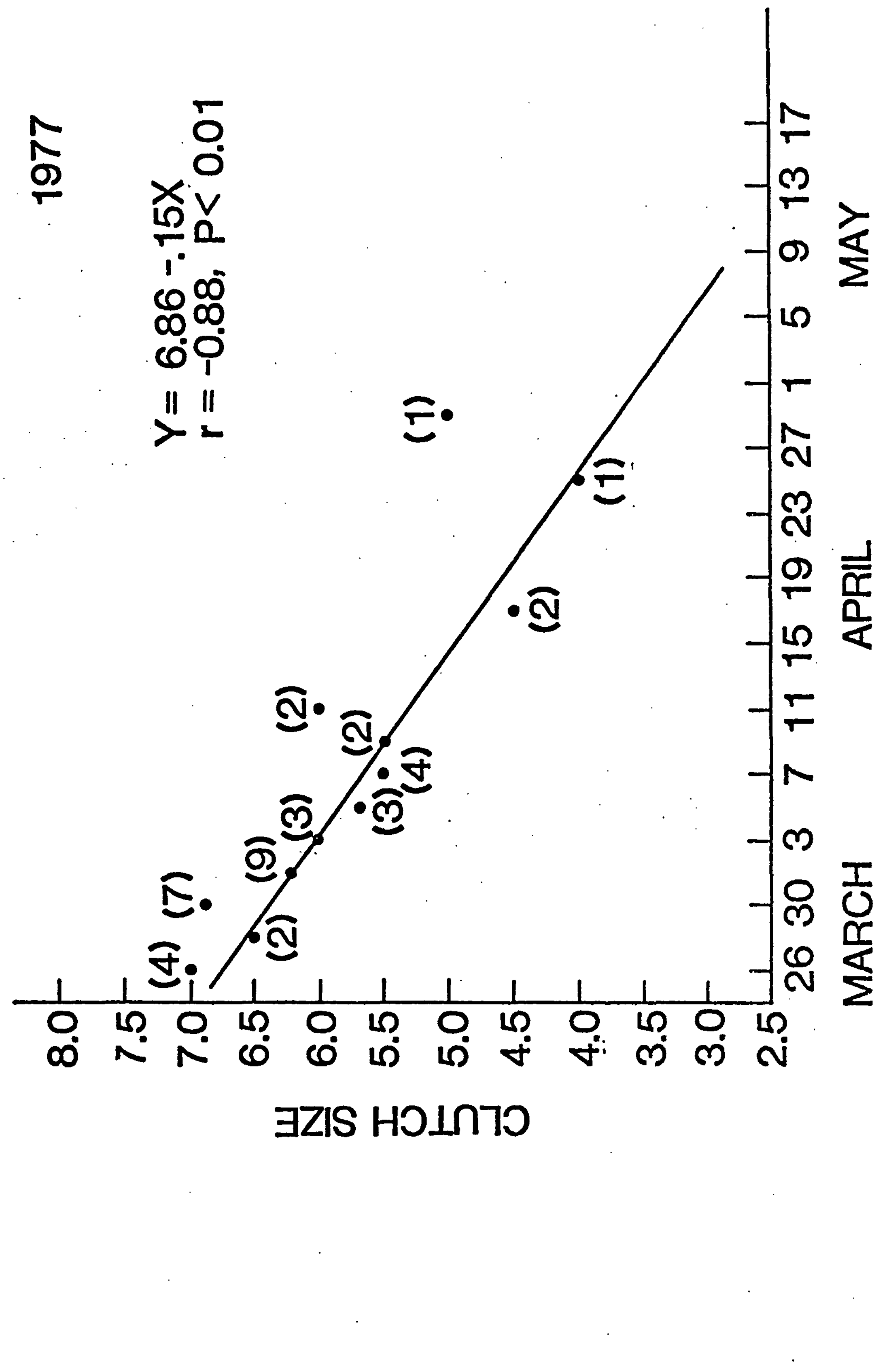
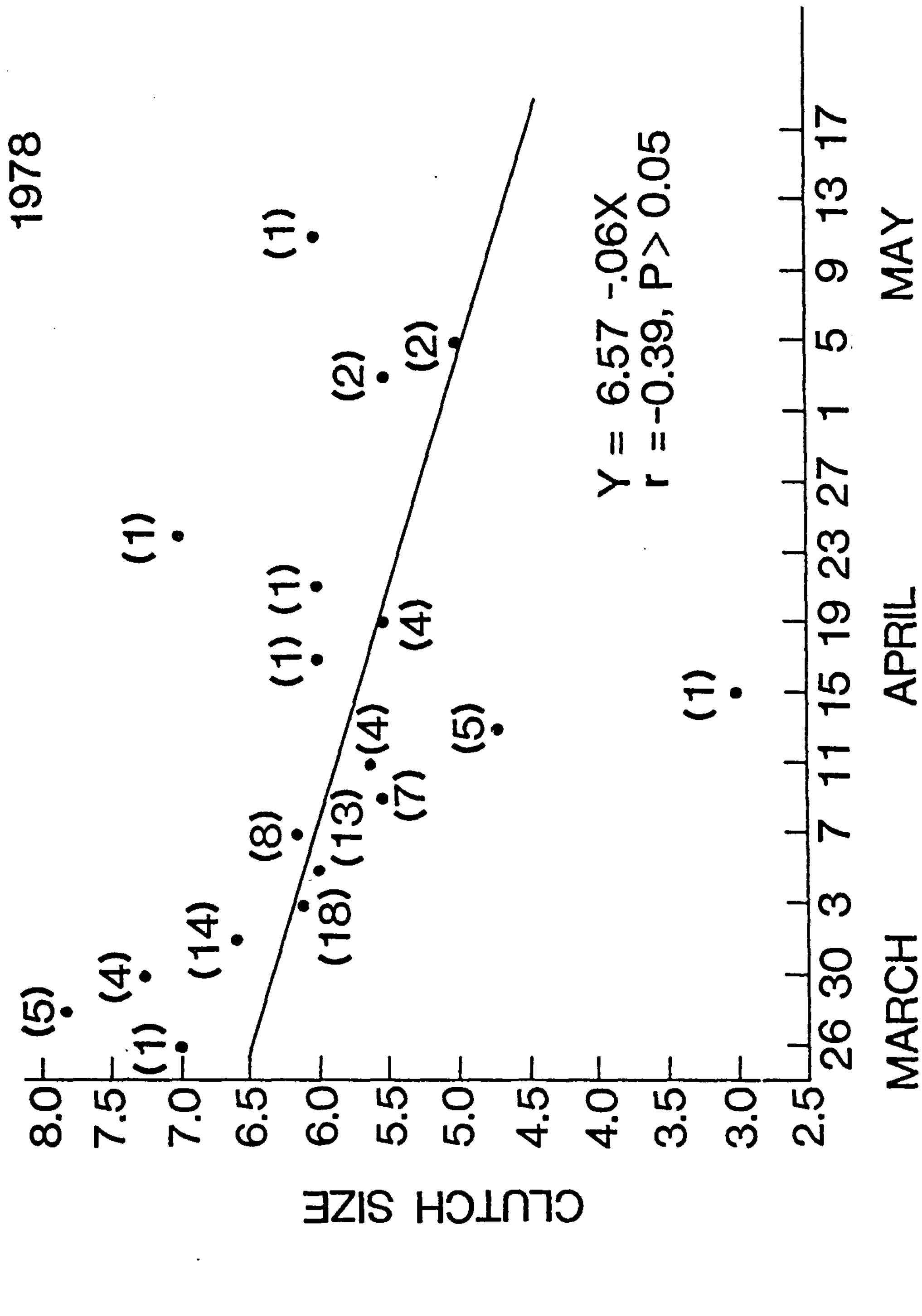

1977
Y = 6.86 -.15X
r = -0.88, P< 0.01
CLUTCH SIZE
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
26
30
3
7
11
15
19
23
27
1
5
9
13
17
MARCH
APRIL
MAY
(4)
(7)
(2)
(9)
(3)
(3)
(4)
(2)
(2)
(2)
(1)
(1)

Fig. 6. Clutch size in relation to initial laying date, 1978. Mean clutch sizes are shown for 2-day periods. Number of clutches is in parentheses


1978
CLUTCH SIZE
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
26 30 3 7 11 15 19 23 27 1 5 9 13 17
MARCH
APRIL
MAY
Y = 6.57 -.06X
r =-0.39, P> 0.05
(5)
(4)
(1)
(14)
(18)
(8)
(13)
(7)
(4)
(5)
(1)
(1)
(4)
(1)
(1)
(2)
(2)
(1)

(Table 5). The difference was highly significant both years (1977, $P < 0.0005$; 1978, $P < 0.0005$).

Hatching dates

The first nests to hatch were on 4 May 1977 and on 3 May 1978. Most nests hatched 10-20 May both years of the study. The last nest to hatch each year was on 3 June 1977 and 11 June 1978.

The length of the nesting season (date of the first egg laid to the date that the last nest ends) was longer in 1978 than in 1977. In 1977, the season was 71 days (25 March-3 June) and ended with the hatching of eggs. In 1978, the season was 85 days (26 March-18 June) and ended with the desertion of failed eggs after overtime incubation.

Nesting success

Of the 211 nests found during the study, 166 (79%) hatched at least 1 egg (Table 6). Nest success was 69 percent in 1977 and 82 percent in 1978. There was no difference in the nesting success among the 6 wetland types in northwestern Iowa in 1978 ($X^2 = 6.65$, $P < 0.25$).

Desertion was the main cause of nest failure each year (Table 6) and was greater in 1977 (17%) than in 1978 (9%). Predation was not an important cause of failure either year, and flooding of nests occurred only in 1978 (Table 6). Egg failure (infertile or dead embryo), stolen clutches, and nest destruction by wind or muskrats (*Ondatra zibethicus*), when combined, were only half as important as desertion (Table 6).

In 1978, within-wetland nearest neighbor distances were measured for 147 goose nests. This distance is an estimate of the tolerance nesting pairs have for each other. Successful nests (n = 121) had a

Table 5. Comparison of clutch size between nests initiated early with those initiated late in the nesting season, 1977 and 1978

	First half[a]	Second half
1977	25 March-1 April	2 April-8 May
Total nests	22	18
Mean clutch size	6.59	5.39
Standard deviation	0.91	1.14
S.E.M.	±.19	±.27
Range	5-8	3-7
1978	26 March-4 April	5 April-11 May
Total nests	50	41
Mean clutch size	6.50	5.54
Standard deviation	1.02	1.16
S.E.M.	±.14	±.18
Range	4-9	3-8

[a]The first 50 percent of the nests initiated were considered early nests. All nests on the median day were grouped in the first half.

Table 6. Fate of all giant Canada goose nests in northwestern Iowa, 1977-1978, grouped according to wetland class

Nest fate		Wetland class[a]						
		III	IV-1	IV-2	IV-3	V-3	V-4	Total
Hatched	1977	0 (0)[b]	9 (64)	12 (67)	11 (74)	0 (0)	5 (71)	37 (69)
	1978	1 (34)	19 (73)	51 (85)	32 (86)	17 (85)	9 (82)	129 (82)
	Combined	1 (34)	28 (70)	63 (81)	43 (83)	17 (85)	14 (78)	166 (79)
Deserted	1977	0 (0)	3 (17)	2 (11)	2 (13)	0 (0)	2 (29)	9 (17)
	1978	0 (0)	5 (19)	5 (8)	3 (8)	2 (10)	0 (0)	15 (9)
	Combined	0 (0)	8 (20)	7 (10)	5 (10)	2 (10)	2 (11)	24 (11)
Predated	1977	0 (0)	0 (0)	2 (11)	0 (0)	0 (0)	0 (0)	2 (4)
	1978	1 (33)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
	Combined	1 (33)	0 (0)	2 (1)	0 (0)	0 (0)	0 (0)	3 (1)

Flooded	1977	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	1978	1 (33)	1 (4)	3 (5)	0 (0)	1 (5)	0 (0)	6 (4)
	Combined	1 (33)	1 (3)	3 (4)	0 (0)	1 (5)	0 (0)	6 (3)
Other[c]	1977	0 (0)	2 (14)	2 (11)	2 (13)	0 (0)	0 (0)	6 (10)
	1978	0 (0)	1 (4)	1 (2)	2 (6)	0 (0)	2 (18)	6 (4)
	Combined	0 (0)	3 (7)	3 (4)	4 (7)	0 (0)	2 (11)	12 (6)
Total	1977	0 (0)	14 (100)	18 (100)	15 (100)	0 (100)	7 (100)	54 (100)
	1978	3 (100)	26 (100)	60 (100)	37 (100)	20 (100)	11 (100)	157 (100)
	Combined	3 (100)	40 (100)	78 (100)	52 (100)	20 (100)	18 (100)	211 (100)

[a]After Stewart and Kantrud (1971).

[b]Percent.

[c]Includes clutches failed, stolen, blown apart by wind, or disturbed by muskrats.

mean distance of 129 m while failed nests ($n = 26$) had a mean distance of 92 m. The difference in these distances approached significance ($t = 1.68$, $0.10 > P > 0.05$), indicating that the closer 2 nests are, the greater is the chance that 1 nest will fail.

The fates of all nests placed in ANS and NNS were determined for each site type (Table 7). Elevated barrels, floating barrels, man-made islands, and natural islands had similar, high nesting success (Table 7). The poorest nesting success (23%) occurred on vegetation hummocks and old muskrat houses. This type of nest site was subject to more desertion, predation, and flooding than any other nest site (Table 7).

Nesting success was compared between ANS and NNS (Table 8). In 1977, the difference between the proportion of successful and failed nests in ANS and NNS approached significance ($P < 0.10$). In 1978, and when data for both years were combined, the differences between the proportions of successful and failed nests in ANS and NNS were highly significant ($P < 0.01$). Nesting success was greater in ANS than in NNS.

Few nests failed once incubation began (Table 9). Nesting success for the 2 years in all nests in which incubation started was 91 percent The major cause of nest failure once incubation started was egg failure for the entire clutch, while desertion, predation, and flooding were less important (Table 9).

<u>Egg success</u>

Of the 1,126 eggs laid in 205 nests, 862 (77%) hatched (Table 10). Egg success was 68 percent in 1977 and 80 percent in 1978. Egg failure

Table 7. Fate of giant Canada goose nests grouped according to nest site, 1977-1978

Nest fate		Elevated barrel		Floating barrel		Nest basket		Man-made island		Natural island		Hummock or muskrat house		Ground		Total	
Hatched	1977	23	(68)[a]	9	(90)	1	(100)	0	(0)	0	(0)	3	(44)	1	(50)	37	(69)
	1978	74	(88)	12	(80)	1	(100)	36	(83)	4	(80)	0	(0)	2	(67)	129	(82)
	Combined	97	(82)	21	(84)	2	(100)	36	(83)	4	(80)	3	(23)	3	(60)	166	(79)
Deserted	1977	6	(18)	0	(0)	0	(0)	0	(0)	0	(0)	2	(28)	1	(50)	9	(17)
	1978	9	(11)	2	(13)	0	(0)	4	(10)	0	(0)	0	(0)	0	(0)	15	(9)
	Combined	15	(13)	2	(8)	0	(0)	4	(10)	0	(0)	2	(16)	1	(20)	24	(11)
Predated	1977	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	2	(28)	0	(0)	2	(4)
	1978	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	1	(17)	0	(0)	1	(1)
	Combined	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	3	(23)	0	(0)	3	(1)

Flooded	1977	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
	1978	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	5	(83)	1	(33)	6	(4)
	Combined	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	5	(38)	1	(20)	6	(3)
Other[b]	1977	5	(14)	1	(10)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	6	(10)
	1978	1	(1)	1	(7)	0	(0)	3	(0)	1	(20)	0	(0)	0	(0)	6	(4)
	Combined	6	(5)	2	(8)	0	(0)	3	(0)	1	(20)	0	(0)	0	(0)	12	(6)
Total	1977	34	(100)	10	(100)	1	(100)	0	(100)	0	(100)	7	(100)	2	(100)	54	(100)
	1978	84	(100)	15	(100)	1	(100)	43	(100)	5	(100)	6	(100)	3	(100)	157	(100)
	Combined	118	(100)	25	(100)	2	(100)	43	(100)	5	(100)	13	(100)	5	(100)	211	(100)

[a]Percent.

[b]Includes clutches failed, stolen, blown apart by wind, or disturbed by muskrats.

Table 8. Chi-square tests for nesting success of giant Canada geese using artificial nest structures (ANS) versus natural nest sites (NNS) in northwestern Iowa, 1977-1978

	Nest type	Fate of nest		Chi-square at 1 d.f.
1977		Successful	Failed	
	ANS	33	12	
	NNS	4	5	2.90, P < 0.10
1978		Successful	Failed	
	ANS	123	20	
	NNS	6	8	16.21, P < 0.01
Combined		Successful	Failed	
	ANS	156	32	
	NNS	10	13	19.06, P < 0.01

Table 9. Fate of giant Canada goose nests in which incubation had begun, 1977-1978

Nest fate	1977		1978		Combined	
Hatched	37	(82)[a]	129	(94)	166	(91)
Deserted	2	(5)	0	(0)	2	(1)
Predated	1	(2)	1	(1)	2	(1)
Flooded	0	(0)	1	(1)	1	(1)
Other[b]	5	(11)	6	(4)	11	(6)
Total	45	(100)	137	(100)	182	(100)

[a]Percent.

[b]Includes clutches failed, stolen, blown apart by wind, or disturbed by muskrats.

Table 10. Fate of giant Canada goose eggs in northwestern Iowa, 1977-1978

Egg fate	1977		1978		Combined	
	Number	Percent	Number	Percent	Number	Percent
Hatched	195	68.2	667	79.4	862	76.6
Deserted	25	8.7	43	5.1	68	6.0
Predated	9	3.1	5	0.6	14	1.2
Flooded	---	---	19	2.3	19	1.7
Egg failure[a]	46	16.2	83	9.9	129	11.5
Broken by hen	---	---	3	0.3	3	0.3
Lost from nest	5	1.7	20	2.4	25	2.2
Stolen	6	2.1	---	---	6	0.5
Total eggs	286	100.0	840	100.0	1,126	100.0
Nests	52		153		205	

[a]Includes embryo death and infertile eggs.

and desertion were the 2 major reasons that eggs did not hatch (Table 10).

Hatching success (percent of eggs in clutches incubated full term that hatched) was determined from 1,002 eggs (Table 11). In 1977 and 1978, hatching success was 79 percent and 88 percent, respectively.

In 1978, 1 goose unsuccessfully parasitized a mallard (Anas platyrhynchos) nest with 1 egg. This same year, a deserted clutch of 10 eggs was found that was believed to be the result of 2 females laying.

Second nests

Although geese were not individually marked, indirect evidence of second nesting was observed each year. Second nests were of 2 types: 1) a continuation nest in which a goose, after losing the original nest during laying, continued the laying cycle in a new location (Brakhage 1965, Cooper 1978), and 2) a renest in which a goose, after losing the original nest during incubation, began a new laying cycle in a new nest (Brakhage 1965, Cooper 1978).

No evidence of continuation nesting was observed in 1977. In 1978, new nests were found in the vicinity of 4 nests that were flooded and deserted during the laying cycle. If these new nests were, in fact, continuation nests, then the geese involved each laid 8-10 eggs for the season.

Renests can usually be identified by the lateness of their establishment (Cooper 1978). Using this criteria, there were probably 4 renests in 1977 and 12 renests in 1978 (Fig. 4). In 1978, 1 known renest was observed. The goose involved lost a 6 egg clutch due to high winds during the second week of incubation. The renest was located less than

Table 11. Hatching success of eggs in clutches incubated full term, 1977-1978

Egg fate	1977		1978		Combined	
	Number	Percent	Number	Percent	Number	Percent
Hatched	195	79.3	667	88.2	862	86.0
Egg failure[a]	46	8.7	83	11.0	129	12.9
Broken by hen	---	---	3	0.4	3	0.3
Lost from nest	5	2.0	3	0.4	8	0.8
Total eggs	246	100.0	756	100.0	1,002	100.0
Nests	40		127		167	

[a]Includes embryo death and infertile eggs.

70 m from the original nest and contained 6 eggs. This nest also was destroyed by high winds.

Gosling production

In 1977, no goslings were found dead in nests. In 1978, 4 goslings were found dead in nests. Two of these were trampled, and 2 were trapped between nesting material and the inside wall of elevated barrels.

Eggs from 165 nests produced 877 goslings for a mean initial brood size of 5.32 goslings. Mean initial brood sizes for ANS and NNS were larger in 1977 than in 1978 (Table 12). Mean initial brood size for the study was significantly greater from ANS than from NNS ($P < 0.05$).

Gosling Habitat Use and Survival

Habitat use

Throughout the brood rearing season in 1977, droughty conditions caused many wetlands to shrink in size. This left a ring of mudflats that soon were covered with lush annual plants, particularly golden dock (*Rumex maritimus*) and smartweed (*Polygonum lapathifolium*). Broods of goslings spent most of their time loafing and foraging along these mudflats. Goslings foraged heavily on golden dock and smartweed. When the geese became alarmed, the adults led the brood into the open water of the wetland.

In 1978, adequate water was available throughout the brood rearing season. Perennial plants, mostly hardstem and softstem bulrush (*Scirpus acutus* and *S. validus*), river bulrush (*S. fluviatilis*), and cattail (*Typha* sp.), became abundant in wetlands where mudflats existed the

Table 12. Initial brood size of giant Canada geese from successful nests in northwestern Iowa, 1977-1978

	ANS			NNS			All nests		
	1977	1978	Combined	1977	1978	Combined	1977	1978	Combined
Number of nests	32	123	155	4	6	10	36	129	165
Total goslings	184	651	835	17	25	42	201	676	877
Mean brood size	5.75	5.29	5.39	4.25	4.17	4.20	5.58	5.24	5.32
Standard deviation	1.27	1.57	1.53	2.50	1.94	2.04	1.48	1.60	1.58
S.E.M.	±.22	±.14	±.12	±1.25	±.79	±.65	±.25	±.14	±.12
Range	3-8	1-8	1-8	1-7	1-7	1-7	1-8	1-8	1-8

previous year. These dense stands of emergent vegetation restricted my ability to observe brood habitat use. Where mudflats were available, broods used them as in 1977. In 1978, many more man-made islands were available for use as loafing sites by broods. Man-made islands receiving heavy use by broods lacked vegetation and were surrounded by water as well as dense stands of emergent vegetation. In these situations, goslings foraged on softstem and river bulrush. When alarmed, broods tended to hide in the emergent vegetation rather than swimming to open water.

Many of the brood rearing areas that were protected and had nearby upland vegetation (grasses and annuals) for foraging were used both years. This suggests that within a complex of wetlands, some brood rearing areas are somewhat traditional. These traditional areas were utilized by increasing numbers of goslings as the brood rearing season progressed. Some adults moved their broods as much as 1.6 km to reach these areas.

Creching behavior

Creches or gang broods (Brakhage 1965, Warhurst 1974) generally started forming once goslings were 1-week-old or older. Creches at the traditional rearing areas became quite large. The largest creche in 1977 consisted of 72 4-5-week-old goslings and 22 adults and subadults. In 1978, 1 pair of adults had a creche of 43 2-week-old goslings.

Gosling survival

Gosling survival was higher in 1977 than in 1978. In 1977, an estimated 288 goslings left their nests in the principal study area.

Goslings were readily visible on mudflats in 1977, and the final count at banding age was 283 goslings. Based on this data, survival was very high (98%). Possible biases in this estimate were 1) not finding all of the nests or seeing all of the goslings and 2) unequal numbers of goslings entering and leaving the study area. The warm, dry weather conditions in 1977 were excellent for rearing broods and gosling survival was probably greater than 90 percent.

In 1978, 463 goslings left their nests in the principal study area. An estimated 340 goslings (73%) survived to banding age. At outlying Fallow Marsh and Virgin Lake, 40 goslings left nests and 32 goslings (80%) survived to banding age. Survival of goslings in 1978 was probably 73-80 percent. During the first 2 weeks of the hatching season, the weather was cold and wet, and several isolated, early broods lost more than 50 percent of their goslings during the first few days following hatching.

Generally, most of the goslings observed appeared to be in excellent condition both years. Rarely, a weak gosling was seen with its brood shortly after the brood's nest departure. These individuals likely perished.

Unfavorable weather appeared to be the greatest mortality factor during this study. Predation by farm dogs and great horned owls (*Bubo virginianus*) occurred but was not important. I saw no evidence of gosling mortality from any disease.

Nest Site Selection

Availability and use of nest structures

Nest site availability and use on the principal study area were investigated at 4 wetlands in 1977 and 11 wetlands in 1978. Both NNS and ANS were investigated.

In both years, muskrat populations in northwestern Iowa were very low, and few muskrat houses were available for Canada goose nest sites. Other typical NNS available were natural islands and hummocks of *Typha* sp. and *Scirpus* sp.

Due to low water levels, most of the natural islands were connected to shore in 1977 and 1978, and geese rarely used them for nest sites. Most islands that were surrounded by water had geese nesting on them. In addition to nests on hummocks, geese utilized marsh vegetation to build floating nests against emergents. These nests were found only in marshes having a good interspersion of emergents and water. A total of 16 nests were found on NNS in the principal study area: 3 on natural islands, 11 in emergent vegetation, and 2 on the ground within 5 m of open water.

The principal study area contained many ANS both years (Table 13). In 1977, the 4 wetlands studied had 173 ANS. In 1978, the 11 wetlands of the principal study area had 379 ANS.

Both years, floating barrels received the highest percentage of use (56%) (Table 13). Percent use of this structure was greater in Class IV-3 wetlands (68%) than in Class V-4 wetlands (39%) (Table 13). Elevated barrels received the next highest percent use (36%) (Table 13).

Table 13. Use of artificial nest structures in relation to wetland class on the principal study area, 1977 and 1978[a]

Structure type		Wetland class									
		IV-1		IV-2		IV-3		V-4		Total	
		Avail[b]	Used[c]	Avail	Used	Avail	Used	Avail	Used	Avail	Used
Elevated	1977	54	14 (26)[d]	15	11 (73)	23	7 (30)	5	2 (40)	97	34 (35)
barrel	1978	59	12 (20)	17	13 (76)	47	17 (36)	7	5 (71)	130	47 (36)
	Combined	113	26 (23)	32	24 (75)	70	24 (34)	12	7 (58)	227	81 (36)
Floating	1977	0	0 (0)	0	0 (0)	12	7 (58)	8	3 (37)	20	10 (50)
barrel	1978	0	0 (0)	0	0 (0)	15	11 (73)	10	4 (40)	25	15 (60)
	Combined	0	0 (0)	0	0 (0)	27	18 (68)	18	7 (39)	45	25 (56)
Elevated	1977	8	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	8	0 (0)
nest	1978	4	0 (0)	0	0 (0)	0	0 (0)	1	1(100)	5	1 (20)
basket	Combined	12	0 (0)	0	0 (0)	0	0 (0)	1	1(100)	13	1 (8)

Man-made	1977	48	0 (0)	0	0 (0)	0	0 (0)	0	0 (0)	48	0 (0)
island	1978	73	10 (14)	50	18 (36)	87	7 (8)	0	0 (0)	210	35 (17)
	Combined	121	10 (8)	50	18 (36)	87	7 (8)	0	0 (0)	258	35 (14)
Total	1977	110	14 (13)	15	11 (73)	35	14 (40)	13	5 (38)	173	44 (25)
	1978	136	22 (16)	67	31 (46)	149	35 (23)	18	10 (56)	370	98 (26)
	Combined	246	36 (15)	82	42 (51)	184	49 (27)	31	15 (48)	543	142 (26)

[a]After Stewart and Kantrud (1971).

[b]Avail = available.

[c]Use indicated by presence of at least one egg or fresh down.

[d]Percent.

During the study, the percent use of elevated barrels was highest in Class IV-2 or hemi-marsh (Weller and Spatcher 1965) wetlands (75%) (Table 13). Man-made islands were not used in 1977 because none were surrounded by water. In 1978, water surrounded many of these and 17 percent were used (Table 13). The percent use was highest in Class IV-2 wetlands (36%) (Table 13). A few elevated nest baskets were available for use during the study, but only one was used (Table 13).

Percent use of all ANS in 1977 (25%) was similar to that of 1978 (26%). These percentages do not reflect the actual increase in nesting that probably occurred on the principal study area in 1978. Of the 206 more ANS investigated in 1978 than in 1977, 167 were new man-made islands available for the first time in 1978. The highest percentage of use for all ANS was in Class IV-2 or hemi-marsh wetlands (51%) (Table 13). Next highest were Class V-4 (48%) and Class IV-3 (27%) wetlands (Table 13).

Nest site selection

To try to understand what factors affect nest site selection, multivariate analysis of variance and stepwise discriminant function analysis were used to analyze differences between used and unused ANS in 1978. One discriminant function was calculated for the 2 groups (used and unused) compared within each structure type: elevated barrels and baskets, floating barrels, and man-made islands. All variables were entered in the discriminant function except those that were perfectly correlated.

Five elevated nest baskets and 120 elevated barrels were analyzed. A multivariate analysis of variance indicated that a highly significant difference existed between used and unused elevated barrels (F = 6.23, 13, 111 d.f., P = 0.0001). The discriminant function analysis ranked 10 variables according to their standardized canonical coefficients (Table 14). The wetland cover class and occurrence or absence of water surrounding the structure were the most important characteristics discriminating between used and unused elevated barrels (Table 14). Density of successful pairs, distance to permanent water, nest height, and distance to the nearest shoreline all contributed similarly to the discriminant function (Table 14). Used elevated barrels tended to be in slightly more open than hemi-marsh wetland situations and tended to be completely surrounded by water (Table 14). Used elevated barrels were closer to permanent water, lower in height, closer to open water, in smaller wetlands, in less dense vegetation, and had higher successful pair densities than unused elevated barrels (Table 14).

Actual use of elevated barrels was compared with predicted use to develop correct classification probabilities (Morrison 1976). Using the ranked variables determined from discriminant function analysis, elevated barrels and baskets were classified as used or unused based on each structure's characteristics rather than on actual use. Of the used and unused elevated structures, 75 percent and 83 percent, respectively, were correctly classified. The high percent of correct classifications indicates a fairly good discrimination between used and unused groups.

Misclassifications in elevated barrels are illustrated in Fig. 7. Each structure was plotted by its Mahalanobis distance (Morrison 1976) from used and unused group centers. A correctly classified used

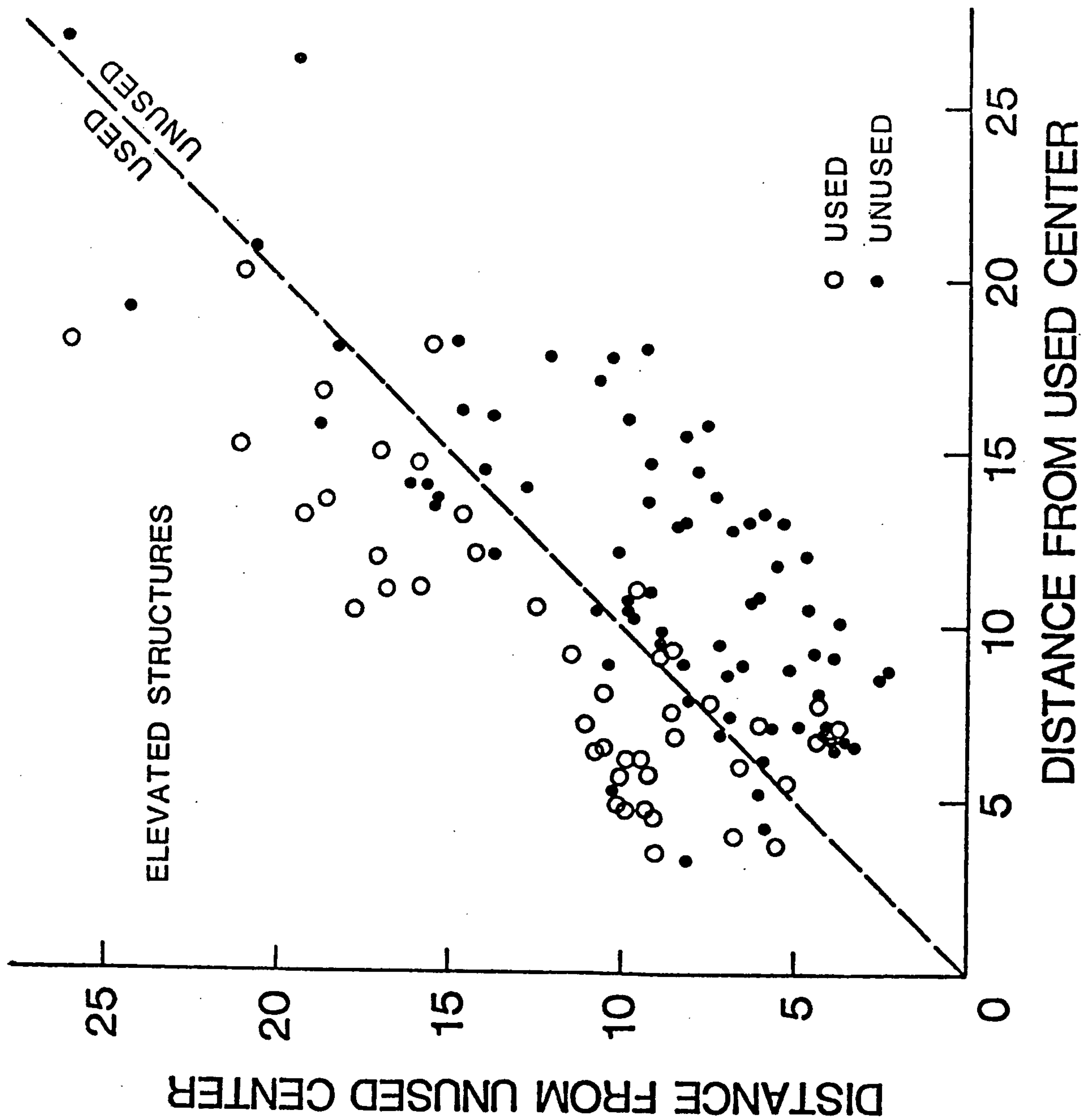
Table 14. Mean (standard error of mean) and standardized coefficients for canonical variables measured on and around elevated barrels and nest baskets used and not used by Canada geese as nest sites in 1978

Variable	Used (n = 48)		Unused (n = 77)		Standardized coefficient for canonical variable[a]
Wetland cover class (1-4)	2.4	(±.14)	1.8	(±.11)	0.895
Occurrence (0) or lack (1) of surrounding water	0.08	(±.04)	0.58	(±.06)	-0.695
Density of successful pairs (pairs/ha)	0.40	(±.05)	0.25	(±.02)	0.287
Distance to permanent water (m)	265.6	(±45.1)	321.2	(±34.3)	0.259
Nest height (cm)	137.9	(±4.6)	163.3	(±3.5)	-0.257
Distance to nearest shoreline (m)	40.6	(±4.7)	41.0	(±4.0)	0.249

Cover class of surrounding vegetation (1-4)	2.1	(±.19)	3.1	(±.14)	0.182
Artificial nest structure density (ANS/ha)	1.5	(±.13)	1.3	(±.07)	0.150
Wetland area (ha)	55.8	(±7.3)	67.6	(±3.5)	0.129
Distance to open water (m)	7.3	(±2.2)	20.6	(±3.1)	-0.112

[a]The largest absolute values belong to variables that best account for variation between the groups.

Fig. 7. Generalized distance (Mahalanobis Distance-squared Units) of each used and unused elevated barrel or nest basket from used and unused group centers (based on stepwise discriminant function analysis). See text for explanation


ELEVATED STRUCTURES
USED
UNUSED
o USED
• UNUSED
DISTANCE FROM USED CENTER
DISTANCE FROM UNUSED CENTER
0
5
10
15
20
25

structure, based on that structure's characteristics, would be plotted above the used-unused center line. A correctly classified unused structure similarly would be plotted below the center line. Incorrectly classified used and unused structures would be below and above the line, respectively. There was a good separation between used and unused structures (Fig. 7). Used elevated barrels that were misclassified as unused were either in wetlands with very dense vegetation or without surrounding water. Unused structures were misclassified primarily because they were surrounded by open water or were in wetlands with sparse vegetation. Used elevated barrels seemed to form 2 groups based on differences in wetland size, successful pair density, and ANS density between the groups (Fig. 7). These 2 groups were still similar enough to be well-separated from unused elevated barrels (Fig. 7).

The multivariate analysis of variance on 25 floating barrels showed no significant differences between used and unused structures ($F = 0.82$, 6, 18 d.f., $P = 0.57$). The discriminant function analysis ranked 5 variables according to their standardized canonical coefficients (Table 15). The area of the wetland and the density of successful pairs were the most important characteristics discriminating between used and unused groups. Used floating barrels tended to be in smaller wetlands with higher successful pair densities than unused floating barrels (Table 15).

Correct classification probabilities were derived for floating barrels. Floating barrels were classified as used or unused based on each structure's characteristics. Of the used and unused floating barrels, 80 percent and 50 percent, respectively, were classified correctly. This discrimination is not as good as was found for elevated

Table 15. Mean (standard error of mean) and standardized coefficients for canonical variables measured on and around floating barrels used and not used by Canada geese as nest sites in 1978

Variable	Used (n = 15)		Unused (n = 10)		Standardized coefficient for canonical variable[a]
Wetland area (ha)	88.7	(±13.6)	133.3	(±17.4)	-1.620
Density of successful pairs (pairs/ha)	0.20	(±.05)	0.11	(±.05)	-1.273
Nest height (cm)	35.0	(±2.0)	37.3	(±2.0)	-0.626
Wetland cover class (1-4)	3.3	(±.12)	3.6	(±.16)	-0.242
Distance to nearest shoreline (m)	39.4	(±8.3)	37.1	(±11.6)	-0.079

[a]The largest absolute values belong to variables that best account for variation between the groups.

barrels. The small sample size probably caused the poorer discrimination as well as the insignificant F-statistic in the multivariate analysis of variance.

The misclassification of used and unused floating barrels is illustrated in Fig. 8. Used structures were misclassified because they occurred on large wetlands. Unused floating barrels were misclassified because they occurred on medium sized wetlands with medium successful pair densities. Used floating barrels are loosely grouped when plotted, but unused structures are not grouped except for 4 floating barrels that occurred on large wetlands.

The multivariate analysis of variance on 152 man-made islands yielded a highly significant difference between used and unused structures ($F = 3.34$, 12, 139 d.f., $P = 0.0003$). The discriminant function analysis ranked 9 variables (Table 16). Distance to permanent water, wetland area, and ANS density were the most important characteristics discriminating between used and unused manmade islands (Table 16). Used man-made islands tended to be farther from permanent water, occurred on smaller wetlands, were farther from shoreline, were closer to open water, and were more often surrounded by water than unused man-made islands (Table 16).

Correct classification probabilities were developed for man-made islands. Of the used and unused man-made islands, 32 percent and 93 percent, respectively, were correctly classified. The large number of unused man-made islands provided enough information for a prediction of their lack of use and greatly contributed to the significance of the multivariate analysis of variance F-statistic. Used man-made islands

Fig. 8. Generalized distance (Mahaloanobis Distance-squared Units) of each used and unused floating barrel from used and unused group centers (based on stepwise discriminant function analysis). See text for explanation

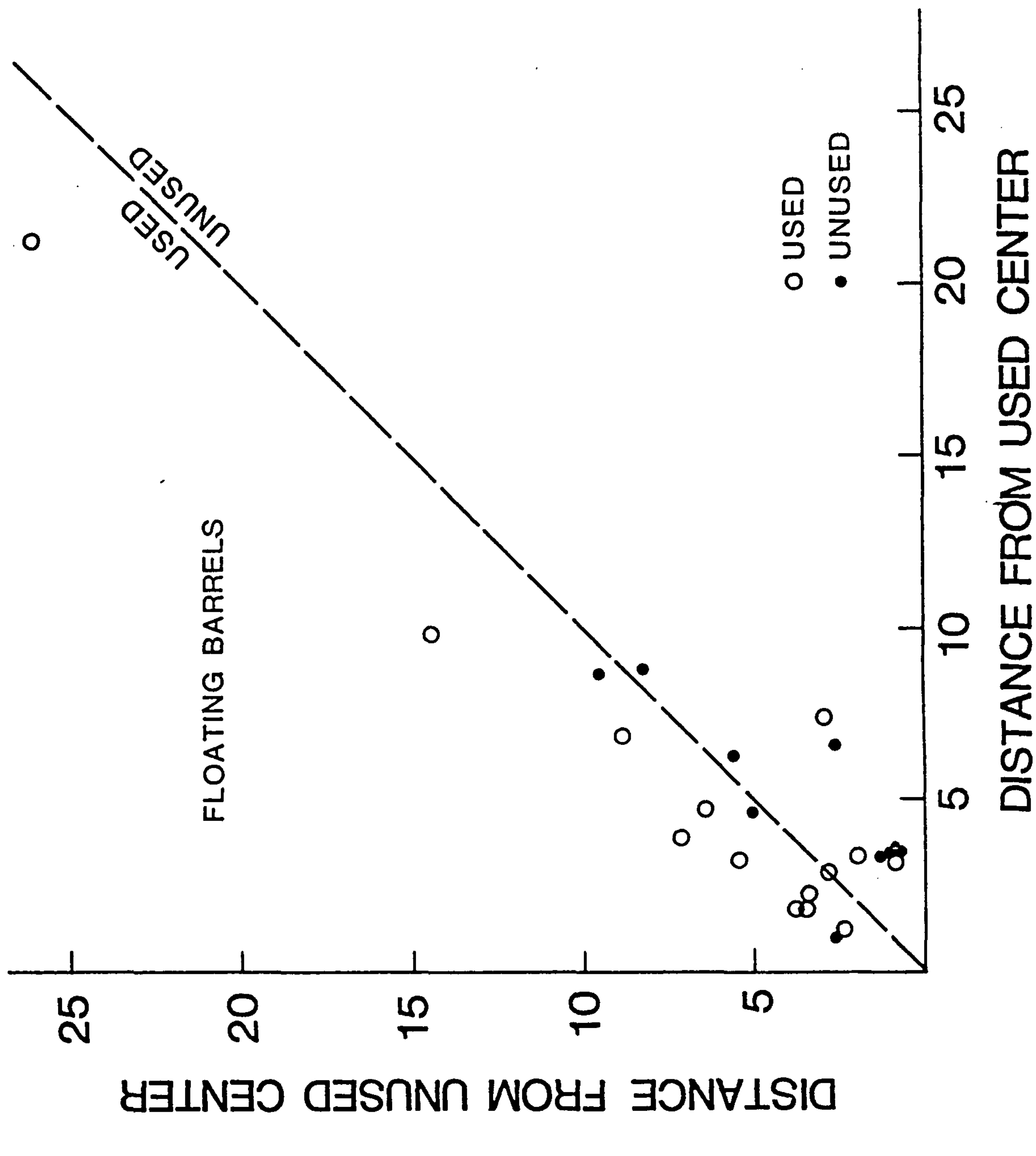

FLOATING BARRELS
USED
UNUSED
○ USED
● UNUSED
DISTANCE FROM USED CENTER
DISTANCE FROM UNUSED CENTER
5
10
15
20
25

Table 16. Mean (standardized error of mean) and standardized coefficients for canonical variables measured on and around man-made islands used and not used by Canada geese as nest sites in 1978

Variable	Used (n = 34)		Unused (n = 118)		Standardized coefficient for canonical variable[a]
Distance to permanent water (m)	394.8	(±48.4)	255.7	(±22.7)	1.194
Wetland area (ha)	37.3	(±4.0)	49.6	(±2.8)	-0.976
Artificial nest structure density (ANS/ha)	1.5	(±.09)	1.5	(±.06)	0.946
Wetland cover class (1-4)	1.9	(±.13)	2.0	(±.08)	0.848
Distance to nearest shoreline (m)	44.3	(±6.7)	36.0	(±2.8)	0.556
Distance to open water (m)	2.0	(±.26)	3.9	(±.61)	-0.391

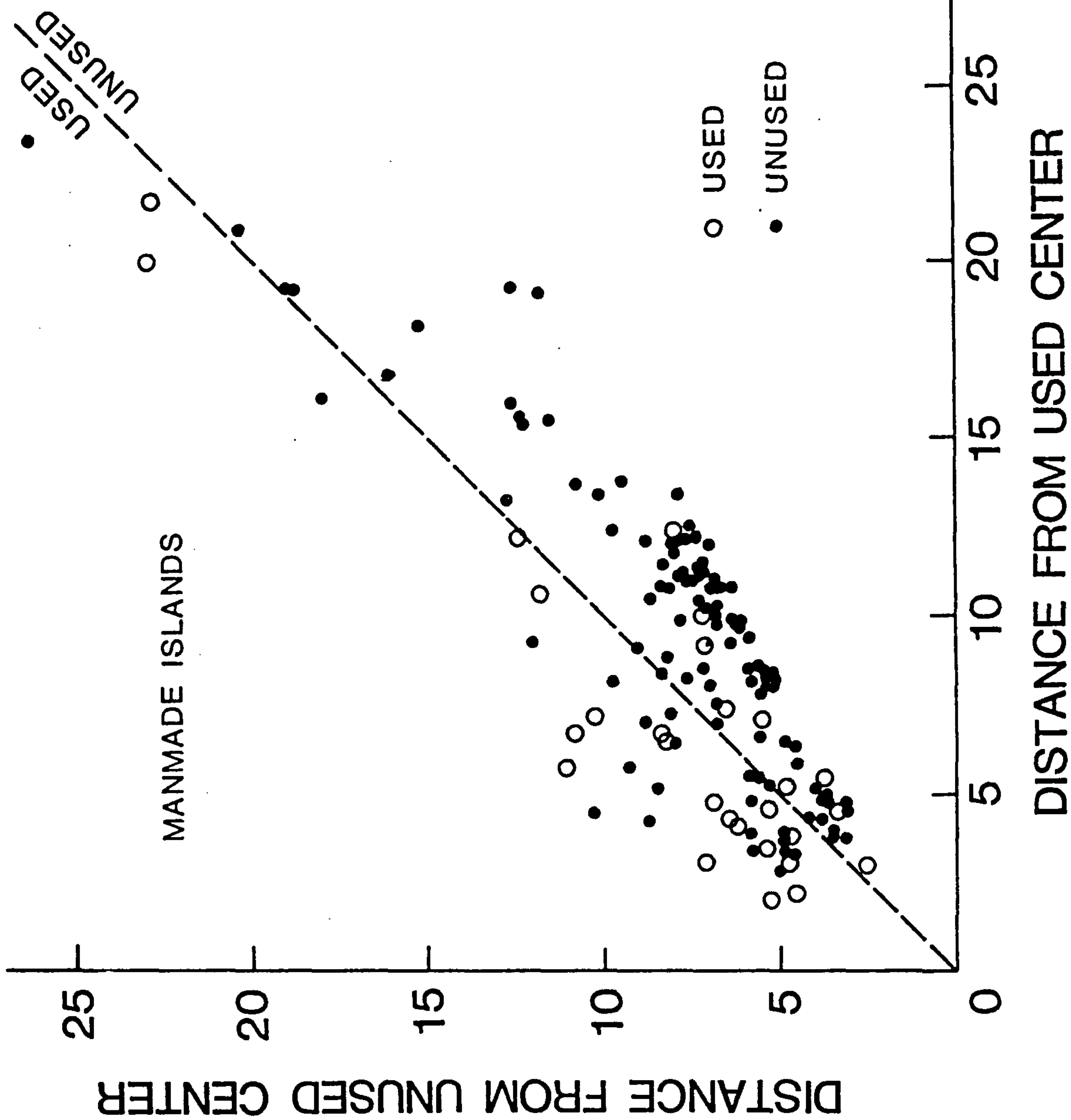
Cover class of surrounding vegetation (1-4)	1.7	(±.19)	1.9	(±.13)	0.224
Occurrence (0) or lack (1) of surrounding water	0.06	(±.04)	0.35	(±.04)	-0.150
Nest height	152.8	(±6.6)	158.2	(±2.7)	-0.035

[a]The largest absolute values belong to variables that best account for variation between the groups.

could not be predicted by the characteristics in this discriminant function analysis.

Misclassifications of used and unused man-made islands are illustrated in Fig. 9. Misclassified used structures occurred closer to permanent water and were in larger wetlands than those man-made islands classified correctly. Misclassified unused man-made islands were farther from permanent water and in smaller wetlands than those unused structures classified correctly. Used man-made islands are scattered over the used and unused portions of the graph illustrating the poor prediction of this group's use (Fig. 9). Unused structures are widely scattered as well, but most are clustered in the unused portion of the graph as was predicted (Fig. 9).

Fig. 9. Generalized distance (Mahalanobis Distance-squared Units) of each used and unused man-made island from used and unused group centers (based on stepwise discriminant function analysis). See text for explanation


MANMADE ISLANDS
USED
UNUSED
o USED
• UNUSED
DISTANCE FROM USED CENTER
DISTANCE FROM UNUSED CENTER
0
5
10
15
20
25

DISCUSSION

Nesting Season and Productivity

The spring arrival dates observed during this study were similar to dates for other flocks in the north central states (Hanson 1965, Dill and Lee 1970, Hilley 1976). As in other studies of giant Canada geese, when geese arrived, major lakes were icebound (Hanson 1965, Cooper 1978). At Marshy Point, Manitoba, geese arrived when mean daily air temperatures reached 0 C, and shallow, well-vegetated marshes were free of ice (Cooper 1978). These conditions coincided with the peak of spring arrival in Iowa both years and are probably the factors controlling arrival for this flock.

Initial laying dates during this study were similar to those found in other studies of giant Canada geese in the north central states (Brakhage 1965, Zicus 1974, Hilley 1976, Sayler 1977). Cooper (1978) stated that temperature indirectly controls initiation of laying by its influence on snow and ice melt. However, the dates that the first eggs were laid were nearly identical both years despite warmer temperatures and earlier disappearance of ice from the smaller marshes in 1977. Geese were on the nesting grounds sooner in 1977 than in 1978. This suggests that photoperiod as well as temperature and ice conditions determine laying by mid-continental nesting geese. Murton and Westwood (1977) and Murton and Kear (1978) have stressed the importance of photoperiod in the breeding cycles of waterfowl. Yolk development, which commences 10-13 days prior to laying (Grau 1976), is stimulated in northern nesting geese by their arrival at the breeding grounds or by their departure from the final migration staging area (Raveling 1978). Arrival may have stimulated yolk development in 1978, but in 1977 geese were on the Iowa nesting grounds longer than the period necessary for yolk development.

The overall pair density of 0.12 pairs/ha of wetland found in 1978 cannot be compared to densities reported for most Canada goose populations. Usually these densities are reported for island nesting colonies and are quite high. The highest density recorded for an island nesting population was 222 nests/ha at Dog Lake, Manitoba (Klopman 1958). At At Marshy Point, Manitoba, Canada geese nest in ANS, muskrat houses, and marsh vegetation, with densities ranging from 0.04 to 0.05 nests/ha (Cooper 1978). In Iowa, pair densities ranged from 0.02 to 0.90 pairs/ha with highest densities occurring in hemi-marsh situations (Table 3). The hemi-marsh might allow higher densities to exist because of visual isolation due to the interspersion of water and vegetation. In Alberta, higher densities of Canada goose nests occurred on areas of an island that had sufficient vegetation to visually isolate nests (Ewaschuk and Boag 1972).

The mean clutch size (6.01 eggs) for all completed clutches in this study is higher than those reported for other populations of Canada geese (Table 17). The mean clutch size for 63 nests from 1966 through 1970 for this Iowa population was 5.0 eggs (Bishop and Howing 1972). Since Canada geese 5 years old and older lay the largest clutches (Brakhage 1965, Cooper 1978), the high mean clutch size in my study could be the result of a majority of nesting geese being fairly old.

Table 17. Comparison of reproductive parameters from selected Canada goose flocks

Location	Mean clutch (all nests)	No. of nests	Nest success (%)	No. of nests	Egg success (%)	No. of eggs
Branta canadensis minima						
Yukon Delta, Alaska	4.2	550	72	814	68	3,459
B. c. interior						
Hudson Bay, Ontario	4.5	272	--	--	75-85	--
B. c. moffitti						
Honey Lake, California	5.5	127	57	418	--	--
Lassen County, California	5.5	330	68	360	71	1,904
Flathead Valley, Montana	5.3	358	61	423	53	1,912
Columbia River, Washington	--	--	70	3,824	--	--
B. c. maxima						
Dog Lake, Manitoba	5.1	93	46	104	51	476
Trimble, Missouri	5.6	147	65	256	73	828
Seney, Michigan	5.1	442	65	643	62	3,095
Crex Meadows, Wisconsin	5.9	172	74	204	--	--

[a]Survival estimated to banding age.

Hatching success (%)	No. of eggs	Mean brood size at nest departure	No. of broods	Est. gosling survival to fledging (%)	No. of goslings	Source
--	--	4.0	205	87	--	Mickelson 1975
--	--	--	--	--	--	Raveling and Lumsden 1977
95	681	5.1	127	--	--	Dow 1943
--	--	4.6	246	--	--	Naylor 1953
95	1,105	4.9	220	81	1,390	Geis 1956
93	14,116	4.9	2,688	--	--	Hanson and Eberhardt 1971
--	--	5.1	48	--	--	Klopman 1958
77	707	4.2	131	68	--	Brakhage 1965
--	--	4.6	417	75	1,289	Sherwood 1966
97	736	5.0	141	--	--	Zicus 1974

Table 17. (Continued)

Location	Mean clutch (all nests)	No. of nests	Nest success (%)	No. of nests	Egg success (%)	No. of eggs
E. Colorado	4.7	379	74	896	--	--
N.E. South Dakota	5.2	248	87	283	78	1,414
Twin Cities, Minnesota	5.6	277	67	332	61	1,730
Marshy Point, Manitoba	5.6	542	75	542	67	2,912
N.W. Iowa 1977	6.1	44	69	54	68	286
N.W. Iowa 1978	6.0	141	82	157	80	839
N.W. Iowa 1977-1978	6.0	185	79	211	77	1,126

Hatching success (%)	No. of eggs	Mean brood size at nest departure	No. of broods	Est. gosling survival to fledging (%)	No. of goslings	Source
--	--	3.7	307	62-84	--	Szymczak 1975
--	--	4.7	213	--	--	Hilley 1976
96	1,089	4.8	220	68	225	Sayler 1977
97	1,871	5.0	373	--	--	Cooper 1978
79	246	5.6	36	>90[a]	288	This study
88	756	5.2	129	73-80[a]	503	This study
86	1,002	5.3	165	73-90+[a]	791	This study

Mean clutch size was higher in ANS than in NNS although not significantly higher (Table 4). Similar results have been reported in Montana (Craighead and Stockstad 1961), Missouri (Brakhage 1965), and South Dakota (Hilley 1976). This could be a result of experienced, older geese occupying safe, desirable ANS before younger geese, forcing the younger geese to nest in NNS.

Clutch size declined as the nesting season progressed (Figs. 5 and 6, Table 4). This is probably due to younger geese initiating nests later in the season (Cooper 1978) and to smaller completed clutches in continuation nests (Cooper 1978). Atwater (1959), Brakhage (1965), and Cooper (1978) have shown that there are no significant differences between the clutch sizes of original nests and renests. The decline in eggs per day (0.15 eggs/day in 1977 and 0.06 eggs/day in 1978) was similar to that found in 2 other studies of Canada geese. At Hudson Bay, Ontario, clutch size declined 0.11 eggs/day and 0.14 eggs/day in 1968 and 1969, respectively (Raveling and Lumsden 1977). At Marshy Point, Manitoba, clutch size dropped 0.17, 0.14, and 0.23 eggs/day in 1969, 1970, and 1971 (Cooper 1978). The decline in Iowa was twice as sharp in 1977 as in 1978 (Figs. 5 and 6). The more gradual decline in 1978 is probably due to a greater number of renests that year.

The length of the nesting season (71 days in 1977 and 85 days in 1978) was similar to those reported for other populations in the north central states. The ranges for 3 studies were 61-69 days in Illinois (Kossack 1950), 64-79 days in Missouri (Brakhage 1965), and 70-80 days in Wisconsin (Zicus 1974). The nesting season is shorter in Canada

(53-61 days at Dog Lake, Manitoba, Klopman 1958 and 50-53 days at Hudson Bay, Ontario, Raveling and Lumsden 1977). At northern latitudes, weather is the most important factor controlling the length of the nesting season because less time is available for renesting. Mid-continental nesting geese have sufficient time for renesting, and the amount that occurs directly affects the length of the nesting season. Although geese were not individually marked for this study, indirect evidence of renesting was obtained. More renesting probably occurred in 1978 and accounts for the longer nesting season. Perhaps fewer geese renested in 1977 because low water levels made most nest sites unattractive to geese.

The nesting success of 79 percent found in this study is higher than that found for most Canada goose populations (Table 17). Nesting success for 63 nests from 1966 through 1970 for this Iowa population was 76 percent (Bishop and Howing 1972). Nesting success was high in my study because most geese nested in the safe, secure ANS (Table 7). Other studies have shown higher nesting success in ANS than in NNS (Craighead and Stockstad 1961, Brakhage 1965, Hilley 1976, Sayler 1977, Cooper 1978).

Desertion was the chief cause of nest failure in this study. Several other studies found desertion to be the major cause of nest failure (Geis 1956, Munro 1960, Hanson and Eberhardt 1971, Ewaschuk and Boag 1972, Hilley 1976, Sayler 1977, Cooper 1978). Desertion occurred most often during laying. Cooper (1978) has also made this observation at Marshy Point, Manitoba. Most studies attribute desertion to intense competition for nest sites or crowded conditions on islands. Cooper

(1978) found a direct linear relationship between nest density and desertion rates. In my study, nearest nesting neighbors were farther away from successful nests than from unsuccessful nests. No information is available on the maximum densities for Canada geese nesting in marshes and utilizing ANS or NNS (mainly muskrat houses). Some information on maximum densities is available for island nesting populations (Munro 1960, Ewaschuk and Boag 1972), but density increased with vegetation density, thus making conclusions difficult. In my study, desertion was greater in ANS than in NNS (Table 7). Cooper (1978) states that the reasons for this are the higher strife and desertion associated with the limited number of preferred nest structures and the inability to find abandoned nests on natural sites. On the principal study area, ANS are abundant, but attractive or suitable ANS (due to placement) may be limited in number. Desertion was greater in 1977 (Table 6). That year low water levels may have limited the number of suitable nest sites.

The egg success of 77 percent determined in this study is higher than that reported for most Canada goose populations (Table 17). Egg success for 63 nests from 1966 through 1970 for this Iowa population was 81 percent (Bishop and Howing 1972). Egg failure and desertion were the main reasons that eggs did not hatch in my study. The differences in egg success between 1977 and 1978 (Table 10) might again be due to a lack of suitable ANS and NNS in 1977 as a result of low water levels. Increased strife at nests could lead to disruption of incubation causing increased embryo deaths and to desertion.

Hatching success (86%) was not as high as has been found for other Canada goose populations (Table 17). The reasons for lower hatching success in this study, particularly in 1977, are not known but could be due, in part, to disruption of incubation.

During this study, second nests added little to overall productivity. The reason for this is that relatively few original nests failed. Cooper (1978) had the same conclusions from his work at Marshy Point, Manitoba where nesting success was also high. Geis (1956) and Brakhage (1965) felt that second nests added significantly to the flock's productivity. In their studies, nest failure was more common, and more geese probably attempted second nests. Second nests could become very important in years when many original nests fail. In my study, there were probably more renests in 1978 than in 1977 (Fig. 4). Again, low water levels in 1977 may have discouraged renesting due to a lack of suitable nest sites. Nest success was low in 1977 (69%), yet little renesting occurred.

The mean brood size (5.3 goslings) at nest departure is higher than that found for other populations of Canada geese (Table 17). This can be explained by the larger clutches found during this study. The difference between mean brood size in 1977 and 1978 is a result of a greater proportion of clutches greater than or equal to 6 eggs in 1977 than in 1978 (Table 4). The significant difference in mean brood size between ANS and NNS, despite the insignificant difference in clutch size between the two, is a result of increased hatching success in ANS. This may be due to better temperature insulating qualities in ANS.

Gosling Habitat Use and Survival

During this study, mudflat shorelines and man-made islands were an important component of brood rearing habitat. Broods made extensive use of mudflats in 1977. In 1978 the few available mudflats also were used by broods. Dill and Lee (1970) reported that sandbars and mudflats are preferred areas due to their proximity to succulent, green plants for foraging and to water for escape. In 1978 many broods made use of man-made islands for loafing and roosting. Brakhage (1965) reported similar use of small islands by broods in Missouri. Along the Columbia River in Washington, popular brood rearing areas had gently sloping shorelines, were free from human disturbance, and had a nearby abundance of pasture grasses (Hanson and Eberhardt 1971). Hanson (1965) stressed the importance of bluegrass (*Poa pratensis*) as food for both adults and goslings. In Iowa, several brood rearing areas were adjacent to uplands containing bluegrass.

Several brood rearing areas were used both years indicating that their use may be traditional. Other studies have found that some areas attract large numbers of goslings every year (Williams and Marshall 1938, Geis 1956, Hanson and Eberhardt 1971, Szymczak 1975). These areas contained the previously mentioned characteristics of preferred brood rearing habitat. Szymczak (1975) also noted that broods moved from small wetlands to traditional locations on large impoundments. In Iowa, broods typically moved from densely vegetated wetlands to less vegetated, more permanent wetlands.

Creches or gang broods were common both years of the study. Creches were especially large at the traditional brood rearing areas. This has been noted by others (Geis 1956, Brakhage 1965, Warhurst 1974). Creching did not seem to increase gosling mortality. In an intensive study of Canada goose creching behavior in Ohio, creches had survival value because the largest creches were extremely wary (Warhurst 1974). Creches also offered protection from predation, exposure, or accident for goslings that were separated from their own brood or had wandered away.

Gosling survival in this study (73-90+%) was in the range reported for other studies (Table 17), weather being the major mortality factor. More cold, rainy weather occurred in 1978, causing increased mortality over that found in 1977. In Missouri, predation and hail storms accounted for most of the gosling mortality (Brakhage 1965). Geis (1956) found that predation as goslings were being led to brood rearing areas caused most mortality.

Nest Site Selection

During this study, Canada geese primarily nested in ANS. This was due to the low water levels or absence of water in many wetlands, particularly in 1977, and the scarcity of muskrat houses. Muskrat houses and natural islands have been shown to be preferred NNS (Kossack 1950, Geis 1956, Hammond and Mann 1956, Klopman 1958, Munro 1960, Hanson 1965, Hanson and Eberhardt 1971, Ewaschuk and Boag 1972, Zicus 1974, Mickelson 1975, Hilley 1976, Raveling and Lumsden 1977, Cooper 1978).

In Iowa, use of ANS varied with habitat and structure type (Table 13). Elevated barrels in Class IV-2 wetlands and floating barrels in Class IV-3 wetlands received the highest use. In northeastern South

Dakota, elevated platforms contained the most nests, with the greatest number in all ANS being found in Class IV-3 wetlands (Hilley 1976). I found the highest use of all ANS in Class IV-2 wetlands. The Class IV-2 wetland, or hemi-marsh, has been shown to be preferred habitat for certain waterfowl species (Flake et al. 1977) and marsh birds (Weller and Spatcher 1965).

Percent use of all ANS during the study (26%) was similar to that found in northeastern South Dakota (Hilley 1976) and Montana (Craighead and Stockstad 1961). Percent use of ANS was 59-68 percent in Colorado (Will and Crawford 1970), 15-53 percent in California (Rienecker 1971), 52-53 percent in Wyoming (Bone 1973), and 55 percent in Manitoba (Cooper 1978). The lower use of ANS in my study may be due to reduced water levels and the small amount of wetland habitat in the preferred hemi-marsh vegetation stage.

Little quantitative information is available on the factors that affect nest site selection, particularly ANS selection, by Canada geese. Discriminant function analysis has been used to determine which factors were important for distinguishing between used and unused ANS in north-eastern South Dakota (Hilley 1976) and between used and unused muskrat houses and natural islands in southeastern Michigan (Kaminski and Prince 1977). In my study, discriminant function analysis was used to obtain similar information for elevated barrels and nest baskets, floating barrels, and man-made islands.

Wetland cover class and occurrence of surrounding water were the most important characteristics separating used from unused elevated structures (Table 14). Wetland area and pair density were most important in separating used from unused floating barrels (Table 15). Distance to permanent water, wetland area, and ANS density best discriminated used from unused man-made islands (Table 16). Hilley (1976) found that water depth, number of nests on the wetland, and density of surrounding cover were the best variables separating used from unused ANS Width of muskrat house top and percent slope of island relief were the best discriminators for those 2 nest types (Kaminski and Prince 1977).

The average characteristics of used and unused elevated barrels and nest baskets, floating barrels, and man-made islands are listed in Tables 14, 15, and 16. From these, generalizations can be made about the characteristics of all 3 types of ANS selected by Canada geese.

A wetland cover class between 2 and 3 had the highest use for all 3 ANS types. This is probably important in reducing territorial strife by maintaining some visual isolation of the activities of the breeding pairs.

ANS on smaller wetlands received more use. Smaller wetlands may provide more protection from wind and waves than larger wetlands.

Used elevated structures and man-made islands tended to be surrounded by less dense vegetation than unused structures. This further supports the evidence that Canada geese prefer nest sites offering good visibility (Williams and Sooter 1940, Geis 1956, Hammond and Mann 1956, Klopman 1958, Hilley 1976, Kaminski and Prince 1977, Cooper 1978).

Nearly all ANS that were used were surrounded by water. The preference that Canada geese have for islandlike situations seems to be true also for ANS. Hilley (1976) found that use of ANS increased when they were in deeper water.

Nest heights of used ANS were slightly lower than those of unused structures. Craighead and Stockstad (1961) found higher nest platforms were more attractive nest sites. Brakhage (1965) found no relationship between nest height and use.

Used ANS were typically closer to open water than unused ones. This characteristic of Canada goose nest sites has been observed by others (Williams and Nelson 1937, Kaminski and Prince 1977, Cooper 1978).

Distances to nearest shoreline were greater for used floating barrels and man-made islands than those unused structures, but similar for used and unused elevated barrels and nest baskets. Kaminski and Prince (1977) found that used islands were farther from shore than unused islands. Structures that are farther from shore probably offer greater security from predation.

Used elevated structures were closer to permanent water than unused ones. The reverse was true for man-made islands. Since broods traveled as far as 1.6 km, ANS will probably receive highest use when placed no farther than that distance from permanent water.

Used elevated structures and floating barrels tended to be found on wetlands with higher densities of successful pairs. This has been noticed by Rienecker (1971) and Hilley (1976). This indicates that geese will readily utilize ANS when pair densities are high. It is not known how high densities of pairs using ANS can be before intraspecific strife reduces production and ANS use.

The results concerning ANS density and its effect on ANS use are not clear. Elevated structures received more use on wetlands with higher densities of ANS. There is no apparent difference in ANS density between used and unused man-made islands, despite this variable being third in importance for discriminating between the two (Table 16).

MANAGEMENT RECOMMENDATIONS

The northwestern Iowa Canada goose flock is highly productive. Because of this, the factor ultimately limiting this flock's expansion will be the amount of breeding habitat. Wetlands in northwestern Iowa should be placed in public ownership whenever possible to insure their availability for nesting geese. In order to maximize goose production on existing wetlands, further research will be necessary to determine the effects of high pair density, high ANS density, social interactions, and wetland cover on production and ANS use.

More research is needed to determine the age structure of the breeding population. Recruitment of new cohorts into the breeding population may be limited due to the competition for nest sites among older geese. The number of geese that return to northwestern Iowa to breed their first year is not known. Individually marking a segment of each year's hatch with neck-bands will enable researchers to examine these questions.

Wetland management for the breeding population should emphasize maintenance of the hemi-marsh or Class IV-2 wetland. Evidence from this study indicates that the hemi-marsh supports higher densities of nesting pairs and has higher percentages of ANS receiving use. Where water levels can be controlled, those marshes that become more open than a Class IV-3 wetland should be drawn down to allow re-vegetation. Basic wetland management should then follow that suggested by Linde (1969) and the Atlantic Flyway Council (1972).

Upland management for the Canada goose breeding population should emphasize intensive management at traditional brood rearing areas. If these areas occur on private lands, they should be purchased or leased when possible and fenced off from surrounding private land to maintain control of gosling movements. Brood rearing uplands should be maintained in pasture-like conditions by seeding to bluegrass and mowing only as often as necessary to maintain succulent growth. An alternative to this might be seeding brood rearing uplands to an alfalfa-brome mixture that would also provide some nesting cover for ducks. If the number of goslings becomes too large in one area, new brood rearing areas may be established by seeding to bluegrass to attract broods.

The use of ANS should be continued, particularly in years of very low water levels or few muskrat houses. New ANS and old ones that do not receive use should be placed in the wetland according to the specifications determined in this study.

Elevated barrels should be placed in openings in the marsh vegetation, ideally, about 40 m from the nearest shoreline. They should be in locations that will surround them with water in all but the driest years, and the barrel should be about 140 cm above the average water level. Best results should occur when elevated barrels are placed no farther than 275 m from permanent water and in wetlands smaller than 60 ha.

Floating barrels should be placed in wetlands no larger than 100 ha unless they are placed in areas sheltered from prevailing winds. They should also be about 40 m from the nearest shoreline.

Man-made islands should be constructed about 40 m from the nearest shoreline in openings in the marsh vegetation where they will be surrounded by water in all but the driest years. Man-made islands should be seeded to bluegrass to control erosion yet provide good visibility for nesting geese. Islands seeded to bluegrass also will be attractive to goslings as loafing and roosting sites. Best results will probably occur when man-made islands are placed no farther than 275 m from permanent water and in wetlands smaller than 50 ha.

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