1976

Productivity of A Resident Giant Canada Goose Flock in Northeastern South Dakota

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PRODUCTIVITY OF A RESIDENT GIANT CANADA GOOSE FLOCK IN NORTHEASTERN SOUTH DAKOTA

BY

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A thesis submitted in
partial fulfillment of the requirements for
the degree Master of Science, Major in
Wildlife and Fisheries Science
South Dakota State University

1976

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SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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ACKNOWLEDGMENTS

I am sincerely grateful to my graduate advisor, Dr. Raymond L. Linder, Leader, South Dakota Cooperative Wildlife Research Unit, for his assistance during my study and in thesis preparation and review. I also wish to thank Dr. Frank Schitoskey Jr., Dr. Paul A. Vohs Jr., and Thomas L. Kuck for assistance in manuscript editing. I am also grateful to Dr. W. Lee Tucker for his help with the statistical portions of this project and in thesis review.

I am especially grateful to my fellow graduate student, Thomas C. Tacha, for his help and support throughout the project and thesis preparation. His help and advice were invaluable.

I would like to thank the personnel of the South Dakota Department of Game, Fish and Parks, especially the Webster District Office for advice and assistance during the study. Appreciation is also extended to the personnel of Waubay National Wildlife Refuge for their assistance with the project field work.

Lastly, I would like to thank my wife, Marty, for her support and encouragement throughout the project. I could not have accomplished this project without her help.

Financial support was provided by Pittman-Robertson funds W-75-R through the South Dakota Cooperative Wildlife Research Unit. Cooperators include the South Dakota

Department of Game, Fish and Parks, South Dakota State University, the Wildlife Management Institute and the U.S. Fish and Wildlife Service.

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PRODUCTIVITY OF A RESIDENT GIANT CANADA GOOSE FLOCK IN NORTHEASTERN SOUTH DAKOTA

Abstract

J. David Hilley

A 2-year study (1974-1975) of a resident Canada goose (Branta canadensis maxima) flock is reported. Twenty-four percent of the artificial nest structures (ANS) available were used by nesting geese. Artificial nesting structures, islands, muskrat houses and peninsulas were used by geese as nesting sites. Mean clutch size of completed nests was 5.14 in 1974 and 5.26 in 1975. Mean clutch size was 5.38 on ANS and 4.89 on NNS for the 2-year study. At least one egg hatched in 87 percent of the 283 nests located during the study. Larger clutches had a higher hatchability. Nest success was greater on ANS than NNS (X^2 21.001, $P < .01$, 1 d.f.). The main cause of unsuccessful nests was desertion by the nesting pair. Predation and flooding were not major factors in determining nest success. Overall hatching success was 78 percent of 1414 eggs. Nests on ANS had a higher percent hatchability than nests on NNS. Eggs in 213 nests produced 1003 goslings during the study. Mean initial brood size was 4.75 in 1974 and 4.67 in 1975. The relationship between public versus private ownership of land and nest success was significant

(X^2 6.030, $P<.05$, 1 d.f.) in 1974 but not significant in 1975. Discriminant analysis of 18 factors associated with nesting indicated that water depth, number of nests on wetland and density of surrounding cover were the most important variables in determining use or nonuse of an ANS.

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INTRODUCTION

Giant Canada geese (*Branta canadensis maxima*) nested in northeastern South Dakota prior to 1900 but by 1950 they were considered extinct (Delacour 1954). Excessive hunting and egg gathering by early settlers were among the causes leading to their decline (Lengkeek 1973).

Examination of a Canada goose flock in Rochester, Minnesota resulted in the rediscovery of the giant Canada goose by Harold C. Hanson of the Illinois Natural History Survey in 1962 (Hanson 1965). Subsequent examination of other Canada goose flocks in the Great Plains states revealed that substantial numbers of the subspecies still existed.

In 1937, 30 Canada geese of breeding age were reintroduced to the Waubay National Wildlife Refuge in Day County, South Dakota. These geese were donated by a local hunting guide, Mr. Jack Rommel, from a pinioned decoy flock he maintained (Drewien and Johnson 1968). These birds, which were descended from eggs gathered from the wild in the early 1900's, were later classified as the giant subspecies (Hanson 1965). More breeders were added to the flock over the years and a program for the release of free-flying young was initiated (Drewien and Johnson 1968). The population grew to approximately 2000 birds by fall, 1973.

My study was initiated in 1974 to measure: (1) Productivity of the resident giant Canada goose flock in northeastern South Dakota and (2) Use of public versus private land and artificial nest structures (ANS) versus natural nest sites (NNS) for nesting by the geese.

STUDY AREA

The study area of 9101 km^2 includes all of Marshall and Day counties, Clark County north of U.S. Highway 212, Codington County north of U.S. Highway 212 and west of U.S. Highway 81, Grant County west of U.S. Highway 81 and Roberts County west of U.S. Highway 81 and South Dakota Highway 15. The area is located within a glaciated highland area, 485-605 m in elevation, between the James River Lowland and the Minnesota-Red River Lowland (Westin et al. 1967).

The study area is located within the region known as the prairie potholes (Smith et al. 1964). The topography is nearly level to rolling and the land is covered with glacially formed depressions. These depressions have collected water to form the lakes and marshes used by the Canada geese. Soils of the region consist of clays, silts and loam till that developed as a result of the late Wisconsin glacial drift (Westin et al. 1967).

Oosting (1948) classified the region as the Tall Grass Prairie association of the Grassland formation. Dominant plant species include big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), switch-grass (*Panicum virgatum*), and indian grass (*Sorghastrum nutans*) (Johnson and Nichols 1970). Major land uses are cow-calf operations and small grain farming.

Climate is typical of the northern Great Plains, characterized by wide variations in summer and winter temperatures. Annual average mean temperature is 5.5 C, varying from a monthly mean of -12.2 C in January to 21.1 C in July (Spuhler et al. 1971). Temperature extremes of -40.5 C and 42.7 C have been recorded for Webster, South Dakota, in the study area (Drewien and Johnson 1968). Average annual precipitation is 50.9 cm., varying from 1.3 cm. in January to 10.2 cm. in June (Spuhler et al. 1971). Most of the precipitation falls within the 125-day average growing season.

METHODS AND MATERIALS

Areas where geese had nested in earlier years were searched to locate as many nests as possible. A news release was used to solicit information on nest locations from the public in 1974. Personnel of the Soil Conservation Service, South Dakota Department of Game, Fish and Parks and Waubay National Wildlife Refuge were also requested to report nest sites encountered.

Each nest was classified as an artificial or natural nest site. Artificial nesting structures (ANS) have been provided on Waubay Refuge since 1958 and on state-owned land since 1961 (Drewien and Johnson 1968). Four basic types were used: (1) a wire frame containing two bales of hay or flax straw supported by four steel fence posts; (2) circular fiberglass platforms, mounted on tubular metal poles; (3) upended cylindrical, 8-feet tall, flax-straw bales, wrapped in polyurethane rope; and (4) man-made earthen islands.

All ANS in the study area were examined to determine usage. Since Canada geese show a preference for islands as nest sites (Geis 1956, Klopman 1958), islands were also examined for nests.

Each nest was visited twice during the nesting season. Clutch size and date of nest initiation were collected on the first visit. Time of nest initiation was determined by counting eggs, multiplying 1.5 days per egg (Kossack 1950, Brakhage 1965) and counting backward from the date of visit. Number of eggs hatched and nest success were recorded on the second visit. Duration of visits to the nest was minimized to reduce desertion or location of the nest by predators because of human activity.

Eighteen factors were measured in 1975 on 221 ANS to determine why nesting geese used a particular ANS in preference over other ANS in the study area (Table 1). Because of the importance of islands to nesting geese, nesting variables were also measured at nest sites on natural islands in an attempt to determine nest site preferences (Table 2). A rating, on a 1-7 scale, was assigned to factors 14-18 (Table 1) and 8-11 (Table 2) to allow statistical analysis.

Land ownership was determined for each nest to estimate the relative importance of private land and public land to nesting geese. A random sample of 460 quarter-section plots was searched to provide statistical basis for estimating value of public versus private land for nesting geese.

Table 1. Factors measured relative to each artificial nest structure, 1975.

1.	Height above water
2.	Water depth (at nest)
3.	Distance to nearest active farmstead
4.	Distance to open water
5.	Distance to emergent vegetation
6.	Distance to nearest nest
7.	Distance to open shore
8.	Height of surrounding cover
9.	Acres of open water
10.	Acres of wetland
11.	Percentage of surface water
12.	Percentage of open water
13.	Number of nests on wetland
14.	Degree of lake use by man
15.	Density of surrounding cover
16.	Structure condition
17.	Degree of muskrat use on wetland
18.	Visibility (at nest height)

Table 2. Factors measured relative to each nest site on natural islands, 1975.

1. Distance to nearest active farmstead
2. Distance to open water
3. Acres of open water
4. Acres of wetland
5. Percentage of surface water
6. Percentage of open water
7. Number of nests on wetland
8. Degree of lake use by man
9. Density of surrounding cover
10. Degree of muskrat use on wetland
11. Visibility (at nest height)
12. Size of island
13. Number of nests on island
14. Distance to nearest nest
15. Depth of water to nearest shore
16. Distance to nearest shore
17. Evidence of predators

RESULTS AND DISCUSSION

Nesting Phenology

Giant Canada geese are among the first waterfowl to return each spring to the study area. They often precede other waterfowl species by several weeks, arriving when the lakes are still ice bound. Arrival usually occurs in early March on the Waubay NWR and varied from 24 February to 19 March for the period of 1969-75 (Ed Fromelt, U.S. Fish and Wildlife Service, Waubay NWR, personal communication). Dates of arrival for Canada geese at Seney NWR, Michigan, in the spring are generally early March and not later than March 30 (Hanson 1965). Seney NWR has a similar latitude to the study area.

Of 150 nests found in 1974, 115 were found prior to hatching of the eggs. In 1975, 133 nests were located prior to hatching of the eggs.

Peak of nest initiation, based on 20 nests, with known time of initiation, was April 8-14 for 1974 (Fig. 1). Peak hatch in 1974 of 13 known nests was May 15-21 (Fig. 2). The peak of initiation for 25 nests was April 29-May 5 in 1975 and peak hatch was June 4-10 of 20 known nests. The nest initiation curve for 1974 was considered comparable to that reported in Wisconsin by Collias and Jahn (1959).

Fig. 1. Chronology of nest initiation by giant Canada geese, 1974-1975.

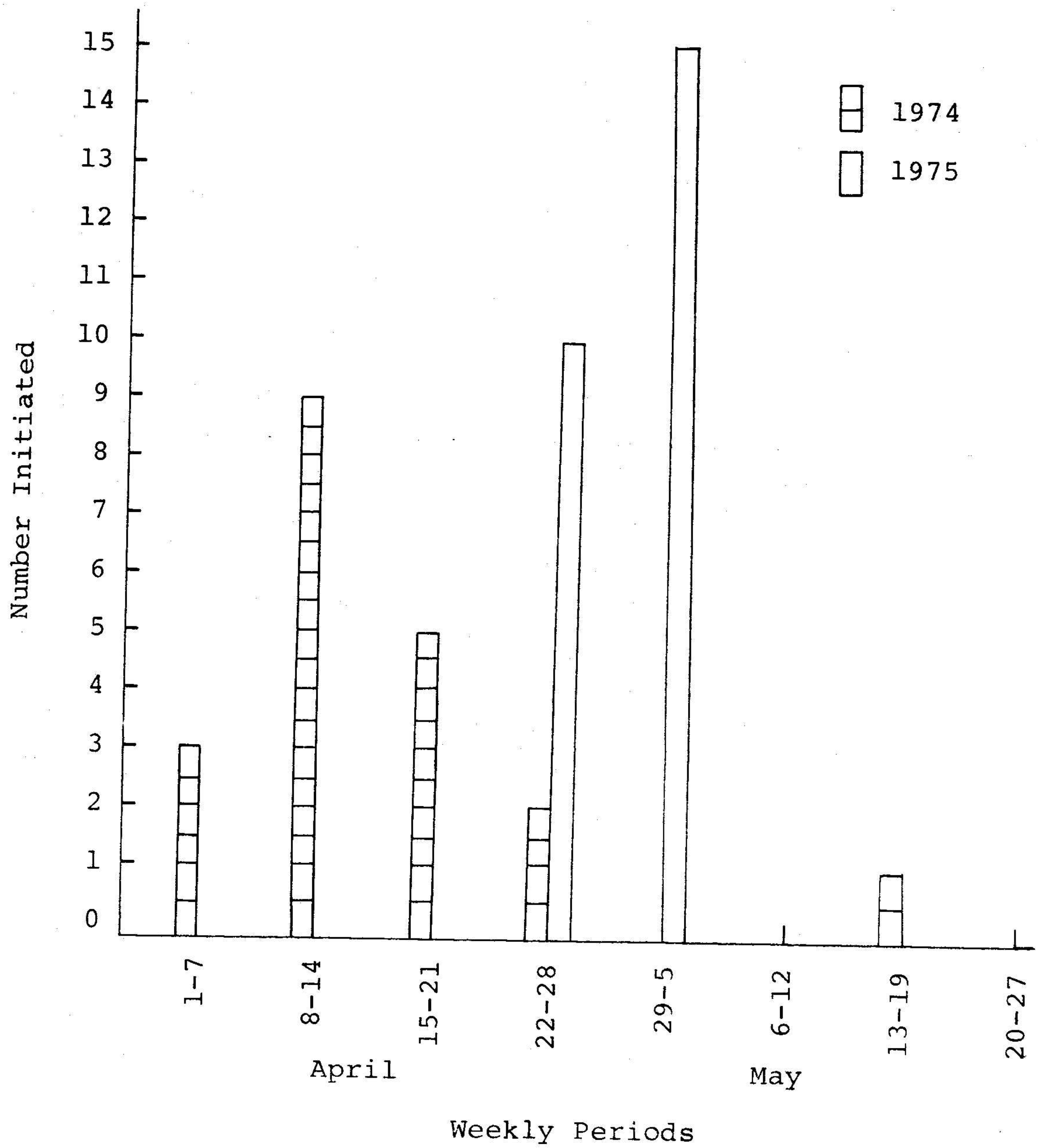
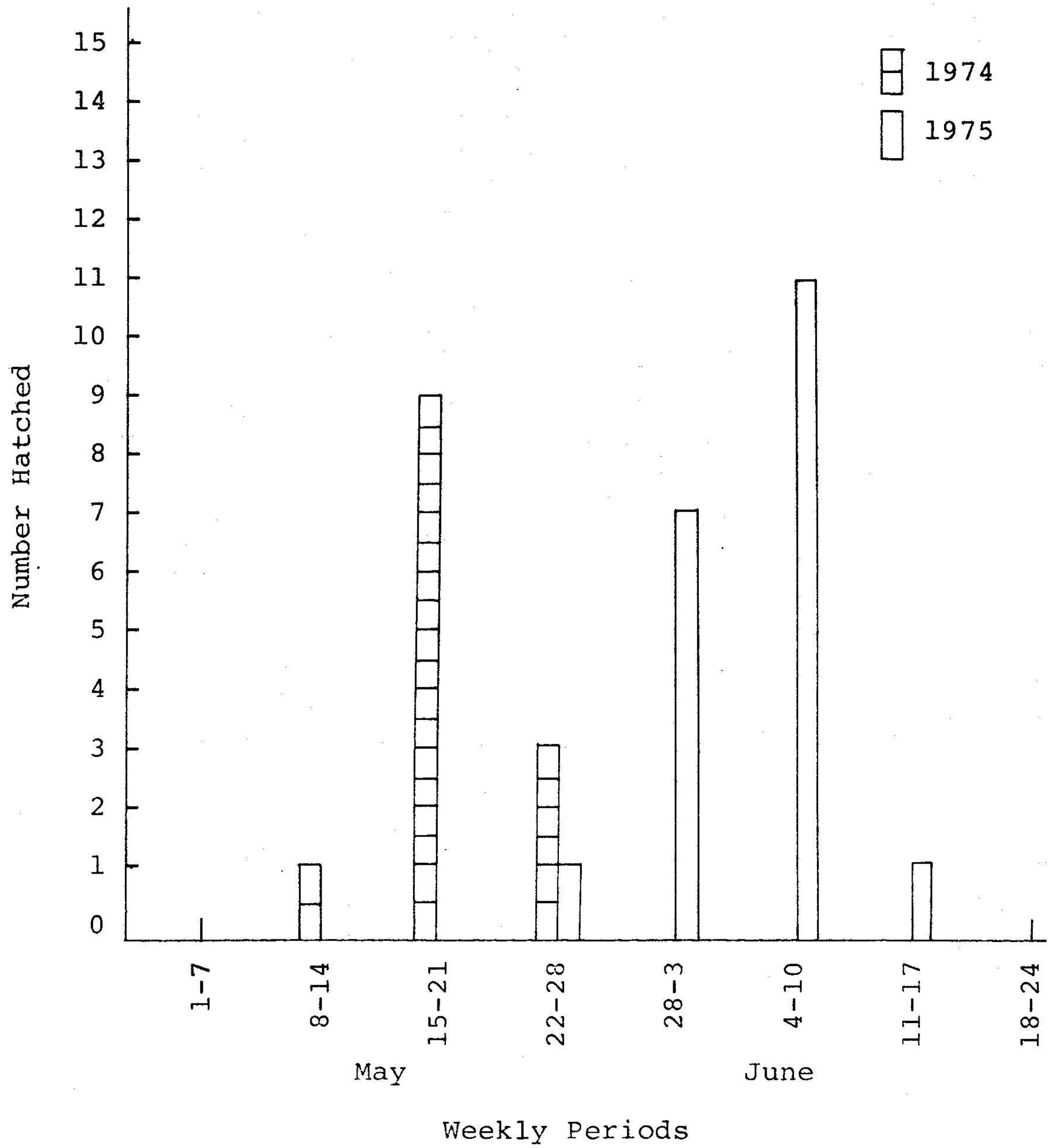


Fig. 2. Chronology of hatching by giant Canada geese, 1974-1975.



Nest Locations

The breeding population of Canada geese in northeastern South Dakota appeared to be concentrated in three major lake regions: Bitter Lake, Day County; Kettle Lake, Marshall County; and Waubay Lake, Day County. A smaller concentration was located in the Drywood Lake area, Roberts County.

Twenty-four percent (90) of 369 ANS was used by nesting geese in 1974 (Table 3). The number of ANS was reduced to 354 in 1975 and 26 percent (93) was used by nesting geese.

The second largest number of nests was located on islands. Thirty-four percent (51) of the nests in 1974 and 27.8 percent (37) of the nests found in 1975 were located on islands (Table 3). Geis (1956), Vermeer (1970), and Lengkeek (1973) also indicated heavy use of islands by nesting geese. Hammond and Mann (1956) reported that freedom from disturbance, high ratio of water-to-land edge and readily available food, water, nesting cover and loafing sites were important factors available to geese nesting on islands.

The size of nine islands used by geese in 1975 ranged from .04-1.9 ha, with an average size of .5 ha. Distance from the island to the nearest shore ranged from 36.6 m to 274.5 m with a mean distance of 112.1 m. Average water depth to the nearest shore was .5 m for the nine

Table 3. Location of nest sites utilized by giant Canada geese in northeastern South Dakota, 1974-1975.

Location	Number of nests			Percent of nests		
	1974	1975	Total	1974	1975	Total
Islands	51	37	88	34.0	27.8	31.1
Peninsula		2	2		1.5	0.7
Shore	1		1	0.7		0.4
Artificial Structures						
Man-made Islands	5	6	11	3.3	4.5	3.9
Round Straw Bales	3	6	9	2.0	4.5	3.2
Fiberglass Platforms	12	17	29	8.0	12.8	10.2
Fence Post Platforms	70	64	134	46.7	48.1	47.3
Muskrat Houses	8	1	9	5.3	0.8	3.2
Total	150	133	283	100.0	100.0	100.0

islands. The average distance between nests was 19.7 m, excluding those nests on wetlands containing no other goose nests.

Nest density varied between islands and between years on islands. Two islands in the Kettle Lake area had high nest densities both years. A 1.9 ha island contained 14 nests in 1974 and 16 nests in 1975. A smaller island (.70 ha) contained 11 nests each year during the study.

Eighteen nests were located on one island (approx. 1.9 ha) in Opitz Lake, in 1974, and no nests were found on the same island in 1975. No explanation was apparent for the difference since 15-20 pairs of geese were observed on the island several times during the 1975 breeding season. The only major physical difference noted was a lower water depth surrounding the island in 1975. Hammond and Mann (1956) noted that geese prefer to nest in locations where predators are avoided. The lower water levels may have allowed predators access to the island in Opitz Lake, as indicated by the abundance of raccoon tracks.

Nine nests (3.2 percent) were located on top of muskrat (Ondatra zibethicus) houses during the study period. Steel et al (1957) reported that muskrat houses were used as nest sites by Canada geese in Idaho. Two nests (0.7 percent) were found on peninsulas during the study. Atwater (1959) found nests on peninsulas when islands were not available. Only one nest (0.4 percent) was found on a wetland shoreline during the 2 year period.

Wetland classification followed the method of Stewart and Kantrud (1971). Class IV wetlands contained 80 nests (67.8 percent) and Class V contained 35 nests (29.7 percent) of the 118 nests measured in 1975 (Table 4). Three nests (2.5 percent) were located on Class III wetlands. No goose nests were located on Class I and Class II wetlands.

Clutch Size

Clutch size was calculated from eggs found in completed clutches (Table 5). Mean clutch size was higher in nests in ANS than in nests in NNS (Table 5). Brakhage (1965), in Missouri, found mean clutch size of 5.5 for elevated nest structures and 4.6 for nests on the ground.

Mean clutch size varied between successful and unsuccessful nests. For unsuccessful nests, the mean clutch size was 4.18 and 3.85 for 1974 and 1975, respectively. Mean clutch size, on successful nests only, was 5.36 for 1974 and 5.42 for 1975.

Larger clutches had a higher hatchability than smaller clutches. Hatchability of clutches with four eggs or less was 70 percent in 1974 and 72 percent in 1975, while clutches, for the same period with five or more eggs had a hatchability of 70 and 94 percent. Lengkeek (1973) has also shown a higher hatchability for eggs in larger clutches.

Table 4. Wetland classes used by giant Canada geese for nesting in northeastern South Dakota, 1975.

Classification	Nests on ANS		Nests on NNS	
	Number	Percent	Number	Percent
Class I and II	No goose nests found on these classes			
Class III				
Cover type 1	2	2.5		
2				
3	1	1.3		
4				
Class IV				
Cover type 1	7	8.8		
2	7	8.8		
3	56	70.9	9	23.1
4	1	1.3		
Class V				
Cover type 3	1	1.3		
4	3	3.8	30	76.9
Dugout	1	1.3		
Total	79	100.0	39	100.0

Table 5. Clutch size for giant Canada goose nests in northeastern South Dakota, 1974-1975.

	1974			1975		
	ANS	NNS	Combined	ANS	NNS	Combined
Number of nests	67	48	115	93	40	133
Mean clutch size	5.40	4.77	5.14	5.36	5.02	5.26
Standard Deviation	1.41	1.72	1.57	1.48	1.76	1.57
Standard Error	± .17	± .25	± .15	± .15	± .28	± .14
Range	2-9	1-11	1-11	1-10	1-9	1-10

Brakhage (1965) suggested that larger clutches may result from older birds with more nesting experience.

Nesting Success

At least one egg hatched in 247 (87 percent) of the 283 nests located during the 2 years (Table 6). Nest success was 90 percent for 1975 and 85 percent for 1974. The 87 percent overall nest success for this study was higher than the nest success reported by Brakhage (1965) and Lengkeek (1973) for other flocks of *B. c. maxima*.

Chi-square tests showed a highly significant difference ($P < .01$) between nest success of ANS and NNS for both 1974 and 1975 (Table 7). A higher proportion of artificial nest sites contained successful nests when their distribution was compared to that of natural nest sites (Table 8). Brakhage (1965) reported 73 percent success for geese nesting in elevated tubs and only 47 percent in natural nest sites. Rienecker (1971) found 98 percent success on ANS compared to 69 percent on ground nesting geese in California.

Desertion was the main cause of unsuccessful nests during the 2 year period (Table 7). Geis (1956), and Hanson and Eberhardt (1971) also found desertion to be a major factor contributing to nest failure. NNS had higher desertion rates than ANS in both 1974 and 1975. Crowding and territorial strife may have been contributing factors to nest desertion since the majority of the natural nest sites were located on islands. Hanson and Browning (1959)

Table 6. Fate of giant Canada goose nests in northeastern South Dakota, 1974-1975.

Nest Fate	Number of nests			Percent of nests		
	1974	1975	Combined	1974	1975	Combined
Hatched	127	120	247	84.6	90.2	87.3
Deserted	18	8	26	12.0	6.0	9.2
Destroyed						
Avian Predator	1	1	2	0.7	0.8	0.7
Mammalian Predator	1	3	4	0.7	2.2	1.4
Unknown Predator	2	1	3	1.3	0.8	1.1
Flooded	1		1	0.7		0.3
Total	150	133	283	100.0	100.0	100.0

Table 7. Chi-square tests for nest success or failure of giant Canada geese, on ANS versus NNS, in northeastern South Dakota, 1974-1975.

Type of Nest	Fate of Nest		Chi-square at 1 d.f.
1974			
	Success	Failure	
ANS	83	7	9.894**
NNS	44	16	
1975			
	Success	Failure	
ANS	89	4	10.504**
NNS	31	9	
1974-1975			
	Success	Failure	
ANS	172	11	21.001**
NNS	75	25	

**=Highly Significant ($P<.01$)

did not feel that crowding contributed to nest abandonment. However, Rienecker (1971), in California, felt that territorial conflicts, resulting from crowding on preferred islands, did contribute to desertion.

Predation was not a major factor in determining nest success. Nine nests were destroyed by predators in the 2 year study period; six were on artificial nest structures. Brakhage (1965) found a higher rate of predation on nests located on the ground than on nests in elevated tubs. In my study the majority of natural nests were found on islands which may account for the lower rate of predation.

Raccoons (*Procyon lotor*) and striped skunks (*Mephitis mephitis*) were found to be the major mammalian nest predators. Two nests on elevated structures were destroyed by avian predators. Ring-billed gulls (*Larus delawarensis*) were suspected predators because of their presence in the vicinity of both destroyed nests. Hammond and Mann (1956) reported gulls (*Larus* spp.) as nest predators on unattended goose nests.

Flooding of nest sites was not as important in this study as in studies by Miller and Collins (1953), and Lengkeek (1973). Only one nest was classified as destroyed by flooding in the 2-year period.

Success of Eggs

Overall hatching success was 78 percent of 1414 eggs in 283 nests (Table 9). This percentage was calculated

Table 8. Fate of giant Canada goose nests on ANS and NNS in northeastern South Dakota, 1974-1975.

Fate of nests	Nests on ANS				Nests on NNS			
	1974		1975		1974		1975	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Hatched	83	92.3	89	95.7	44	73.3	31	77.5
Deserted	3	3.3	2	2.1	15	25.0	6	15.0
Destroyed								
Avian Predator	1	1.1	1	1.1				
Mammalian Predator	1	1.1					3	7.5
Unknown Predator	2	2.2	1	1.1				
Flooded					1	1.7		
Total	90	100.0	93	100.0	60	100.0	40	100.0

Table 9. Fate of giant Canada goose eggs in northeastern South Dakota, 1974-1975.

Egg Fate	Number of eggs			Percent of eggs		
	1974	1975	Combined	1974	1975	Combined
Hatched	545	561	1106	76.3	80.1	78.2
Destroyed						
Avian Predator	6	13	19	0.8	1.9	1.4
Mammalian Predator	2	14	16	0.3	2.0	1.1
Unknown Predator	14	5	19	2.0	0.7	1.4
Broken by Hen	2	2	4	0.3	0.3	0.3
Abandoned	141	105	246	19.7	15.0	17.3
Flooded	4		4	0.6		0.3
Total	714	700	1414	100.0	100.0	100.0

using all known nests, including those where clutch size and hatch were approximated. The hatchability found in this study is lower than that reported by Dow (1943) and Hanson and Browning (1959), but slightly higher than that found by Brakhage (1965).

Hatchability varied between ANS and NNS, with ANS having the higher percent hatchability (Table 10). Brakhage (1965) found a higher percentage of eggs hatching from ground nests (77 percent) compared to elevated artificial structures (72 percent).

The greatest egg loss was attributed to abandonment. Abandonment accounted for the loss of 246 eggs (17.3 percent) during the study period. Predation was responsible for the loss of 54 eggs (3.9 percent) during the study period. Loss of eggs from flooding and breakage by the hen was minimal.

Gosling Production

Eggs in 213 nests produced 1003 goslings during the study. Only successful nests where the clutch size and the number of eggs hatched were known were included in this total. Mean initial brood size for all broods was comparable both years (Table 11). Drewien and Johnson (1968) reported an overall mean brood size of 4.3 goslings while clutches on elevated artificial structures averaged only 3.6 goslings per brood.

Five goslings were found dead in artificial nesting structures during the study period. Four appeared to have

Table 10. Fate of giant Canada goose eggs on ANS and NNS in northeastern South Dakota, 1974-1975.

Egg Fate	ANS				NNS			
	Number		Percent		Number		Percent	
	1974	1975	1974	1975	1974	1975	1974	1975
Hatched	367	419	84.0	84.0	178	142	64.3	70.6
Destroyed								
Avian Predator	6	13	1.4	2.6				
Mammalian Predator	2		0.5			14		7.0
Unknown Predator	12	5	2.7	1.0	2		0.7	
Broken by Hen	2	1	0.5	0.2		1		0.5
Abandoned	48	61	10.9	12.2	93	44	33.6	21.9
Flooded					4		1.4	
Total	437	499	100.0	100.0	277	201	100.0	100.0

Table 11. Initial brood size of giant Canada geese from successful nests in northeastern South Dakota, 1974-1975.

	All Nests		ANS		NNS	
	1974	1975	1974	1975	1974	1975
Number of nests	93	120	60	89	33	31
Mean	4.75	4.67	5.03	4.71	4.24	4.58
Standard Deviation	1.63	1.62	1.58	1.55	1.60	1.84
Standard Error	± .17	± .15	± .20	± .16	± .28	± .33
Range	1-9	1-8	1-9	1-7	1-6	1-8

been trampled. The fifth gosling was found dead in a crevice between the straw bales on the structure.

Public versus Private Land

Chi-square tests indicated a significant ($P < .05$) relationship between land ownership (public versus private) and nest success in 1974, but the relationship was not significant in 1975 (Table 12). The lack of a consistent trend between years precluded further analysis of these data.

A survey of the 460 quarter-section plots revealed that 285 plots contained no habitat for nesting geese. The remaining 175 plots were searched and 11 nests were found; 6 on public and 5 on private land. Analysis showed the survey to be invalid for testing the value of public versus private land for nesting geese because of the concentration of breeding geese into certain areas. To be valid the sample should be stratified to account for the uneven distribution of geese.

Nesting Factors

A stepwise discriminant analysis was used to evaluate 18 variables associated with nesting on 221 ANS and to show whether an increase or decrease of the individual variables influenced the use of the ANS (Table 13).

Using the variables listed (Table 13), the analysis predicted that an ANS would be used or unused and compared this classification with the actual usage of the structure.

Table 12. Chi-square tests for nest success or failure of giant Canada geese on public versus private land in northeastern South Dakota, 1974-1975.

Fate of Nest	Land Ownership		Chi-square at 1 d.f.
1974			
	Public	Private	
Success	84	43	6.030*
Failure	9	14	
1975			
	Public	Private	
Success	84	36	3.049 n.s.
Failure	6	7	

*=Significant (P<.05)

n.s.=Not Significant

Table 13. Variables associated with nests of Canada geese, in order of importance for use or nonuse of 221 ANS in northeastern South Dakota, 1975, as determined by discriminant analysis.

Relationship[a]	Variable
+	Water depth
+	Number of nests on wetland
-	Density of surrounding cover
-	Degree of lake use by man
+	Structure condition
o	Distance to open water
o	Distance to emergent vegetation
-	Acres of open water
+	Acres of wetland
-	Distance to nearest active farmstead
o	Distance to nearest nest
+	Percentage of surface water
-	Percentage of open water
-	Visibility (at nest height)
+	Height above water
-	Height of surrounding cover

[a]+ = Positive relation = more of variable influences use
- = Negative relation = less of variable influences use
o = Not determined = amount of variable that influences

The overall percentage of nests correctly classified was 72.8 percent, using all 18 variables. The percentage correctly classified following the entry of the first three variables (Table 13) was also 72.8 percent. The remaining 15 variables were of minimal value in predicting utilization of each ANS. Distance to open shore and degree of muskrat use on the wetland were variables that were omitted from the analysis because they did not meet or maintain the tolerance levels set for the computer program.

Discriminant analysis was also used to evaluate variables associated with success or failure of goose nests on 79 artificial structures (Table 14). The percentage of nests successfully classified was 92.4 when only the first six variables were entered, and predictive success did not increase with addition of other variables. Distance to open water, acres of wetland, degree of lake use by man and density of surrounding cover were variables that did not meet or maintain analysis tolerance levels and were not entered into the computations.

A third discriminant analysis was applied to variables associated with success or failure of 37 NNS located on islands (Table 15). A positive relationship was found for all variables, except the degree of muskrat use on the wetland. The positive relationship means that the success of the nest is influenced by an increase in the variable, assuming the other variables are unchanged. Acres of wetland,

Table 14. Variables associated with nests of Canada geese, in order of importance for success or failure of nests on 79 ANS in northeastern South Dakota, 1975, as determined by discriminant analysis.

Relationship[a]	Variable
-	Distance to nearest active farmstead
+	Distance to nearest nest
+	Degree of muskrat use on wetland
-	Percentage of open water
+	Height of surrounding cover
-	Distance to emergent vegetation
-	Acres of open water
+	Water depth
+	Visibility (at nest height)
+	Distance to open shore
-	Percentage of surface water
-	Structure condition
-	Height above water
+	Number of nests on wetland

[a]+ = Positive relation = more of variable influences success
 - = Negative relation = less of variable influences success

Table 15. Variables associated with nests of Canada geese, in order of importance for success or failure, of 37 island NNS in northeastern South Dakota, 1975, as determined by discriminant analysis.

Relationship[a]	Variable
-	Degree of muskrat use on wetland
+	Size of island
+	Number of nests on wetland
+	Density of surrounding cover
+	Distance to nearest active farmstead
+	Distance to open water
+	Acres of open water
+	Depth of water to nearest shore
+	Percentage of surface water
+	Distance to nearest nest
+	Visibility (at nest height)

[a]+ = Positive relation = more of variable influences success
 - = Negative relation = less of variable influences success

percentage of open water, degree of lake use by man, number of nests on island, distance to nearest shore and evidence of predators did not meet tolerance levels and were omitted from the analysis. Overall percentage of nests correctly classified was 78.4.

CONCLUSIONS

Nest success of the giant Canada goose flock in northeastern South Dakota was comparable or higher than success reported for other B. c. *maxima* flocks. Desertion of the nest was the most common cause for nest failure. Predation and flooding did not appear to be major factors in limiting success of the nests studied. Since nest success appears adequate to support or increase the population, additional research should attempt to determine gosling mortality to allow estimates of production to flight stage.

Artificial nest structures, islands, muskrat houses and peninsulas, in the order listed, were the nest sites used by the geese. The majority of the nests were located on Class IV and Class V wetlands. A higher proportion of nests on ANS were successful than nests on NNS. Mean clutch size in nests on ANS was larger and percent hatchability was higher than nests on NNS.

The highest densities of nests recorded during the study were located on islands. The reason for these high nest densities may be due to the relative lack of disturbance by predators and humans on island nest sites. Because of the importance of islands to nesting geese, management could be directed toward construction of islands during dry periods by separating distal portions of peninsulas from the mainland.

Discriminant analysis of the variables evaluated in this study indicates that water depth, number of nests on the wetland, and density of surrounding cover were the three most important variables in predicting utilization of ANS. These variables should be considered in the placement of future structures. The remaining 15 variables evaluated were of minimal value in predicting use or nonuse of a nest structure.

Relationship between land ownership (public versus private) and nest success was inconclusive. More research is needed to determine the relative value of both public and private land for nesting geese.

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