BREEDING CHARACTERISTICS

OF A

CAPTIVE FLOCK OF CANADA GEESE

by

John P. Weigand

AN ABSTRACT OF

A thesis submitted to the College of Science and Arts
Michigan State University of Agriculture and
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the requirements for the degree of

MASTER OF SCIENCE

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Title: Breeding characteristics of a captive flock of Canada geese.

ABSTRACT

An attempt was made to establish basic information on the nesting density, productivity, and behavior of a captive Canada goose flock at the Mason Game Farm near Mason, Michigan. A brief history of the acquisition and management of the flock is given.

Territories, and behavior patterns displayed by the geese in territorial defense, are described. Discussion of copulatory behavior of a mated pair and the probability of promiscuous breeding by unmated geese are given. Several instances of remating after death of a mate are recorded. Reactions of nesting Canada geese to other waterfowl and whitetail deer are discussed.

An average nesting density of 2.9 pairs per acre prevailed during the 1959 nesting season and an average clutch size of 5.44 eggs per nest was computed for the period 1953 through 1959. Islands, floating platforms and ditchbanks were the most preferred areas for nesting. Incubator-hatched first-clutch eggs had an average hatching success of 34.7 per cent over a seven-year period; incubator-hatched second-clutch eggs averaged a 37.1 per cent success over a four-year period. In contrast, second-clutch eggs hatched by the geese had a 60.1 per cent hatching success over a three-year period.

Desertion of nest sites was believed due primarily to overcrowding of the geese. It was found that, over the seven-year period, an average of 65 percent of the geese renested after an average renesting interval of 17.5 days.

It was suggested that further detailed studies of behavior patterns and causes of low hatching success in incubators be undertaken. Furthermore, it was recommended to increase the extent of ditchbanks and the number of floating platforms on the pond, and thereby increase egg and gosling production of the captive flock.

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Gratitude is also expressed to my wife, Judith, for her encouragement and help in typing the manuscript.

INTRODUCTION

Canada geese (Branta canadensis) are raised at the Mason Game Farm, Mason, Michigan, for the purpose of starting new resident flocks in suitable breeding areas in Michigan. The breeding geese are permanent captives; their offspring and geese failing to breed are released for restocking.

Propagation is both from artificially-incubated and naturally-hatched eggs. There is evidence that at least some behavior characteristics related to breeding habits are inherited in this species (for example, see Balham, 1954). In view of the widespread distribution of the captive birds into new breeding areas and the possible introduction of their behavior patterns into the wild population, it seemed desirable to document the breeding history and behavior patterns of this density-tolerant flock. The study was conducted from late March until early June, 1959.

DESCRIPTION OF THE STUDY AREA

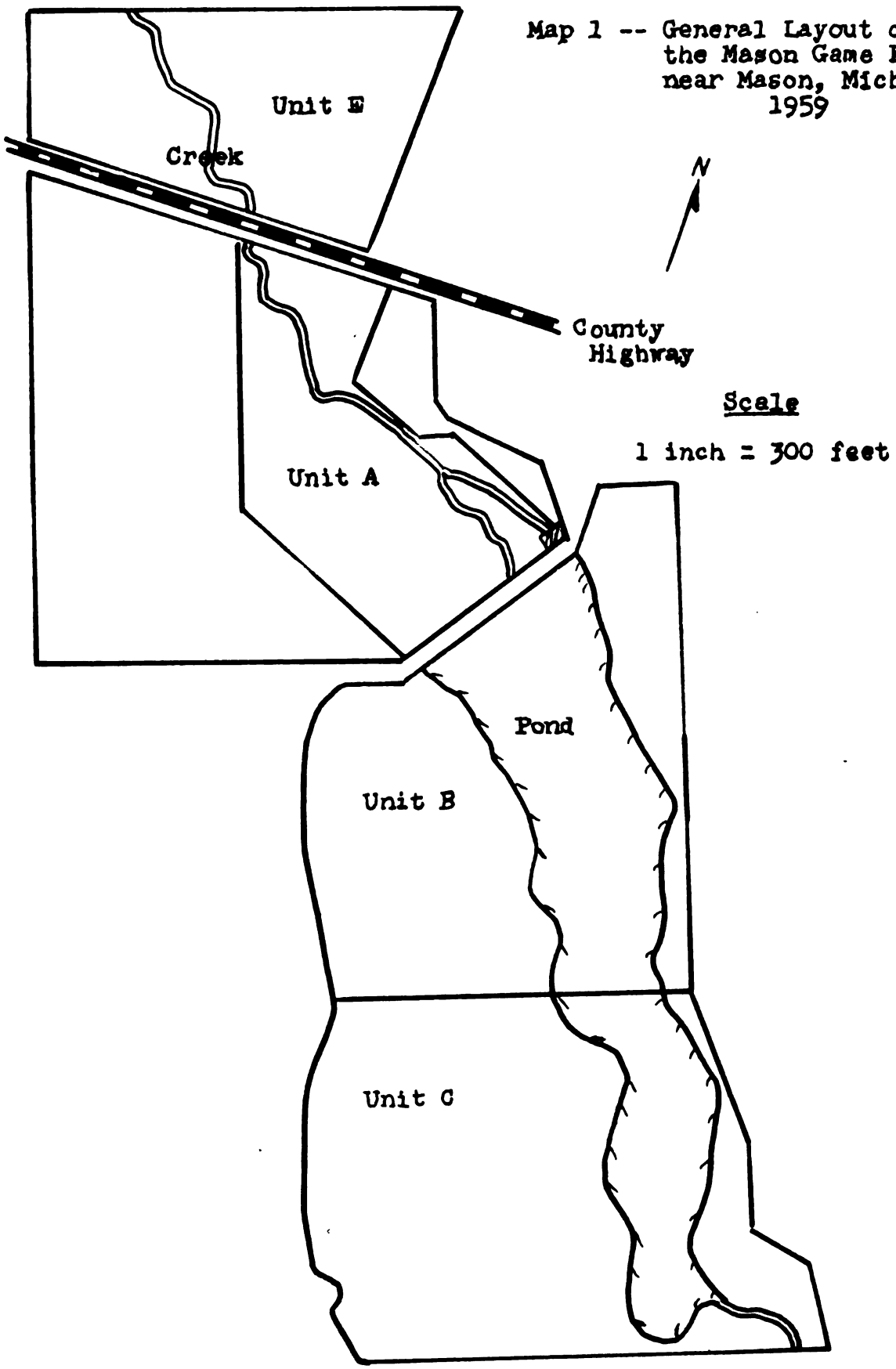
The Mason Game Farm is in gently rolling farming country and includes an impounded creek. The farm is divided into five fenced units (Map 1), four of which in 1959 contained a nesting population of 110 pairs of geese.

At the time of the study, Unit A (Map 2) consisted of two areas: a wooded parkland of 6.5 acres and about nine acres of cropland. Vegetation in the parkland was primarily American elm (Ulmus americanus) and willow (Salix sp.) with some white ash (Fraxinus americana) and white oak (Quercus alba). There was no understory of shrubs; only annual and perennial weeds and grasses were present. Bare earth was exposed on much of the surface. The cropland was usually planted in corn (Zea mays) for winter forage for the geese.

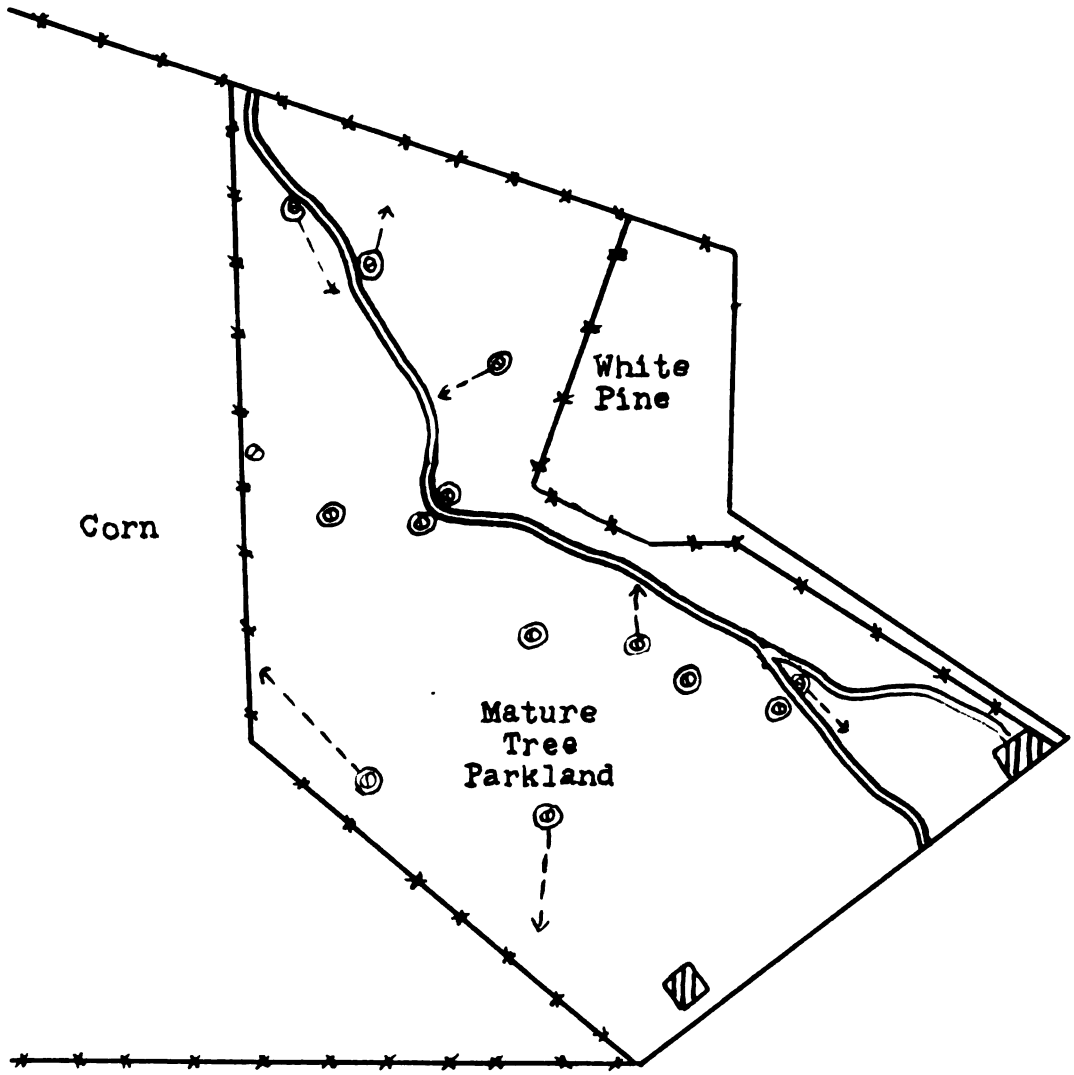
Unit B (Map 3) contained the upper 5.5 acres of the 8.3 acre pond. The upper border of the pond was an earthen dike with two water-control devices. Maximum pond depth was about six feet. Several mud bars and partly sunken logs, which served as resting and preening areas for the geese, were present. The major land portion of six acres was planted with annual brome (Bromus arvensis) and oats (Avena sp.). American elms and willows were the main trees along the western shore. Rocks lined the northern two-thirds of this shoreline. Stands of willow, white pine (Pinus strobus), red pine (Pinus resinosus) and red maple (Acer rubrum) grew along the eastern shoreline.

Unit C (Map 4), 11.6 acres, contained the lower 2.8 acres of the pond. A field planted in oats occupied one-half of the eastern portion of the land; wooded parkland and a beech-sugar maple (Fagus grandifolia-

Map 1 -- General Layout of the Mason Game Farm near Mason, Michigan 1959



Map 2 -- Unit A



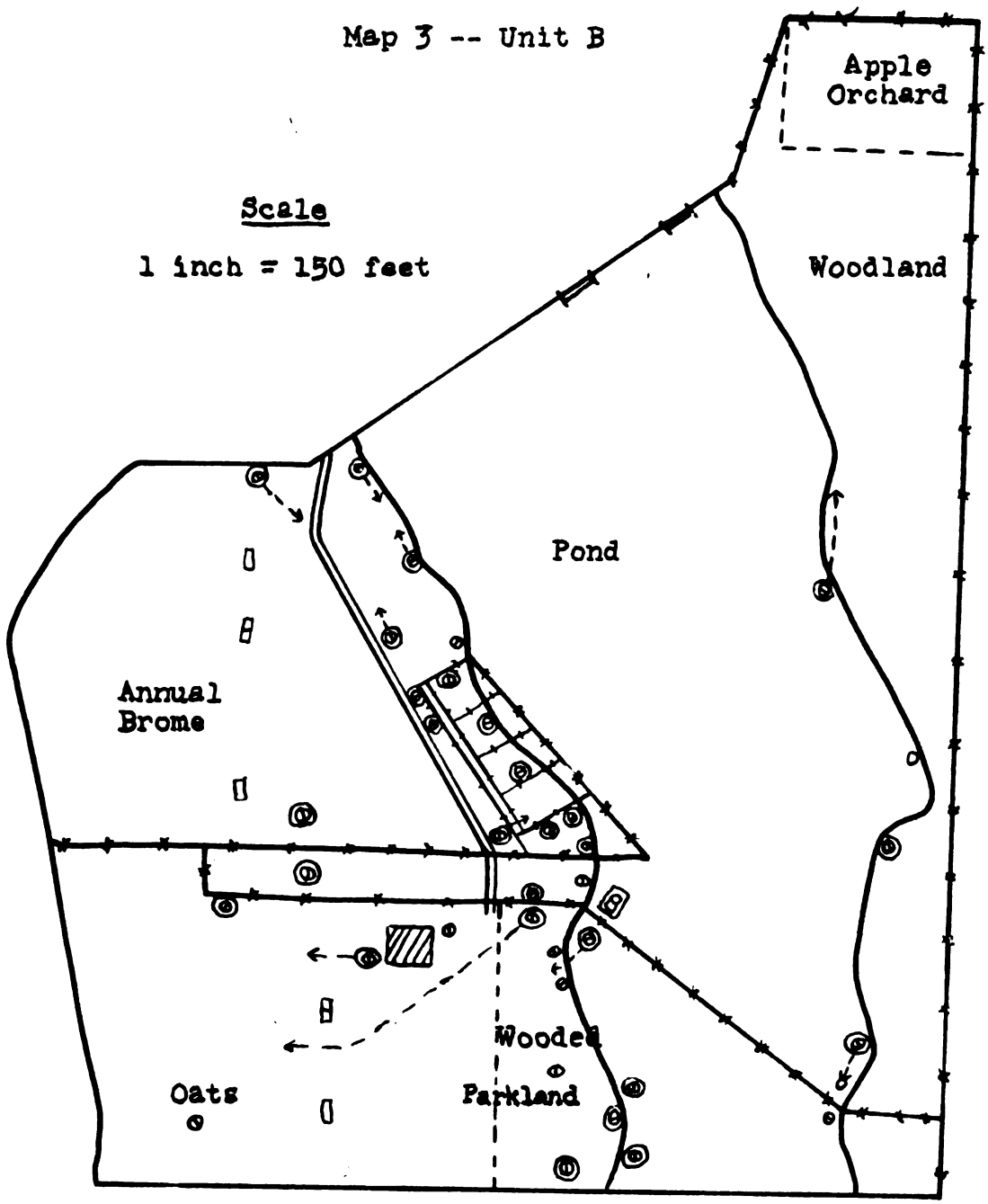
Legend

- First clutch nest
- Second clutch nest
- Indicates moving to new location for second clutch
- Fence
- Buildings

Scale

1 inch = 150 feet

Map 3 -- Unit B



Legend

- First clutch nest
- Second clutch nest
- Nest on elevated structure
- Nest on floating platform on pond
- Indicates moving to new location for second clutch
- Fence
- Cover type boundary
- Water-control device
- Building

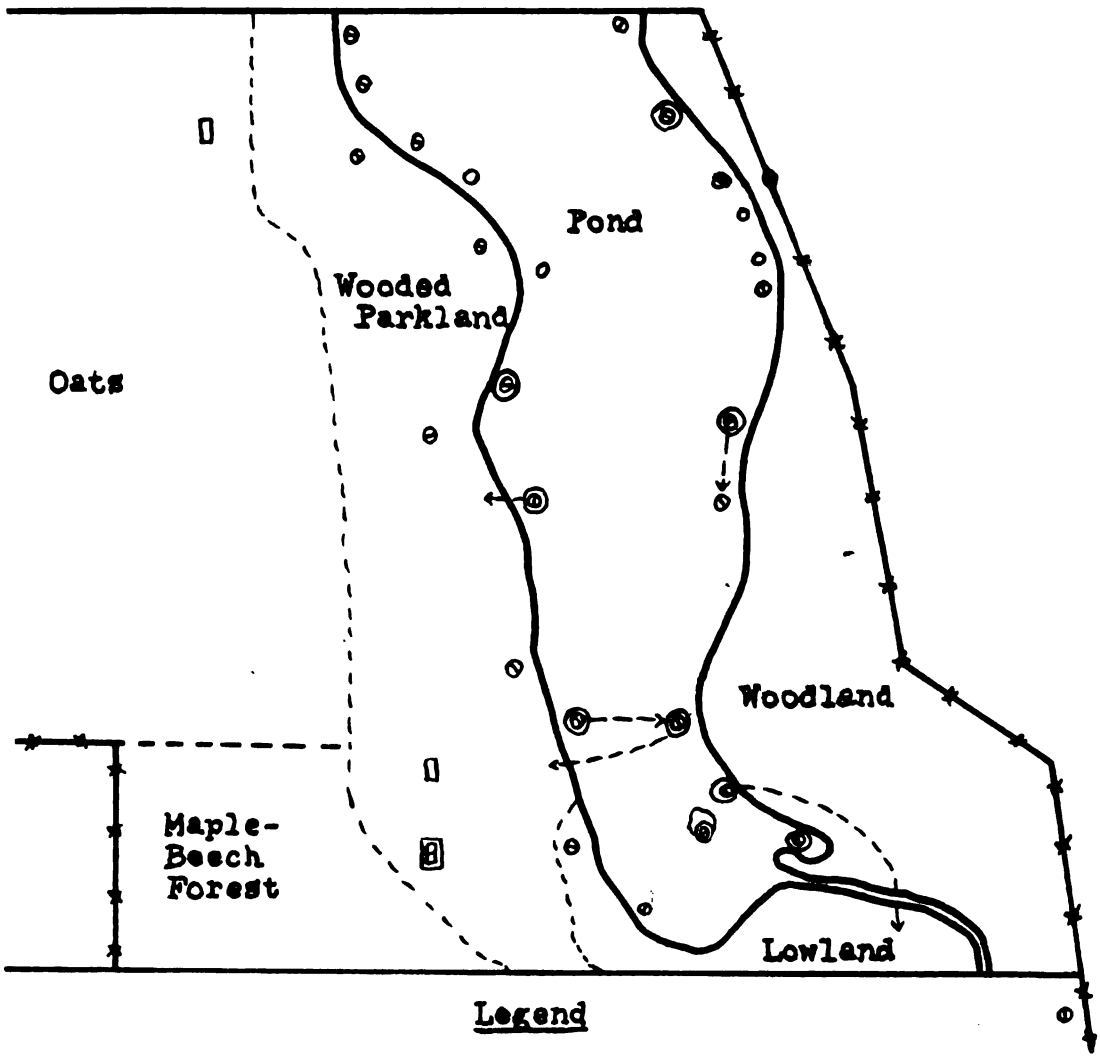
Acer saccharum) forest occupied the remaining half. The western land portion was sparsely covered by American elm, oak and basswood (Tilia americana). An island, densely vegetated with rose (Rosa sp.), was in the lower end of the pond.

Unit E (Map 5) contained 6.9 acres. The area east of the creek was planted with bluegrass (Poa pratensis), annual brome, and rye (Secale sp.). Vegetation along the creek banks was nettle (Urtica sp.) and mullein (Verbascum thapsis). Red pine and white spruce (Picea glauca) were the main tree species on the eastern border of the unit. The area west of the creek contained a meadow of rye, bluegrass and perennial weeds. The two islands at the southern end of the creek were densely covered with young willows. These islands were one to three feet above the surrounding water level.

Since Unit D was not used for nesting in 1959, description of the unit has been omitted.

Ten elevated structures had been placed in the units for nesting use. These were on land and away from the water. They were wooden frames, four feet by six feet, covered with chicken wire and mounted horizontally on legs about a foot above the ground. Each contained several bales of straw. Sometimes one or two bales were broken up by the manager and the loose straw spread out on the frame. In other instances, loose straw was placed on top of several solid bales. In Units B and C, the lower halves of barrels, and in one a shallow wooden box, were placed, open end up, on floating platforms anchored in the pond. These were filled with loose straw.

Map 4 — Unit C



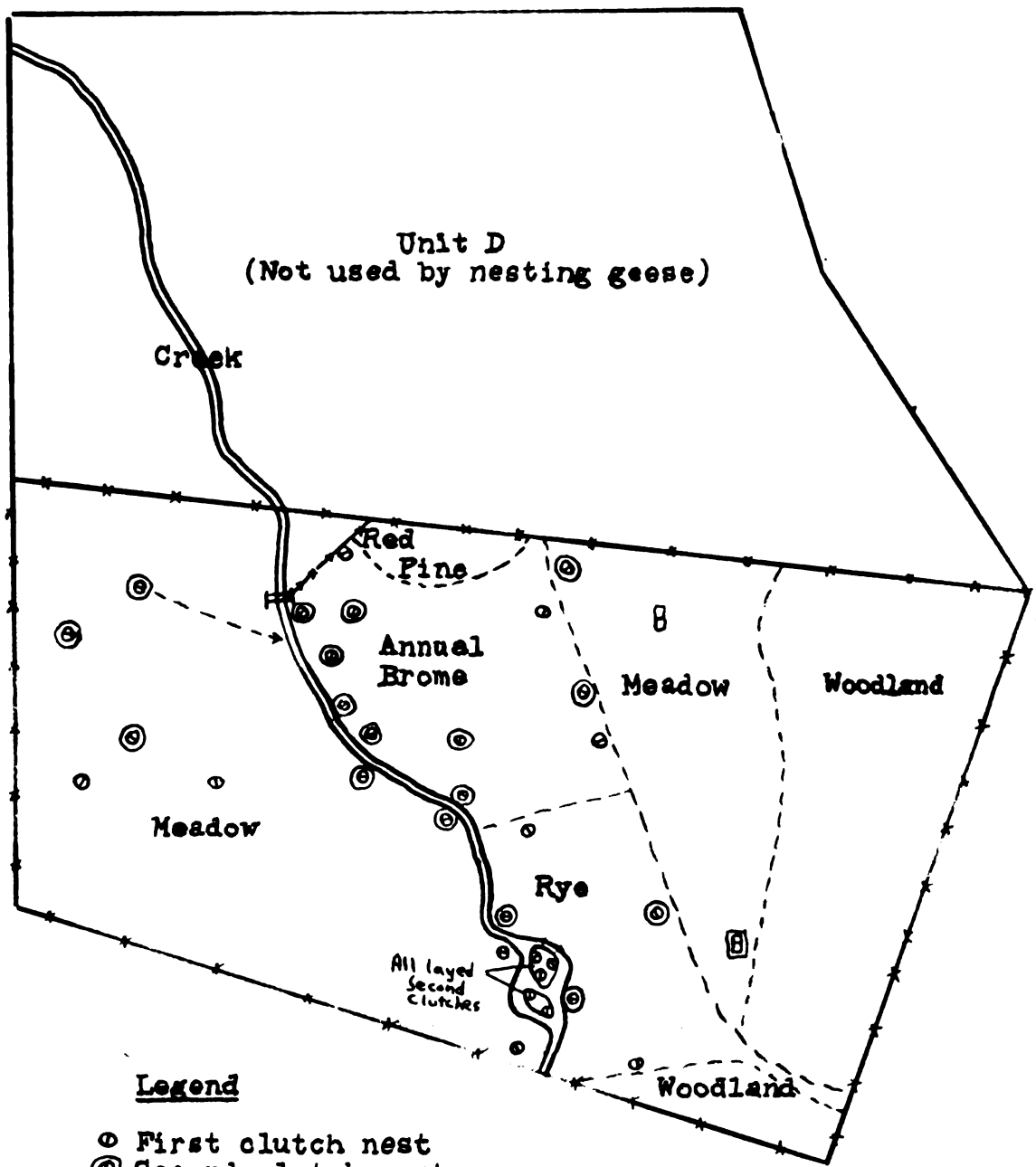
Legend

First clutch nest
Second clutch nest
Nest on elevated structure
Nest on floating platform in pond
Indicates moving to new location for second clutch
Fence
Cover type boundary

Scale

1 inch = 150 feet

Map 5 -- Unit E



Legend

- First clutch nest
- Second clutch nest
- Nest on elevated structure
- Indicates moving to new location for second clutch
- Fence
- Cover type boundary
- Water-control device

Scale

1 inch = 150 feet

METHODS OF STUDY

Trips to all nest sites were made once or twice a week, accompanying the farm manager on his feeding and egg-collecting routes. Nests were mapped and marked with white wooden stakes, each exhibiting a code letter. Band numbers of mated individuals were listed in conjunction with stake locations in recording observations.

Periodically during the nesting and laying season behavior data were collected by field observations from several lookout points.

Clutch size, hatching success, and renesting data were obtained from the game farm records which dated back to 1953.

FLOCK HISTORY AND OPERATIONAL MANAGEMENT

The initial flock comprised three wild pairs of geese which stopped at the farm during the spring of 1920. They brought off four young during their first months of captivity and all were retained at the farm. This provided the nucleus for the present flock.

In 1951, several unrelated geese were acquired from the Seney National Wildlife Refuge in the Upper Peninsula of Michigan. An additional introduction into the breeding stock occurred in 1957, when a private individual donated 15 geese. The major portion of the breeding stock therefore, 110 pairs as it existed in 1959, was composed of birds which had been hatched and retained at the farm. The breeders acquired since 1953 have been wing-clipped annually; geese acquired earlier were pinioned. All geese were leg-banded at the time of acquisition.

All of the five farm units, except Unit D, contained nesting geese. Yearling and two-year-old geese were held there during the nesting season. Unit A was used in winter to hold the entire flock.

Placing of the paired geese in a given nesting unit (Map 1) was arbitrary on the part of the farm manager except that older established breeding pairs were returned to the unit in which they had nested in previous years. Pairs newly-mated since the last nesting season were then placed in the units until the farm manager, on the basis of previous experience with nesting geese, judged that the limit of toleration of crowding had been reached. Selection of a nest site, nest-building, and laying of at least one clutch of eggs by a pair indicated that the pair was successfully established.

Pairs having no success in nesting in one unit were moved to another. This continued until a site was selected and nest-building began, or until the laying of eggs by other pairs began. In the latter case, unsuccessful pairs were left in that unit for the remainder of the laying season, whether they nested or not. It is the policy of the game farm to hold geese until they are two-years old before introducing them into a stocking area. Pairs which failed to nest after three years were shipped to a stocking area along with some of the two-year-old geese.

Nesting geese were provided with food once daily. A shallow feeding pan placed near each nest site was filled with a mixture of one-third each of shelled-corn, wheat and commercial turkey breeder-pellets. Additional food was obtainable by grazing on oats, rye, annual brome, and junegrass planted for that purpose. Unmated geese were also provided with food.

During the laying of the first clutch, the eggs were collected daily at the time of feeding. When the first egg appeared in the nest, it was taken for artificial incubation and replaced by an artificial egg. This artificial egg, developed by Game Farm Manager Pollok, and still under study by him, was left in the nest throughout the laying of the first clutch. When a period of two to three days elapsed without an egg being laid, the first clutch was judged to have been completed for that goose and the artificial egg was removed. Pairs which layed a second clutch or laid a first clutch late in the season (in May), were allowed to retain their eggs for parental incubation.

TERRITORIAL BEHAVIOR

Territorial pairs are defined by Hanson and Browning (1959) as "pairs of geese that were observed to be closely associated with a small area and that retained their identity with relation to other geese." An established nesting pair (Balham, 1954) is dominant over all other geese within its territory. Balham stated two functions of the territory: (1) to prevent disturbance of the incubating female, and (2) to provide social stimulation between the members of a pair.

A territory, in the present study, consisted of the area defended by a pair of geese. It contained the nest and its surroundings, and adjoining areas for grazing and preening. In the case of pairs nesting along a shoreline, it also included a portion of water.

On the game farm mated geese began selecting nest sites and establishing territories in early March. Pollok, (pers. comm.) indicated that older nesting pairs returned to their old nest sites and territories while pairs mated since the previous nesting season tended to select sites in remaining vacant areas for establishment of territories. Upon selection of a nest site by the female, the male established and defended the territory containing the site.

The hours from 5 a.m. to 7 a.m. and from 4 p.m. to 7 p.m. were the periods of most active territorial defense during the study. This was also the period for general bathing, drinking and grazing. Geese traveling to and from water from sites on the mainland necessarily often crossed several neighboring territories. Since one pair was seen returning to its territory just after dawn, it was suspected that some of the less aggressive geese went down to water before daylight.

Intrusion of territories by other geese and by humans brought about slightly different types of defense. Although the geese were accustomed to the daily intrusion of the farm manager, who could walk within the boundaries of a territory with little interference, all but one pair would attack as he approached the nest site. Encroachment within territorial boundaries by strange geese would cause immediate alarm and attack by the defending gander. Balham (1954) also found that "geese which were continually exposed to the activities of man reacted to intrusion at the nest with defense and flight attack."

In defending his territory from other geese, the gander first bobbed his head and neck up and down, occasionally turning the side of his head toward his aggressors, revealing the white cheek patch. He then approached the intruders while honking loudly. If the intruding geese did not then retreat, the defending gander would run at it, thrusting his neck and head forward and hissing. Retreat by the intruder occurred in most instances. When an aggressive pair did succeed in driving a neighboring pair from the latter's nest, the former would usually increase their territory toward the abandoned nest. They were not observed to include this second nest within the new boundary. Similar findings were reported by Collias and Jahn (1959).

In one case an intruder met the attack of the defending gander in the water. For about a minute they grasped one another's necks with their bills and pounded each other with their wings. Nearby geese began to honk loudly. Finally the invader began to retreat toward its own territory. The defending gander then mounted the back of the intruder, and holding the defeated male's head under water with his bill, rode

along as the latter swam across the pond. At one point, escape attempts of the invader became feeble and seemed to cease. Then, with a sudden forward thrust, it upset its rider and swam back to its mate.

The victor returned to his territory, honking loudly and periodically rising up from the water to beat the air with outstretched wings. Geese adjacent to the victor's territory continued to honk until the latter reached its mate at the nest. The winner then preened itself and activity in the area returned to normal.

The intensity of territorial defense as evidenced by the number of times pairs defended their territories, was observed to increase during nest-building and egg-laying, and reached its peak during incubation. Territorial defense continued until the first clutch had been completed and all of the eggs were taken by the manager. During the renesting interval (see beyond) territorial defense slackened noticeably. Upon preparation of the nest for the second clutch, defense of the territory would resume. Since about 70 per cent of the renesting geese (see Maps 2 - 5) occupied the same nest for the laying of both clutches, territorial boundaries remained about the same.

Copulatory Behavior. Copulation was observed only once. This was by a pair which had completed its first clutch and had temporarily left the nesting site. About 2 p.m. on April 22, the pair was observed in the pond going through a long series of head and neck bobbings (see Collias and Jahn, 1959). Each dipped its head and neck under the water and then threw the head upward and toward the back. After several minutes of this behavior, the male swam to the female and mounted her while holding the back of her neck with his bill. He then reared back

for several seconds with his wings outstretched and it was suspected by the author that coition occurred at this time. The two birds separated immediately afterward and began another shorter series of head bobbings. On completion of this display, they swam to a log together and preened themselves.

Pollok, who works with the geese throughout the year, advised that he had observed similar copulatory behavior, but only on a few occasions during the daytime. Balham (1954) did not observe copulation on the nesting grounds in Manitoba and suspected that it occurred during spring migration. The Michigan date does not completely clarify this point but indicates that copulation may occur on the nesting grounds.

Collias and Jahn (1959) reported observing frequent copulations in captive geese during the day, with the most active time for this behavior between 7 a.m. and 9 a.m. and between 1 p.m. and 3 p.m. It is believed, without actual evidence, that at least some copulation occurred between sunset and the following sunrise in the present study. This seemed especially likely for mainland pairs (see beyond) which would have had to cross other territories to reach water. No copulations were observed to occur on land.

Behavior of Unmated Geese During the Nesting Season. A flock of unmated mature geese was placed with the mated geese in Unit C with the thought that they might mate and nest, but they did not. Several untended eggs were laid at random throughout the unit which could have been laid by these geese or by mated birds.

The unmated geese were not observed to disturb nesting pairs in the vicinity and, for the most part, nesting geese displayed no defense

behavior in their presence. This type of discrimination somewhat resembles Hochbaum's (1955) observations that mallard (Anas platyrhynchos) drakes on their breeding territories give no response to migrant mallard pairs passing overhead while resident pairs that threaten to alight in his domain are driven away.

Re-mating After the Death of a Mate. Several incidences of re-mating after the death of one member of a pair have been recorded at the farm (Pollok, unpublished). In the cases recorded it was the male which died and the female then attempted to mate again within a year or two. No mating was observed during the same season that the mate died.

Collias and Jahn (1959) recorded a female goose that continued to incubate her eggs for 10 days after the death of her mate. Then she paired with another male and deserted her eggs.

In the present study, one female lost her mate shortly after completion of the first clutch and almost immediately an unmated male began to court her. Although the new male continued to escort the female on her wanderings about the unit, she gave no indication of completely accepting him and no copulation was observed.

Interspecific Relationships. Five blue geese (Chen caerulescens) and one male lesser snow goose (Chen hyperborea hyperborea) were present in Unit C and the lower part of Unit B. Four of the blue geese tended to remain in a single flock and did not seem to disturb the nesting Canadas. Like the unmated Canada geese, they had access to all parts of the unit including the pond. Pollok reported (in conversation) that the remaining blue goose, a male, was mated to a Canada female during the 1958 nesting season. Although he successfully defended the nest site and she layed a clutch of six eggs, the eggs were found to be infertile.

In 1959, this female mated with a male Canada goose. The pair was placed in a pen (Map 3) and the female built her nest against the fence. Continued attempts were made through the fence by the male blue goose to drive off the Canada male, but with no success. The blue also tried unsuccessfully to court the female and win her from the new mate. Several times the Canada male stood on the back of the female as he rebuffed the blue's courtship.

The single male snow goose courted a female Canada in 1959 and although he kept all other geese from her, copulation was not observed and no nest was made.

Two pairs of wood ducks (Aix sponsa) nested in two of the elevated wood duck houses on the pond. They were observed swimming near goose nests several times but no attempt was made by the geese to drive them away.

Two great blue herons (Ardea herodias) which reportedly had nested near Unit C in previous years, returned in late April. Shortly after dawn one morning, they flew to the shallow water near the lower end of the pond. One pair of geese pursued the herons to the edge of the pond and then returned to their nest. At a later date, three pairs of geese made an attempt to drive a heron from the pond. While the attempt eventually succeeded, the herons continued feeding in the vicinity. On another occasion, a gander rushed a heron from behind but stopped short when the latter threatened to strike at the goose.

Once several whitetail deer (Odocoileus virginianus) were seen going down to water in Unit E. Upon their approach, widespread honking occurred and geese in the path of the deer moved to one side. The geese

seemed confused while the deer watered. After the deer left the unit, the geese returned to their nests and became quiet.

NESTS AND NESTING DENSITY

Maximum nesting density is desirable at the game farm for high egg and gosling production. High densities would also be desirable in the wild where suitable breeding areas are limited.

From observations in ten years of management at the Seney National Wildlife Refuge in Michigan, Johnson (1947) concluded that on refuges nesting geese cannot be crowded if high gosling production is expected. He also concluded that not more than one nesting pair to each half acre or acre of nesting territory was desirable. Unit nest densities at the game farm ranged between 2.2 and 4.9 pairs per acre (Table 1). Average nesting density on the mainland alone (see beyond) was about 2.8 pairs per acre.

Table 1. Unit Nesting Density

Unit	No. Acres	No. Nesting Prs.	No. Pairs per Acre
A	6.5	14	2.2
B	13.6	38	2.8
C	10.8	24	2.2
E	6.9	34	4.9
Totals	37.8	110	3.0

Williams and Marshall's (1937) study revealed that 77 per cent of the nests of wild geese at the Bear River Refuge, Utah, were within 30 feet of water. Atwater (1958) noted that the majority of his study nests in Montana were in open, short-grass areas within 25 yards of water. Hanson and Browning (1959) located an average of 7.6 territorial pairs per river-mile based on four years of observations on the Hanford Reservation in Washington. In the present study of captive birds, 54 per cent of the 110 nests studied were within 30 feet of water. Within 30 feet of the pond and stream, there was one nest per 166 feet of shoreline, or about 32 nests per mile of shoreline.

Nests at the game farm were composed mostly of the loose straw distributed to the geese, with some down feathers and grass. The shortest and longest distances between two adjacent nests were 10 feet and 300 feet. Kossack's (1950) figures on these distances for wild geese were 40 feet and 90 feet.

Craighead and Craighead (1949) noted that 95 per cent of wild geese nesting in the Snake River in Idaho were on islands. Geis (1956) observed island-nesting in over 90 per cent of 479 pairs of geese in the Flathead Valley of Montana. Naylor (1953) recorded an island of 30 yards by 75 yards, which contained 31 wild goose nests. Sixteen of the nests were deserted, resulting in a final nesting density of about 32 pairs per acre. Steel, Dalke, and Bizeau (1957) indicated that 16 per cent of 380 nests at Gray's Lake in Idaho were on islands and that 77 per cent were on muskrat houses. Miller and Collins (1953) also found a distinct preference for islands and muskrat houses as nesting sites.

At the game farm, in terms of density, shorelines were the most preferred areas for nesting (Table 2). The wooded shoreline was found to have the highest nesting density with 6.4 pairs per acre. It included the greater portion of the pond shoreline in Units B and C, and the entire creek shoreline in Unit A.

Table 2. Nest Site Preferences

Cover Type	No. Nests	Acreages	Nests per Acre
Islands and floating platforms	29	8.3*	3.2*
Wooded shoreline**	21	3.3	6.4
Meadows	15	3.2	4.6
Barren streambanks	9	0.2	4.2
Annual brome fields	9	3.3	2.4
Wooded parklands	21	11.6	1.6
Oat and rye fields	7	10.0	0.7

* The acreage given is that of the pond. The nest density using this acreage is lower than some of those following. Highest preference is assigned this category, however, because of the high degree of use of these sites (see text).

** Within 30 feet of shoreline.

Kossack (1950) observed 10 and 12 wild goose nests per acre in 1945 and 1946 respectively on a 2.3 acre island in Illinois. Hammond and Mann (1956) found that Canada geese nesting on the Lower Souris Refuge in North Dakota had increased to 16 nests per acre on islands by 1953. Jensen and Nelsen (1948) determined nesting densities of wild geese on small islands in an irrigation reservoir to be 54 to 66 nests per acre.

On the present study site, the six pairs of geese nesting on the three islands present, totaling 0.021 acres, represented an island nesting density of 286 pairs per acre. Doubtless, however, some water areas (here of unknown size) should be included as portions of the geese's total occupied area, and such additions would be relatively much more important for small islands and would reduce this apparent concentration somewhat.

Half of the ten nest platforms described earlier were used during the 1959 nesting season. Twenty-three of the 29 floating structures were used during the first laying period and nine during the second. One pair of geese in Unit C controlled two floating platforms but used only one during its two nestings.

Three pairs nested in the rocks along the pond shore in Unit B. These nests were constructed of twigs and down; no straw was used although it was readily available.

The least preferred cover type was fields containing oats and rye.

CLUTCH SIZE

Records kept during the period 1953 through 1959, showed that the average size for the first clutch of eggs ranged from 5.0 in 43 nests in 1955 to 6.0 in 29 nests in 1953 (Table 3) with a seven-year average of 5.5. Second clutch sizes during the years 1953 through 1956, when the second clutch was also removed for incubator hatching, ranged from 5.0 to 5.6 with a mean of 5.3. Those second clutches retained and incubated by the geese, 1957 through 1959, ranged from 5.2 to 5.9 with a mean clutch size of 5.6 (from data of Table 4). The mean overall clutch size of 5.44, for the seven-year period, was similar to average clutches found in wild geese (Table 5).

Table 3. Clutch Size -- First Clutch

Year	No. Nesting Prs.	Clutch Size Frequency									Total Number Eggs	Ave. Clutch Size
		1	2	3	4	5	6	7	8	9		
1953	29	-	-	2	-	7	11	7	1	1	173	5.97
1954	38	1	2	-	5	9	11	6	1	2	214*	5.63
1955	43	3	1	4	5	10	15	4	-	1	214	4.98
1956	56	2	3	3	7	13	14	11	1	2	297	5.30
1957	96	2	4	6	15	24	28	16	-	1	497	5.18
1958	104	1	2	3	10	19	42	19	7	1	599	5.76
1959	110	1	2	6	13	19	32	33	4	-	626	5.69
Totals	476	10	14	24	55	101	153	96	14	8	2620	5.50

*Includes one clutch of ten eggs.

Table 4. Clutch Size -- Second Clutch

Year	No. Nesting Prs.	Clutch Size Frequency								Total No. Eggs	Ave. Clutch Size
		1	2	3	4	5	6	7	8		
1953	23	1	-	1	2	8	6	4	1	124	5.39
1954	20	-	-	2	-	5	10	3	-	112	5.60
1955	17	1	-	-	2	7	7	-	-	86	5.06
1956	39	3	2	1	3	9	14	6	-	194	4.97
1957**	45	-	1	3	7	12	19	3	-	234	5.20
1958**	80	-	2	-	6	18	43	8	2	460*	5.90
1959**	85	2	1	-	8	17	37	19	1	484	5.69
Totals	309	8	6	7	28	76	136	43	4	1706	5.40

* Includes single clutch of twelve eggs.

** Eggs during these years were incubated naturally by the parent birds; in earlier years, all eggs were incubated artificially.

Table 5. Average Clutch Sizes of Canada Geese

Authority	Location	Status of Population	No. Nests	Ave. Clutch Size
Collias and Jahn (1959)	Wisconsin	Captive	17	5.2
Dow (1943)	California	Wild	140	5.09
			215	5.10
Geis (1956)	Montana	Wild	169	5.55
			189	5.15
Hanson and Browning (1959)	Washington	Wild	1032	5.3 (1953,'55) 5.5 (1954,'56)
Miller and Collins (1953)	California	Wild	201	5.13
Naylor (1953)	California	Wild	360	5.53
Steel, Dalke and Bizeau (1957)	Idaho	Wild	361	5.2
Present Study	Michigan	Captive	476	5.44

HATCHING DATES AND INCUBATION PERIOD

The only hatching dates recorded at the game farm for first clutch eggs were for 1953 through 1956. The earliest hatching dates varied from May 7 in 1953 to May 16 in 1956.

Game farm records for these years revealed that the annual average lengths of incubation periods for 2620 incubator-hatched first-clutch eggs were 28.6 to 29.2 days. For second-clutch eggs incubator-hatched prior to the 1957 laying season, the incubation period ranged from 28.1 to 28.6 days. These findings are similar to those of Atwater (1958) who observed that incubator-hatched eggs required about 28 days of incubation.

HATCHING SUCCESS

Game farm records disclosed hatching successes for first clutches from 28.0 per cent in 1956 to 47.4 per cent in 1953 (Table 6) or 1.5 to 2.8 goslings hatching per nesting pair (Table 3). That portion of the second clutch which was incubator-hatched during the 1953-56 period had 27.3 to 47.5 per cent success in hatching (Table 7) or about 1.4 to 2.5 hatched goslings per nesting pair (Table 4). However, in 1957-59 when nesting geese were allowed to retain their second clutches for natural incubation, hatching success increased to limits of 55.6 and 63.9 per cent (Table 8), or 2.9 to 3.7 goslings per pair (Table 4).

In contrast, studies involving wild geese show much higher rates of hatching success. Hanson and Browning (1959) found hatching on the Hanford Reservation in Washington over a four-year period (1952-56) to be 92 per cent successful. Miller and Collins' (1953) survey of 201 nests in California indicated an 87 per cent hatching success with an average hatch per nest of 4.43 goslings. Steel et al. (1957) in Idaho computed a hatching success of 91 per cent in 1949, 83 per cent in 1950 and 88 per cent in 1951 with an average hatch per nest ranging from 4.2 in 1949 to 4.6 in 1951.

Table 6. Fate of Eggs by Percentages, First Clutches[1]

Year	Total Eggs	Infertile[2]	Dead Embryos	Goslings Hatched	Misc. Mortality
1953	173	34.7	13.9	47.4	7 Destroyed by vandals
1954	214	23.8	35.1	38.8	1 Frozen 4 Stolen
1955	214	30.4	28.5	33.6	15 Stolen 1 Broken[3]
1956	297	22.9	48.8	27.9	1 Broken[3]
1957	497	23.8	35.9	38.1	4 Broken[3] 3 Goslings dead in nest 4 Missing[4]
1958	599	24.4	32.6	42.6	2 Broken[3] 1 Missing[4]
1959	626	28.9	36.9	31.6	16 Broken or taken by predators
Totals	2620	27.0	33.1	37.1	59

1 Incubator hatched.
2 Appeared infertile when candled; may have contained some embryos which died within 24 hours after the eggs were laid.
3 Broken by parent geese walking on nest.
4 May have rolled into heavy brush or water, or may have been stolen.

Table 7. Fate of Second-Clutch Incubator-Hatched Eggs

Year	Total Eggs	Infertile (%)	Dead Embryos (%)	Goslings Hatched (%)	Misc. Mortality
1953	139	10.1	15.1	47.5	38 Rotten
1954	112	46.4	10.7	42.9	
1955	86	37.2	23.3	34.9	3 Broken* 1 Missing**
1956	194	21.7	49.0	27.3	3 Broken* 1 Stolen
Totals and Averages	531	28.9	24.5	38.2	46

* Caused by parents walking on nest.
** May have rolled into heavy brush or water, or may have been stolen.

Table 8. Fate of Second-Clutch Naturally-Hatched Eggs

Year	Total Eggs	Infertile (%)	Dead Embryos (%)	Goslings Hatched (%)	Misc. Mortality
1957	234	6.0	23.5	55.6	16 Broken* 1 Stolen 6 Goslings dead in nest 3 Nests flooded 9 Missing**
1958	457	4.6	17.4	63.9	12 Broken* 17 Taken by predators 11 Goslings dead in nest 1 Nest flooded 21 Missing**
1959	484***	5.6	30.4	60.7	16 Broken*
Totals and Averages	1175	5.4	23.8	60.1	113

* Caused by parents walking on nest.
** May have rolled into heavy brush or water, or may have been stolen.
*** Plus twelve goslings found dead in nest.

Salter (1958) in Idaho found an average of 4.6 to 5.2 goslings per pair in 273 to 345 pairs, respectively. Williams and Marshall (1938) stated that in Utah, of 84 nests found, there was an average of 3.9 goslings per nest.

Infertile eggs ranged from 10.1 to 46.4 per cent (Tables 6 and 7) among those incubator-hatched, and from 4.6 to 6.0 for naturally-hatched eggs (Table 8). In wild geese, Steel et al. (1957) attributed only seven per cent loss in successful nests to infertility. Kossack (1950) found only 4.6 per cent of 325 eggs to be infertile in 1945 and 1.7 per cent of 404 eggs in 1946. Two per cent of the 350 eggs in Naylor's (1953) study proved to be infertile. Miller and Collins (1953) found 1.9 per cent of 810 eggs to be infertile. Hanson and Browning's (1959) study revealed one to two per cent infertile eggs.

In the present study, losses assigned to infertility are not only markedly higher than those reported by other workers, but are also higher for artificially-incubated eggs (Table 6) than for those incubated naturally (Table 8). Apparently either (a) more infertile eggs were among those collected than the geese normally retained in naturally-incubated clutches, or (b) some of the losses listed as due to infertility actually were of fertile eggs which died in handling before conspicuous embryonic development occurred. Since there is no appreciable difference in clutch size between eggs collected and those hatched naturally (Tables 3 and 4), the first factor seems to be unlikely.

NEST DESERTION

Miller and Collins (1953) in northeastern California found that there was a high rate of nest desertion due to crowding and intraspecific strife. Naylor's (1953) study included an island (30 yards by 75 yards) on which crowded conditions resulted in the desertion of 16 of the 31 goose nests.

On the game farm, desertion of nesting sites also was believed to be due primarily to crowding. In one case, a single pair succeeded in driving two adjacent pairs from their nests. Since maximum egg production was desired at the farm, this aggressive pair and a small portion of its territory was enclosed with chicken-wire fencing. This action resulted in the less-aggressive pairs returning to their nest sites and to the continued egg-laying of all three pairs.

Flooding was not a major factor in nest desertion in the present study. Of 45 second-nests incubated by geese in 1957, only three were destroyed by flooding. Of 80 second-nests in 1958, only one was flooded.

Salter (1958) attributed a decline in goose egg production in Idaho to raccoons (Procyon lotor) and badgers (Taxidea taxus) during 1952-1955. In a later study (1959), he listed inclement weather and predation as the chief factors in nest desertion. Geis (1956) indicated that 14 per cent of 141 unhatched eggs were destroyed by crows (Corvus brachyrhynchos) in the Flathead Valley of Montana.

Predation on eggs at the game farm occurred only on a minor scale. A total of 4326 eggs was layed from 1953 to 1959 and only 39 (less than

one per cent) were destroyed or stolen by predators. Principal mammalian predators in the area were the raccoon, striped skunk (Mephitis mephitis) and red fox (Vulpes fulva). Although crows were common in the game farm area, no evidence of egg destruction by them was found by the farm manager. Predation did result in some observed nest desertion, but in all instances the geese selected a new nest site and continued egg laying.

Geis (1956) attributed increased nest desertion to disturbance by humans over extended periods. Hochbaum (1944) found that frequent disturbance of nesting mallards and canvasbacks (Aythya valisineria) by humans resulted in several desertions.

Disturbance of geese by humans at the game farm did occur during daily feeding and egg collecting by the manager or his aide. The geese became accustomed to this intrusion, however, and although defense behavior was displayed daily, no nest desertion due to disturbance was observed.

RENESTING

Attempts to definitely establish that renesting activities occur among wild birds are difficult without marked birds (see Barraclough, 1954). However, Balham (1954) noted renesting in a pair of geese at Delta, Manitoba, whose first clutch of three eggs was frozen and cracked early in the nesting season. Abandonment of the first nest site occurred after the third day of incubation. He also recorded four pairs which did not renest after their nests were lost to flooding in late May.

On the present study area, it was found (Tables 3 and 4) that 38.5 to 79.3 per cent of the geese, with a seven-year average of 65 per cent, renested after removal of the first clutch. Two pairs in 1959, which had their first egg-laying attempts interrupted by aggressive neighbors, laid their first clutches while surrounding geese were incubating second clutches.

Balham, in the case of the pair of geese whose eggs were frozen (see above), noted a "renesting interval" (see Sowls, 1955) of 11 days. At the Mason Game Farm, in all but a few instances, the first clutch of eggs was taken by the farm manager one egg at a time as they were layed. In the few exceptions where the entire clutch was taken at once, incubation had not progressed more than five days and these geese also renested. Based on the 309 pairs of geese which renested (Table 4), the renesting interval was found to range between eight and 27 days, averaging 17.5 days.

Sowls (1955) found, in 21 female ducks, that there was a statistically greater average number of eggs in the first clutch than in the second but that "the difference is not great enough to distinguish first clutches from renests." Atwater (1958), in working with wild geese in Montana, found it difficult to classify second nests as such on nest appearances alone.

At the game farm there was an average drop in clutch size of only 0.1 egg (Tables 3 and 4) between first and second clutches. Second nests were not noted to be different in structure or appearance from first clutch nests.

CONCLUSIONS AND SUGGESTIONS FOR MANAGEMENT

Description of the behavior patterns exhibited by this captive flock of geese is still incomplete. More detailed studies of behavior in one pen unit would be desirable. Behavior of the wintering flock, behavior of yearling and two-year-old geese during the breeding season, relationship of the family within the flock, and mating behavior should be studied where the birds are conspicuously color-marked. Comparisons should be made with similar studies of wild geese.

Several behavior patterns might be inherited by the offspring of this density-tolerant flock and introduced into wild goose populations by restocking suitable breeding areas with these progeny. The ability of these captive geese to reproduce under crowded conditions would be a valuable characteristic to be instilled in wild geese where breeding areas are limited in number and size. A study involving a number of offspring hatched in an incubator, introduced into a stocking area, and followed through several nesting seasons would contribute additional information concerning the inheritance of some of these factors.

Since ditchbanks were among the more preferred sites for nests, efforts could be made at the Game Farm to increase their extent. Experimental increases in the number of islands, the most preferred sites for nesting, would be desirable. Nesting platforms on the pond, which showed a 79 per cent use for first clutches and 31 per cent for second clutches, could be constructed at low cost. Such structures could be placed along the eastern pond shoreline in Units B and C, and along the northwestern shore in Unit B.

Game Farm records revealed that almost two-thirds of all artificially-incubated eggs failed to hatch, while only one-fourth to one-third failed to hatch when they were incubated by the geese. Furthermore, one-third of the nesting pairs did not lay a second clutch after the first was removed. The expected production of day-old goslings for a sample of ten pairs of adults under the present system of handling thus would be:

5.5 eggs per pair X 1/3 survival in incubator = 18

plus 5.5 X 2/3 renesting X 2/3 survival under parents 24

Goslings = 42

The same number of adults hatching one clutch naturally would produce 5.5 eggs per pair X 2/3 survival = 36 goslings.

In view of these and other data, several recommendations are made:

1. The costs of raising the additional 17 per cent of goslings under the present system should be compared with the costs of keeping perhaps a slightly larger colony on a less intensive basis to determine whether a change in production methods is desirable.

2. Since an increase in hatching success even to 80 per cent in one naturally-incubated clutch would surpass the present total production and since this level of success is commonly exceeded in wild flocks, experimentation should be undertaken toward gaining increased success in natural production alone.

3. Since the high loss among newly-collected eggs seems to occur as a result of handling, a study of the effects of various egg-handling techniques on hatchability would be desirable.

SUMMARY

A study was conducted from late March through early June, 1959, to contribute to the knowledge of productivity, nesting density and behavior of Canada geese. The geese studied were at the Michigan Department of Conservation Game Farm near Mason, Michigan.

A brief history of the acquisition and management of the goose flock is given. Positive identification of all nesting geese by sex was possible from leg bands. Nest locations were marked with white wooden stakes exhibiting coded letter combinations.

After selection of a nest site by the female, the male established and defended the territory which included the nest site and surrounding areas used for grazing and preening. Territorial defense increased in intensity until the beginning of incubation; it then decreased until the goslings hatched, when defense of the territory ended.

In defending his territory from intruding geese, the gander displayed a typical behavior pattern which began with a series of neck and head bobbings and loud resonant honking; and, was climaxed by the hissing, running attack and fighting with the intruder.

Pre-copulatory behavior consisted of the female and male swimming close to each other, dipping their heads and necks under water, and then throwing them upward and backward. After several minutes of this display, the male mounted the female's back. After copulation there was another, shorter series of head and neck dippings followed by a period of preening and resting.

Several cases of geese remating after death of a mate were recorded.

Five blue geese, a lesser snow goose, and several wood ducks in the area evoked little concern from the nesting Canada geese. Several observations were made of attempts to drive great blue herons from the pond. White-tail deer going down to water at the creek caused great alarm and confusion of the nesting geese.

Overall average density of 110 nesting pairs was 3.0 pairs per acre. Islands and floating platforms were the most preferred areas for nesting while fields containing oats and rye were the least utilized. Nesting density along the shoreline was computed to be 32 nests per mile of shoreline. The shortest and longest distances between adjacent nests were 10 feet and 300 feet respectively.

During the 1959 nesting season half of the ten elevated structures and 23 of the 29 floating platforms were used for the first clutch. Several of these structures were also used for the second clutch.

The average clutch size over a seven-year period, for the first clutch eggs was 5.5. Incubator-hatched second-clutch eggs averaged 5.3 eggs per nest while parental-hatched second-clutch eggs averaged 5.6. Clutch sizes found most frequently were five, six, and seven, and ranged in size from one egg to twelve eggs. Incubator-hatched eggs required an incubation period of 28.1 to 29.2 days.

The seven-year average hatching success for first clutches was 37.1 per cent. Incubator-hatched second clutch eggs had a hatching success of 38.2 per cent while these second clutch eggs hatched by the geese had a 60.1 per cent hatching success.

Desertion of nest sites was believed to be due primarily to overcrowding of the geese. Flooding, predation and disturbance by humans were not believed to be major factors in nest desertion.

It was found that 39.9 to 79.3 per cent, with a seven-year average of 65 per cent, of the geese renested upon removal of the first egg clutch. The renesting interval ranged from eight to 27 days, with a seven-year average period of 17.5 days.

Suggestions for further study of behavior patterns and for management of the goose flock are given.

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