Waterfowl nesting on islands in two ponds of the Canyon Ferry Wildlife Management Area, Montana
by Thomas Lee Carlsen

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University


Abstract:
Waterfowl nesting on artificial islands in 2 ponds of the Canyon Ferry Wildlife Management Area was studied from 1982-1983. A total of 37 nests of 4 species of ducks were found on islands in Ponds 3 and 4. The mallard (Anas platyrynchos) and the redhead (Aythya americana) were the 2 most common nesting species. A total of 222 nests of Canada geese (Branta canadensis moffittii) were located on islands in Pond 3 and 111 in Pond 4 during the course of the study. Physical characteristics of islands were measured to determine their possible influences on nesting densities, number of nests/island, nesting success and egg success. Nest site measurements were compared to analogous measurements made at random sites to investigate selection for particular nest site characteristics.

Nesting densities of ducks in Pond 3 averaged 49.8 nests/ha in 1983. Canada goose nesting densities in 1983 averaged 64.3 and 39.8 nests/ha in Ponds 3 and 4, respectively. Perimeter of the island was the most influential variable in determining waterfowl nesting densities. Islands with small perimeters had high nesting densities. Ducks selected islands averaging 0.07 ha in size. Canada geese used a wide range of island sizes and islands averaging 0.1 ha were able to support more than 1 nest. Nest success of ducks was 75.7% for the 2 years. Destruction by avian predators and flooding of nests were the main causes of failure. Nest success for geese on Ponds 3 and 4 in 1983 was 92.4% and 90.1%, respectively. Islands with more than 1 goose nest had a slightly lower nest success than islands with a single nest. The distance of the island to the mainland and the spacing of islands were not influential in nesting success. Ducks selected sites in dense, high vegetation offering concealment of the nest. Geese, nesting solitarily, selected nest sites with greater visibility than geese nesting on islands with more than 1 nest. Visual barriers, in the form of willow, allowed close spacing of nests on single islands as well as concentrated use of closely-spaced, small, dredged islands.

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by

Thomas Lee Carlsen

A thesis submitted in partial fulfillment
of the requirements for the degree

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APPROVAL

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Thomas Lee Carlsen

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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## ABSTRACT

Waterfowl nesting on artificial islands in 2 ponds of the Canyon Ferry Wildlife Management Area was studied from 1982-1983. A total of 37 nests of 4 species of ducks were found on islands in Ponds 3 and 4. The mallard (Anas platyrynchos) and the redhead (Aythya americana) were the 2 most common nesting species. A total of 222 nests of Canada geese (Branta canadensis moffittii) were located on islands in Pond 3 and 111 in Pond 4 during the course of the study. Physical characteristics of islands were measured to determine their possible influences on nesting densities, number of nests/island, nesting success and egg success. Nest site measurements were compared to analogous measurements made at random sites to investigate selection for particular nest site characteristics. Nesting densities of ducks in Pond 3 averaged 49.8 nests/ha in 1983. Canada goose nesting densities in 1983 averaged 64.3 and 39.8 nests/ha in Ponds 3 and 4, respectively. Perimeter of the island was the most influential variable in determining waterfowl nesting densities. Islands with small perimeters had high nesting densities. Ducks selected islands averaging 0.07 ha in size. Canada geese used a wide range of island sizes and islands averaging 0.1 ha were able to support more than 1 nest. Nest success of ducks was 75.7% for the 2 years. Destruction by avian predators and flooding of nests were the main causes of failure. Nest success for geese on Ponds 3 and 4 in 1983 was 92.4% and 90.1%, respectively. Islands with more than 1 goose nest had a slightly lower nest success than islands with a single nest. The distance of the island to the mainland and the spacing of islands were not influential in nesting success. Ducks selected sites in dense, high vegetation offering concealment of the nest. Geese, nesting solitarily, selected nest sites with greater visibility than geese nesting on islands with more than 1 nest. Visual barriers, in the form of willow, allowed close spacing of nests on single islands as well as concentrated use of closely-spaced, small, dredged islands.

# INTRODUCTION

The continued loss of waterfowl habitat through drainage has resulted in an effort in recent years to increase waterfowl nesting densities in smaller blocks of habitat. The construction of mammal-free nesting islands has proved an effective management tool towards achieving this objective. Several studies have shown waterfowl will readily accept islands as nesting areas and will nest at higher densities with greater success than on nearby mainland sites (Hammond and Mann 1956, Keith 1961, Duebbert 1966, 1982, Vermeer 1970, Ewaschuk and Boag 1972, Johnson et al. 1978, Giroux 1981, Duebbert et al. 1983). Hammond and Mann (1956) described criteria for the construction of islands for nesting waterfowl while Kaminski and Prince (1977) and Giroux (1981) reported on specific factors involving island selection, number of nests and nesting success.

The construction of a 4 pond system with artificial islands on the Canyon Ferry Wildlife Management Area (CFWMA) presented the opportunity to study island nesting by an expanding Canada goose population and a pioneering duck population. This study concentrated on the 2 ponds containing a majority of the islands as well as most of the goose and duck nests. The specific objectives of the study were: (1) to determine species and numbers of ducks using the islands for nest sites; (2) to identify factors important in influencing the number and success of island nesting waterfowl; (3) to determine specific nest site preferences on the islands; (4) to compare the productivity of nesting waterfowl on the 2 ponds; and (5) to develop a sampling system for future use in searching for duck nests. Field work was conducted from mid-June to mid-August, 1982 and from mid-March to mid-August, 1983.

# DESCRIPTION OF STUDY AREA

The study area consisted of Ponds 3 and 4 lying within the Canyon Ferry Wildlife Management Area (CFWMA) on the south end of Canyon Ferry Reservoir near Townsend, Montana (Figure 1). Construction of the reservoir was completed by the Bureau of Reclamation in 1954 as a power generating, flood control, irrigation and recreation project. The reservoir extends downsteam from Townsend 40 kilometers (km) (25 miles (mi)) to Canyon Ferry Dam about 27 km (17 mi) east of Helena, Montana. It has a surface area of 14,251 hectares (ha) (35200 acres (a)) and is 7.2 km (4.5 mi) at its widest point.

Original management of the reservoir called for maintaining high water levels to maximize power generation. To meet flood control needs, water management changed in 1966, calling for late season drawdowns exposing as much as 3683 ha (9100 a) of mud flats at the upper end of the reservoir (Denson et al. 1978). The strong winds prevalent in the area and the exposed mud flats created a serious dust problem, eventually resulting in the Bureau of Reclamation being cited by the State Department of Health in April, 1971 for exceeding state air pollution standards. Several methods to alleviate the

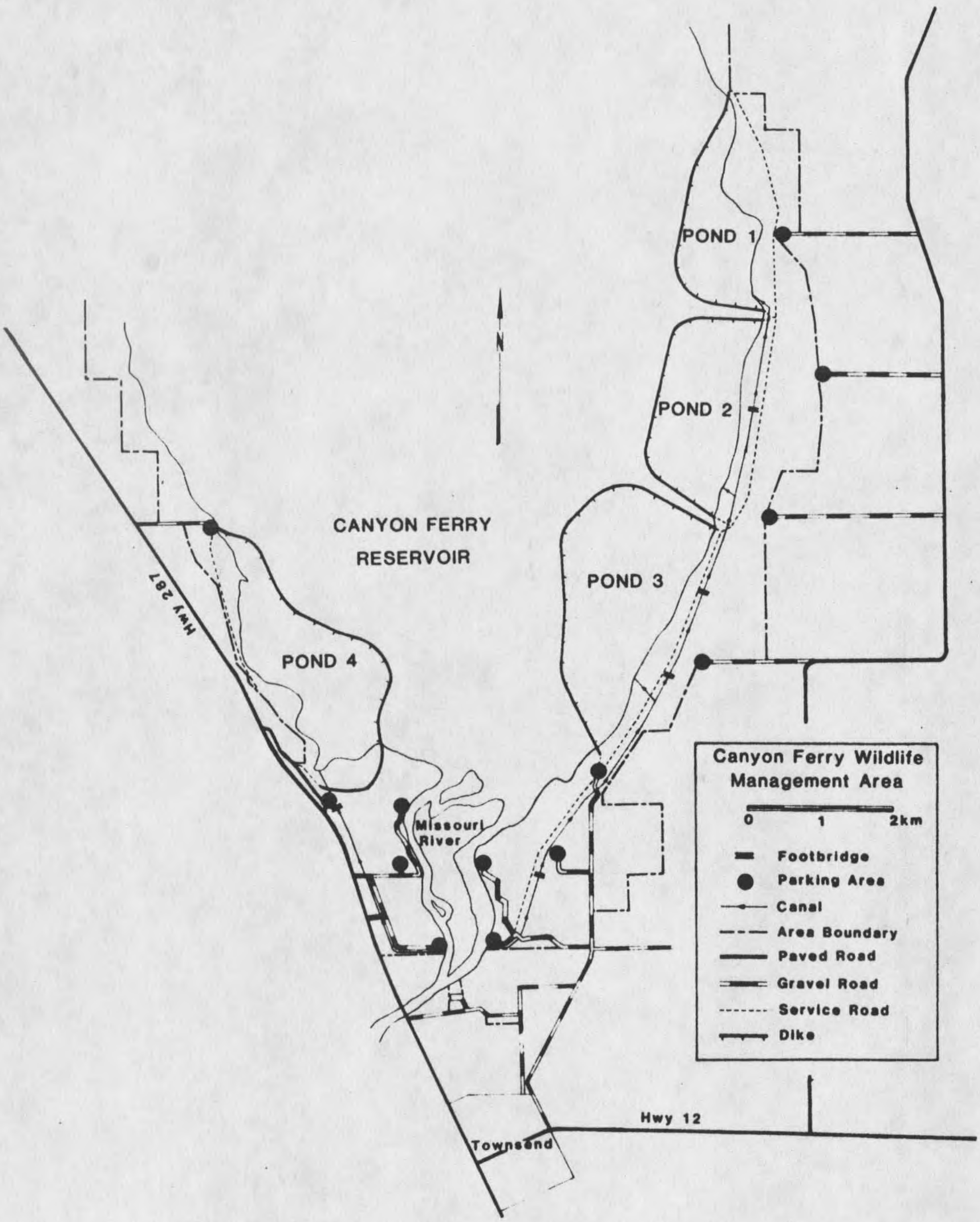


Figure 1. Map of Canyon Ferry Wildlife Management Area showing study area, Ponds 3 and 4.

dust problem had failed. That same year Congress authorized the Bureau to begin the Canyon Ferry Conservation and Wildlife Enhancement Project which resulted in the construction of 4 dikes enclosing 769 ha (1900 a) of the exposed area and the excavation of 1093 ha (2700 a) of material from the reservoir side of the dikes to be deposited within the 4 subimpoundments. The 2024 ha (5000 a) area plus the pond system thus created by the project was to be managed by the Montana Department of Fish, Wildlife, and Parks. Wildlife biologists had input into the design of the pond-island systems throughout the construction phase which began in 1973 and was completed in 1977. Islands were built by hauling material onto the ice during the winter and from dredged material being pumped into the ponds. Pond 3, with 149 ha (369 a) of surface area, contains about 240 islands (1.6 islands/ha) depending on the water level in the pond (Figure 2). Pond 4, which has 155 ha (384 a) of surface area, contains 61 islands (0.4 islands/ha) and a long dredged flat which is partially exposed during the goose nesting season (Figure 3). The islands in Pond 3 have a total area of 5.76 ha (14.23 a) and in Pond 4, 4.42 ha (10.93 a). Water levels in the ponds are maintained through inlet canals from the Missouri River and outlet gates on the dikes, and can be manipulated as long as the reservoir water level is below that of the ponds. When reservoir levels exceed those in

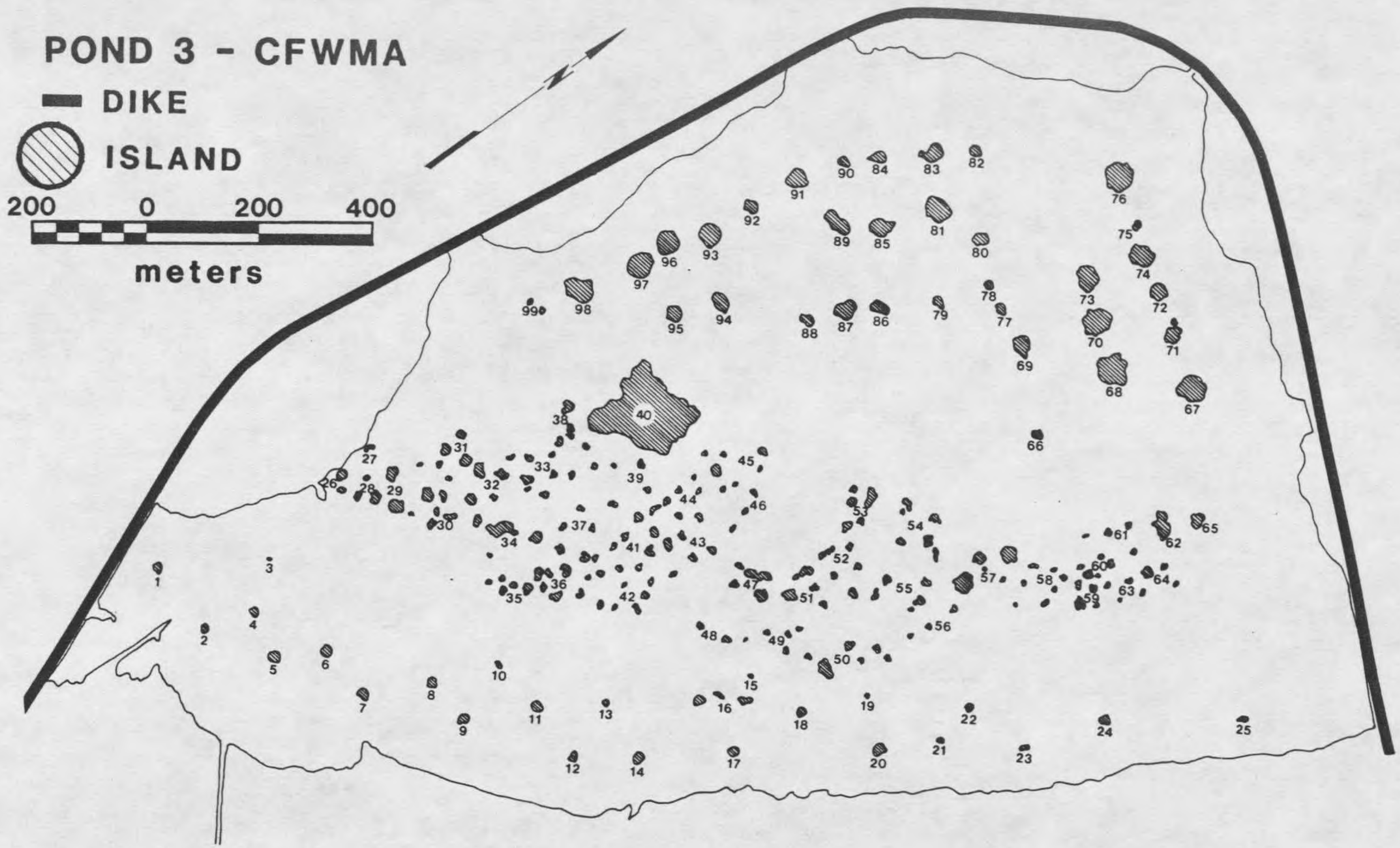


Figure 2. Map of Pond 3 on the CFWMA.

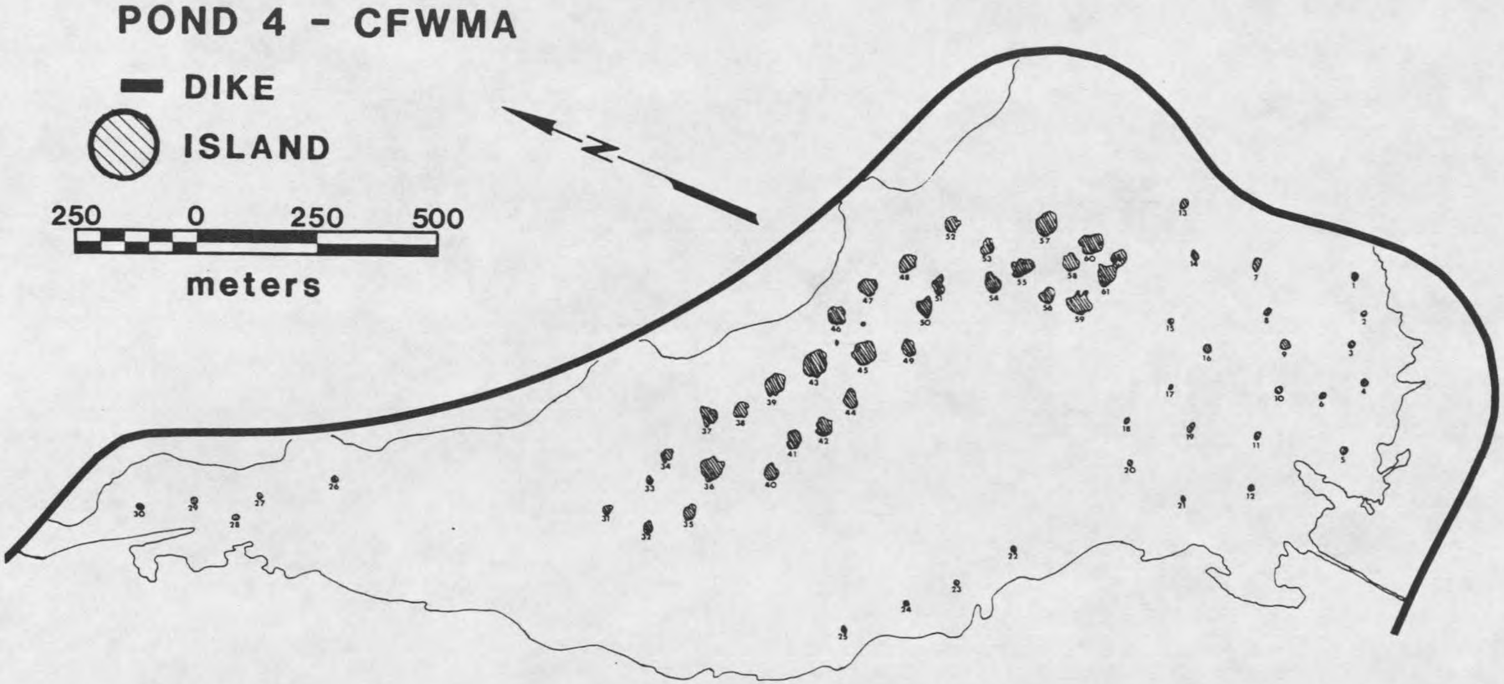


Figure 3. Map of Pond 4 on the CFWMA.

the ponds, seepage through the dikes occurs causing a rise in pond water levels.

The islands, constructed primarily from a gravel-silt material and being exposed to strong winds, pose a harsh environment for vegetation. Artificial seedings of grasses and legumes have been slow to become established. Vegetation on the islands consists mainly of willow (Salix spp.) and annual forbs. A list of plants occurring on the islands in both ponds can be found in Tables 27 and 28 in the Appendix.

Pond 4 was the first to be impounded and had islands available for nesting in 1974. Dike and island construction was completed on all ponds in 1977 and islands were available for nesting in 1978.

Emergent vegetation (Scirpus spp.) from local sources and purchased root stock have been transplanted in both study ponds and again has been slow to establish due to the harsh environment and fluctuating water levels.

High turbidity and fluctuating water levels likewise have impeded the establishment and expansion of submergent vegetation. Pond 3, the younger of the 2 study ponds, has a greater distribution and diversity of submergent vegetation. A species list of submergent plants found in the ponds appears in Table 29 in the Appendix.

# METHODS

Systematic searches for duck nests were conducted at approximately 3 week intervals in 1982 and 1983. Two complete searches were made in 1982, beginning in mid June. Four searches were made in 1983, the first running concurrently with the goose nest search in late April. All islands were completely searched. When a hen was flushed, its species was determined, its eggs were counted, and the cover at its nest classified as willow, residual cover or new growth. Eggs were candled to determine the stage of development (Weller 1956), covered with the nest down to prevent cooling and lessen the chance of predation, and a field map drawn showing location of the nest. Duck species was determined at nests without an attending hen by characteristics of the down and contour feathers (Broley 1950).

All islands have been searched annually for goose nests since completion of the ponds. Islands in Ponds 3 and 4 were searched on April 26 and 27, 1982 and April 18 and 19, 1983 after observations indicated that a majority of nests were well into incubation. The attending goose was flushed, clutch size determined and eggs were covered with down. In 1983 cover at the nest was classified into 1 of

4 categories: structure (logs placed in the shape of a V), willow, exposed, or residual cover. Field maps showing the locations of the nests were drawn in 1983.

Duck nests were visited on or shortly after the projected hatching date to determine the nest fate. A nest was considered successful if at least 1 egg hatched. Terminology used by Miller and Collins (1953) was employed in presenting nesting data. Unhatched eggs were examined and classified as containing a dead embryo or being infertile (Kossack 1950). The predators of destroyed nests were identified from descriptions given by Rearden (1951). After nest fate was determined, nests were marked with flagging to facilitate relocation.

The fate of all 1982 goose nests was not determined due to the difficulty of relocating nests in new vegetation by late June. In 1983 the fate of all goose nests was determined approximately 3 weeks after the nest search.

In 1982 a representative sample of islands was selected which was felt to show variation in parameters being measured. Sixteen islands were sampled in Pond 3 and 15 in Pond 4. Island samples in both years included all islands with multiple goose nests and all islands with duck nests. In 1983 islands were stratified into 3 size groups and a random sample drawn from each group. A total of 46 islands in Pond 3 and 30 in Pond 4 were selected.

Island 40 in Pond 3, being somewhat anomalous because of its large size, was not included in statistical analyses but measurements were made at nest sites in the same manner as for those on other islands in 1983.

All nest measurements were made after nest fate was determined, to lessen the chance of desertion. New vegetation growth had started so vegetation measurements, while different than those present at the initiation of nesting, were relative between islands. Measurements made on both duck and goose nests were the average height of vegetation taken 0.5 meters (m) from the nest in each cardinal direction, and the distance from the nest to water. Density board readings using a modification of the method described by Jones (1968) were taken at duck nests in 1982 and duck and goose nests in 1983. The degrees of visibility to open water was determined for all goose nests and taken with a hand held compass 30 centimeters (cm) above the nest. Distance to the nearest neighbor and visual obstruction between nearest neighbors, using a method modified from Robel (1969), were made on islands with more than 1 goose nest. In 1983 the same measurements taken at nest sites were made at random sites located on sampled islands using a coordinate system.

Island measurements included area and perimeter of islands, distance of the island to the nearest shoreline, and between-island measurements made from air photos taken in 1979. Canopy coverage was calculated using the line-intercept method along east-west and north-south transects in 1982 (Canfield 1941). The height of vegetation was recorded at intervals along the same transects. Maximum depth of water between islands and the nearest shoreline was measured. The maximum elevation of an island above the waterline was determined using a Stratolevel.

Water transparency readings using a Secchi disk and fluctuations in pond water elevations were made both years of the study.

Stepwise regression was used to analyse variation in nesting densities and hatchability of eggs. Stepwise discriminant analysis was used to classify islands by the number of nests per island and nest success. Analysis of variance was used to analyze nest site measurements. Random sites on islands with and without nests were analysed to detect differences between islands used or not used for nesting. Also, measurements at nest sites were compared to those at random sites on the same islands to determine if there was selection for particular habitat components. All percentage data were transformed using an angular transformation and a logarithmic transformation was used to linearize the regression function and to stabilize the variance of the error terms (Sokal and Rohlf

1981). All statistical tests were made using BMDP (Dixon 1983) statistical packages at the Montana State University Computer Center.

# RESULTS

## Nest Search

Four species of ducks, mallard (Anas platyrhynchos), gadwall (Anas strepera), pintail (Anas acuta), and redhead (Aythya americana) nested on islands both years of the study. Eleven duck nests were located in 1982, all in Pond 3. Twenty two nests in Pond 3 and 4 nests in Pond 4 were located in 1983. Nest locations in Ponds 3 and 4 for both years are shown in Figures 4 and 5, respectively. Nest locations by species and island are given for both years in Table 30 in the Appendix.

Canada goose nest surveys on the Missouri River and pond portions of the CFWMA since 1974 indicate a stable or slightly declining breeding segment on the river and a progressive colonization of the pond system (Table 1). The contribution of islands in Ponds 3 and 4 to the increase in the number of nests and the percent of islands used for nesting in each pond by year is shown in Table 2. Locations of goose nests in Ponds 3 and 4 for 1983 are shown in Figures 6 and 7, respectively.

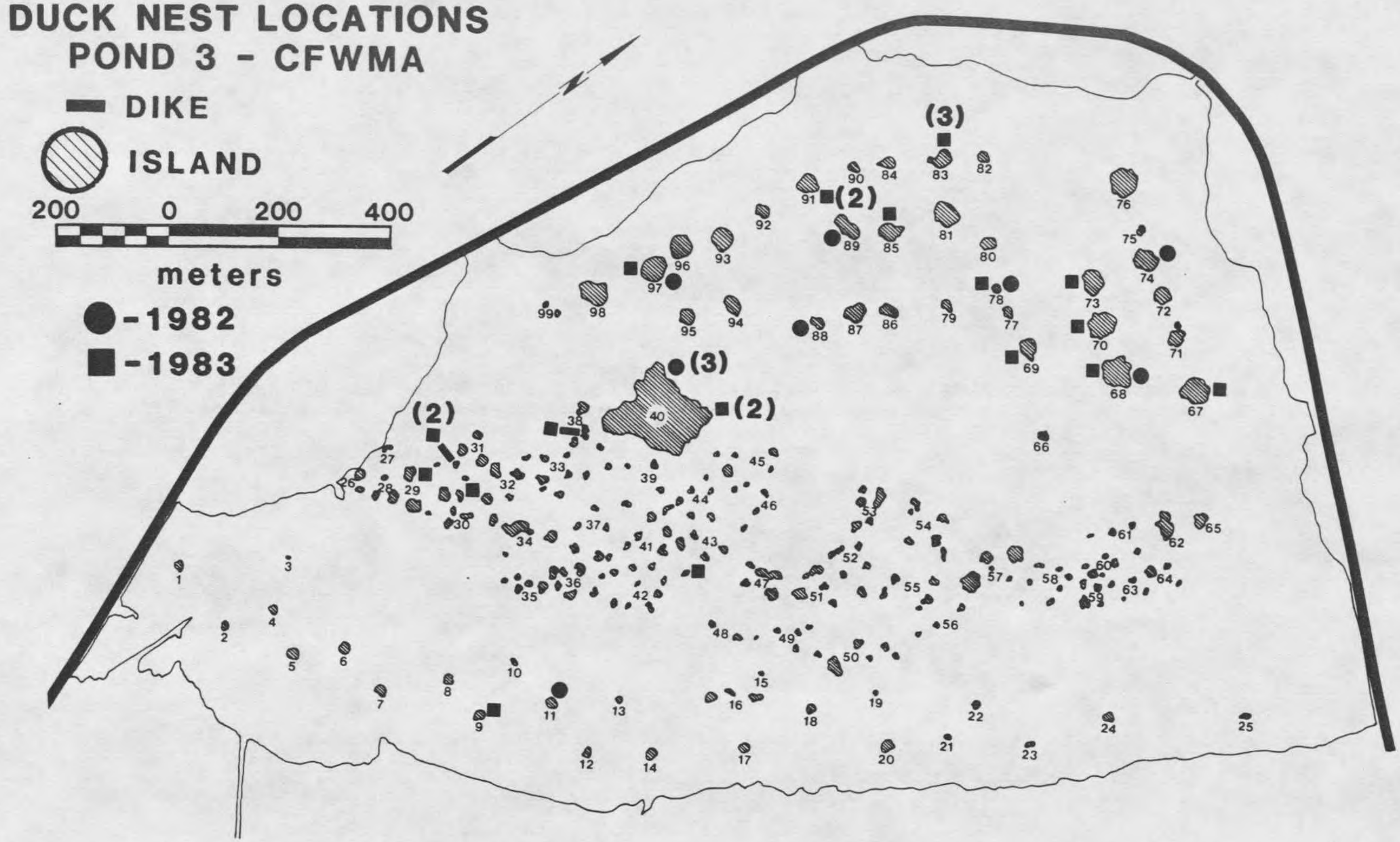


Figure 4. Duck nest locations in Pond 3, CFWMA, 1982-83. Numbers in parentheses indicate if there was more than 1 nest on an island.

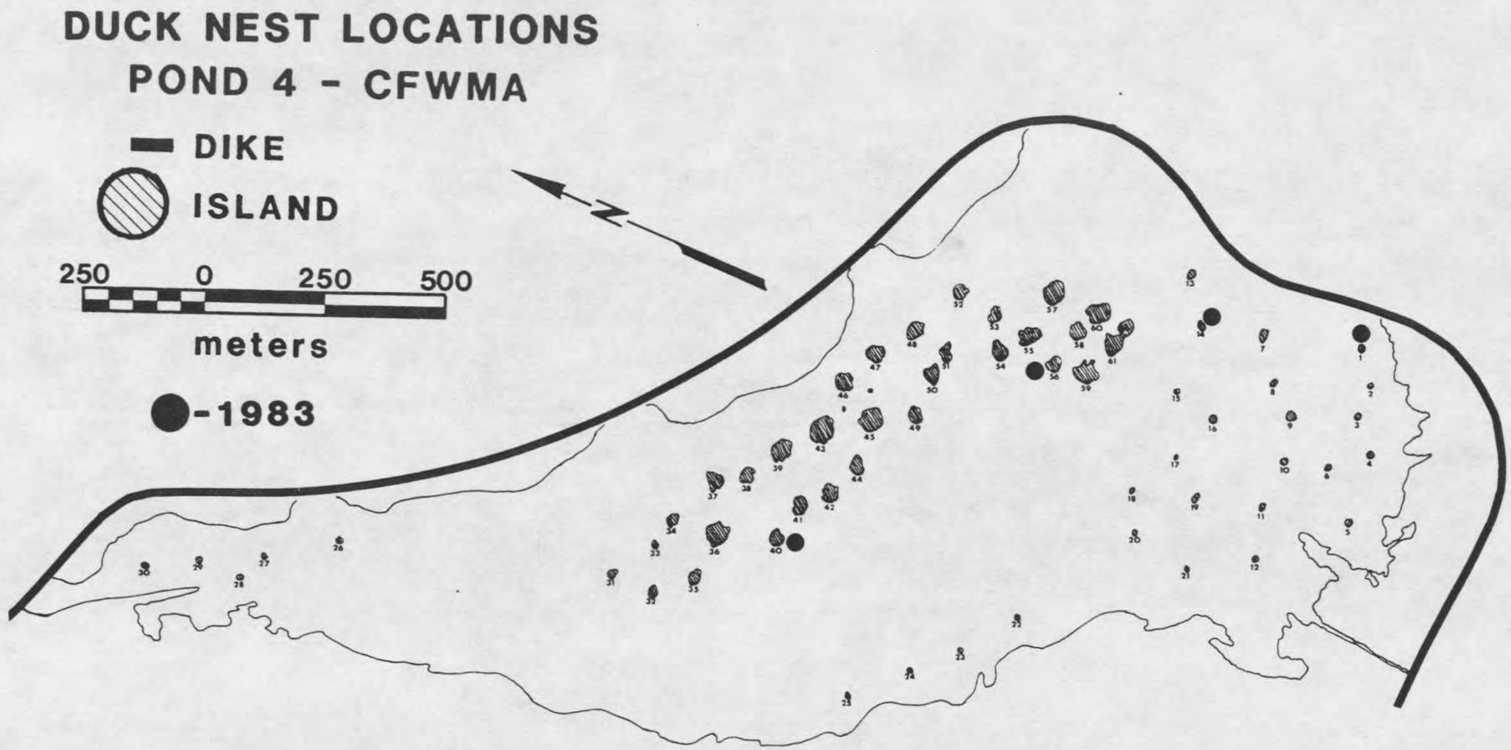


Figure 5. Duck nest locations in Pond 4, CFWMA, 1983.

Table 1. Distribution of Canada goose nests on the CFWMA, 1974-1983 (Eng, R.L. and J. Herbert unpubl. data).

| Year | River | Ponds | Total | % In ponds |
|---|---|---|---|---|
| 1974 | 47 | 6 | 53 | 11 |
| 1975 | 45 | 6 | 51 | 12 |
| 1976 | 42 | 18 | 60 | 30 |
| 1977 | 43 | 39 | 82 | 48 |
| 1978 | 50 | 42 | 92 | 46 |
| 1979 | 30 | 51 | 81 | 63 |
| 1980 | 28 | 63 | 91 | 69 |
| 1981 | 30 | 114 | 144 | 79 |
| 1982 | 24 | 169 | 193 | 87 |
| 1983 | 32 | 201 | 233 | 86 |

Table 2. Number of Canada goose nests on islands in Ponds 3 and 4 and percent of islands used for nesting, CFWMA, 1974-1983 (Eng, R.L. and J. Herbert unpubl. data).

| | Pond 3 | | Pond 4 | |
|---|---|---|---|---|
| Year | Number of nests | Islands used | Number of nests | % Islands used |
| 1974 | - | - | 6 | 11 |
| 1975 | - | - | 6 | 12 |
| 1976 | - | - | 18 | 30 |
| 1977 | - | - | 20 | 24 |
| 1978* | 15 | 6 | 22 | 40 |
| 1979 | 14 | 6 | 31 | 56 |
| 1980 | 25 | 10 | 36 | 67 |
| 1981 | 59 | 22 | 44 | 72 |
| 1982 | 104 | 34 | 51 | 80 |
| 1983 | 118 | 38 | 60 | 80** |

* Island construction completed in both ponds.
** Four nests on dredged flat not included in calculation.

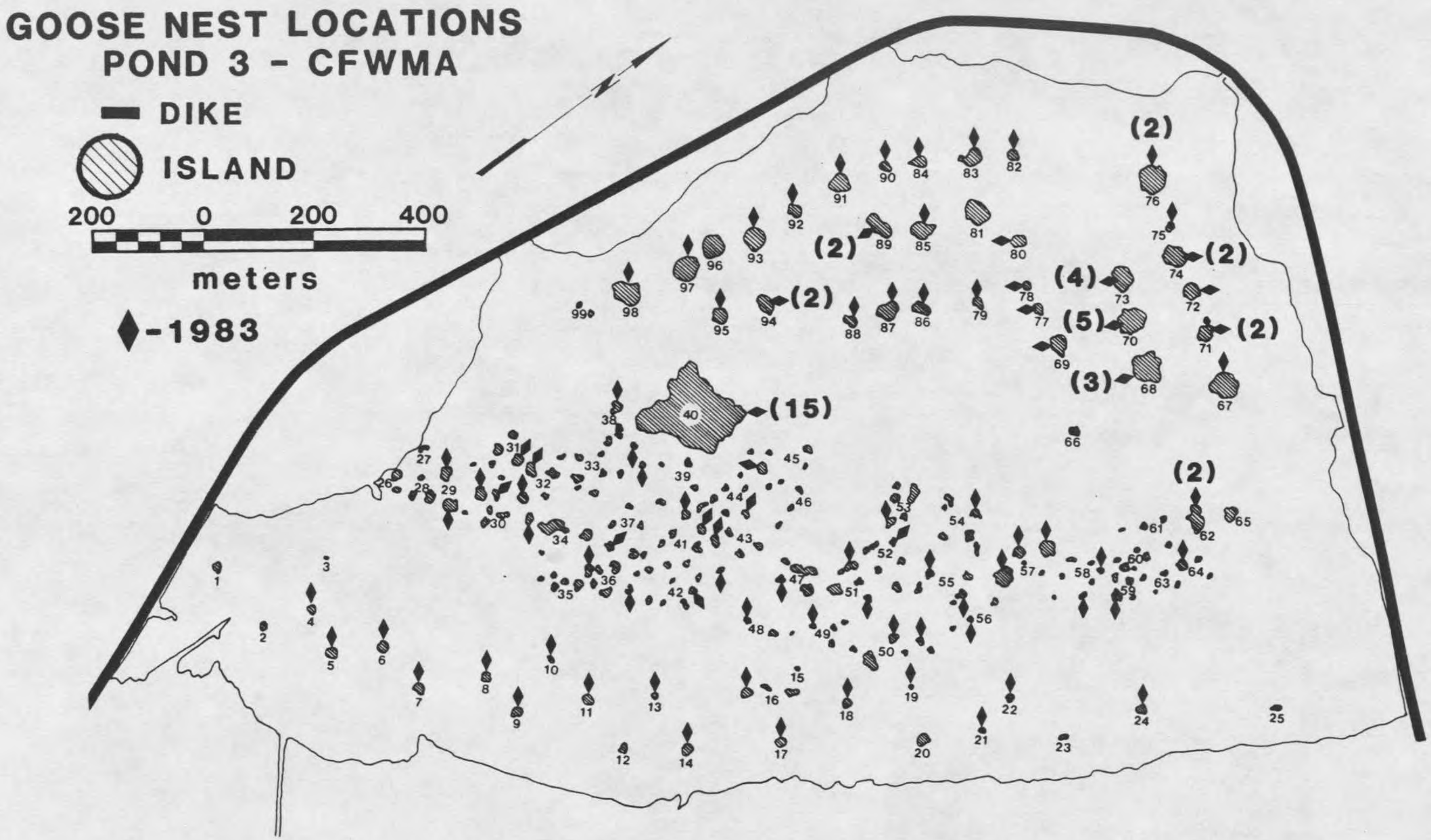


Figure 6. Canada goose nest locations in Pond 3, CFWMA, 1983. Numbers in parentheses indicate if there was more than 1 nest on an island.

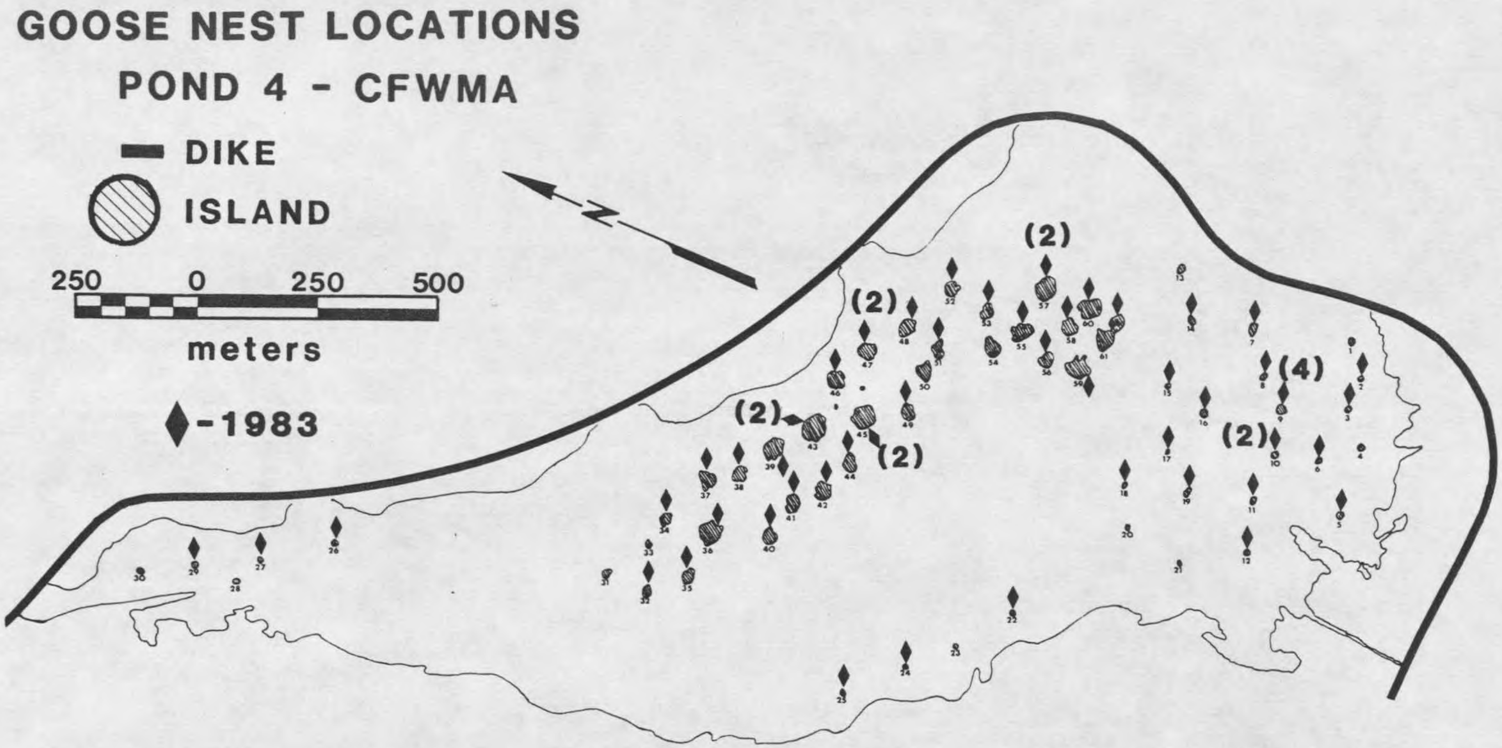


Figure 7. Canada goose nest locations in Pond 4, CFWMA, 1983. Numbers in parentheses indicate if there was more than 1 nest on an island.

Fate of Nests

Fate of duck nests in Pond 3 is shown by species for 1982 and 1983 in Tables 3 and 4, respectively. All duck nests in 1982 were successful. In 1983, 4 nests on Pond 3

Table 3. Fate of duck nests in Pond 3, CFWMA, 1982.

| Species | Number | Hatched | Destroyed | Unknown | % Successful |
|---|---|---|---|---|---|
| Mallard | 8 | 8 | 0 | 0 | 100.0 |
| Gadwall | 1 | 1 | 0 | 0 | 100.0 |
| Pintail | 1 | 1 | 0 | 0 | 100.0 |
| Redhead | 1 | 1 | 0 | 0 | 100.0 |
| Total | 11 | 11 | 0 | 0 | 100.0 |

Table 4. Fate of duck nests in Pond 3, CFWMA, 1983.

| Species | Number | Hatched | Destroyed | Unknown | % Successful |
|---|---|---|---|---|---|
| Mallard | 13 | 10 | 2 | 1 | 76.9 |
| Gadwall | 1 | 1 | 0 | 0 | 100.0 |
| Pintail | 2 | 1 | 1 | 0 | 50.0 |
| Redhead | 6 | 3 | 3 | 0 | 50.0 |
| Total | 22 | 15 | 6 | 1 | 68.2 |

were destroyed by unidentifed avian predators. Potential avian predators observed on the area are the California gull (Larus californicus), ringed-billed gull (Larus delawarensis), black-billed magpie (Pica pica), common raven (Corvus corax), and the common crow (Corvus brachyrhynchos). Large breeding colonies of California and ringed-billed gulls were located on islands 69, 70, and 73 and lesser colonies on adjacent islands in Pond 3 both years of the study. Gulls have been reported to be serious predators of duck eggs (Odin 1957). Destroyed eggs were typically found scattered around the nest or on adjacent islands where they were carried and then eaten. Two of the 3 redhead nests listed as destroyed were flooded by rising pond levels in July.

Four mallard nests were found on Pond 4 in 1983. Two of the nests were successful, 1 was destroyed by an unidentified predator, the other by magpies (observed).

The fate of goose nests located in 1983 is shown in Table 5. The high nest success in both ponds is reflected by the low number of nests that were deserted or destroyed. In Pond 3, 5 of the 8 nests that were deserted were on islands with more than 1 nest. The 1 nest of unknown fate, located on island 5, appeared to have been destroyed by a predator. However, territorial aggression observed from pairs nesting on islands 4 and 6 may have caused desertion prior to predation. Only 1 nest on Pond 4 was classified as deserted. This nest was on a small haul island where 4 nests were located. The 5 nests listed as having unknown fate were possibly destroyed by predators. No sign of the eggs or fragments were found at the nest sites, nests were not disturbed, nor tracks observed on the islands.

Table 5. Fate of Canada goose nests on islands in Ponds 3 and 4, CFWMA, 1983.

| | Pond 3 | | Pond 4 | |
|---|---|---|---|---|
| Fate | Number of nests | % | Number of nests | % |
| Hatched | 109 | 92.4 | 54 | 90.1 |
| Deserted | 8 | 6.8 | 1 | 5.0 |
| Destroyed | 0 | 0 | 1 | 1.5 |
| Unknown | 1 | 0.8 | 5 | 3.4 |
| Total | 118 | 100.0 | 60 | 100.0 |

## Egg Success

The fate of duck eggs in successful nests on Pond 3 is shown in Tables 6 and 7 for 1982 and 1983, respectively. Hatchability of mallard eggs was high both

Table 6. Fate of duck eggs on Pond 3, CFWMA, 1982.

| Species | Eggs | Hatched | Infertile | Dead embryo | Unknown |
|---|---|---|---|---|---|
| Mallard | 58 | 58(100)* | 0 | 0 | 0 |
| Gadwall | 9 | 6(66.7) | 0 | 3 | 0 |
| Pintail | 7 | 7(100) | 0 | 0 | 0 |
| Redhead | 7 | 6(85.7) | 0 | 0 | 1 |

* Number and percent

Table 7. Fate of duck eggs Pond 3, CFWMA, 1983.

| Species | Eggs | Hatched | Infertile | Dead embryo | Unknown |
|---|---|---|---|---|---|
| Mallard | 77 | 76(98.7)* | 0 | 0 | 1 |
| Gadwall | 8 | 8(100) | 0 | 0 | 0 |
| Pintail | 4 | 4(100) | 0 | 0 | 0 |
| Redhead | 29 | 19(65.5) | 0 | 8 | 2 |

* Number and percent

years while the redhead, the other common nesting species, had a relatively low egg success in 1983. Data for both years and ponds were combined to calculate average clutch size for each species. Clutch size averages were 8.0, 8.5, 5.5, and 9.0 for the mallard, gadwall, pintail, and redhead, respectively.

In addition to the 29 eggs laid by redheads in successful nests, 18 "dump" eggs were laid. Eight eggs were laid in 3 mallard nests and 10 in 2 other redhead nests. Only 1 "dump" egg was known to have hatched, the others dying in various stages of development. Parasitic egg laying is a common trait of redheads (Weller 1959).

The fate of eggs in successful goose nests is shown in Table 8. Only successful nests of known clutch sizes were used in the calculations. Pond 3 had 101 nests with an average clutch size of 5.7 eggs. Pond 4 had 54 nests with an average clutch size of 5.3 eggs. Clutch sizes on both ponds ranged from 1 to 11 eggs.

Table 8. Fate of Canada goose eggs on Ponds 3 and 4, CFWMA, 1983.

| | Pond 3 | | Pond 4 | |
|---|---|---|---|---|
| Fate | Number of eggs | % | Number of eggs | % |
| Hatched | 557 | 96.2 | 281 | 98.9 |
| Infertile | 6 | 1.0 | 1 | 0.4 |
| Dead embryo | 12 | 2.1 | 0 | 0.0 |
| Unknown | 4 | 0.7 | 2 | 0.7 |
| Total | 579 | 100 | 284 | 100 |

## Nesting Season

The length of the duck nesting season was calculated for 1983 and was determined by backdating from the date of the first hatching clutch, using the average incubation period and egg laying interval for each species given by Bellrose (1978), to the hatching of the last clutch. Data for mallards were combined for both ponds. The lengths of the nesting seasons were, mallard (April 22 - July 14), gadwall (June 23 - July 25), pintail (May 7 - June 3), and redhead (May 29 - July 25).

The length of the 1983 goose nesting season, using criteria by Vermeer (1970), was calculated by backdating from the observation of the first brood to the hatching of the last clutch. The first egg was estimated to have been laid on March 11 on Pond 3 and on March 12 on Pond 4. The length of the nesting season on Ponds 3 and 4 were approximately 74 and 66 days, respectively. The longer nesting period for Pond 3 was due to 1 late nesting goose which successfully hatched a clutch on May 24.

## Nesting Density

The 4 duck nests found on Pond 4 are not included in any of the statistical analyses due to their small sample size. Nesting densities on island habitat in Pond 3, including the large island, averaged 49.8 nests/ha and varied from 1.7 to 285.7 nests/ha over the 2 year period. In 1983, 5 independent variables describing physical characteristics of the islands were selected to try to explain variation in nest density. The variables are area and perimeter of the islands, distance of the island to the nearest shoreline, maximum depth of water between the island and the nearest shoreline, and maximum elevation of the island above the waterline. Stepwise regression was used to determine which variables explained most of the variation in nest density. Variables are entered into or removed from the regression on the basis of their "F to enter or remove values" with user selected limits of significance. The results of the analysis are shown in Table 9. Eighty four percent of the variation in density of duck nests is explained by the 4 variables which entered the regression. Perimeter and area are related

Table 9. Results of a stepwise regression with density of duck nests as the dependent variable, N=14 islands, Pond 3, CFWMA, 1983 (+ = positive influence; - = negative influence).

| Independent variable | Multiple $r^2$ | Adjusted $r^2$ | MSE |
|---|---|---|---|
| -Perimter | 0.60 | 0.57 | 1818.3 |
| -Area | 0.74 | 0.69 | 1284.2 |
| +Distance to shore | 0.81 | 0.75 | 1060.1 |
| -Elevation | 0.84 | 0.77 | 950.8 |

measurements and were both included in the analysis because the length of shoreline or perimeter might influence the number of nests initiated on an island. Together the 2 variables explain 74% of the variation in nesting density. Smaller islands had higher densities than large islands. Four of the 6 nests on small islands were redheads. The highest density recorded was a redhead nest on an island only 0.004 ha in size with a perimeter of 22.0 m. The majority of the smaller islands in Pond 3 are in the dredged cluster located through the mid portion of the pond. These islands tend to be farther from shore and also have a lower elevation than the haul islands on the east shoreline and the large dredged islands along the dike side of the pond. Although the large dredged islands support more duck nests, the average nesting density of 20.9 nests/ha (SE=5.9, N=10) was much lower than on the small dredged islands ($\bar{x}$=148.7 nests/ha, SE=50.0, N=5). Six of the 22 nests located in 1983 were on islands 0.020

ha or smaller, had a perimeter of 57.0 m or less, and have an average elevation of 0.8 m (2.6 feet(ft)) above a pond water elevation of 1157.0 m (3796 ft).

Nesting densities of geese for 1983 in Pond 3 averaged 64.3 nests/ha and ranged from 7.8 to 250.0 nests/ha. Densities in Pond 4 averaged 39.8 nests/ha and varied from 7.5 to 95.2 nests/ha. The same set of independent variables, plus the distance to the nearest island and the nearest island with a nest, were employed in the regression analysis of goose nesting densities. The results of the analysis for Ponds 3 and 4 are shown in Tables 10 and 11, respectively.

Island perimeter and the distance from the island to the nearest shoreline explained 88% of the variation in Canada goose nesting densities in Pond 3. Islands with small perimeters located far from shore had the highest nesting densities. Twelve of the sampled islands with an average perimeter of 37.0 m, (SE=0.1) and an average distance of 189.0 m, (SE=30.9) from the nearest shoreline had densities greater than 50 nests/ha. The large dredged islands support more nests per island; however, the average density of 20.6 nests/ha (SE=1.1, N=15) was considerably less than on the 12 small islands ($\bar{x}$=105.0 nests/ha, SE=35.2).

Table 10. Results of a stepwise regression with density of Canada goose nests as the dependent variable, N=29 islands, Pond 3, CFWMA (+ = positive influence; - = negative influence).

| Independent variable | Multiple $r^2$ | Adjusted $r^2$ | MSE |
|---|---|---|---|
| -Perimeter | 0.87 | 0.86 | 0.23 |
| +Distance to shore | 0.88 | 0.87 | 0.21 |

Three variables entered the regression equation in the analysis of Pond 4 nesting densities. Most of the variation (94%) in density was explained solely by the perimeter of the islands. Islands with small perimeters

Table 11. Results of a stepwise regression with density of Canada goose nests as the dependent variable, N=24 islands, Pond 4, CFWMA (+ = positive influence; - = negative influence).

| Independent variable | Multiple $r^2$ | Adjusted $r^2$ | MSE |
|---|---|---|---|
| -Perimeter | 0.94 | 0.94 | 0.81 |
| +Elevation | 0.95 | 0.95 | 0.66 |
| -Area | 0.96 | 0.96 | 0.63 |

($\bar{x}$=41.7 m, SE=1.2, N=13) had higher densities ($\bar{x}$=57.2 nests/ha, SE=1.1) than islands with large perimeters ($\bar{x}$=130.0 m, SE=1.1, N=11) which had average densities of 11.8 nests/ha, (SE=1.1). The highest density (95.2 nests/ha) recorded on Pond 4 was on a haul island with a perimeter of 34.0 m. The island supported 2 goose nests. The islands with higher densities also had slightly higher islands mentioned earlier were an average of 1.8 m, (SE=0.1) above a pond water level of 1157.0 m (3796.0 ft).

Number of Nests/Island

The islands in both ponds are relatively small compared to some reported in the literature. While nesting densities may be high on small islands the number of nests may be low. An important consideration of the study was to compare characteristics of islands used and not used for nesting by ducks. Another aspect of the study was the occurrence of multiple goose nests on an island. Multiple nesting by geese first occurred on islands in Pond 3 in 1981. In 1982 Pond 3 had 5 islands and Pond 4 had 1 island with more than 1 nest. Ten islands in Pond 3 and 6 in Pond 4 had multiple nesting in 1983.

To determine which if any physical characteristics of the islands would tend to allow duck or multiple goose nesting, the same set of independent variables used in the regression analysis of density were entered into a stepwise discriminant analysis. In discriminant analysis groups are assigned a priori and variables entered into the discriminant function based on their ability to discriminate among the groupings. Because few islands had more than 1 duck nest, island groupings for the duck analysis were islands without a nest and islands with 1 or analysis were islands without a nest and islands with 1 or more nests. Island groupings for the goose analysis were islands without a nest, islands with 1 nest, and islands with 2 or more nests. The model used in the analysis was Fisher's linear discriminant function:

$$D_i = C + d_{i1}Z_1 + d_{i2}Z_2 + \ldots + d_{ip}Z_p$$

where: $D_i$ = is the discriminant score, C is a constant, d's are coefficients for the canonical variables, Z's are values for each variable, and p is the number of discriminating variables. A discriminant score is calculated for each island and on the basis of this score the island is placed into the appropriate group. A high percent of correctly classified islands indicates a good set of discriminating variables.

The number and percent of sampled islands without a duck nest was 31(67%) and with a nest 15(33%). The results of the discriminant analysis are shown in Table 12. Perimeter of the island was the only variable entered by the analysis into the discriminant function. The size of the islands as measured by the perimeter variable was significantly different for the 2 groups ($F=10.71$, $df=1,44$, $P<0.005$).

Ducks tended to nest on islands with larger perimeters ($\bar{x}=51.1$ m, SE=6.2, N=15). Histograms of island perimeters forming frequency distributions for both groups

Table 12. Results of a 2 group discriminant analysis. Grouping and sample size (N) were islands without nests (31) and islands with nests (15), ducks, Pond 3, CFWMA, 1983.

| | Discriminant function |
|---|---|
| | 1 |
| Canonical correlation | 0.44236 |
| Variable | Coefficients for canonical variables |
| Perimeter | -0.02687 |
| Constant | 1.70833 |

shows overlap in each size category (Figure 8). The tendency for ducks to nest on islands with larger perimeters is evident as 73% of islands with a nest had perimeters of 51.0 m or more and 9 of 15 islands with a nest had perimeters of 98.0 m or more. When classifying islands as to group membership, 73.9% were correctly classified. Six of the 31 islands without a nest were classified as having a nest while 6 of the 15 islands with nests were classified as not having a nest. The discriminant function classifies islands with perimeters greater than 63.6 m to the group of islands with a nest. Based on perimeter alone, islands with small perimeters were classified as not having a nest regardless of their nesting status. This again is a reflection of the redheads preference for nesting on small islands as 4

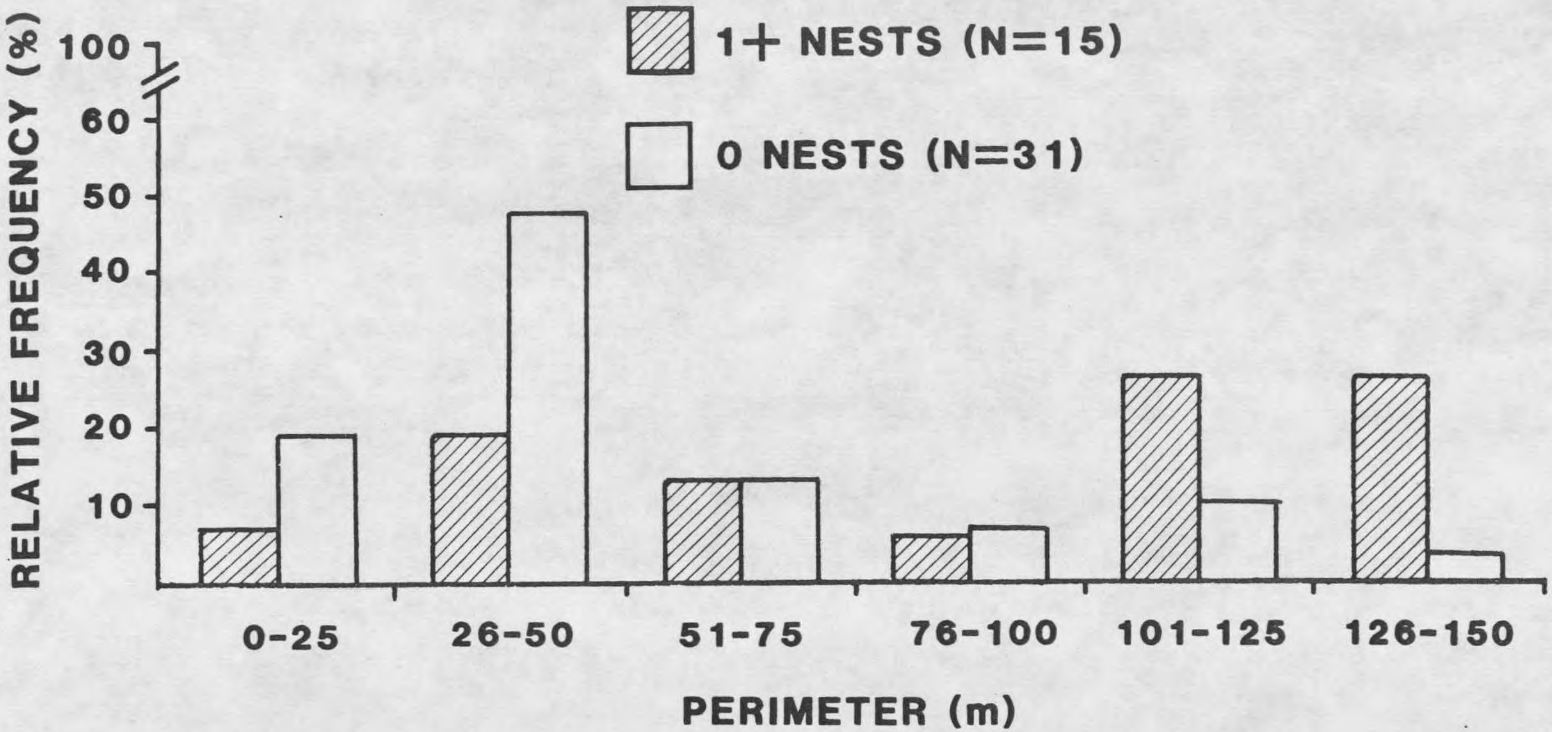




Figure 8. Relative frequency of island perimeters for islands with and without a duck nest in Pond 3, CFWMA, 1983.

of the 6 islands misclassified had redhead nests.

For the goose analysis on Pond 3 the number and percent of sampled islands in the 3 categories were 17(37%), 20(44%), and 9(19%), respectively. In Pond 4 the number and percent were 5(17%), 19(63%), and 6(20%), respectively.

Two variables entered the discriminant functions in the Pond 3 analysis. The maximum elevation variable was statistically different (F=27.54, df=2,43, P<0.001) for the 3 island groupings as was the combination of elevation and area of the islands (F=12.79, df= 4,84, P<0.001). Results of the discriminant analysis are shown in Table 13.

Table 13. Results of a 3 group discriminant analysis. Groupings and sample size (N) were islands with 0 nests (17), 1 nest (20), and 2+ nests (9) of Canada geese in Pond 3, CFWMA, 1983.

| | Discriminant function | |
|---|---|---|
| | 1 | 2 |
| Proportion of total dispersion | 0.96050 | 0.03950 |
| Canonical correlation | 0.76858 | 0.23670 |
| Variable | Coefficients for canonical variables | |
| Area | -13.86026 | 38.00739 |
| Elevation | -2.04833 | -3.54513 |
| Constant | 119.19902 | 203.89425 |

The first discriminant function with a canonical correlation of 0.77 accounted for over 96% of the dispersion among groups. The second discriminant function contributed less than 4% in explaining dispersion among the 3 groupings and has very little discriminating power. Means and standard errors for area and elevation for each grouping are shown in Table 14. When classifying each island as to group membership 88.2% of islands without a nest, 50.0% of islands with 1 nest, and 77.8% of islands with 2 or more nests were classified correctly for

Table 14. Means and standard errors for variables entered into the discriminant functions for nest groupings of Canada geese in Pond 3, CFWMA, 1983.

| | 0 Nests | | 1 Nest | | 2+ Nests | |
|---|---|---|---|---|---|---|
| Variable | $\bar{X}$ | SE | $\bar{X}$ | SE | $\bar{X}$ | SE |
| Area (ha) | 0.01 | 0.002 | 0.035 | 0.009 | 0.101 | 0.015 |
| Elevation (m) | 1157.6 | 0.04 | 1158.0 | 0.09 | 1158.5 | 0.13 |

a total percent correct classification of 69.6%. A graph of discriminant scores for each island for the 2 canonical variables is shown in Figure 9. A canonical variable is the linear combination of the variables measured which best discriminates among the groupings. The graph shows that mean discriminant scores for the group without a nest and the group with 1 nest are close and overlap of islands from the 2 groups occurs. The poor classification of

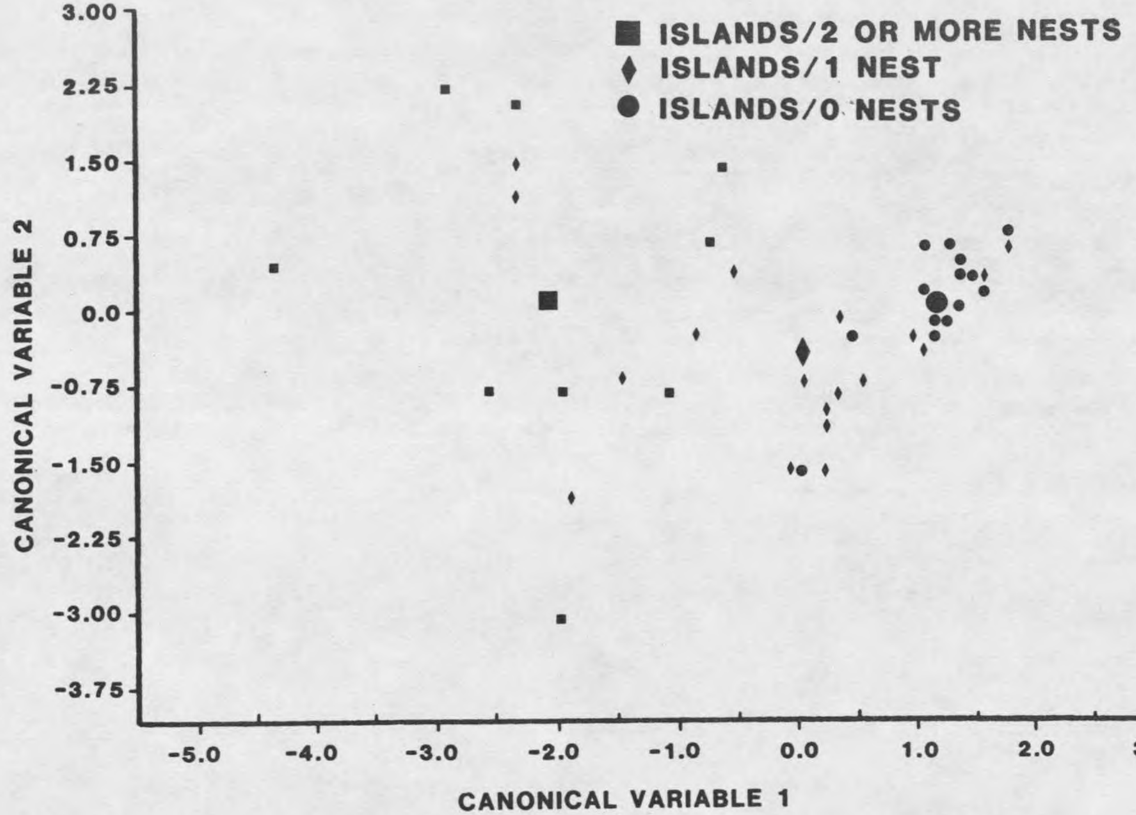


Figure 9. Plot of canonical variables for 3 island groupings showing the discriminant score for each island. Large symbols are the mean discriminant score for each group. Canada geese, Pond 3, CFWMA, 1983.

islands with 1 nest is exemplified by the fact that 6 of the 20 sampled islands which had 1 nest were on small islands with an average area of 0.007 ha, (SE=0.001) and were classified as not having a nest. Also 4 of the 20 islands with an average area of 0.097 ha, (SE=0.02) were classified as having 2 or more nests. Islands without a nest were an average of 0.6 m, 1 nest an average of 1.0 m, and 2 or more nests an average of 1.5 m above a pond water elevation of 1157.0 m (3796.0 ft).

In the Pond 4 analysis 4 variables entered the discriminant functions: area, elevation, perimeter, and the distance to shore. The 4 variables in combination were significantly different for the 3 island groupings ($F=4.1$, $df= 8,48$, $P<0.005$). Results of the discriminant analysis are shown in Table 15. Most of the discriminating ability of the analysis occurs in the first discriminant function, accounting for more than 91% of the total dispersion. Means and standard errors for the variables entering the functions by groupings are shown in Table 16. The classification of islands into group membership resulted in 80% of islands with 0 nests, 68.4% of islands with 1 nest, and 100% of islands with 2 or more nests being classified correctly for a total 76.7% correct classification. Figure 10 shows a plot of discriminant scores for each island for the 2 canonical variables and mean discriminant scores for each grouping.

Table 15. Results of a 3 group discriminant analysis. Groupings and sample size (N) were islands with 0 nests (5), 1 nest (19), and 2+ nests (6) of Canada geese in Pond 4, CFWMA, 1983.

| | Discriminant function | |
|---|---|---|
| | 1 | 2 |
| Proportion of total dispersion | 0.9133 | 0.0867 |
| Canonical correlation | 0.7728 | 0.35126 |
| Variable | Coefficients for canonical variables | |
| Area | -9.54398 | 6.33115 |
| Perimeter | 13.56673 | -11.88379 |
| Distance to shore | -1.54645 | -3.21583 |
| Elevation | -2.06054 | -0.28300 |
| Constant | 104.54652 | 41.56022 |

Table 16. Means and standard errors for variables entered into the discriminant functions for nest groupings of Canada geese in Pond 4, CFWMA, 1983.

| | 0 Nests | | 1 Nest | | 2+ Nests | |
|---|---|---|---|---|---|---|
| Variable | $\bar{X}$ | SE | $\bar{X}$ | SE | $\bar{X}$ | SE |
| Area (ha) | 0.021 | 0.009 | 0.034 | 0.006 | 0.102 | 0.006 |
| Perimeter (m) | 53.0 | 0.63 | 68.4 | 0.36 | 110.9 | 0.79 |
| Distance to shore (m) | 64.9 | 0.94 | 124.5 | 0.47 | 127.2 | 0.71 |
| Elevation (m) | 1158.7 | 0.28 | 1158.6 | 0.09 | 1159.0 | 0.08 |

As in the Pond 3 analysis the distance between mean discriminant scores for islands without a nest and islands with 1 nest is small and overlap occurs between the 2

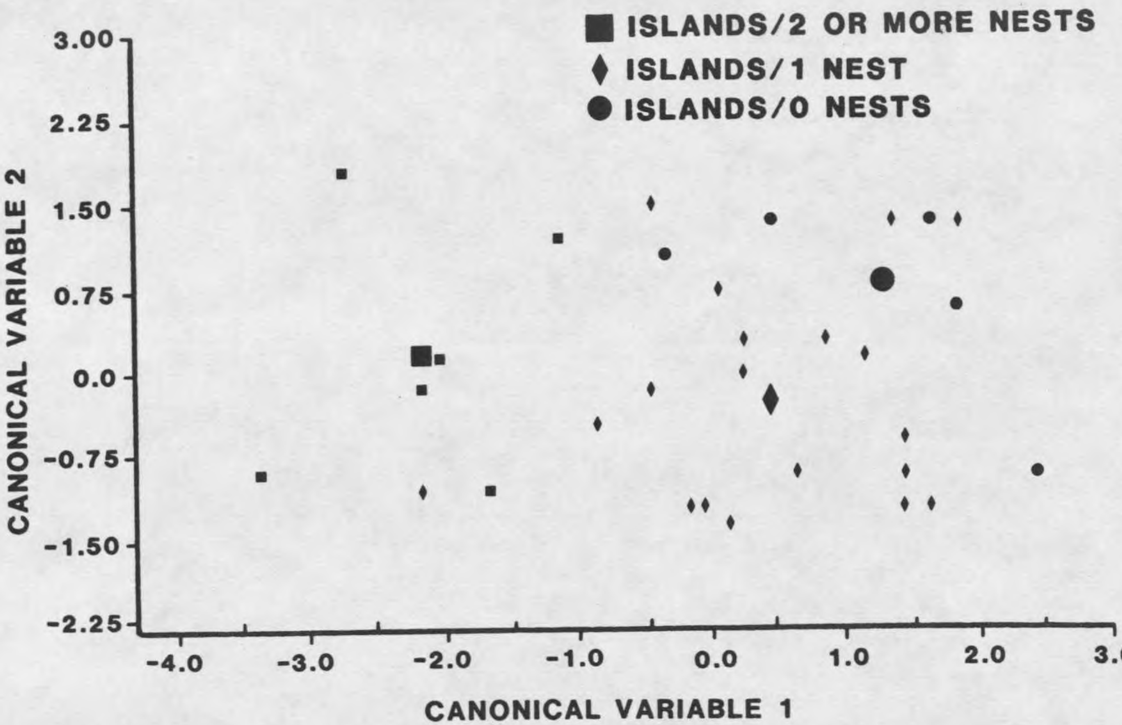


Figure 10. Plot of canonical variables for 3 island groupings showing the discriminant score for each island. Large symbols are the mean discriminant score for each group. Canada geese, Pond 4, CFWMA, 1983.

groups. Five of the 19 islands with 1 nest were misclassified as not having a nest and 1 island was misclassifed as having more than 1 nest. The analysis failed to predict use of small islands for nesting. Four of the islands misclassified had an average area of 0.015 ha while 1 large dredged island was misclassified as not having a nest because it was only 40 m from shore. Islands without a nest and with 1 nest had essentially the same average elevation while islands with 2 or more nests were an average of 2.0 m above a pond water elevation of 1157.0 m (3796.0 ft). This particular model classified all islands with multiple nests correctly.

## Nest Success

The overall duck nest success of 75.7% (28 of 37 nests) typifies the high rate of nest success attained on islands. Also nest success for island nesting geese on both ponds in 1983 was over 90%. Nest success on islands for ducks often declines because of an increase in predation or nest destruction from a host of other factors. Success for geese on the other hand declines primarily because of increased nesting densities followed by increased territorial aggression and a resultant high nest desertion (Ewaschuk and Boag 1972).

Discriminant analysis was used to explore whether density of nests, number of nests per island, or the physical parameters of the islands had any effect on nest success for ducks and geese. Two groupings were used; either the nest was successful or not. The independent variables used were the same set of variables used in the regression analysis of density plus density of nests and number of nests on an island.

In the analysis of duck nest success 2 variables entered the discriminant function. The maximum elevation of the island above the waterline was statistically different for the 2 groupings ($F=15.61$, $df= 1,17$, $P<0.005$), as were elevation and maximum depth of water between the island and the shoreline in combination ($F=10.57$, $df= 2,16$, $P<0.005$). The results of the discriminant analysis and the means and standard errors for the variables entering the discriminant function are shown in Tables 17 and 18, respectively.

Two of 6 nests which were not successful failed due to flooding. These were redhead nests and again is a result of selecting small islands for nesting which have a low maximum elevation. The other 4 unsuccessful nests were destroyed by predators. Classification of nests into group membership resulted in 83.3% of unsuccessful nests and 92.3% of successful nests being correctly classified for a 89.5% total correct classification. The frequency distribution formed by the discriminant scores for both groups is depicted by the histogram in Figure 11.

Table 17. Results of a 2 group discriminant analysis. Groupings and sample size (N) were successful nests (13), unsuccessful nests (6) for ducks on Pond 3, CFWMA, 1983.

| | Discriminant function |
|---|---|
| | 1 |
| Canonical correlation | 0.75439 |
| **Variable** | **Coefficients for canonical variables** |
| Depth | -0.10654 |
| Elevation | -2.40349 |
| Constant | 141.35974 |

Table 18. Means and standard errors for variables entered into the discriminant function for the groupings of duck nests on Pond 3, CFWMA, 1983.

| | Successful | | Unsuccessful | |
|---|---|---|---|---|
| Variable | $\bar{X}$ | SE | $\bar{X}$ | SE |
| Depth (dm) | 16.1 | 1.36 | 8.8 | 2.39 |
| Elevation (m) | 1158.4 | 0.09 | 1157.8 | 0.15 |

Although the discrimination among the 2 groups is good the small sample size and few number of nests that fall into the unsuccessful group leads to skepticism of the analysis. It is likely however, that with the present level of predation on duck nests, island elevation will be an important variable in determining nest success. Once

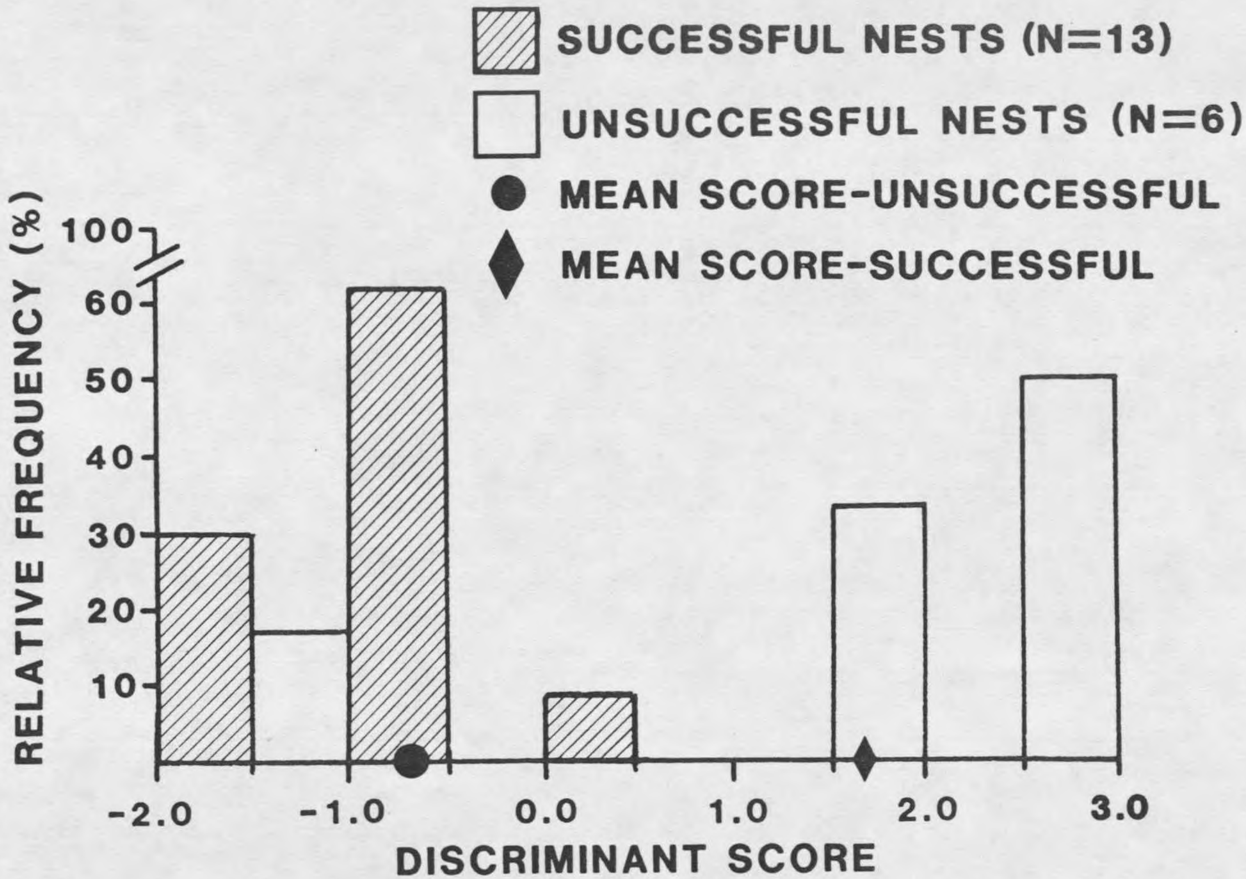


Figure 11. Relative frequency of discriminant scores for islands with successful and unsuccessful duck nests in Pond 3, CFWMA, 1983.

the pond elevation rises above 1157.3 m, flooding occurs on many of the small dredged islands. Islands with unsuccessful and successful nests were an average of 0.7 m and 1.4 m above a pond water level of 1157.0 m (3796.0 ft), respectively. The entering of depth into the discriminant function is thought to be incidental since the large dredged islands where most of the duck nests were located also are surrounded by deeper water. The depth of water between islands and the shoreline is important as a deterrent to predatory mammals. The maximum depth of water around islands with unsuccessful nests was adequate to act as a deterrent and no mammalian predation was recorded.

The islands sampled in Pond 3 had 38 successful goose nests out of a total of 43 while in Pond 4, 30 of 33 were successful. The few nests that fall into the unsuccessful group make statistical analysis dubious. No variables were entered into the discriminant analysis based on F to enter values for Pond 4. One variable, elevation, entered the discriminant analysis for Pond 3. Results of the analysis are shown in Table 19.

Successful nests were on islands with elevations slightly less ($\bar{x}$=1158.2 m, SE=0.07) than islands with unsucessful nests ($\bar{x}$=1158.6 m, SE=0.33). While not statistically significant (F=2.09, df=1,41, P=0.24) unsuccessful nests tended to be on larger islands with

Table 19. Results of a 2 group discriminant analysis. Grouping and sample size (N) were successful nests (38), unsuccessful nests (5), for Canada geese on Pond 3, CFWMA, 1983.

| | Discriminant function |
|---|---|
| | 1 |
| Canonical correlation | 0.22010 |
| Variable | Coefficients for canonical variables |
| Elevation | 2.15921 |
| Constant | -125.84015 |

more nests per island. The larger islands also had slightly higher elevations. Four of the 5 unsuccessful nests were on large islands with more than 1 nest. Nest success on the large islands with multiple nests was less (82.6%) than on islands with 1 nest (95.1%). Figure 12 shows the overlap of discriminant scores for the 2 island groupings. The ability of the analysis to classify nests into the right group was poor as only 53.5% were correctly classified. Poor discriminatory ability based on elevation is indicated by the insignificant difference in elevation among the 2 groupings. The analysis resulted in 15 of 23 nests on large islands being misclassified based solely on elevation.

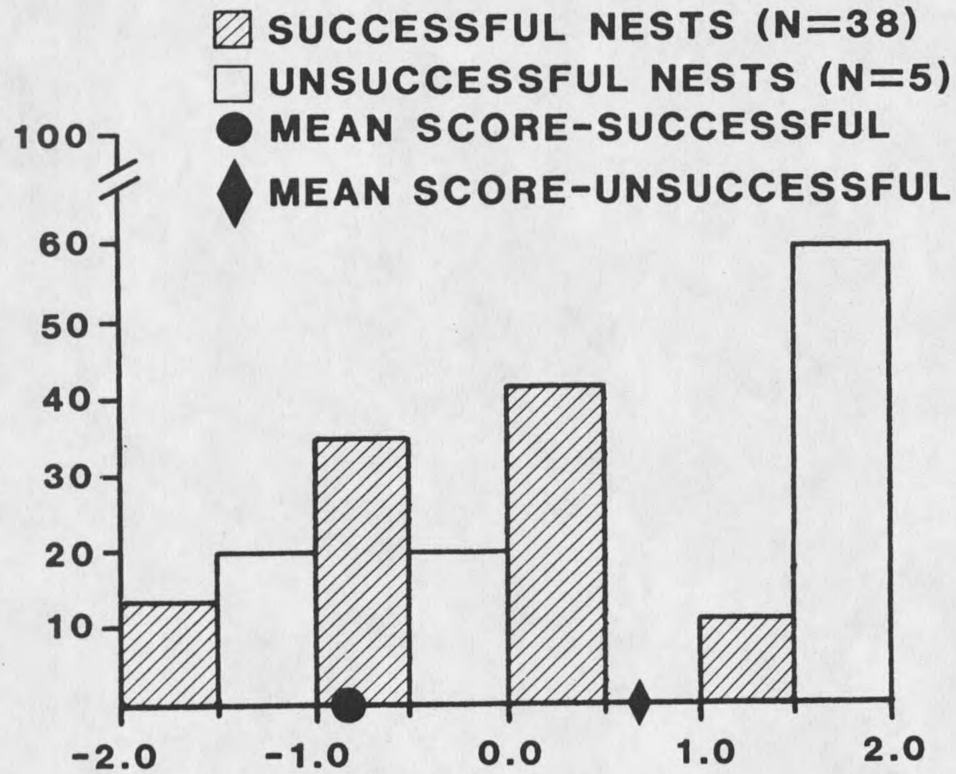


Figure 12. Relative frequency of discriminant scores for islands with successful and unsuccessful goose nests in Pond 3, CFWMA, 1983.

The statements above also apply to goose nests on Pond 4. Unsuccessful nests tended to be on larger islands with more nests per island.

## Hatchability

The percent of eggs hatching in successful nests, like nest success, is a measure of the productivity of a population. Hatchability for geese tends to decline as nesting density increases due to territorial aggression. With high nest densities on islands, geese sometimes leave the nest before all the eggs have hatched (Naylor 1953). Ducks are somewhat more density tolerant except at very high nest concentrations, and hatchability is more likely to decline due to climatic factors, or nest parasitism. Stepwise regression was used to determine whether physical characteristics of the islands, number of nests per island, or nesting density were important parameters in determining hatchability.

There was little variation in hatchability of duck eggs so no statistical analysis was done. Hatchability of ducks in Pond 3 averaged 95.1% in 1982 and 91.2% in 1983. The 2 main nesting species, the mallard and redhead, had a 2 year average hatchability of 99.3% (134 of 135 eggs) and 69.4% (25 of 36 eggs), respectively. Nest parasitism by redheads on mallard nests had no effect on mallard hatchability. Intraspecific nest parasitism by the redhead however was felt to have decreased the number of eggs hatching in 1 nest. An original clutch of 11 eggs had 5 "dump" eggs deposited after the host hen had been incubating for several days. All of the host eggs were possibly not equally incubated since only 7 of the original clutch hatched. Partial flooding of 1 redhead nest decreased the number of eggs hatching. The nest, located in a depression, was partially flooded by a rising pond level. The hen initially increased the height of the nest and eventually moved the whole nest approximately 4 dm from the water. Some of the embryos died in the process and 3 of 9 eggs eventually hatched.

Hatchability for geese on Pond 3 was 96.2% for 579 eggs and 98.2% on Pond 4 for 281 eggs. One variable entered the regression in the Pond 3 analysis, nearest active island ($F=2.8$, $df=1,36$, $P=0.24$, $N=38$), explaining only 7% of the variation. Nine nests had a hatchability less than 100%. These nests were on islands slightly farther from the nearest active island ($\bar{x}=46.2$ m, $SE=5.43$) than islands with 100% hatchability ($\bar{x}=33.8$ m, $SE=3.28$, $N=29$).

Only 1 successful goose nest on Pond 4 had a hatchability less than 100% and no analysis was done.

Nest Site Characteristics

In 1983 4 variables for duck nests and 5 for goose nests and random sites were used to describe the physical presence of the nests and random sites. The variables for duck nests were: distance from the nest to water, average height of the vegetation around the nest, and 2 different density board readings. The same 4 variables were measured at goose nests and random sites plus degrees of visibility. The density board readings provide an index of the visibility of the site from above (density board 1) and from ground level (density board 2). On Pond 3, measurements were taken at 19 duck nests, 43 goose nests, and 156 random sites. On Pond 4, measurements were taken at 4 duck nests, 33 goose nests, and 106 random sites. The duck nest data from Pond 4 were not included in the statistical analysis due to their small sample size.

Two types of analyses, utilizing analysis of variance, were done using mean values for nest and random site measurements on each sampled island. The first analysis tested for differences in measurements taken among 2 island groupings for ducks (0 nests and 1 or more nests) and 3 island groupings for geese (0 nests, 1 nest, and 2 or more nests), using random site measurements. The second analysis compared nest sites with random sites on islands used for nesting by ducks, and for geese compared islands with 1 nest to islands with 2 or more nests (between factor), and nest sites versus random sites (within factor). This analysis was undertaken to investigate selection for nest site characteristics in relation to that which was available on a random basis.

Early nesting dabbling ducks used residual cover, primarily yellow sweetclover (Melilotus officinalis), as the main cover type. As the nesting season progressed into June, willow (Salix spp.) became the dominant cover type for all duck species.

Random sites on islands with 1 or more duck nests were significantly (P=0.013) farther from water than islands without nests. Random sites on islands with a nest were an average of 4.9 m (SE=0.91, N=15) and on islands without a nest 2.5 m (SE=0.46, N=31) from the water. No significant difference was detected for height of vegetation nor density board readings for the 2 groups.

All variables are significantly different when comparing nest sites to random sites on the same island (Table 20). Nest sites were farther from the water, had higher vegetation around the nest, and were less visible from above the nest and at ground level than randomly located sites. Means and standard errors for nest and random sites are given in Table 21.

Ninety goose nests were classified as to cover type on Pond 3 in 1983 with 22% of the nests being located in log structures, 66% in willow, and 4% in residual cover.

Table 20. Results of the nest site versus random site analysis for islands with duck nests on Pond 3, CFWMA, 1983, N=15 islands.

| Variable | F-value | df | P-value |
|---|---|---|---|
| Distance to water | 4.57 | 1,13 | 0.050 |
| Height of vegetation | 22.31 | 1,13 | <0.001 |
| Density board 1 | 41.51 | 1,13 | <0.001 |
| Density board 2 | 39.55 | 1,13 | <0.001 |

Table 21. Means and standard errors for random sites (N=57) and nest sites of ducks (N=19) on islands in Pond 3, CFWMA, 1983.

| | Nest site | | Random site | |
|---|---|---|---|---|
| Variable | $\bar{X}$ | SE | $\bar{X}$ | SE |
| Distance to water (m) | 7.3 | 1.23 | 4.9 | 0.91 |
| Height of vegetation (dm) | 17.2 | 2.10 | 7.5 | 1.47 |
| Density board 1 (%) | 12.0 | 0.24 | 62.0 | 0.36 |
| Density board 2 (%) | 1.0 | 0.11 | 23.0 | 0.29 |

Of the 51 nest sites classifed in Pond 4, 47% were in log structures, 27% in willow, 18% exposed, and 8% were in residual cover.

The random site analysis on Pond 3 for the 3 goose nest groupings indicated a significant difference for all variables except density board 1. As the number of nests increases, degrees of visibility decreases, distance to water and the average height of vegetation increases, and density board 1 measurements decrease for random sites (Figure 13). The significance of the difference in the

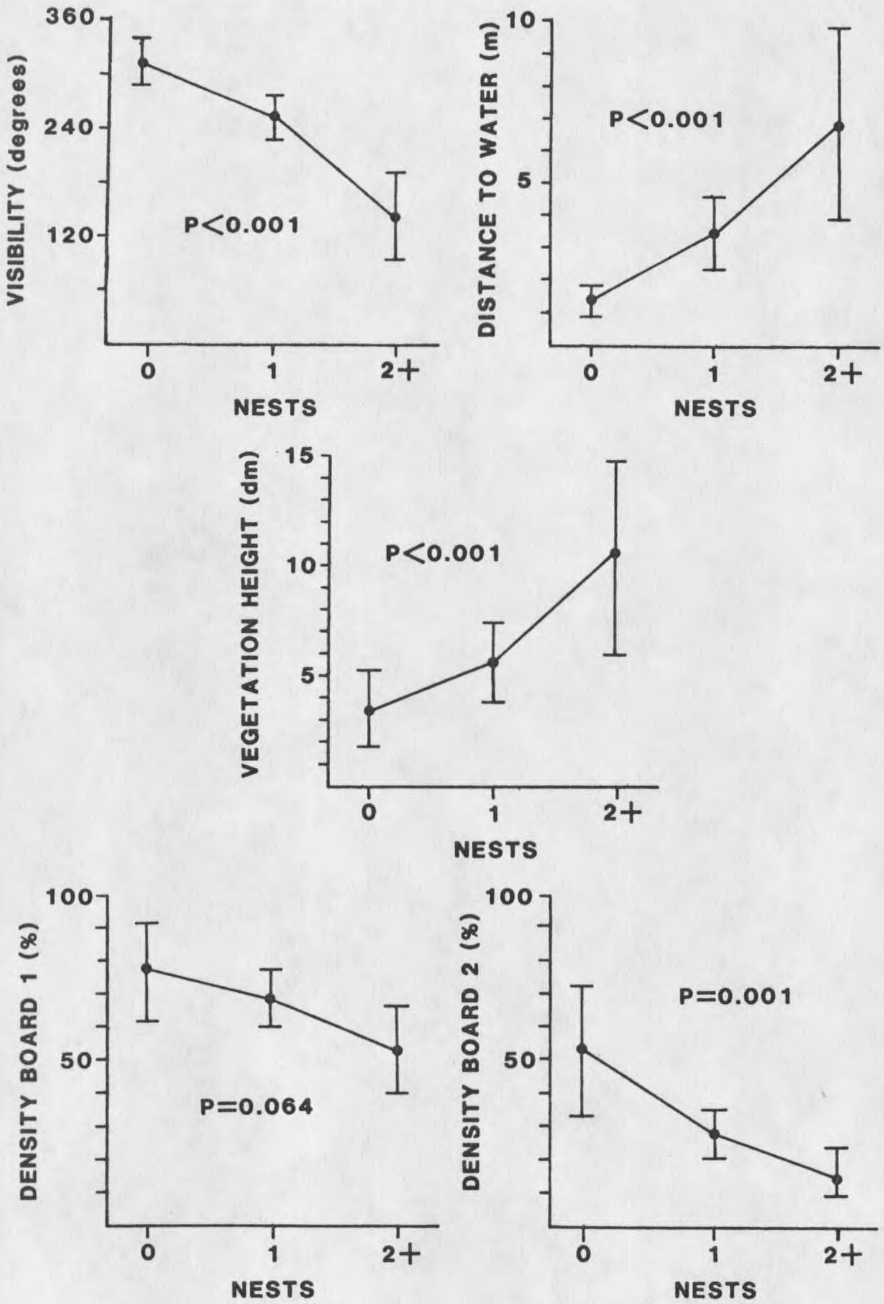


Figure 13. Means and 95% confidence intervals for goose nest-site variables measured at random sites on islands (N) with 0 nests (17), 1 nest (20), 2+ nests (9) in Pond 3, CFWMA, 1983.

means of the 3 groups is given by the P-value for each variable.

Three of the 5 variables were significantly different for islands with 1 nest versus islands with 2 or more goose nests (Table 22). Four of the 5 variables were significantly different for the nest sites versus random sites (Table 23). The extent of these differences and where it occurs can be determined by considering the interaction of the between and within factors. This is shown graphically in Figure 14, a plot of the means for both factors. The P-value indicates the degree of interaction between the factors. The slope of each line shows the difference between the nest groupings while the relative distance between the 2 lines represents the difference between nest and random sites. Degrees of visibility, which was not significantly different for nest versus random sites, has a high degree of interaction as

Table 22. Results of the between factor (islands with 1 nest (N=20) versus islands with 2 or more nests (N=9)) analysis for Canada geese on Pond 3, CFWMA, 1983.

| Variable | F-value | df | P-value |
|---|---|---|---|
| Degrees visibility | 27.17 | 1,27 | <0.001 |
| Distance to water | 7.83 | 1,27 | <0.009 |
| Height of vegetation | 4.77 | 1,27 | <0.037 |
| Density board 1 | 2.65 | 1,27 | 0.115 |
| Density board 2 | 0.10 | 1,27 | <0.753 |

Table 23. Results of the within factor (nest versus random sites) analysis for Canada goose nests on Pond 3, CFWMA, 1983, N=29 islands.

| Variable | F-value | df | P-value |
|---|---|---|---|
| Degrees visibility | 2.08 | 1,27 | 0.161 |
| Distance to water | 9.23 | 1,27 | <0.005 |
| Height of vegetation | 20.00 | 1,27 | <0.001 |
| Density board 1 | 7.98 | 1,27 | <0.009 |
| Density board 2 | 57.14 | 1,27 | <0.001 |

mean values are almost the same on sites from islands with 2 or more nests. Density board 2 readings have a high degree of interaction since the visibility index from sites on islands with 2 or more nests increases slightly at nest sites and decreases at random sites. Also the degree of separation as measured by the difference in mean values for nest versus random sites is only 10% on sites from islands with 2 or more nests. The distance from the nest to water and the average height of vegetation increases while the visibility index from above the nest (density board 1) decreases as the number of nests increases.

The distance from the random site to water was the only variable significantly different ($P<0.001$) for the random site analysis on Pond 4 (Figure 15). As the number of nests per island increases, random sites were farther from the water.

Comparing sites from islands with a single goose nest

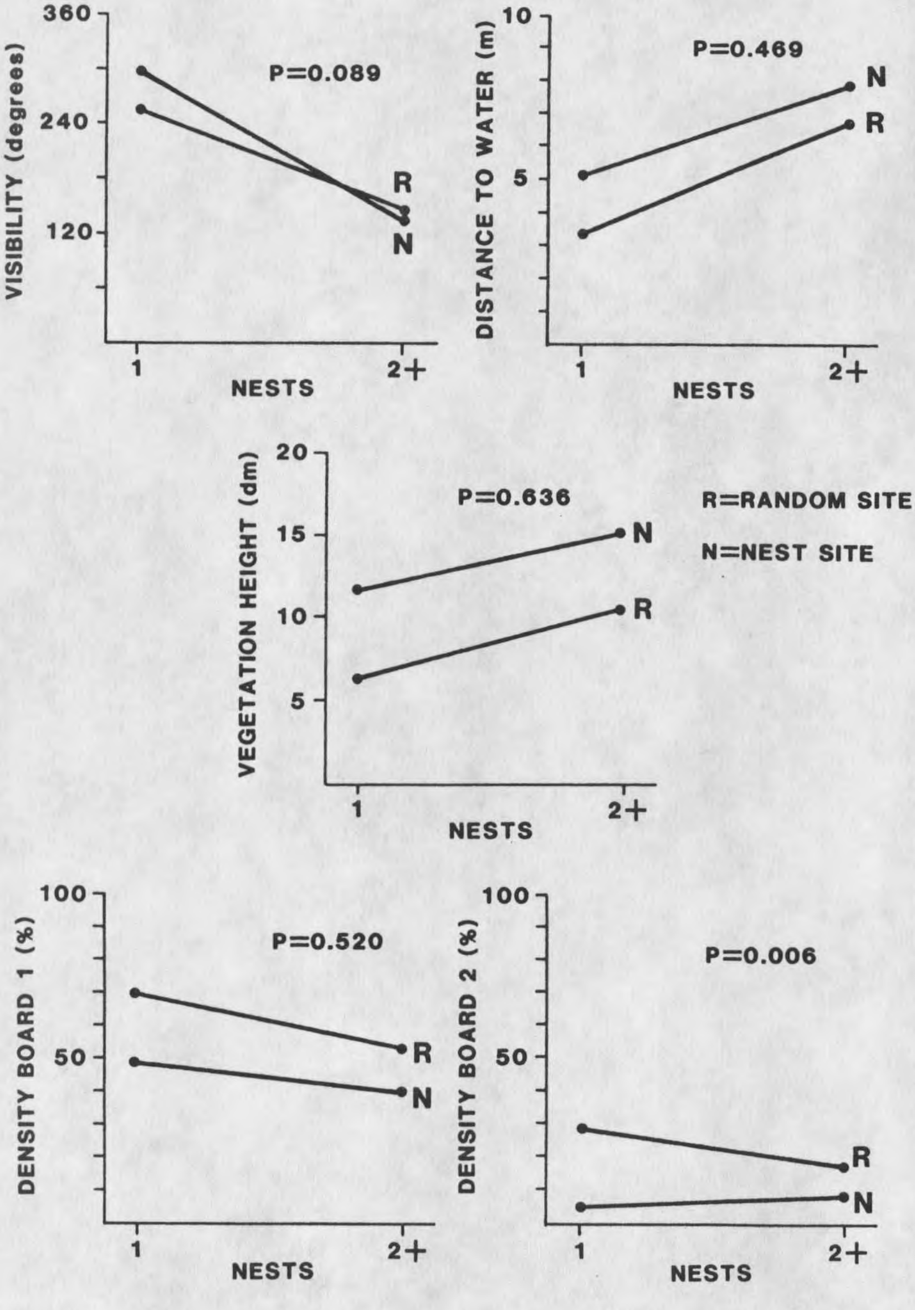


Figure 14. Means for variables measured at random and nest sites for 2 groupings of Canada goose nests on islands in Pond 3, CFWMA, 1983.

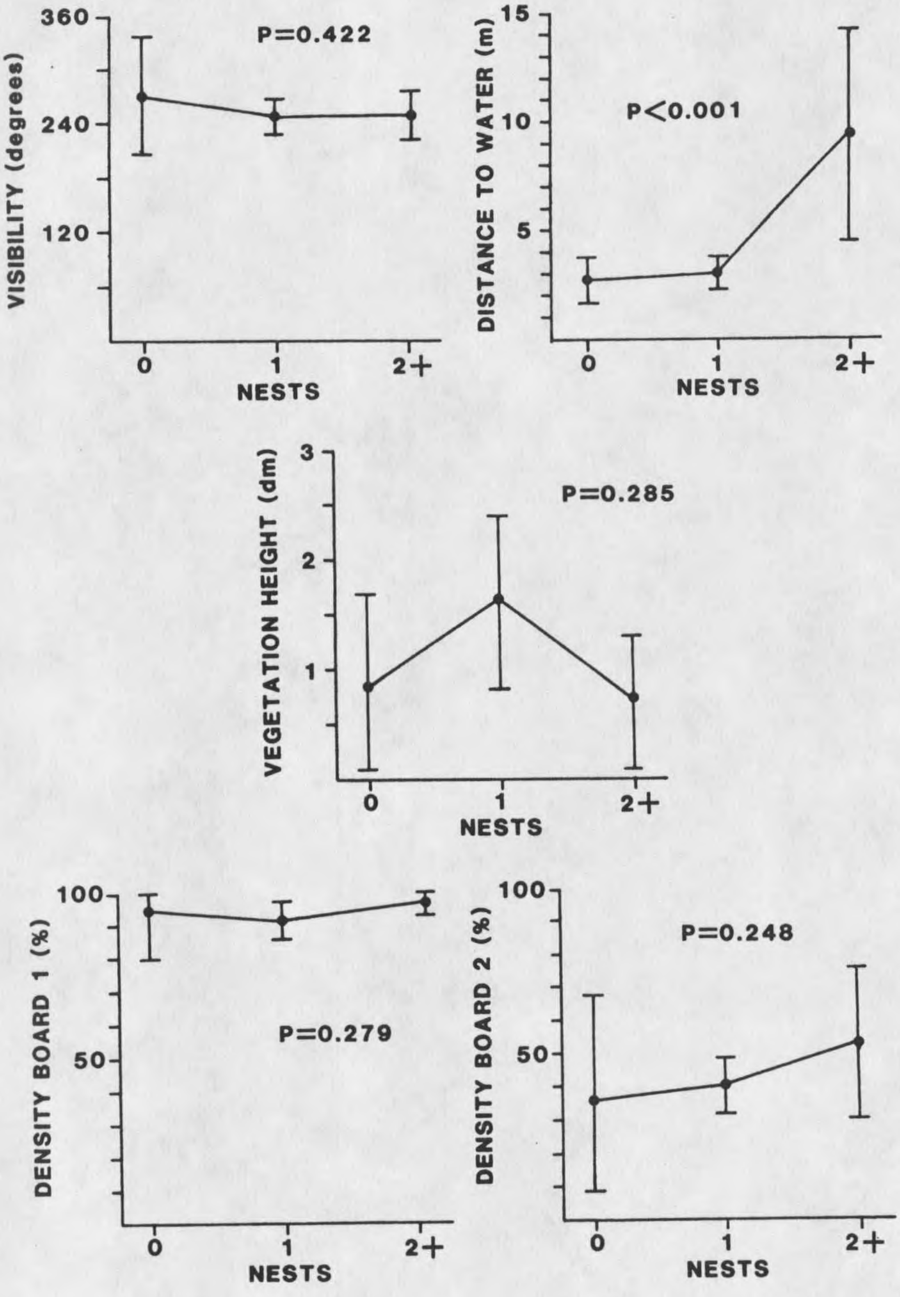


Figure 15. Means and 95% confidence intervals for goose nest-site variables measured at random sites on islands (N) with 0 nests (5), 1 nest (19), 2+ nests (6) in Pond 4, CFWMA, 1983.

to sites from islands with 2 or more nests on Pond 4, 2 variables were found to be statistically different (Table 24). Four of the 5 variables were significantly different for the nest versus random sites (Table 25). Figure 16 shows the group means and degree of interaction for the 2 factors. Most of the difference occurring between nest and random sites occurs on islands with 1 nest for degrees of visibility and distance to water. As the number of nests increases, the degrees of visibility

Table 24. Results of the between factor (islands with 1 nest (N=19) versus islands with 2 or more nests (N=6)) analysis for Canada geese on Pond 4, CFWMA, 1983.

| Variable | F-value | df | P-value |
|---|---|---|---|
| Degrees visibility | 3.29 | 1,23 | 0.083 |
| Distance to water | 16.38 | 1,23 | <0.001 |
| Height of vegetation | 0.69 | 1,23 | 0.415 |
| Density board 1 | 1.30 | 1,23 | 0.266 |
| Density board 2 | 7.92 | 1,23 | <0.01 |

Table 25. Results of the within factor (nest versus random sites) analysis for Canada goose nests on Pond 4, CFWMA, 1983, N=25 islands.

| Variable | F-value | df | P-value |
|---|---|---|---|
| Degrees visibility | 2.96 | 1,23 | 0.099 |
| Distance to water | 5.98 | 1,23 | 0.023 |
| Height of vegetation | 5.52 | 1,23 | 0.028 |
| Density board 1 | 6.70 | 1,23 | 0.016 |
| Density board 2 | 53.73 | 1,23 | <0.001 |

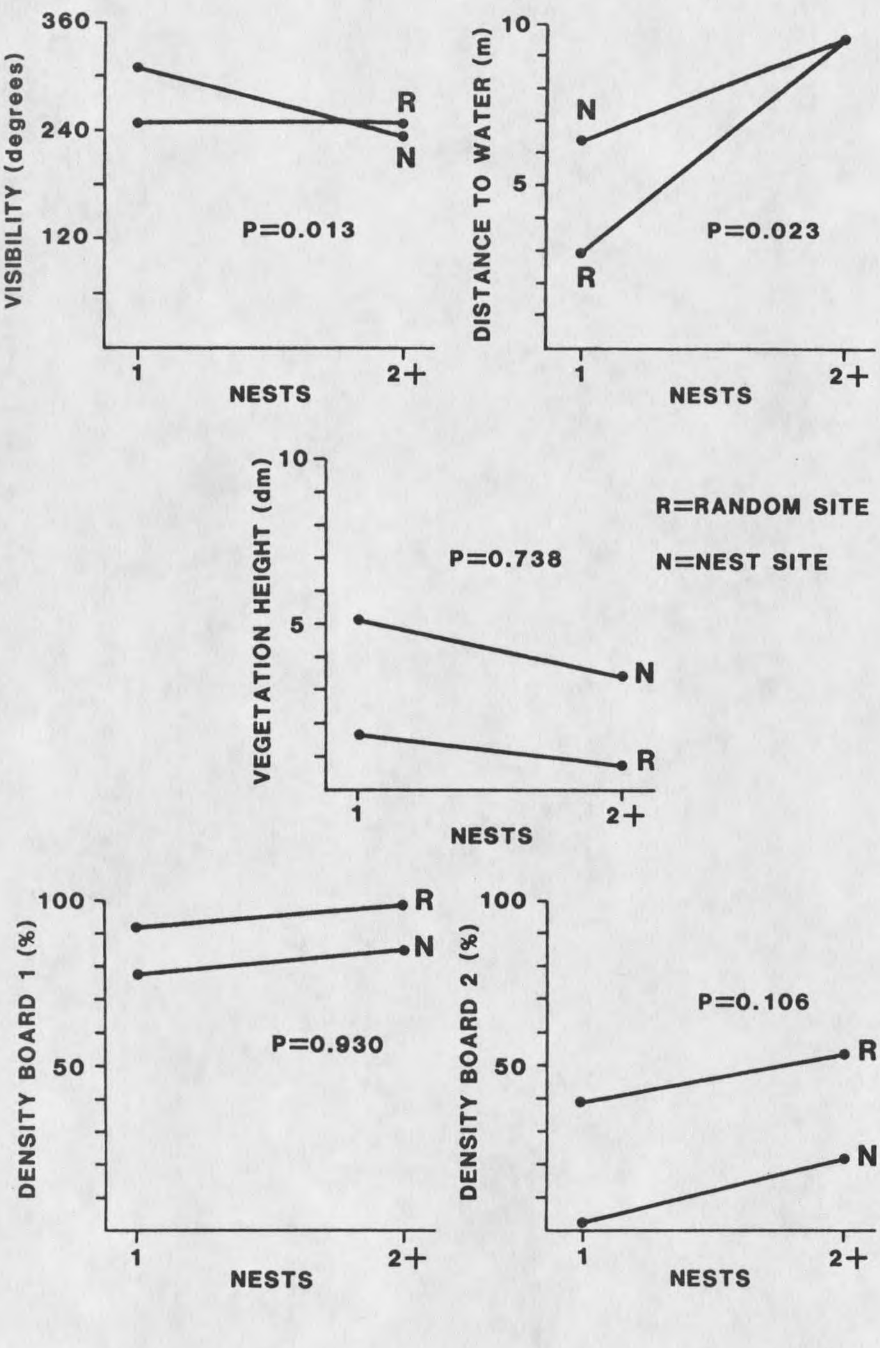


Figure 16. Means for variables measured at random and nest sites for 2 groupings of Canada goose nests on islands in Pond 4, CFWMA, 1983.

and the average height of vegetation decreases while the distance to water and both density board readings increase.

Islands/Multiple Nests

Ewaschuck and Boag (1972) and Giroux (1981) point out the importance of visual barriers between nesting geese when more than 1 nest is located on the same island. The barrier provides visual isolation for the incubating goose thus decreasing the number of territorial interactions between adjacent pairs. This was also evident at CFWMA. Measurements of visual obstruction were made on islands with multiple nests on the study ponds both years. Readings were taken between a nest and its nearest neighbor. A pole marked off in 1/2 decimeters (dm) was placed in nest A and readings taken of the height of visual obstruction from the nearest nest B. Sightings to the pole were taken at 2 heights above nest B, 30 centimeters (cm), the approximate vision level of an incubating goose and at 75 cm, the approximate height of a standing goose. The height of the pole obstructed from vision was then recorded. Measurements were later separated into 5 height classes: class 1 = 0 dm, class 2 = 1-5 dm, class 3 = 6-10 dm, class 4 = 11-15 dm, and class 5 = 16+ dm. Data from 1982 and 1983 for each pond were combined. The assumption in making these measurements is that the nest is the focal point of the territory defended by the gander. The measurements, following this assumption, then provide an index to the ability of the vegetation around the nest site and/or topography of the island to visually isolate nest sites. The percent of nests from the 30 and 75 cm levels in each height class for the measurements is depicted by the histograms in Figures 17 and 18, respectively. Most of the nests on Pond 3 islands were in class 5 (16+ dm) for both measurements while the nests on Pond 4 were more evenly distributed in the 5 height classes. The lack of a visual barrier between adjacent nests was evident for 2 unsuccessful nests on islands with multiple nesting.

Some obvious differences exist between the 2 ponds with respect to the vegetation on the large dredged islands, which support most of the multiple nesting. Although the speciation of plants is similar, the percent canopy cover and the average height of vegetation measured along transects in 1982 were much less on Pond 4. Eight large dredged islands in Pond 3 had an average percent canopy cover and height of vegetation of 53.9% and 6.8 dm respectively while the same measurements on 8 islands in Pond 4 were 25.4% and 3.3 dm respectively. The concealment of nests on Pond 3 islands as indicated by the density board measurements were also more than twice that of Pond 4 nests.

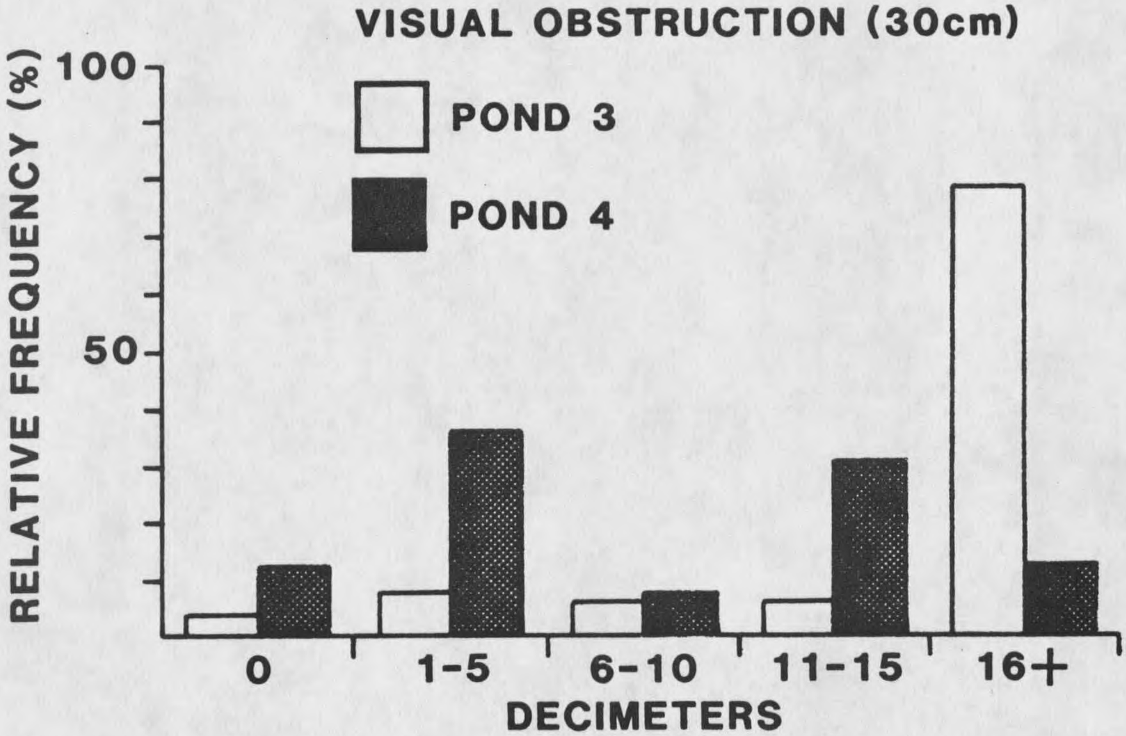


Figure 17. Relative frequency of height classes of visual obstruction between Canada goose nests at 30 cm above the nest on Ponds 3 and 4, CFWMA, 1982-83.

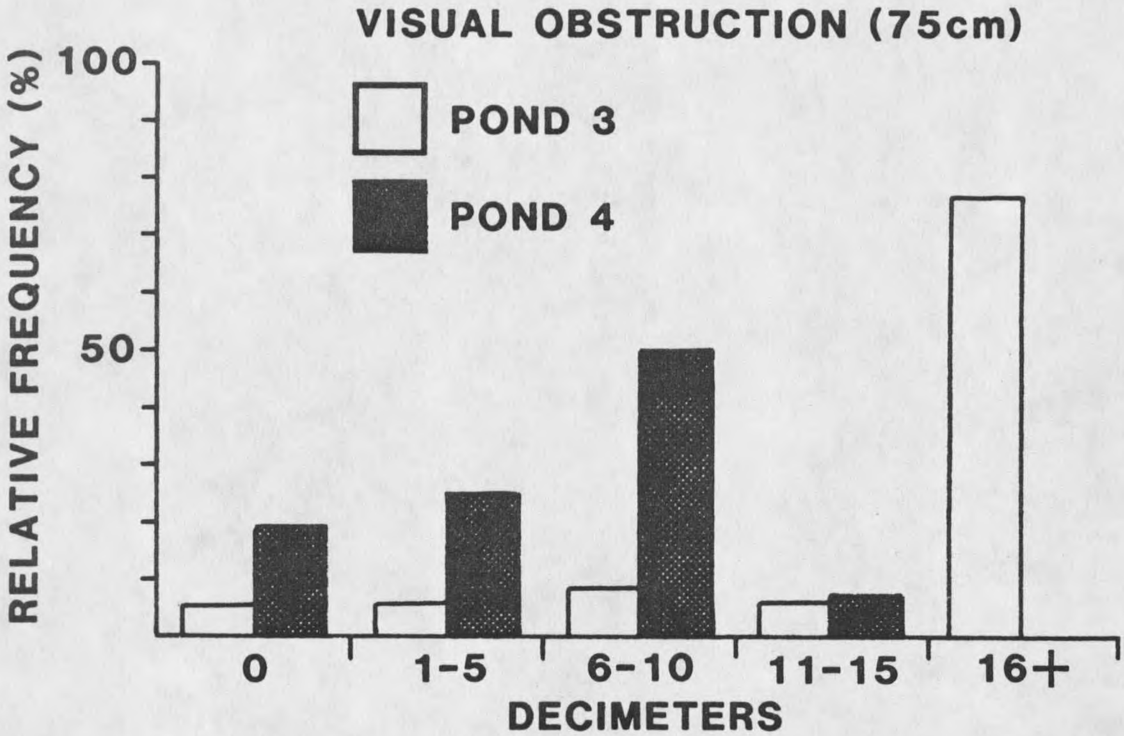


Figure 18. Relative frequency of height classes of visual obstruction between Canada goose nests at 75 cm above the nest on Ponds 3 and 4, CFWMA, 1982-83.

The distance between nearest nests on islands with multiple nests in Pond 3 averaged 14.5 m and varied from 1.0 to 30.8 m. The average distance on Pond 4 was 10.3 m and varied from 2.4 to 22.9 m.

Four islands in Pond 3 have had more than 1 nest since 1981. One of these, island 40, will be considered separately. The other 3 islands 68, 70, and 73, were mapped from photos taken in 1982 and are shown in Figure 19. Canada goose nest locations are shown for 1982 and 1983. Fidelity to 1982 nest locations is evident as 8 1983 nests were on or in proximity to former nest sites. Also of interest is the apparent uniform spacing of nests, especially on islands 70 and 73. Nests in all cases were located in dense willow near an opening. The interspersion of cover and openings on island 70 allows easy access to the nest site and at the same time, due to the complex edge created, provides visual isolation between nests. Plans were made, during the winter of 1982-83, to modify the vegetation on some adjacent islands which were becoming overgrown with willow to create an interspersion of cover and open areas similar to that on island 70. Due to snow cover and difficulty in cutting through dense willow, vegetation was modified on only 1 island (68). Also, instead of being able to create the edge effect like on island 70, swaths were cut creating 3 separate blocks indicated by the dashed lines in Figure

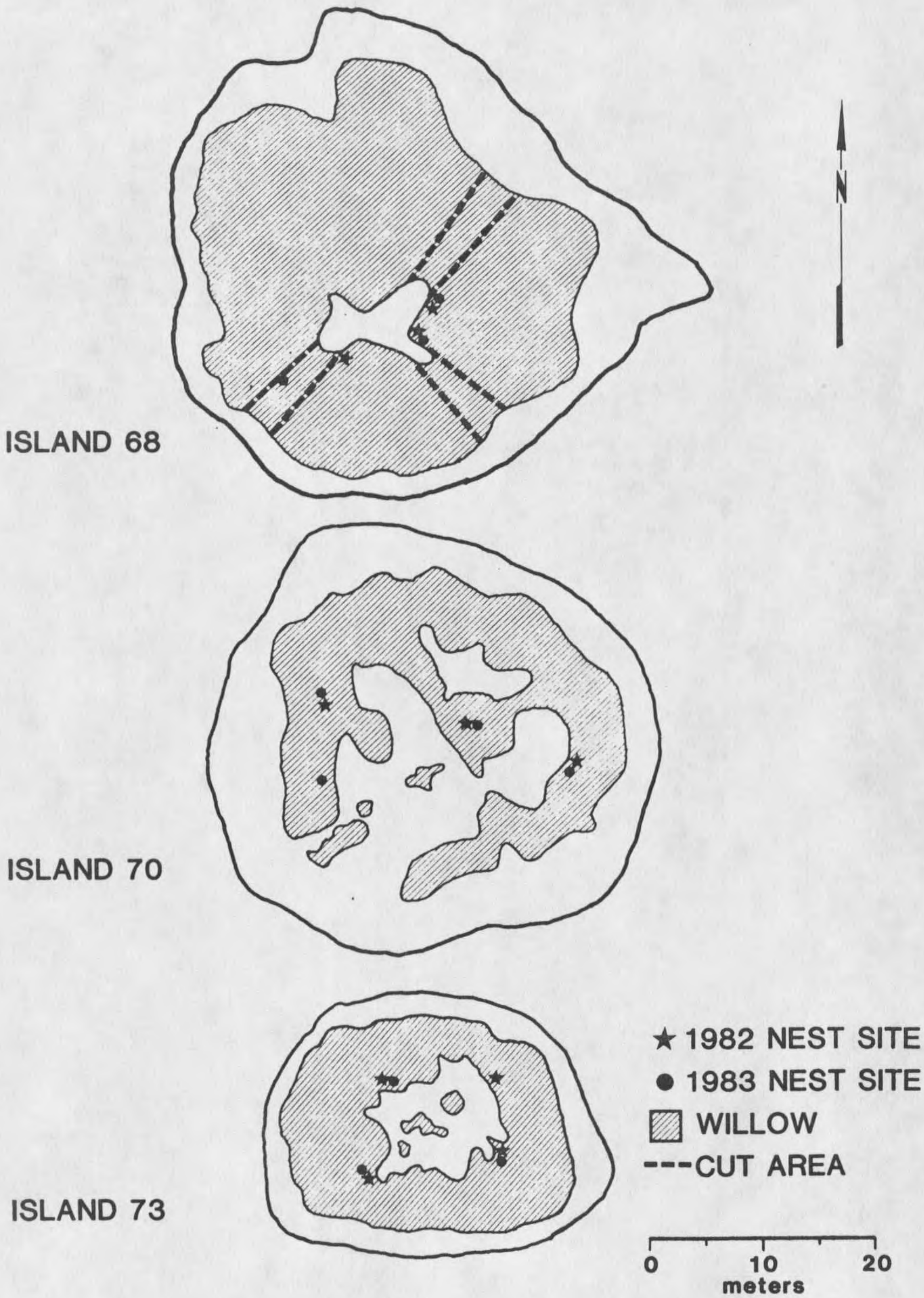


Figure 19. Map of 3 islands with histories of multiple nesting showing distribution of Canada goose nests in relation to cover and each other, Pond 3, CFWMA, 1983.

19. One 1983 goose nest on island 68 was located along the edge of 1 cut. While this effort in cover manipulation wasn't totally successful, modification of monotypic cover, such as dense stands of willow, and creating an interspersion of cover and openings would probably allow greater goose nesting densities on the large dredged islands.

Island 40 in Pond 3 is 1.2 ha (2.8 a) in size and was first used by nesting geese in 1980 when 1 nest was located. There were 4 goose nests in 1981, 14 in 1982, and 15 in 1983. Figure 20 shows 1983 goose and duck nest locations. Both duck nests were mallards. Table 26 shows means and standard errors for nest site measurements. Measurements were similar to other nest sites on islands with multiple nests in Pond 3. Eighty seven percent of

Table 26. Means and standard errors for nest site measurements of Canada geese on island 40, Pond 3, CFWMA, 1983.

| Variable | $\overline{X}$ | SE |
|---|---|---|
| Degrees visibility | 120.00 | 21.42 |
| Distance to water (m) | 15.73 | 2.93 |
| Height of vegetation (dm) | 13.50 | 3.49 |
| Density board 1 (%) | 54.00 | 4.26 |
| Density board 2 (%) | 23.00 | 2.24 |
| Nearest neighbor (m) | 22.60 | 1.63 |

the 30 cm and 93% of the 75 cm visual obstruction measurements were in class 4 and 5. Nests were located

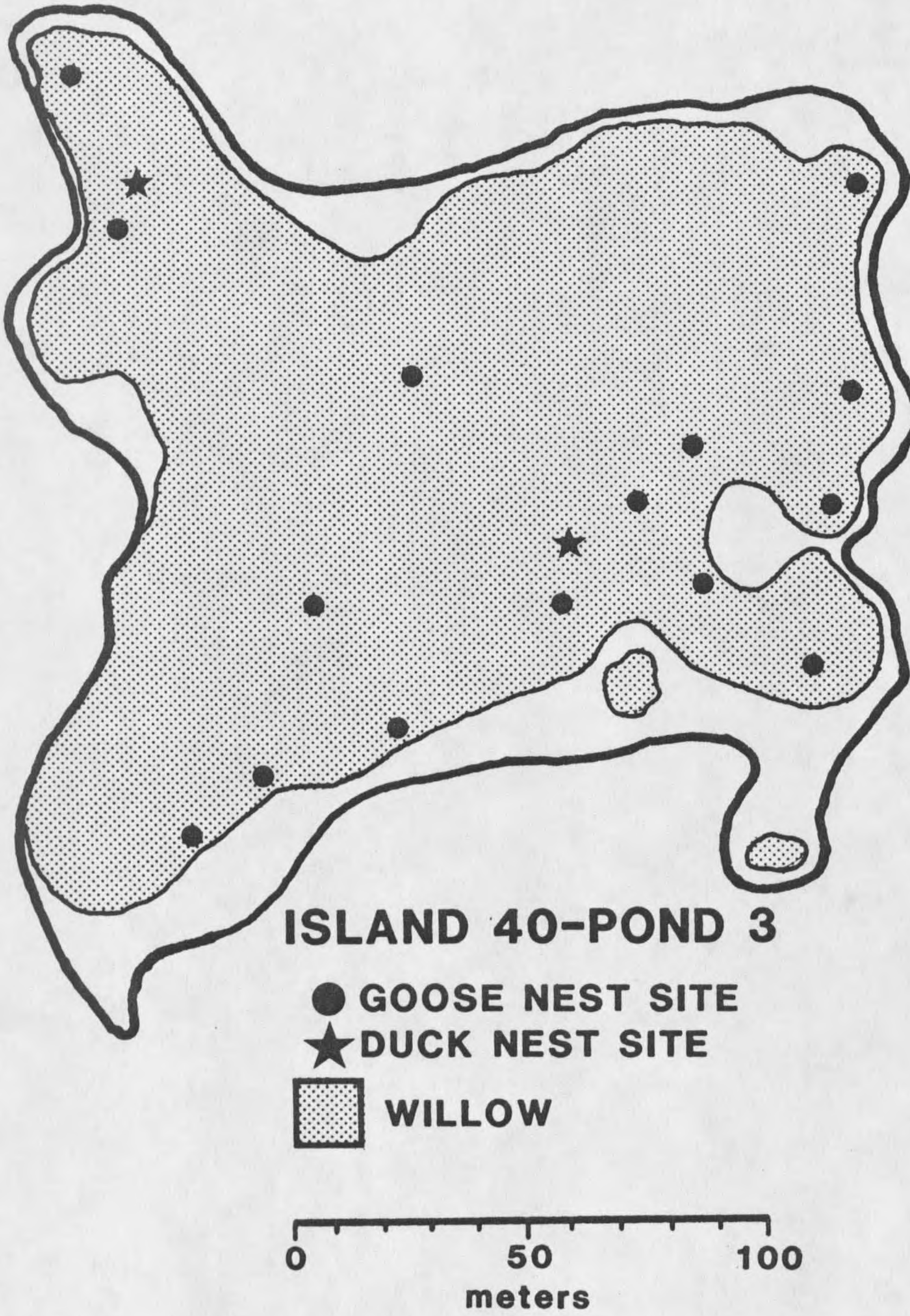


Figure 20. Map of island 40 in Pond 3, CFWMA, showing duck and goose nest location and distribution in 1983.

farther from water on the average than on other islands in Pond 3, and nearest neighbor distances were about twice as great. The method of Clark and Evans (1954) was used to determine the spatial relationship of goose nests on island 40. Nest spacing was found to depart from a random distribution towards uniformity ($P<0.001$). This implies some type of spacing mechanism in nest site location among geese on island 40.

## Pond Measurements

Water levels in all ponds began to rise above desired levels in mid June as reservoir water levels rose above pond levels. Water level fluctuations for Ponds 3 and 4 in 1982 and 1983 are shown in Figures 21 and 22, respectively. Water transparency readings for 1983 are also included on the graphs. Rising water levels tended to decrease water transparency readings in 1983. Based on observation, submergent vegetation distribution and abundance in Pond 3 was less in 1983 than 1982. During the first week of June, 1983 submergents appeared abundant in Pond 3 but rising pond levels seemed to have had a negative effect during this growth phase. Distribution and relative abundance of submergents in Pond 4 appeared somewhat better in 1983 than 1982. Even though submergents in Pond 4 were mainly located in peripheral, shallow areas, they weren't observed because of poor water

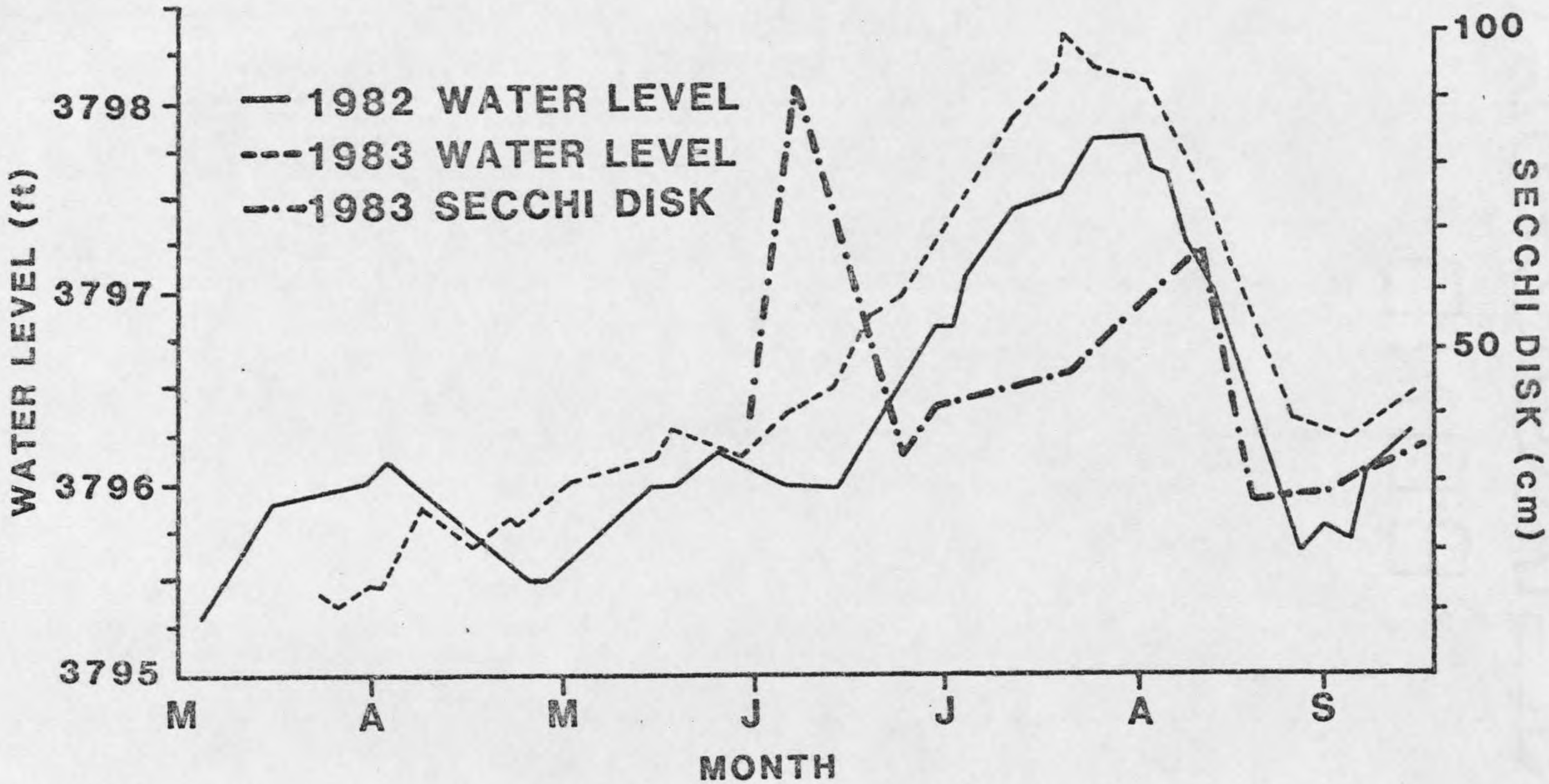


Figure 21. Water level fluctuations for 1982-83 and Secchi disk readings for 1983 in Pond 3, CFWMA.

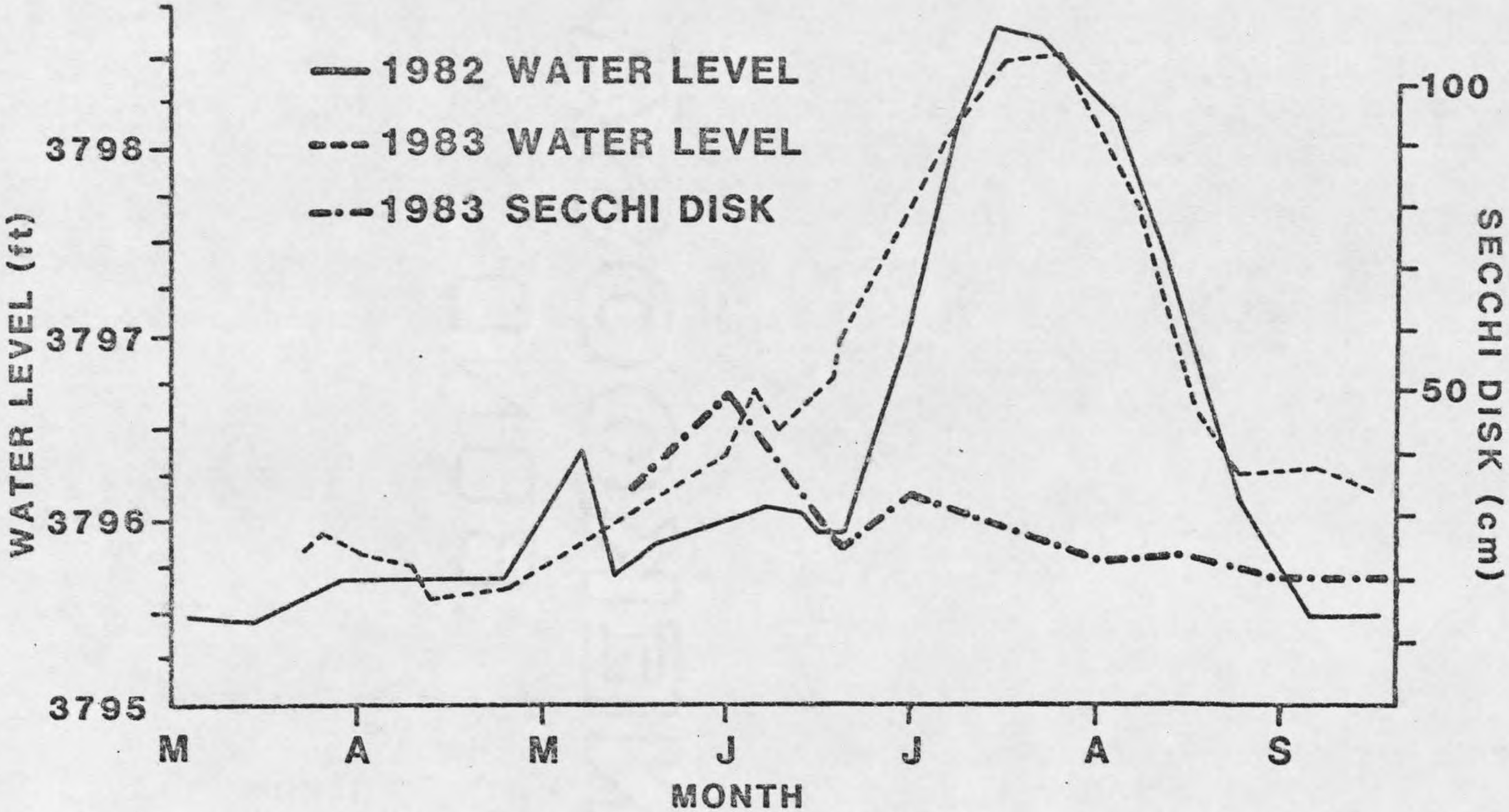




Figure 22. Water level fluctuations for 1982-83 and Secchi disk readings for 1983 in Pond 4, CFWMA.

transparency until August when pond levels began to drop. Water level fluctuations on Pond 4 were similar during 1982 and 1983. Water levels on Pond 3 were greater in depth and duration in 1983 than 1982. This increased depth may be partially responsible for an apparent decrease in submergent vegetation distribution and abundance. In addition to the effect of fluctuating water levels on water transparency, the spawning activity of carp (*Cyprinus carpio*), during early June, stirred up bottom sediments greatly decreasing water transparency.

In 1983 it was noted on July 6 that many of the small dredged islands in Pond 3 were becoming flooded. This occurred at a pond water level of 1157.5 m (3797.5 ft).

# DISCUSSION

Bellrose and Low (1978) in reviewing the status and direction of waterfowl management pointed out the increasing importance of island construction as nesting areas for waterfowl. The pond-island system of the CFWMA is a prime example of the positive response of waterfowl to such newly created habitat.

Since minimal nesting by ducks occurred in the area prior to development of the CFWMA, nesting on the islands by ducks is felt to be the result of pioneering. Ducks have more specific cover requirements than geese and nesting cover acceptable to ducks has developed slowly on the newly created islands. However, more than twice as many nests were located in 1983 than in 1982. As cover suitable to duck nesting develops on the islands and with subsequent homing by current nesters and offspring, even greater use of the islands for nesting sites can be expected.

The dramatic increase in nesting Canada geese since the development of the area is primarily a result of 4 factors: (1) the existence of a local breeding population to colonize new nesting habitat, (2) the propensity for this race to nest on islands, (3) security of island nests from mammalian predation and (4) homing of geese to natal areas.

Several factors are important when considering how waterfowl are currently utilizing this island nesting habitat. It is essential to consider the present population levels of nesting ducks and geese since the present use pattern is likely to change as nesting populations increase. There are also differences normally expressed by diving and dabbling ducks in nest site selection. However, all duck species were combined to acquire an adequate sample for analysis and in so doing species differences were lost. The range in size of islands on the 2 study ponds as well as the number of islands per impoundment is quite different from areas previously reported in the literature. The smallest islands are similar in size to those reported by Johnson et al. (1978) and Giroux et al. (1983), while the largest islands are similar in size to the smallest islands studied by Giroux (1981). Many of the studies done on island nesting waterfowl have been on relatively large islands but where a low density of islands exists compared to CFWMA (Vermeer 1970, Duebbert 1982, Duebbert et al. 1983, Hines and Mitchell 1983). For these reasons, waterfowl utilization of islands at CFWMA may differ somewhat from other areas.

The 4 species of ducks that used islands for nesting during the study are known island nesters, particularly the gadwall and mallard. The redhead, which was the second most common nesting species, is not reportedly a strong island nester. However, the absence of overwater nesting habitat and availability of numerous small islands in Pond 3 may account for the seeming preference for small islands used for nesting in this study.

Density of duck nests was inversely correlated with size and maximum elevation of the island and positively correlated with the distance of the island to the mainland. This is primarily due to the abundance of small, low islands far from shore in Pond 3. Small islands may have a high density but density as a measure of habitat quality by itself may be misleading. More duck nests were located on large islands when comparing islands used to islands not used for nesting. Islands with 1 nest as well as 2 islands that supported more than 1 duck nest in 1983 averaged 0.07 ha. Keith (1961) found islands most heavily used for nesting by waterfowl were at least 0.02 ha in size.

In the nest success analysis in my study, the maximum elevation of an island was the single best variable for discriminating between successful and unsuccessful duck nests. The smaller islands in this study had low elevations above the water level and were subject to flooding with rising levels during mid summer. Also 3 of 4 nests destroyed by avian predators were on islands 0.02 ha or less. Nests on small islands may be more vulnerable to avian predation since they represent a smaller area to be searched by the predator.

The analysis of nest site measurements was divided into 2 separate analyses for ducks and geese plus an additional analysis involving multiple nesting by geese on a single island. These 3 analyses are identified below. First, selection of a particular island for nesting by ducks and/or geese, based on potential nesting sites on the island was shown by the random site analysis. Measurements taken at random sites comparable to those taken at nest sites were tested for differences between islands used and not used for nesting. This provides an indication of the availability of nest sites on an island. Secondly, once an island was chosen, selection for specific cover characteristics at the nest site was shown by comparing measurements taken at the nest site to measurements taken at random sites. Lastly, distinguishing characteristics of goose nest sites were found when comparing goose nest sites on islands with a single nest to nest sites from islands with multiple nests.

The random site analysis for islands used and not used for nesting by ducks indicated that randomly located sites were farther from water on islands used for nesting than on islands not used for nesting. This implies that ducks were selecting larger islands for nesting.

Selection for a particular vegetation structure around the nest site by ducks during this study was evident when comparing nest sites to random sites. Nest sites were located in higher, denser vegetation which is typically located toward the interior portion of the islands. Thus, nests also tended to be farther from the water than if randomly located.

Intra- or interspecfic nest parasitism by redheads had little effect on clutch size or egg success of host hens in this study. However, as duck nesting densities increase, nest parasitism by the redhead is likely to decrease clutch size and egg success of host species (Joyner 1981, Talent et al. 1981).

Canada goose nesting densities on both ponds were inversely correlated with size of island. In 1983, 28% (33 of 118) of the Canada goose nests on Pond 3 were located on islands 0.015 ha or less. All were single nests on small islands which gives a high calculated nesting density.

Density as a measure of the nesting status of an island has more meaning when considering islands with more than 1 nest. Islands in both ponds with more than 1 goose nest averaged 0.1 ha in size and had higher maximum elevations than islands without a nest or with only 1 nest. The nesting density in 1983 on islands with multiple nests averaged 28.1 nests/ha on Pond 3 and 38.0 nests/ha on Pond 4.

Desertion of nests by geese as a result of high nesting densities and subsequent territorial aggression is often cited as the major cause of nesting failure in island nesting studies. Naylor (1953) studying the same race of Canada goose as this study had a maximum nesting density of 155 nests/ha on a 0.2 ha island. The overall desertion rate of 24% in his study was attributed to crowded conditions on islands. Ewaschuk and Boag (1972), on a 6.5 ha island with a reported high nesting density of 19.9 nests/ha, found a desertion rate of 22% primarily caused by agonistic behavior between nesting pairs. Nest success in the above mentioned studies varied from 35 to 69%. The relatively high nest success of 82.6% and low desertion rate (5.1%) on islands with more than 1 goose nest in this study indicates that nesting densities in 1983 had little adverse influence on goose production.

Measurements made at random sites on islands in Pond 3 for 3 groups, i.e. islands without a nest, with 1 nest and with 2 or more, showed the following trend with respect to potential nest sites. Progressing from islands with 0 nests to islands with multiple nests, visibility to open water decreased, vegetation was higher, there was less visibility of the site from above, and sites were located farther from water. In short, islands with adequate cover to provide visual barriers are able to support more than 1 goose nest. Ewaschuk and Boag (1972) felt that the nature of the cover on an island influenced Canada goose nesting densities. Dense vegetation allowed the establishment of small territories and minimized interactions between pairs on the same island.

When comparing Pond 3 measurements taken at nest sites to measurements from random sites, the distance from the nest to water and the height of vegetation were significantly greater and visibility from the nest was less than at random sites. This suggests that geese on Pond 3 are not selecting nest sites at random but choose nest sites away from water which have higher vegetation offering visual isolation of the nest greater than what is randomly available on an island.

In comparing Pond 3 nest sites from islands with a single nest to nest sites from islands with 2 or more nests, nest sites on islands with 1 nest had greater visibility to open water, were closer to water and had lower vegetation surrounding the nest on the average than islands with 2 or more nests.

Sherwood (1968) studying giant Canada geese (Branta canadensis maxima) on the Seney National Wildlife Refuge in northern Michigan found that geese preferred islands with grass and sparse brush 1.5 to 5.1 dm tall, which allowed good visibility of the surrounding area. Kaminski and Prince (1977) working with the same race of goose in southeastern Michigan observed that islands used for nesting had a lower density of vegetation than islands not used. Miller and Collins (1953) reported that the western Canada goose (Branta canadensis moffitti) nesting on islands in northeastern California tended to select nest sites with good visibility close to water. The Pond 3 analysis indicates that geese nesting solitarily on an island select nest sites that allow considerable visibility of the surrounding area while geese nesting on islands with 2 or more nests seek heavy cover to provide visual barriers between nests.

The only difference in the random site analysis for geese on Pond 4 was the distance from the random site to water which was greater on islands used for nesting. Most of this difference occurred on islands with more than 1 nest. Since 4 of the 5 variables measured were significantly different for the 3 groupings in the Pond 3 analysis this implies that based on the measurements taken at random sites there is less difference between island groupings on Pond 4 than on Pond 3.

When comparing Pond 4 goose nest sites to random sites, single nest sites were farther from the water while nest sites on islands with multiple nests were about the same distance to water as random sites. All nests had higher vegetation and were less visible than random sites. Implications of this analysis are that islands in Pond 4 support a less heterogeneous vegetation than islands in Pond 3. There was less difference between islands used and not used for nesting based on the potential of available nesting sites.

When comparing nest sites from islands with 1 nest to nest sites from islands with 2 or more nests in Pond 4 the only significant difference was that the nest sites on islands with multiple nests were farther from the water and were more visible from ground level than single nests. The height of vegetation actually decreased and visibility of the nest site increased at nest sites on islands with multiple nests. This is a reflection of the difference in vegetation between the 2 ponds as nest sites on islands with multiple nests in Pond 3 were more concealed than single nests. The main difference between single and multiple nest sites on Pond 4 was the size of the island. The height of visual barriers between nests on islands with multiple nests in Pond 4 was less than on Pond 3 and frequently the topography rather than vegetation isolated nest sites.

Cover at nest sites on islands with multiple nests in Pond 4 was less for all variables measured than on islands in Pond 3. Islands have been available for nesting longer on Pond 4 but initially consisted solely of small haul islands. Even though the large dredged islands on both ponds are approximately the same age, cover mainly in the form of willow has established more quickly on islands in Pond 3 than Pond 4. The ability of willow to provide a visual barrier between neighboring nests on islands in Pond 3 is likely the reason for more multiple nesting on that pond. This same mechanism seems to occur on many of the small dredged islands in Pond 3. Willow on the small dredged islands appears to allow visual isolation of nests even though spacing of these islands is much closer than recommended in the literature. Sherwood (1968) found that with island spacing less than 46 m desertion usually occured on 1 of the adjacent islands. Giroux (1981) recommended spacing islands at least 100 m apart. Spacing of the sampled small dredged islands in Pond 3 averaged only 14.2 m (SE=1.5, N=22). From the distribution of goose nests (Figure 6) it can be seen that many of the small dredged islands used for nesting were adjacent to each other and a clumped distribution of islands with a nest resulted in some areas. This presents a situation not unlike multiple nests on a single island. If visual isolation is adequate between nesting pairs on the small, closely spaced dredged islands, territorial interactions may be kept to a point where nest desertion is minimal.

Spacing of sampled large dredged islands in Pond 3 averaged 37 m (SE=2.9, N=16) and 43 m (SE=4.2, N=12) in Pond 4. Island spacing, both the distance to the nearest island and the nearest island with a nest, was not a factor influencing nest success in this study. At the population levels of 1983, these island spacings appeared sufficient.

The ability of geese to nest successfully at CFWMA with the relatively close island spacings may be the result of: (1) nesting islands are not limited and therefore territorial aggression is presently not a factor and (2) spacing of nests is a function of the number and distribution of nesting niches provided by island habitat (Klopman 1958). I believe what is occurring, primarily on islands in Pond 3, is a result of the latter. Hammond and Mann (1956) in referring to a hand raised, released flock of Canada geese on the Lower Souris National Wildlife Refuge (North Dakota) reported that tolerances for closer nest spacing appeared to evolve as the breeding population increased. It's possible that in the island nesting situation at the CFWMA, where geese are colonizing new nesting habitat and many are breeding for the first time, they become habituated to closer island spacing.

The distance from the island to the mainland is important in the prevention of mammalian predation on island nesting waterfowl. Hammond and Mann (1956) suggested that islands be separated several hundred feet from the mainland and have a water depth of 30-45 cm between the island and shore. Giroux (1981) recommended a distance of 170 m between islands and the mainland and a water depth of 70 cm between the island and shore. Almost all islands in my study had a maximum water depth between the island and mainland greater than 70 cm; however, many of the shoreline islands are 50 m or less from the mainland. In spite of this no mammalian predation of duck or goose nests was recorded on any of the shoreline islands in either pond. Predators that would be expected to swim to the islands, coyote (Canis latrans), mink (Mustela vison), and raccoon (Procyon lotor) occur on the project but were not commonly observed. Most nest predation on the mainland appeared to be by skunks (Mephitis mephitis) or red fox (Vulpes fulva), neither of which are reported to be strong swimmers.

The normal sequence for water levels in a marsh situation is for a decrease as summer progresses. Submergent and emergent vegetation, characteristic of small ponds, have evolved with this type of water level sequence. The continued rising water levels in both ponds to a somewhat stable level in mid summer with no decline until late summer was detrimental to aquatic vegetation in 1983. Robel (1961), in studying the effect of water depth and turbidity on the growth of sago pondweed (Potamogeton pectinatus) in Utah found that maximum production occurred at a depth of 38 cm. Sago pondweed is 1 of more dominant submergent plants in ponds at the CFWMA and is known to be one of the more important seasonal food items for waterfowl (Anderson and Low 1976).

## Conclusions

Definite differences exist between the 2 study ponds which affect their overall attractiveness to waterfowl. To consider what makes 1 pond more attractive than another it's necessary to look at each pond as a system providing the basic requirements in the life cycle of pre- to post-nesting waterfowl.

Ducks, once reaching the breeding area, require a protein source for egg laying. Pond 3 has a greater abundance of submergent vegetation and would be expected to supply the nutrient-rich invertebrates female ducks seek more so than Pond 4. The specific cover requirements of duck nests are better met by the greater diversity of vegetation and variety of island sizes in Pond 3.

Canada geese arrive on the breeding grounds with an energy reserve attained on the wintering areas, therefore an immediate food supply to obtain minerals and protein for egg formation is of secondary importance (McLanders and Raveling (1981). The primary consideration is establishing a territory for nesting which the islands on both ponds readily provide. Based on the results of this study less cover is available on islands in Pond 4 than on islands in Pond 3, which is probably the major factor in determining the difference in how geese use islands for nesting in the 2 ponds.

Once the eggs have hatched, brood rearing and molting areas, essential elements in waterfowl production areas, become important. Grazing areas for geese are more abundant on the east side of the project than generally available on Pond 4. Flooding of shoreline areas on Pond 3 provides cover and feeding areas for goose and duck broods.

While willow is serving the function of providing nesting cover for geese it appears less attractive to nesting ducks. Due to the extreme height willow attains and its tendency to form dense, decadent stands, it probably is not capable of forming long term, productive nesting cover for a variety of waterfowl species. Duebbert (1982) suggests the establishment of new or manipulation of existing vegetation on islands as a useful management strategy. Some recent studies indicate that western snowberry (Symphoricarpos occidentalis) and woods rose (Rosa woodsii) receive heavy use by nesting mallards and gadwalls. Duebbert et al. (1983) found 97% of 2,361 mallard and gadwall nests were in dense shrub cover composed of the above species. Hines and Mitchell (1983) located 64% of 451 gadwall nests in western snowberry. Duebbert (1982) suggests that the dense and durable cover provided by these shrubs would provide productive, long term nesting cover.

Results of the statistical analyses in this study indicate that islands 0.07 to 0.1 ha in size spaced about 40 m apart would provide islands attractive to duck and goose nesting. However, each area is different as is evident from how waterfowl have responded to a variety of island nesting situations reported in the literature. The type of cover that becomes established on islands plays a vital role in how waterfowl will use islands for nesting. By constructing islands of 1 size and even spacing, diversity of habitat and the ability to meet the nesting requirements of some desirable species may be lost. Also many of the smaller low profile islands in both ponds are essentially unvegetated and are used extensively as loafing sites by resident and migrant waterfowl as well as a variety of other bird species. With an increasing interest in non game species, both aesthetically and monetarily, the ability of waterfowl production areas to be attractive to a number of different species is also a factor to consider.

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# LITERATURE CITED

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# APPENDIX

Table 27. Plant species occurring on islands in Pond 3, CFWMA, 1982-83.

| Species | Common name |
| --- | --- |
| *Amaranthus hybridus* L. | Green pigweed |
| *Artemisia dracunculus* Willd. | False-tarragon sagewort |
| *Artemisia frigida* L. | Fringed sagewort |
| *Chenopodium album* L. | Lamb's quarter |
| *Chenopodium glaucum* L. | Oakleaf goosefoot |
| *Cirsium arvense* (L)Scop. | Canada thistle |
| *Cirsium vulare* (Save)A-S. | Bull thistle |
| *Epilobium angustifolium* L. | Fireweed |
| *Erigeron canadensis* L. | Horseweed fleabane |
| *Melilotus officinalis* (L)Lam. | Yellow sweetclover |
| *Mentha arvensis* L. | Field mint |
| *Phalaris arundinacea* L. | Canarygrass |
| *Polygonum aviculare* L. | Prostrate knotweed |
| *Potentilla anserina* L. | Silver cinquefoil |
| *Potentilla paradoxa* Nutt. | |
| *Salix* spp. | Willow |
| *Salsola kali* L. | Russian thistle |
| *Sisymbrium altissimum* (L)Britt. | Tumblemustard |
| *Sisymbrium loeselii* L. | Smallpod tumblemustard |
| *Verbena bracteata* L&R. | Bracted verbena |

Table 28. Plant species occurring on islands in Pond 4, CFWMA, 1982-83.

| Species | Common name |
| --- | --- |
| *Chenopodium glaucum* L. | Oakleaf goosefoot |
| *Melilotus officinalis* (L)Lam. | Yellow sweetclover |
| *Oenothera biennis* L. | Evening primrose |
| *Potentilla anserina* L. | Silver cinquefoil |
| *Potentilla paradoxa* Nutt. | |
| *Salix* spp. | Willow |
| *Solanum dulcamara* L. | Climbing nightshade |
| *Verbascum thapsus* L. | Flannel mullein |

Table 29. Submergent vegetation species present in Pond 3, CFWMA, 1982-83.

| Species | Common name |
|---|---|
| *Elodea nuttallii* (Planch.)St. John | Common elodea |
| *Myriophyllum spicatum* L. | Eurasian watermilfoil |
| *Potamogeton crispus* L. | Curly pondweed |
| *Potamogeton nodosus* Poir. | Longleaf pondweed |
| *Potamogeton pectinatus* L. | Sago pondweed* |
| *Potamogeton richardsonii* (Benn.)Rydb. | Redhead-Grass |
| *Ranunculus aquatilis* L. | Water buttercup |

* Only species observed in Pond 4.

Table 30. The islands used by duck species on the study area on the CFWMA, 1982-83. Numbers in parentheses are numbers of nests if more than 1.

| Pond | Year | Species | Island(s) |
|---|---|---|---|
| 3 | 1982 | mallard | 11,40(3),68,74,89,97 |
| 3 | 1982 | gadwall | 97 |
| 3 | 1982 | pintail | 88 |
| 3 | 1982 | redhead | 78 |
| 3 | 1983 | mallard | 9,29,31,40(2),68,69,73, 83(2),85,91,97 |
| 3 | 1983 | gadwall | 67 |
| 3 | 1983 | pintail | 38,91 |
| 3 | 1983 | redhead | 30,31,43,70,78,83 |
| 4 | 1983 | mallard | 1,14,40,56 |