NESTING GIANT CANADA GEESE OF SOUTHEASTERN LOWER MICHIGAN

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
Richard Marvin Kaminski
1975

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ABSTRACT

NESTING GIANT CANADA GEESE
OF SOUTHEASTERN LOWER MICHIGAN

By

Richard Marvin Kaminski

Giant Canada geese (*Branta canadensis maxima*) are year-around residents in the Huron River Valley of southeastern Lower Michigan. The flock originated from *maxima* stock that were either released or escaped from private waterfowl collections during the mid-1920's. A study was made during the spring and summer of 1974 to determine the flock's breeding range, to quantitatively describe the nesting habitat, to estimate the size of the breeding population, its productivity, and survival of goslings to fledging.

The flock has expanded its breeding range and now nests in portions of 11 counties near major metropolitan areas. Most nesting pairs (92 percent) preferred wetlands for nesting that had two or more hectares of open water. Nesting wetlands without grazing areas nearby were abandoned by families of geese less than one week after hatching. Principle nesting sites were muskrat lodges (50 percent), floating vegetative mats (27 percent), and islands (23 percent). A multivariate discriminant analysis showed that the top width of muskrat lodges and percent slope of island relief along with the density of island vegetation were most significant in differentiating utilized from non-utilized Canada goose nesting lodges and islands, respectively.

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From an aerial nest census of 310 (5 percent sample) randomly selected quarter sections having wetlands, 526 ± 140 (SE) nesting pairs were estimated to be present in 1974. Most successful first nests (73 percent) were initiated between 17 and 30 March and peak hatch occurred during 28 April and 4 May. Average clutch size was 5.6 ± 0.2 (SE) and large clutches were not established earlier than smaller clutches in 1974. Egg and nest success was 67 and 85 percent, respectively. Hatchability (86 percent) was lowered primarily by embryonic mortality (12 percent). The greatest reduction in mean brood size (11 percent) occurred between the first and second week after hatching. The prefledging period terminated 10 weeks after hatching and resulted in a 24 percent loss from the total number of nidifugous young. Significantly more, 87 percent vs. 71 percent, goslings survived to fledging that were produced from pairs establishing nests later than most nesting geese. Small broods lost significantly fewer individuals (9 percent) than large broods (28 percent).

NESTING GIANT CANADA GEESE
OF SOUTHEASTERN LOWER MICHIGAN

By

Richard Marvin Kaminski

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Fisheries and Wildlife

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Gratitude is extended to the Michigan Department of Natural Resources for providing the helicopter used in nest searching, for partial vehicular support,and for habitat analysis equipment. Special thanks are given to Mr. Gerald F. Martz, waterfowl and wetlands specialist with the Michigan Department of Natural Resources, for his complete cooperation with my many requests.

Mr. Keith Gibeault, my brother-in-law, I thank for his company and assistance with banding operations.

I am ever grateful to Loretta, my wife, for helping with many jobs associated with and not related to this study.

Finally, I offer my gratitude and respect to Al and Jeanne for always being concerned parents.

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INTRODUCTION

The Huron River Valley of southeastern Lower Michigan currently supports the largest feral flock of Canada geese (*Branta canadensis*) in Michigan (Mikula 1970:80). Historical evidence suggests that the Huron River Valley (HRV) flock originated from *B. c. maxima* stock that were either released or escaped from private waterfowl collections of Henry W. Wallace and Edsel Ford, both of Oakland County, during the mid-1920's. Subsequent transplants, releases, and restoration projects by the Michigan Department of Natural Resources plus natural production have contributed to build the population to its current level of approximately 3,500 birds (Fig. 1).

The success of this flock is interesting when one considers its geographical location. It nests near the inhabitation of 4+ million people. Data are needed on the HRV flock and other flocks that nest in proximity to large urban centers. This study was designed to investigate basic parameters associated with the nesting biology and habitat and to compare the findings with studies of geese nesting in more traditional areas. The objectives were to determine the breeding range of the flock, to quantitatively describe some factors associated with nesting wetlands and nest sites, to estimate the size of the breeding population, its productivity, and survival of goslings to fledging.

Fig. 1. The number of Canada geese estimated to be wintering in selected areas of southeastern Lower Michigan from 1969 to 1974 determined by aerial censuses conducted by the Michigan Department of Natural Resources.

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LITERATURE REVIEW

Canada geese (*Branta canadensis*) have been the focus of numerous waterfowl nesting studies in the past. The majority of nesting studies have been confined to the western United States and Canada where Kortright (1953:86) illustrated the species' endemic breeding range. Early studies described populations in Utah (Williams and Marshall, 1937) and California (Dow, 1943). Other populations have been investigated in California (Naylor, 1953; Naylor and Hunt, 1954; Miller and Collins, 1953), Utah (Day, 1964), Idaho (Salter, 1958; Steel et al., 1957), Washington (Hanson and Browning, 1959; Culbertson et al., 1971; Hanson and Eberhardt, 1971), the Pacific Northwest (Jewett, 1949), Montana (Geis, 1956; Atwater, 1959), and Wyoming (Craighead and Craighead, 1949). In Canada, nesting populations have been examined by Caldwell (1967) in Saskatchewan, in Manitoba by Klopman (1958), and in Alberta by Vermeer (1970) and Ewaschuk and Boag (1972). The Northwest Territories were the sites for nesting studies by MacInnes (1962) and MacInnes et al. (1974).

The restoration of breeding Canada goose populations have been most successful with the giant Canada goose subspecies (Zicus, 1974). Nelson (1963) has attributed the success of these efforts to the choice of a proper subspecies for restoration, the re-establishment technique employed, the nesting habitat available, the hunting season security afforded to the birds, and other associated management and

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human oriented problems. Brakhage (1965) described the biology and behavior of restored nesting giant Canada geese in Missouri. Breeding Canada geese have also been successfully reintroduced at Marshy Point, Manitoba where their nesting biology was studied by Cooper (1973). Will (1969) examined re-established nesting Canada geese in Colorado as has Zicus (1974) in Wisconsin.

The endemic breeding range of giant Canada geese covers the southern half of Michigan's Lower Peninsula (Hanson, 1965:44). Personnel from the Michigan Department of Natural Resources have reintroduced 17 free-ranging Canada goose flocks since 1918. Two studies, one conducted by Sherwood (1966) at the Seney National Wildlife Refuge of the Upper Peninsula and the other by Rudersdorf (1962) in southwestern Lower Michigan, examined the nesting ecology and population dynamics of these reintroduced flocks. Weigand et al. (1968) reported on some reproductive aspects of a captive flock of Canada geese kept at the Mason state game farm. Michigan's largest feral flock of Canada geese lives year-around in southeastern Lower Michigan near major metropolitan areas. Only one other known study has documented free-ranging Canada geese nesting in proximity to large urban centers. Sayler and Cooper (1974) are currently investigating the history, status, and nesting ecology of 12 Canada goose flocks breeding in and around the Twin Cities area of Minnesota. Preliminary findings of Sayler and Cooper (1974) suggest that these geese are as successful as those that nest in more traditional nesting areas.

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STUDY AREA

The majority of the study area lies within the Huron River Valley of southeastern Lower Michigan (Fig. 2). It includes portions of 11 counties encompassing approximately 3,500 square miles (9,065 km^2). Michigan's greatest density of humans reside in and near the Huron River Valley. Major metropolitan areas include Jackson, Ann Arbor, Detroit, Pontiac, Flint, and Lansing. Outside the urban areas, much of the area is agriculturally developed with row crops and dairy herds.

The physiography of the region is primarily the result of the Wisconsin glacier (Dorr and Eschman, 1970). The glacier stagnated here leaving behind a morainic topography and thousands of "kettle hole" lakes and marshes. The greatest concentration of wetlands occurs in a broad belt extending just north of Pontiac southwest to Jackson (Table 1). Most lakes freeze over during winter but some remain open housing an appreciable number of wintering Canada geese and ducks. There are four major wintering areas within the study area (Mikula, 1970:80). The largest group of Canada geese winter within Kensington Metropolitan Park on Kent Lake and the nature center pond which is partially kept free of ice by mechanical air compression. Here the birds are fed two to three tons of corn each winter by park personnel.

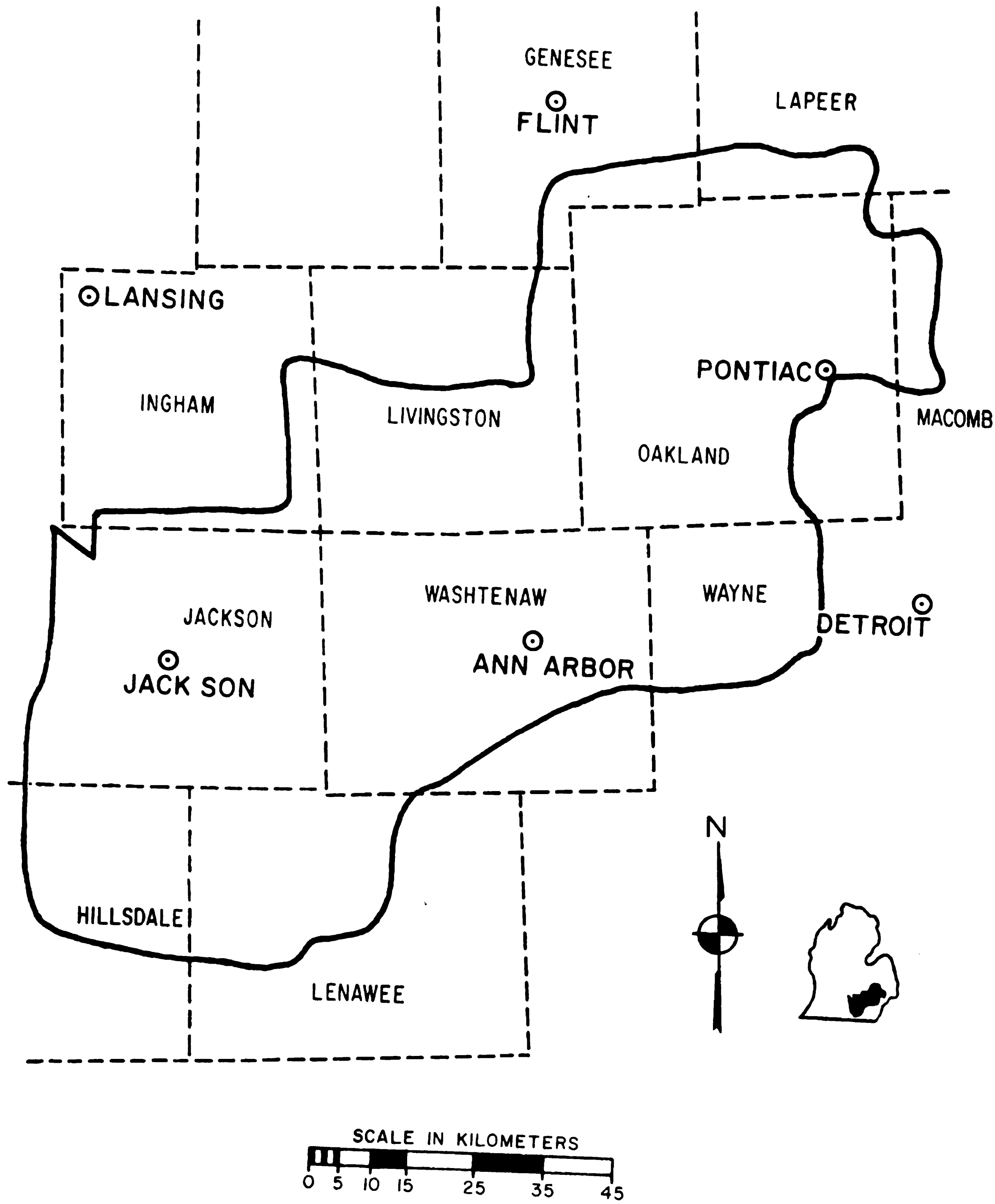

Fig. 2. The study area, Huron River Valley, southeastern Lower Michigan, 1974.

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Table 1. Number and area of available wetlands in southeastern Lower Michigan by county. Summary includes all wetlands equal to and greater than 0.05 ha.

	Entire County[a]		Within Study Area[a]	
County	Number	Area (ha)	Number	Area (ha)
Oakland	1,857	10,325.6	1,400	9,723.8
Jackson	703	4,678.9	528	4,670.9
Livingston	618	4,280.1	443	3,582.5
Lapeer	525	2,027.7	91	156.4
Washtenaw	492	3,949.4	349	4,148.2
Hillsdale	388	1,730.7	149	866.2
Wayne	298	1,169.7	110	40.3
Macomb	278	673.8	55	388.3
Lenawee	252	2,225.3	169	1,861.8
Genesee	213	2,079.3	48	618.9
Ingham	205	799.9	22	78.6
Total	5,829	33,940.4	3,364	26,135.4

[a]From Humphrys and Green (1962).

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Vegetation of the area's wetlands can be categorized into marsh, bog, and upland island communities. Dominant marsh emergents are cattail (*Typha latifolia*), bulrush (*Scirpus* spp.), sedge (*Carex* spp.), and woody species such as willow (*Salix* spp.) and tag alder (*Alnus rugosa*). Common bog species include poison sumac (*Rhus vernix*), royal fern (*Osmunda regalis*), and leather leaf (*Chamaedaphne calyculata*). Island vegetation varies according to successional stage, the intensity of human use, and other factors. Tree species include red oak (*Quercus rubra*), trembling aspen (*Populus tremuloides*), red maple (*Acer rubrum*), American elm (*Ulmus americana*), and basswood (*Tilia americana*). Understories are primarily comprised of hazel (*Corylus americana*), red-osier dogwood (*Cornus stolonifera*), gray dogwood (*Cornus racemosa*), and briar (*Rubus* spp.).

Common floating and submergent aquatics are yellow water lily (*Nuphar* spp.), white water lily (*Nymphaea* spp.), pond weed (*Potamogeton* spp.), water milfoil (*Myriophyllum* spp.), coontail (*Ceratophyllum* spp.), and muskgrass (*Chara* spp.).

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METHODS

An aerial census of nesting Canada geese was conducted with a helicopter provided by the Michigan Department of Natural Resources. The quarter section (65 hectares) was chosen as the sampling unit. Topographic maps of the study area were used to enumerate all quarter sections that contained wetlands (i.e., lakes, ponds, rivers, marshes, and sewage lagoons) and could potentially be nesting habitat for Canada geese. A total of 6,275 quarter sections contained at least one wetland. A five percent sample (n = 310) of quarter sections was randomly selected and positioned on county maps by their appropriate legal description and then systematically searched. The aerial census was conducted for 10 days beginning on 15 April 1974.

After a nest was located from the air, the following information was recorded: (1) location, (2) nest site type (i.e., muskrat (*Ondatra zibethica*) lodge, island, or floating mat), (3) clutch size, when this could be determined, and (4) total number of nesting pairs on the wetland. The nest was photographed from the helicopter at an altitude of 44 meters with a 50 mm lens mounted on a 35 mm camera. From this altitude, an area circumscribing the nest and equivalent to 0.03 hectares (10 m radius) could be drawn on a 4x5 inch photo. The technique was restricted to relatively open nest sites where surface cover was not obstructed by overlaying shrub and/or tree canopies. Percent occurrence of cover appearing on the photos was determined by

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using a transparent acreage dot grid in a manner similar to the procedure described by Phillips (1959:36). Ground truth reconnaissance was conducted soon after the final nest fate was determined and included only the vegetation (dead and perennial) that was available to geese selecting nest sites. Transect lines (0.05 m x 10 m) were extended from the base of the nest in the four cardinal directions. Vegetation intersecting and/or overshadowing the transect along 0.1 m intervals was tallied and an average percent occurrence of cover calculated for each plot.

Two aspects of Canada goose nesting habitat were investigated. The first dealt with certain components associated with the nesting wetland; the second with habitat parameters associated with the nest site.

Nesting wetlands were characterized by a shoreline development index (Reid, 1961:34) which is based on shoreline configuration, percent residential and/or recreational shoreline development, area of open water, and area of emergent vegetation within each nesting quarter section.

To evaluate the magnitude of difference between selected nest sites and ones not utilized by nesting geese, a multi-variate discriminant analysis, modified from Cooley and Lohnes (1971), of various habitat parameters was employed. Nest site types included in the analysis were muskrat lodges and islands. These sites dictated the parameters that were measured. Around muskrat lodge nest sites, the parameters were: lodge height above standing water, width of lodge top, distance to the nearest shoreline, percent occurrence

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occurrence of cover, distance from the lodge to open water, and average height of vegetation for all emergent species within the sample plot. The same measurements were recorded for the nearest muskrat lodge devoid of nesting geese.

Parameters measured on utilized nesting islands and randomly selected non-utilized islands were vegetation density, percent slope at the highest point on the island, island length, distance to nearest shoreline, and average understory height for all plant species occurring within one sample plot circumscribing the nest and within one randomly placed plot, contiguous with the shoreline, on islands not utilized by nesting geese.

A density board, as described by DeVos and Mosby (1969:142) was used to estimate the density of vegetation. One reading was taken within three meters from the water's edge at the north, south, east, and west sides of all islands plus at the nest site on islands utilized by nesting geese. Percent slope was measured using a Haga altimeter. A 2-meter stick calibrated in centimeters was used to measure the height of vegetation. All distance measurements were made with a Bausch and Lombe range finder.

Other data recorded during the relocation of nests from the ground were: (1) number of nesting pairs per wetland;, (2) distance to nearest nesting pair of geese, (3) nest site type, (4) clutch size, (5) egg length and width, and (6) general notes on nest site condition. All eggs were numbered with a lead pencil. Approximate hatching dates, egg success, nesting success, and renesting attempts were recorded. The week of nest establishment was determined by back dating from the hatching week the normal incubation period (28 days) plus

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plus the product of the clutch size times the normal egg laying rate (1.5 days). All nests were visited at least twice prior to the hatch or until the final nest fate was determined.

Nest completions and losses were categorized as successful, predated, deserted, flooded, or failed. Successful nests were those in which at least one egg hatched and the young left the nest. Nests believed to be predated were compared with descriptions presented by Rearden (1951).

All recovered unhatched eggs were opened and examined to diagnose the cause of hatching failure. It was difficult to ascertain infertility because of the decomposed state of many unhatched eggs. Kossack (1950) deemed Canada goose eggs infertile if their contents were congealed and/or deteriorated; however Cooper (1973:278) found no evidence to support Kossack's assumption. Eggs were considered infertile if not possessing vitelline circulatory development or body tissue thus slightly biasing the fertility estimate downwards. Dead embryos were aged using criteria developed by Cooper and Batt (1972).

Brood surveys were conducted weekly to monitor gosling survival from hatching to fledging. The survey was restricted to wetlands that contained broods that could be readily located and identified. Wetlands where brood mixing occurred were not included in the counts.

Canada geese were drive-trapped, throughout the study area, using the method of Cooch (1953), sexed and aged following Hanson (1956:120), and banded with U. S. Fish and Wildlife Service leg bands. Morphometric measurements were obtained following Grieb (1970:9) from yearlings and older geese in order to determine racial identity as

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shown by Hanson (1965). Exposed culmen length and width, tarsus length, middle-toe length, and body weight were recorded and used to differentiate age-sex classes.

All statistical analyses follow standard procedures from Sokal and Rohlf (1969), Kirk (1968), and Cooley and Lohnes (1971). Variation about reported mean values are designated by one standard error.

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RESULTS

Nesting Survey

Of the 310 quarter sections surveyed, 293 contained no nests, 11 had one, four had two, one had three, and one had four. The expanded estimate for the entire study area was 526 ± 140 nesting pairs with an average of 0.08 nests per wetland quarter section. No sufficient evidence ($P > 0.05$) was available to reject the distribution of nests fit to the negative binomial distribution which has a clumped pattern (Elliott, 1971:23).

Jackson county had the greatest number of quarter sections containing wetlands, therefore it was sampled most (Table 2). The number of nests observed in Jackson, Oakland, Livingston, and Washtenaw counties were not significantly different ($X^2 = 2.8$, $df = 3$, $P > 0.05$) from the proportion of wetland areas available in each county. When considered collectively, these four counties contained 486 (92 percent) of the total estimated number of nesting pairs compared to 81 percent of the total number of wetland areas on the study area.

Nesting Range

Although no nesting geese were observed during the aerial survey in Lapeer, Ingham, Genesee, Macomb, or Wayne counties (Table 2), interviews with lake area residents confirmed the presence of nesting geese

Table 2.

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Genesee
Macomb
Wayne
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[b] SE = ±

Table 2. Summary of 1974 aerial Canada goose nesting survey, Huron River Valley, southeastern Lower Michigan.

	Quarter Sections Surveyed		1974 Nesting Pair Density	
County	Number	Percent	Observed	Expanded[a]
Jackson	73	24	6	121
Oakland	58	19	8	162
Livingston	56	18	7	142
Washtenaw	54	17	3	61
Lenawee	22	7	1	20
Hillsdale	16	5	1	20
Lapeer	10	3	0	0
Ingham	9	3	0	0
Genesee	7	2	0	0
Macomb	4	1	0	0
Wayne	1	<1	0	0
Total	310	100	26	526[b]

[a]Expanded Estimate =

$$\frac{1.0}{\dfrac{\text{Total number of 1/4-sections surveyed}}{\text{Grand total of 1/4-sections containing wetlands in the study area}}} \times \text{Number of nests observed}$$

[b]SE = ±140 (calculation of variance based on Cochran, 1963:23).

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in all the above counties excepting Macomb and Wayne. Legal descriptions of the Huron River Valley study area are presented in Appendix A.

The current study area boundary in southcentral Genesee county should be widened westwardly to encompass all of Fenton township (T5N, R6E). Three pairs with two, three, and five goslings, respectively, nested on islands within Lake Ponemah in central Fenton township. A band of lakes in westcentral Hillsdale county extending south of Allen, Michigan and north of Montgomery, Michigan contained nesting geese during years previous to 1974 according to local area residents. This area is approximately 45 diagonal miles from two other Michigan Canada goose subpopulations (Gull Lake and St. Joseph River-Leidy Lake, Rudersdorf, 1962:120) and geese from these areas could be invading westcentral Hillsdale county.

Nesting Wetlands

Morphometric characteristics of wetlands ($n = 30$) containing goose nests were described by four parameters and nest site type within each wetland (Table 3).

Shoreline development (SD) values for nesting wetlands ranged from 0.8 to 3. SD values for wetlands containing the three nest site types (Table 3) differed significantly ($P < 0.01$) which indicates that geese of the Huron River Valley did not select for a specific shoreline configuration in their choice of nesting wetlands.

Residential and/or recreational shoreline development did not deter goose nesting or brood use. Soon after hatching and throughout the summer, geese were observed feeding and loafing on lawns next to

Table 3

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Table 3. Morphometric measurements of 30 wetlands containing nesting Canada geese, partitioned by nest site type, southeastern Lower Michigan, 1974.

Morphometric Parameters of Wetlands	Nest Site Type: Muskrat Lodge (n=18)	Island (n=6)	Floating Mat (n=6)
Shoreline development index	1.2 ± 0.1	2.0 ± 0.3	1.6 ± 0.2
Shoreline recreational/ residential development (%)	13 ± 4	19 ± 13	10 ± 4
Area of open water (ha)	18 ± 5	107 ± 73	43 ± 24
Area of marsh within nesting quarter section (ha)	83 ± 13	0	61 ± 29

lakes. Klopman (1962:126-127) observed similar behavior at Dog Lake, Manitoba. Twelve (40 percent) nesting wetlands had 10 percent or more of their shorelines developed. Nesting wetlands not having grazing areas nearby were abandoned by families early during the first week after hatching. Although lawn grass has been shown to be not highly preferred by foraging geese (Hanson, 1965; Lieff et al., 1970), both goslings and adults were frequently observed consuming it.

The most important factor, other than nest site availability, affecting inhabitation of a wetland by nesting geese appeared to be the area of permanent open water. Ninety-seven percent of the nesting wetlands contained permanent water throughout the year. Ninety-two percent of the nests located during the aerial survey were situated on wetlands having two or more hectares of open water (Fig. 3). Wetlands containing geese nesting on muskrat lodges had the smallest amounts of open water as compared to lakes containing islands with nesting geese which had the largest (Table 3).

Nesting Sites

Although aerial photo estimates of percent cover of vegetation were nine percent higher on the average than ground truth estimates, the two estimates were correlated ($r = 0.86$, $P < 0.01$, Fig. 4). Most of the observed difference was caused by the downdraft from the helicopter propellor which matted down vegetation during photographing.

Nests ($n = 53$) were categorized by the substratum upon which they were built (Table 4). Principle types of nesting substrata encountered during the aerial survey were muskrat lodges (50 percent), floating vegetative mats (27 percent), and natural islands (23 percent).

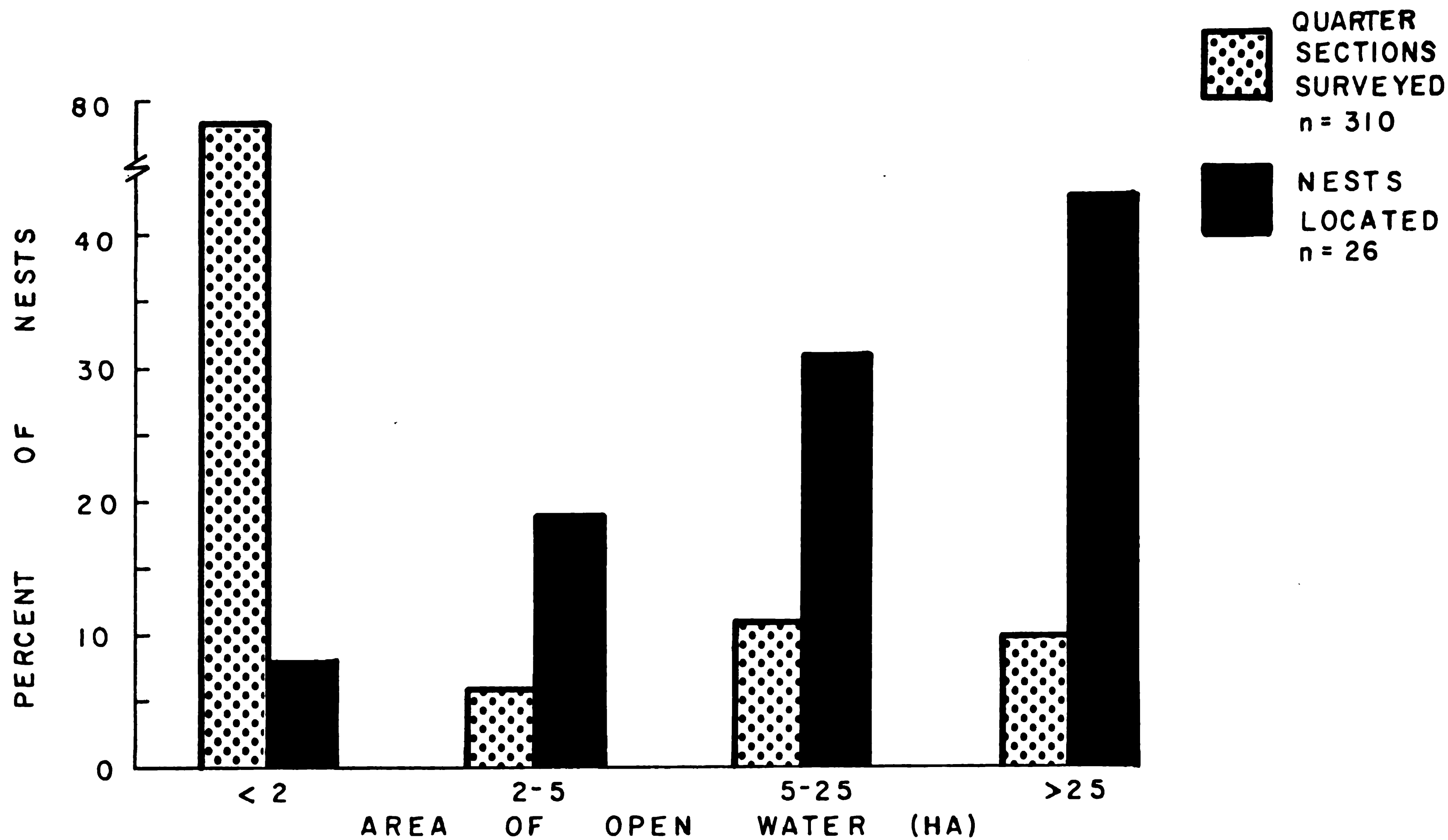

Fig. 3. Percentages of Canada goose nests in relation to the area of open water associated with the nesting wetland.

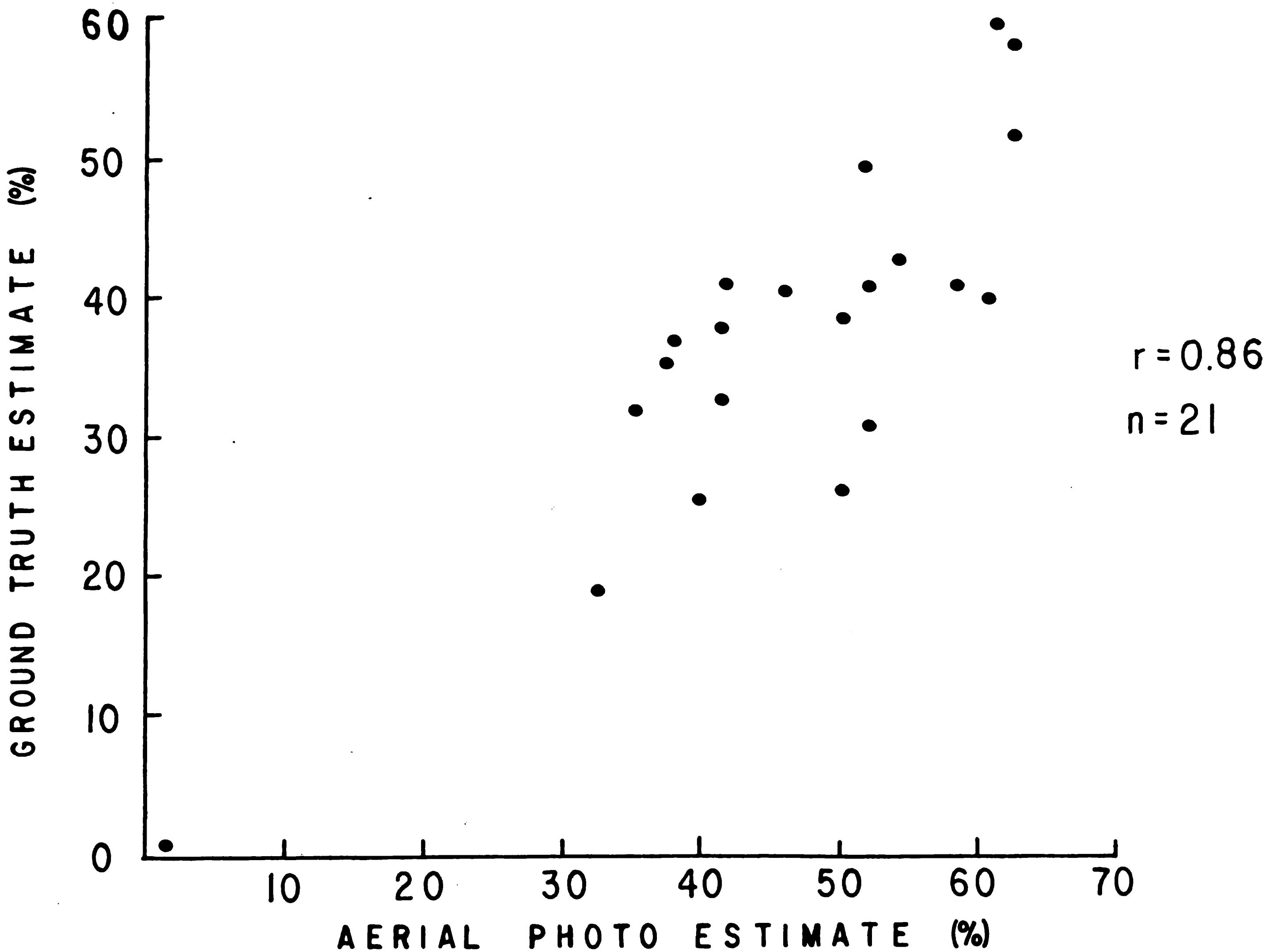

Fig. 4. A scatter-gram depicting the relationship between ground truth percent cover with aerial photo percent cover within 0.03 ha plots around 21 Canada goose nests.

Table 4. Relationship of 53 Canada goose nests to water, location, and nesting site substrata in southeastern Lower Michigan, 1974.

Relationship	Number Located		Total	Percent
	on survey 1/4-sections	off survey 1/4-sections		
Nest surrounded by water				
on muskrat lodges	13	11	24	45
on islands	6	11	17	32
on floating mats	6	1	7	13
on a tree	0	1	1	2
on a duck blind	0	1	1	2
Nest contiguous with shoreline				
on floating mats	1	2	3	6
Total	26	27	53	100

One nest was discovered in a tree crotch and another on the floor of a duck blind, both off survey quarter sections. Twenty-five (96 percent) of the survey nests and 50 (94 percent) of all nests were surrounded by water. Three (6 percent) nests built on floating mats which were contiguous with shorelines were placed not farther than seven meters from open water and not closer than 35 meters from any shoreline.

Muskrat Lodges

Muskrat lodges were the most commonly utilized platforms in 1974. Qualitative appraisals of lodge rigidity and muskrat inhabitation were recorded for both lodges utilized and non-utilized by nesting geese. Lodges were deemed rigid if horizontal movement or vertical submergence was negligible when pressure was exerted on them by the investigator. No preference for rigidity was observed between utilized and non-utilized Canada goose nesting lodges. Muskrat lodges were classed as occupied by muskrats according to criteria suggested by Errington (1963). There was a significant preference ($X^2 = 7.3$, df = 1, $P < 0.01$) by nesting geese for lodges occupied by muskrats (18 of 23) compared to unoccupied lodges 9 of 23). This suggests that lodges occupied by muskrats were probably in better physical condition. Cooper (1973:163) showed that Canada geese nesting at Marshy Point, Manitoba showed no preference for lodges either occupied or unoccupied by muskrats.

A multi-variate discriminant analysis (Cooley and Lohnes, 1971) was employed to determine which parameters that were measured best revealed dissimilarity between muskrat lodges utilized and non-utilized by nesting geese. The goal of discriminant analysis is to assign individuals to a group on the basis of data that are related to the group (Lachenbruch, 1975:1). This analysis computes one or more linear discriminant functions (DF) which maximize the among-group variation. The number of DF extracted depends on the relative sizes of g, the number of groups contrasted, and p, the number of elements of the vector variable (Cooley and Lohnes, 1971:244). In this particular analysis, one DF was calculated because g-1 was less than p (Cooley and Lohnes, 1971:244) and this function assumed 100 percent of the among-group variation. If multiple discriminant functions were obtainable then the first DF would explain the majority of the variation and each succeeding DF less until cumulatively they summed to 100 percent.

Six variables (Table 5), possibly used as proximate factors (Hilden, 1965) by the geese in selecting a nesting site, were measured. The multi-variate analysis of variance revealed a highly significant ($P < 0.001$) discrimination between the contrasted lodge types. The magnitude of the absolute value of the scaled eigenvector coefficient (Table 5) indicated the relative contribution of that particular parameter to the DF. Width of the muskrat lodge top loaded highest among all variables which empirically showed that it was most influential in separating utilized from non-utilized nesting lodges. Inspection of the data revealed that all lodges utilized by geese exceeded one meter in top surface width compared to two of the 23 lodges not utilized by geese. The percent occurrence of cover and height of the lodge above standing water both contributed similarly to the DF. Average height of vegetation around the nest and distance

Table 5. Mean (plus 95% C.I.) and scaled eigenvector values of DF I for parameters measured on and around utilized and non-utilized Canada goose muskrat lodge nesting sites, southeastern Lower Michigan, 1974.

Parameter	Utilized Lodges (n=23)	Non-utilized (n=23)	Scaled Eigenvector[a]
Width of lodge top (m)	1.6 (1.4-1.8)	0.88 (0.80-0.96)	-2.535
Percent occurrence of cover (%)[b]	35.1 (32.4-39.4)	30.2 (25.0-35.5)	-0.786
Lodge height above water (m)	0.34 (0.30-0.38)	0.27 (0.21-0.33)	-0.718
Distance from lodge to open water (m)	17.5 (9.6-25.4)	25.7 (5.7-45.7)	+0.556
Average plot vegetative height for all species (m)	0.82 (0.75-0.89)	0.80 (0.70-0.90)	-0.294
Distance from lodge to nearest shoreline (m)	58.7 (39.3-78.1)	58.9 (39.0-78.8)	-0.289
Root of $W^{-1}A = 1.046$			
Among-group variation accounted for by DF I = 100 percent			
Wilk's lambda = 0.489; df = 6,39; F = 6.79; $P < 0.001$			

[a] Scaled eigenvectors show the relative contribution of the variable to DF I.

[b] Estimates of percent occurrence of cover were retransformed from arcsine transformations (Sokal and Rohlf 1969:386).

to the nearest shoreline varied the least in mean values between groups and offer little in the way of discriminatory power.

Discriminant scores for all muskrat lodges were computed using a standardized grand mean of 50 and standard deviation of 10. A frequency distribution of these scores depicted the relative difference between groups (Fig. 5). Each distribution is comparatively distinct with utilized lodges occupying the lower ranges of discriminant scores. Individual lodges within the 45-55 range, 48 percent of the utilized lodges, could not be clearly assigned to one of the two groups with much confidence.

Emergent and/or woody vegetation was present in all plots (n = 23) containing lodges utilized by nesting geese and in 22 (96 percent) plots around non-utilized lodges. The two most frequent plant associations with both muskrat lodges utilized and non-utilized by geese were *Scirpus* spp. and *Typha latifolia* (Table 6). Muskrat lodges surrounded solely by *Carex* spp. were never utilized by nesting geese; however when *Carex* spp. and *T. latifolia* were interspersed, nesting geese accepted these sites 13 percent of the time.

Vegetation heights for the three most frequently occurring aquatics (*T. latifolia, Scirpus* spp., and *Carex* spp.) were not significantly different ($P > 0.05$) between lodges utilized and not utilized by nesting geese. Pooled mean values (meters) were: *T. latifolia* 0.89 ± 0.04, *Scirpus* spp. 0.88 ± 0.07, and *Carex* spp. 0.54 ± 0.06.

Percent occurrence of cover around both lodge types was analyzed with a random factorial block design (Kirk, 1968). The lodge use class-lodge site interaction was significant (Table 7) which precludes

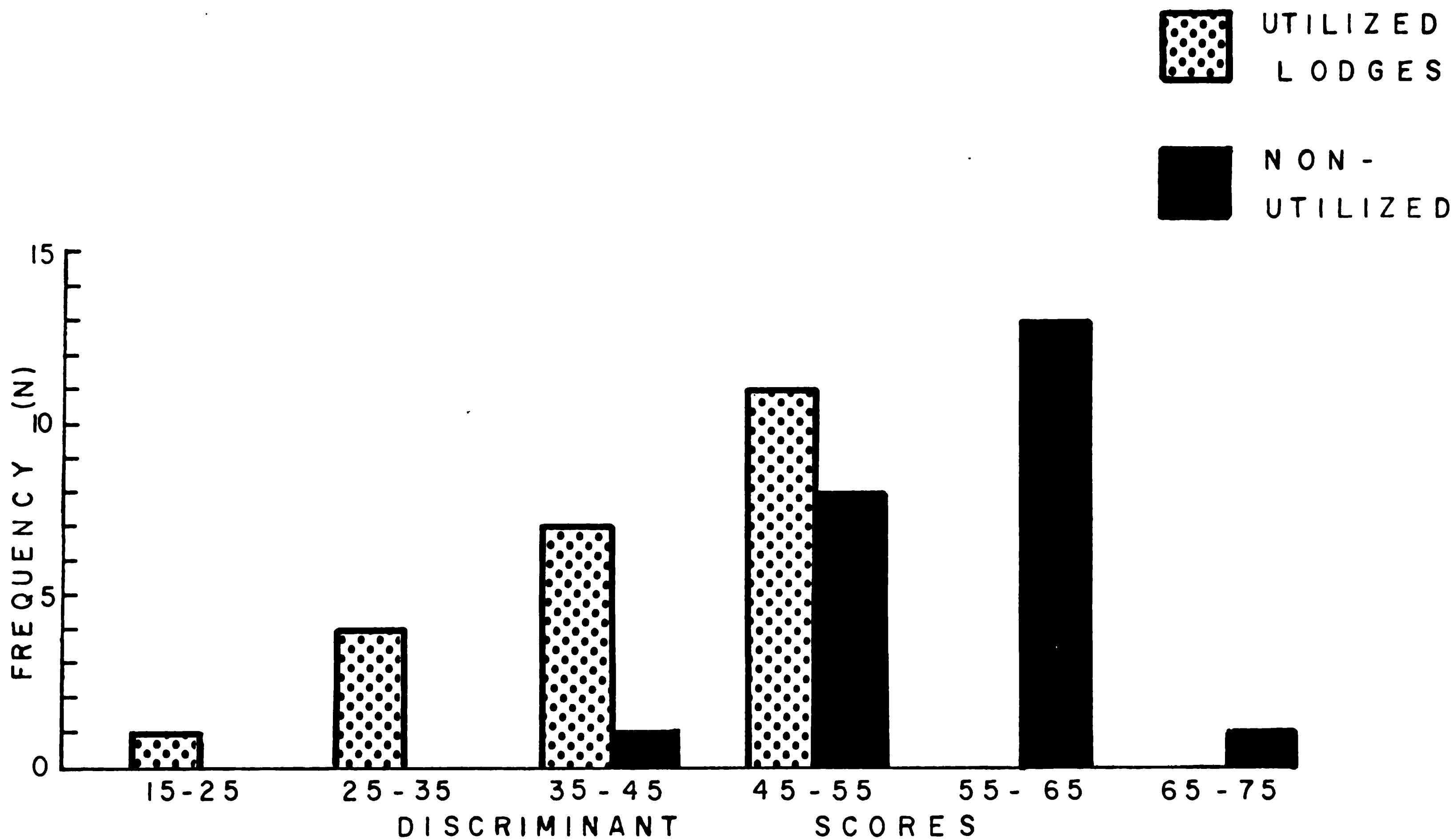

Fig. 5. Frequency distribution of DF scores from parameters measured on and around muskrat lodges both utilized and not utilized by Canada geese as nesting sites. DF scores were standardized on a grand mean of 50 and standard deviation of 10.

Table 6. Frequency of association of vegetation observed in a 10 m radius plot (0.03 ha) around muskrat lodges either utilized or non-utilized by nesting Canada geese in southeastern Lower Michigan, 1974.

Taxon	Frequency (%) Utilized Lodges (n=23)	Frequency (%) Non-utilized Lodges (n=23)	Associated With
Typha latifolia	39	39	None
Scirpus spp.	18	9	*T. latifolia*
Carex spp.	0	18	None
Carex spp.	13	0	*T. latifolia*
Cephalanthus occidentalis	4	4	*T. latifolia*
Scirpus spp.	4	4	None
Carex spp.	4	9	*Scirpus* spp.
Salix spp.	4	4	*Carex* spp.
Plots with other vegetation	13	9	
Plots without vegetation	0	4	
Total plot samples	100	100	

Table 7. Random block factorial ANOVA of percent occurrence of cover within a 0.03 ha plot around 23 muskrat lodges utilized by nesting Canada geese and 23 non-utilized ones.

Source of Variation	df	Mean Square	F-statistic
Utilized/Non-utilized (A)	1	401.26	3.03 ns
Sites (B)	22	357.97	2.70*
Transect Direction (C)	3	259.99	1.96 ns
A X B	22	395.15	2.99*
B X C	66	124.79	0.94 ns
A X C	3	171.85	1.30 ns
A X B X C (Error)	132	132.36	

*P < 0.05.

a comparison among means for main effects (Kirk, 1968) and a test of simple main effects was subsequently employed (Table 8). Percent occurrence of cover around lodges utilized by geese was similar ($P > 0.05$) in all directions while the occurrence of cover around non-utilized lodges was significantly different ($P < 0.05$) thus implying that more heterogeneous amounts of cover were present around the latter.

Percent occurrence of cover by two meter intervals away from lodges utilized and not utilized by nesting geese (Fig. 6) was compared with Scheffe's interval test. There was no significant difference ($P > 0.05$) among lodges within each interval. Although the occurrence of cover increased progressively away from utilized lodges, variation in it also increased from six to 10 meters away from both utilized and non-utilized nesting lodges.

Islands

Thirty-two percent of all goose nests were located on islands. Multi-variate data from equal numbers ($n = 37$) of islands utilized and not utilized by nesting geese was analyzed by DF analysis. Five parameters were measured and contrasting group means are shown in Table 9. The among-group difference yielded a significant ($P < 0.001$) discrimination. Percent slope of island relief had the highest relative power for discrimination, being seven percent greater on the average for utilized than for non-utilized nesting islands. The density of vegetation on the islands also contributed highly to the among-group separation. Although all variables contributed cumulatively to the discrimination, distance from the island to the nearest shoreline, island length, and the height of shrub vegetation

Table 8. Simple main effects ANOVA testing the hypothesis that homogeneous amounts of cover were present around all lodges independent of use by nesting Canada geese. Sources of variation are continued from Table 7.

Source of Variation	df	Mean Square	F-statistic
B for a_1 (utilized)	22	132.47	0.97 ns
B for a_2 (non-utilized)	22	620.78	4.57*
Error	138		

*P < 0.05.

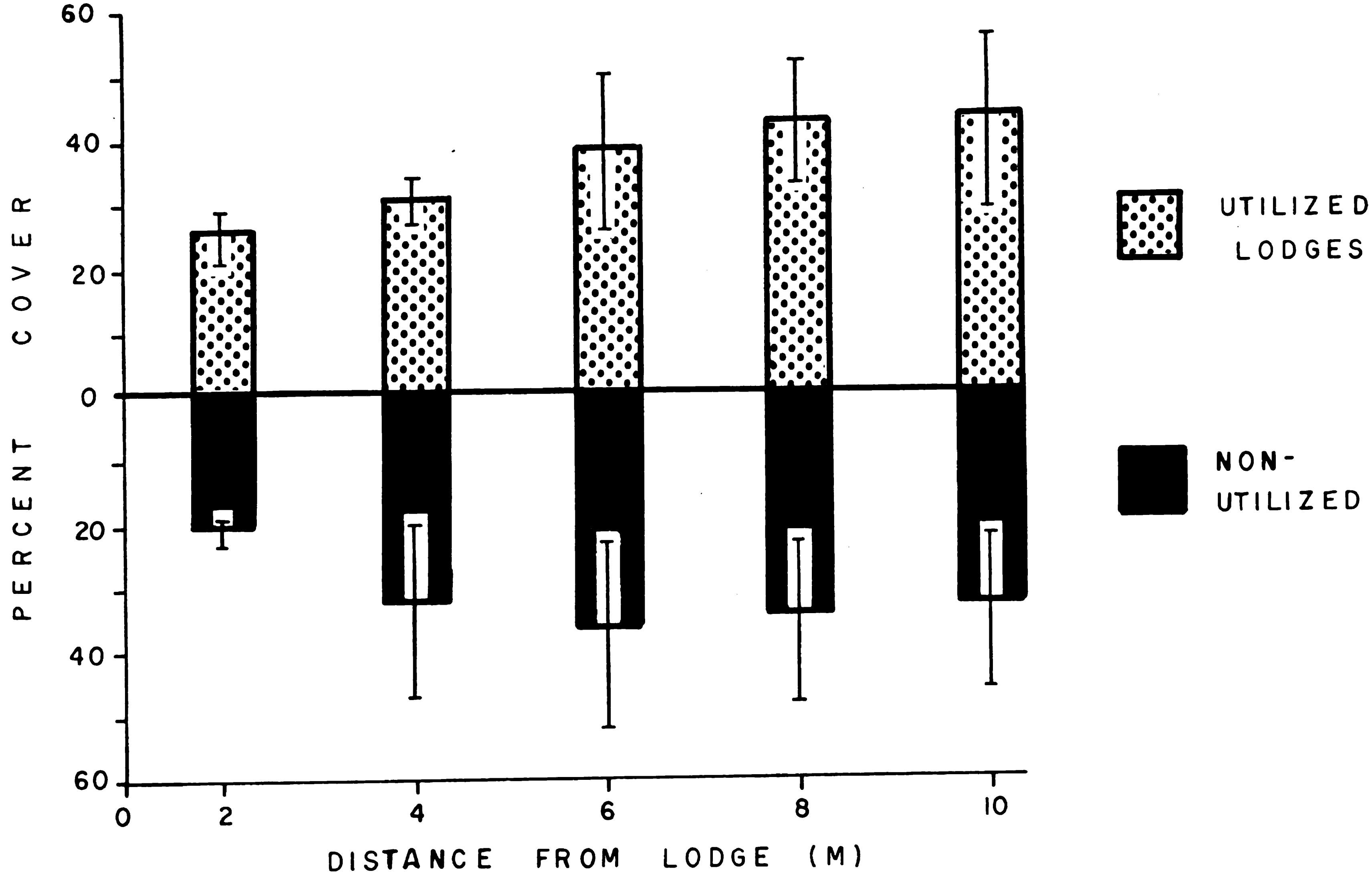

Fig. 6. Mean (plus 95% C.I.) percent occurrence of cover from a 0.03 ha plot around 23 muskrat lodges utilized by nesting Canada geese and 23 non-utilized ones by two meter intervals away from the lodge.

Table 9. Mean (plus 95% C.I.) and scaled eigenvector values of DF I for parameters measured on utilized and non-utilized Canada goose island nesting sites, southeastern Lower Michigan, 1974.

Parameter	Utilized Islands (n=37)	Non-utilized (n=37)	Scaled Eigenvector[a]
Island relief (% slope)	15.7 (13.4-18.1)	8.4 (6.2-10.9)	+24.352
Average island vegetation density (%)	45.7 (36.1-55.3)	62.9 (53.3-72.0)	-16.607
Vegetation density at nest site (%)[b]	17.1 (11.8-23.1)	--	--
Distance from island to nearest shoreline (m)	73.2 (61.1-85.3)	61.4 (45.1-77.7)	+11.788
Island length (m)	65.9 (39.0-92.8)	85.1 (50.8-119.4)	-11.501
Average plot vegetative height for all shrub layer species (m)	1.7 (1.5-1.9)	2.0 (1.6-2.4)	-10.836
Root of $W^{-1}A = 0.439$			
Among-group variation accounted for by DF I = 100 percent			
Wilk's lambda = 0.695; df = 5,68; F = 5.96; $P < 0.001$			

[a]Scaled eigenvectors show the relative contribution of the variable to DF I.

[b]Not included in discriminant function analysis.

All percent estimates were retransformed from arcsine transformations (Sokal and Rohlf 1969:386).

differed slightly in their order of magnitude suggesting a reduced contribution to the DF. DF scores from both island groups show that 41 percent (Fig. 7) of the scores overlap in the 45-65 range thus making it difficult to predict if geese will utilize a particular island within this range based on the parameters measured.

Vegetation obtaining at least 10 percent frequency of occurrence from sampling plots of either utilized or non-utilized nesting islands was considered to be representative of island vegetation (Table 10). Two distinct vegetative life forms typified most islands independent of goose nesting use. Island perimeters were predominantly rimmed with shrub species and devoid of canopied overstories, whereas island interiors were characterized by various densities of shrubs and trees. Plant species conformed closely to the oak-savanna area described by Curtis (1959:88) for Wisconsin's southern hardwood forest.

Quercus spp., *Cornus* spp., and *Salix* spp. occurred most frequently on both islands utilized and non-utilized by nesting geese. *C. racemosa* and *C. stolonifera* occurred on 22 (59 percent) and 20 (54 percent) plots of islands utilized and not utilized by nesting geese, respectively. Dry mesic (Curtis, 1959) islands characteristically had canopies dominated by *Quercus* spp. with *C. racemosa* and/or *Corylus americana* understories and wet mesic (Curtis, 1959) islands had *Salix* spp. canopies with *C. stolonifera* shrub layers.

There was no significant difference ($P > 0.05$) in the height of *Quercus* spp., *C. racemosa*, *C. stolonifera*, and *Salix* spp. among islands utilized and not utilized by nesting geese; therefore the values were pooled. Mean heights (meters) were: *Quercus* spp. 7.0 ± 1.6,

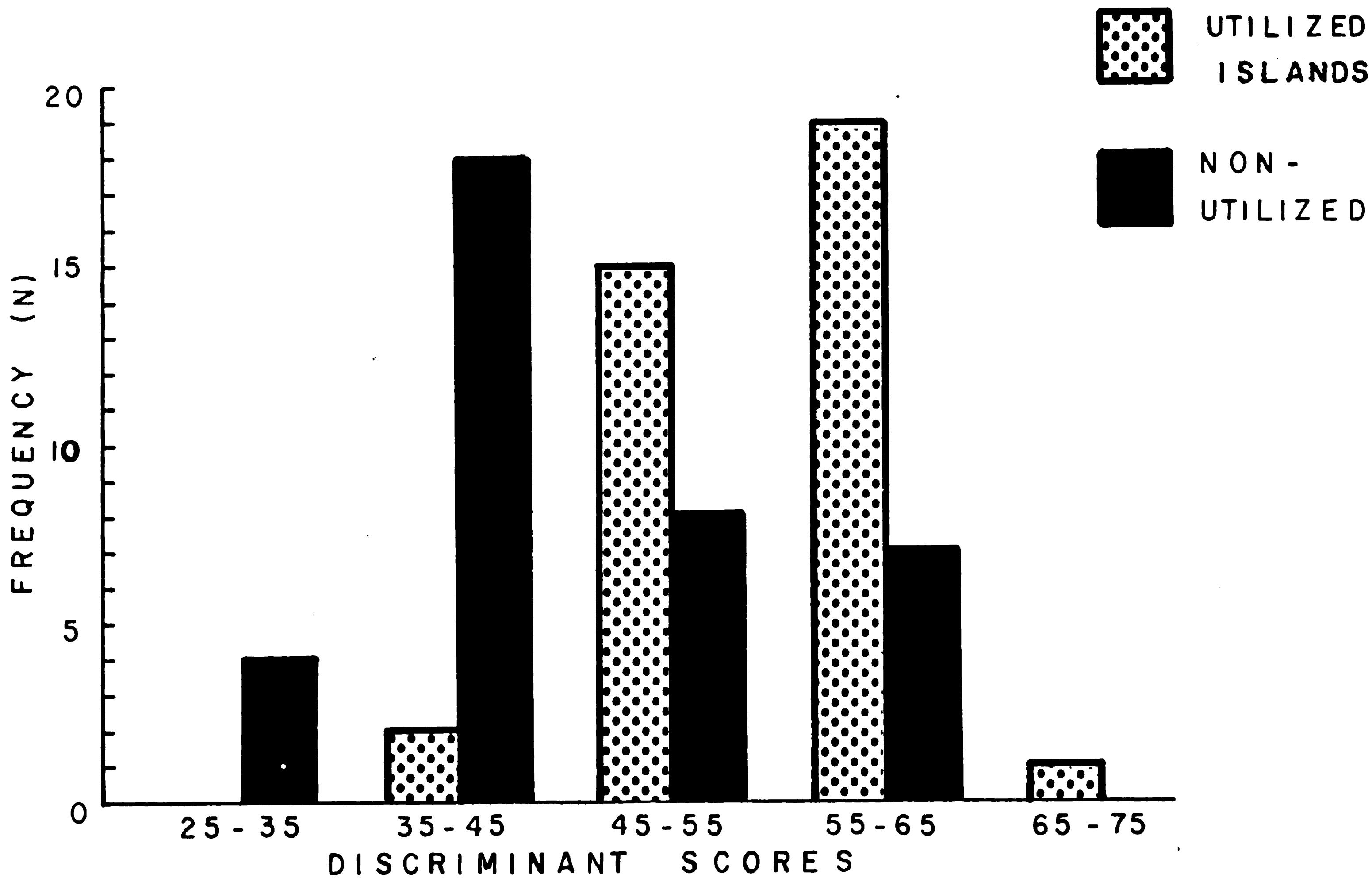

Fig. 7. Frequency distribution of DF scores from parameters measured on islands both utilized and not utilized by Canada geese as nesting sites. DF scores were standardized on a grand mean of 50 and standard deviation of 10.

Table 10. Vegetation occurring in at least 10 percent of the 0.03 ha sample plots (one per island) on islands utilized and non-utilized by nesting Canada geese in southeastern Lower Michigan, 1974.

Taxon	Utilized Nesting Islands (n=37)		Non-utilized Islands (n=37)	
	Number	Frequency (%)	Number	Frequency (%)
Cornus racemosa	22	59	18	49
Cornus stolonifera	19	51	20	54
Quercus spp.	17	46	16	43
Salix spp.	9	24	14	38
Populus tremuloides	--	--	9	24
Rhus typhina	6	16	--	--
Corylus americana	4	11	6	16
Tilia americana	4	11	5	14
Cephalanthus occidentalis	--	--	5	14
Ulmus americana	4	11	--	--
Acer rubrum	--	--	4	11
Rubus spp.	4	11	--	--

C. racemosa 1.8 ± 0.09, *C. stolonifera* 1.6 ± 0.06, and *Salix* spp. 3.3 ± 0.7.

Although the density of vegetation ranged for both utilized and non-utilized islands from zero to 100 percent, the density of vegetation at the nest site ranged from zero to 48 percent. Most of the nests (87 percent) were situated in sparse to lightly dense cover (Table 11). Nesting islands had significantly ($P < 0.01$) less dense vegetation than non-utilized islands (Table 12). Sampling direction and the interaction of direction and type of island use were not significantly different ($P > 0.01$) thus a paired t-test revealed that the density of vegetation at the immediate nest site was significantly less ($t = 6.1$, $df = 36$, $P < 0.005$) than the density of vegetation on the remaining area of the island. Nests were frequently located next to fallen timber or in clones of shrubs.

Floating Mats

Although Zicus (1974:88) believed the use of floating mats as nest sites was unique to the Canada geese nesting in northern Wisconsin, 10 (19 percent) of all nests were located on mats of floating vegetation in 1974. Seven mats were completely surrounded by water and ranged in length from 1.7 to 13.7 meters. The height nests were built above the mats averaged 22 ± 2 cm.

Five floating mats were classified as bogs with *Rhus vernix, Osmunda regalis,* and *Chamaedaphne calyculata* being the most common plant species (Table 13). Four plant species more typically associated with marshes (*T. latifolia, Carex* spp.*, Scirpus* spp., and *Salix* spp.) were present on the other five floating mats containing Canada goose nests.

Table 11. Comparison of vegetation density classifications between utilized Canada goose nesting islands, nest site locations within them, and non-utilized islands in southeastern Lower Michigan, 1974.

Ranges of Vegetation Density (%)[a]	Density Classification[a]	Utilized Nesting Island: Entire Island		Utilized Nesting Island: At Nest Site		Islands Not Utilized	
		Number	Percent	Number	Percent	Number	Percent
0-16	Sparse	5	14	17	46	9	24
16-33	Lightly Dense	14	38	15	41	3	8
33-66	Medium Dense	10	27	5	14	8	22
66 and over	Very Dense	8	22	0	0	17	46
	Total	37	~100	37	~100	37	100

[a]From DeVos and Mosby (1969:142).

Table 12. Two-way ANOVA testing the difference in vegetation density on islands containing Canada goose nests and ones devoid of nests.

Source of Variation	df	Mean Square	F-statistic
Subgroups	7	1562.44	
Utilized/Non-utilized nesting islands (A)	1	7359.26	6.51*
Sampling direction (B)	3	601.06	0.53 ns
A X B interaction	3	591.55	0.52 ns
Error	288	1130.91	

*P < 0.01.

Table 13. The seven most frequently found plant species from a 10 m radius (0.03 ha) plot around 10 Canada goose nests constructed upon floating vegetative mats in southeastern Lower Michigan, 1974.

	Floating Bog (n=5)		Other (n=5)	
Taxon	Number	Frequency (%)	Number	Frequency (%)
Rhus vernix	4	80	--	--
Osmunda regalis	3	60	--	--
Chamaedaphne calyculata	3	60	--	--
Scirpus spp.	2	40	1	20
Typha latifolia	2	40	3	60
Carex spp.	1	20	2	40
Salix spp.	--	--	2	40

Productivity

Nesting Chronology

Nest initiation, defined as the occurrence of the first egg in a clutch (Hanson, 1965:107), spanned a seven week period in 1974 beginning the second full week of March and terminating the fourth week of April (Fig. 8). Only one nest each was initiated during the weeks 10-16 March and 21-27 April with the latter being a renest. Thirty-two (71 percent) nests were initiated between 17-30 March. Nearly one-half (49 percent) of the successful nests were established during the week of 24-30 March. The weeks that females began incubating ranged from 24-30 March to 28 April-4 May. Peak hatch (49 percent) occurred during 28 April and 4 May. The duration of the nesting season encompassed 11 weeks.

Clutch Size

Clutch size for completed clutches ranged from three to eight and averaged 5.6 ± 0.2 (n = 53). One-way analysis of variance showed no significant difference ($P > 0.05$) in clutch sizes among nest site types. Clutch sizes five and six each occurred 17 times and when combined accounted for 64 percent of all completed clutches. Seven, eight, three, and four egg clutches were the next most frequently encountered and represented 15, 8, 8, and 6 percent, respectively, of all clutches.

Large clutches were not established earlier than small clutches in 1974 (Fig. 9) when examined by week of nest establishment. Most (47 percent) of the five egg clutches were established one week

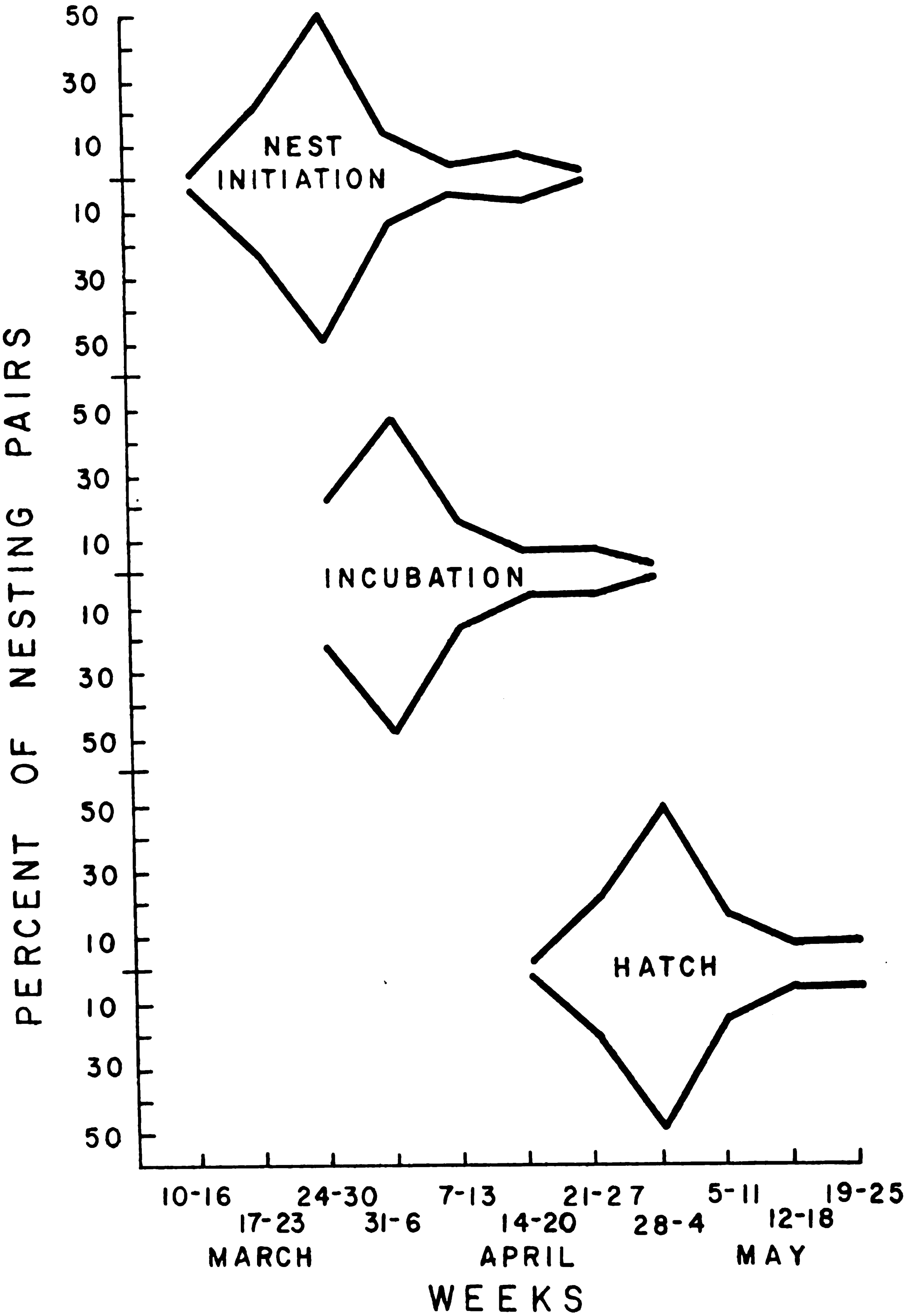

Fig. 8. Chronology of nesting activity of 45 successful Canada goose pairs during 1974 in southeastern Lower Michigan.

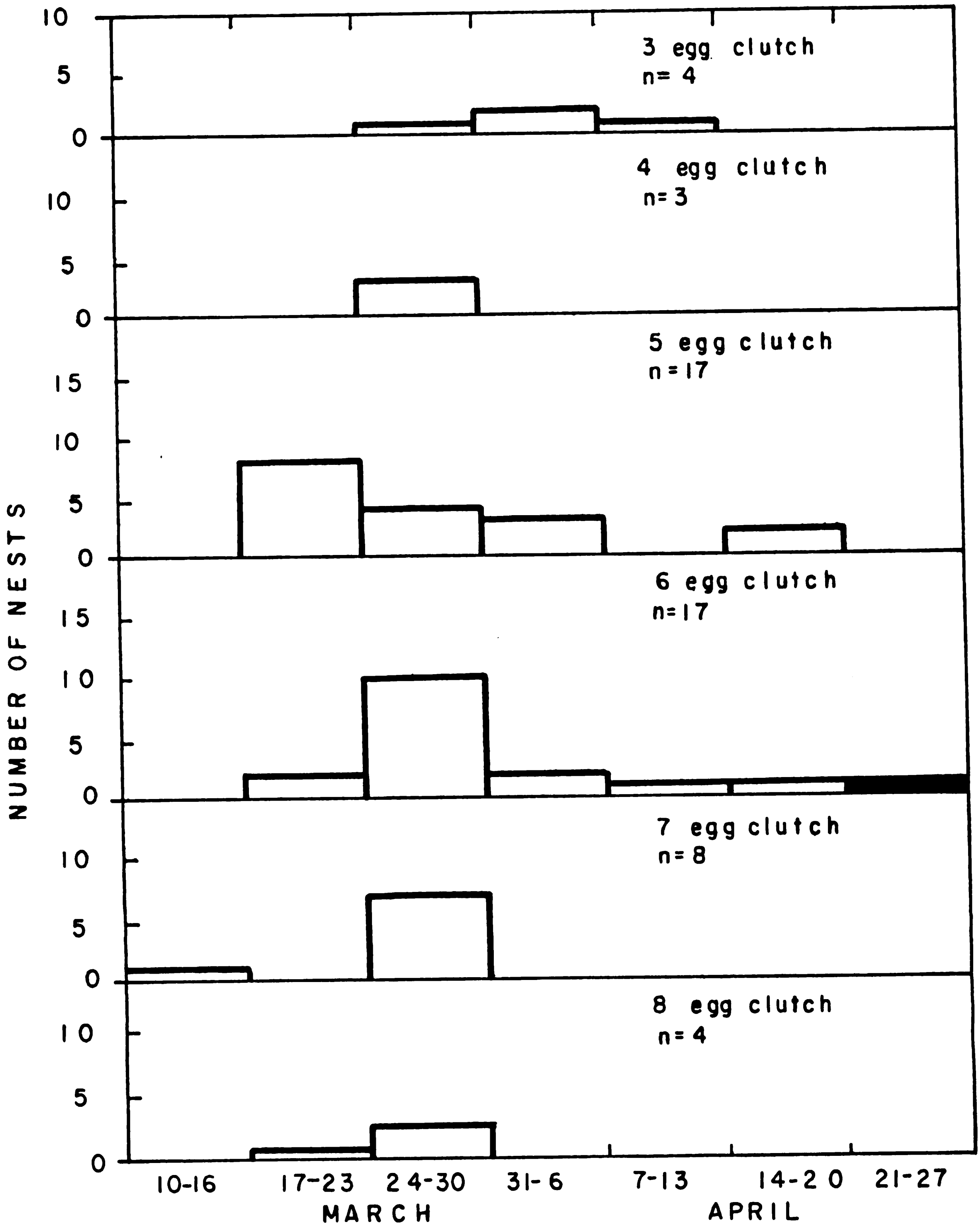

Fig. 9. Relationship between clutch size and nest initiation date, during 1974, for 53 completed Canada goose clutches. Blackened bar represents a renest.

earlier than the peak initiation period for all other clutch size classes. Twenty-eight (53 percent) of all nests (n = 53) were initiated between 24-30 March. Significantly more ($X^2 = 6.7$, df = 1, $P < 0.01$) nesting geese with large clutches (six, seven, and eight eggs) initiated nesting sometime during this period.

Average clutch size for various Canada goose races have been reviewed by Hanson (1965:165). Cooper (1973:201) indicated that clutch sizes for reported *maxima* populations are best approximate measures because few studies have discriminated between continuation, dump, and renests in clutch size computations. No evidence of continuation or dump nests were observed in the 53 nests that were studied in 1974. One renest (clutch size six) was observed.

Egg Size

A total of 228 eggs from 43 different clutches were measured. Mean egg length was 88.2 ± 0.2 mm and width was 59.8 ± 0.1 mm. Both egg length and width varied significantly ($P < 0.01$) between clutch size classes. The observed difference was due probably to such factors as the age of the laying female, her physiological condition during laying, and earliness of nest initiation as shown by Brakhage (1965:759), Cooper (1973:212), Preston (1958:477), and Romanoff and Romanoff (1949:91). Eggs successfully hatched that were measured (n = 150) did not differ significantly ($P > 0.05$) in size from unsuccessful ones (n = 51).

Nesting Success

A nest was deemed successful it at least one egg hatched and the young successfully departed the nest. A total of 45 nests

(85 percent) were successful in 1974 (Table 14) and nest success was not different ($X^2 = 2.4$, df = 3, $P > 0.01$) among nest site types. Geese nesting on islands and muskrat lodges experienced the same nesting success (88 percent) while geese nesting on floating mats had 80 percent success. Eight of the 53 nests were unsuccessful in 1974. Two nests that contained infertile eggs accounted for 25 percent of the completed and unsuccessful clutches. Raccoons (*Procyon lotor*) accounted for 75 percent of the nest destructions.

Egg success was 67 percent (Table 15). Embryonic death was the main factor lowering egg success in 1974. Infertile (9 percent) and predated (5 percent) eggs were secondary and tertiary contributors in decreasing egg success. Embryonic mortality was bimodally distributed with 49 percent and 40 percent of the embryos succumbing during the first and fourth weeks, respectively, of incubation (Table 16).

Only fertile eggs receiving normal incubation were included in the calculation of hatchability which was 86 percent in 1974. No significant difference ($X^2 = 3.3$, df = 2, $P > 0.01$) in hatchability was observed among muskrat lodge, island, and floating mat nest sites. Hatchability was highest among four (92 percent) and eight (100 percent) egg clutches but lowest (79 percent) for six egg clutches.

Brood Size and Gosling Survival

Twenty-three broods were observed weekly from hatching to fledging. A total of 101 goslings successfully departed from the 23 nests. Brood size decreased cumulatively by 21 percent at the end of the third week after hatching (Table 17). The greatest reduction (11 percent) in mean brood size occurred between the first and second

Table 14. Fate of nests and mean clutch size by nest site type for 53 completed Canada goose clutches, southeastern Lower Michigan, 1974.

Nest Site Type	Mean Clutch Size (n)	Nest Fate (%)				
		Successful (n)	Predated (n)	Flooded (n)	Deserted (n)	Failed (n)
Muskrat lodge	5.4 (24)	88 (21)	8 (2)	--	4 (1)	--
Island	5.9 (17)	88 (15)	6 (1)	--	--	6 (1)
Floating mat	5.7 (10)	80 (8)	10 (1)	--	--	10 (1)
Tree	5.0 (1)	--	--	100 (1)	--	--
Duck blind	6.0 (1)	100 (1)	--	--	--	--
Average	5.6 (53)	85 (45)	8 (4)	2 (1)	2 (1)	4 (2)

Table 15. Fate of eggs from 53 Canada goose nests, southeastern Lower Michigan, 1974.

Fate	Number of Eggs	Percent
Successful	199	67
Embryonic death	35	12
Infertile	26	9
Predated	16	5
Broken	6	2
Flooded	5	2
Robbed by human	5	2
Unknown	5	2
Total	297	~100

Table 16. Comparison of embryonic mortality by week of development for four Canada goose populations.

Developmental Stage	Location of Study							
	This Study		Manitoba[a]		Washington[b]		Wisconsin[c]	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Week one	17	49	14	11	515	54	2	15
Week two	1	3	9	7	100	11	0	0
Week three	3	9	50	40	131	14	2	15
Week four	14	40	52	42	199	21	9	70
Total	35	101	125	100	945	100	13	100

[a]Cooper (1973:266).

[b]Hanson and Eberhardt (1971:29).

[c]Zicus (1974:79).

Table 17. Survival of goslings by weekly intervals to fledging for 23 Canada goose broods, southeastern Lower Michigan, 1974.

	Departing Nest	Age Class (weeks)				
		1	2	3	4	5-12
Number of goslings	101	96	86	80	79	77
Cumulative loss (%) of goslings from nest departing total	0	5	15	21	22	24
Mean brood size	4.4± 0.4	4.2± 0.4	3.7± 0.4	3.5± 0.3	3.4± 0.3	3.3± 0.3
Percent loss during each week from mean brood size at nest departure	0	5	11	5	2	2

weeks after hatching. Following the third week, three (3 percent) additional goslings disappeared. The prefledging period terminated with a 24 percent total loss of goslings. Fledging occurred 74 ± 2 days after hatching.

Although goose pairs establishing nests during 17-30 March contributed the majority (69 percent) of goslings, their survival (71 percent) to flight age was significantly less ($X^2 = 2.9$, df = 1, $P < 0.1$) than the survival (87 percent) of goslings from nests initiated between 31 March and 20 April. This suggests that nests initiated during the latter period were timed better to maximize the survival of the offspring. Small broods, 2 and 3 goslings, lost significantly ($X^2 = 3.3$, df = 1, $P < 0.1$) fewer individuals (9 percent) between nest departure and fledging than did larger broods (28 percent) with 4, 5, 6, and 8 goslings per brood.

Identification of Race

Morphometric measurements on geese, by age-sex class, were obtained from 41 different nesting and/or brooding areas within the study area between 18 June and 9 July 1974 (Table 18). With few exceptions, mean values for these measurements fell within the ranges of documented values for giant Canada geese reviewed by Hanson (1965). Qualitative appraisals of plumage characteristics conform closely with Delacour's (1951:5) and Hanson's (1965:41) descriptions of giant Canada geese.

Multiple age-sex contrasts for all measurements were compared using the Bonferroni t-test (Kirk, 1968) to determine if age-sex classes could be differentiated solely on the basis of morphometry

Table 18. Mean values for measurements of molting Canada geese obtained during the period of 18 June-9 July 1974 in southeastern Lower Michigan.

Measurement	Male Adult[a] (n)	Male Juvenile (n)	Male Range[b]	Female Adult[a] (n)	Female Juvenile (n)	Female Range[b]
Culmen length (mm)	65.3±0.3 (115)	63.2±0.5 (42)	57.4-73.5 56.7-70.0	62.6±0.3 (84)	61.3±0.3 (83)	55.3-70.6 54.0-67.8
Culmen width (mm)	25.7±0.1 (115)	25.1±0.2 (42)	22.7-28.6 23.2-28.1	24.6±0.1 (84)	24.5±0.1 (83)	22.2-27.5 22.4-27.4
Tarsus length (mm)	92.8±0.4 (115)	89.2±0.9 (42)	83.0-108.0 77.0-105.0	87.9±0.5 (84)	84.9±0.4 (83)	79.0-101.0 77.0-93.0
Middle-toe length (mm)	100.6±0.4 (115)	97.7±0.9 (42)	87.0-111.0 85.0-111.0	94.8±0.6 (84)	93.0±0.5 (83)	84.0-109.0 82.0-109.0
Weight (gm)	5041.9± 54.2 (44)	4610.9± 85.8 (32)	3745.5-6469.5 3745.5-5675.0	4333.9± 75.7 (44)	3727.6± 161.4 (57)	3291.5-5675.0 3064.5-4880.5

[a]Birds were declared adult if not possessing a bursa of Fabricus, Hanson (1965:120).

[b]Ranges for adult birds are shown above and juveniles follow below.

and/or weight (Table 19). The adult-juvenile female contrast was significantly different ($P < 0.05$) for all measurements except for culmen width which varied least. Although the juvenile male-adult female contrast was not significantly different ($P > 0.05$) for culmen length, tarsus length, and body weight, the magnitude of difference between these age classes should logically be small. Middle-toe length was the most reliable age-sex discriminator being significantly different ($P < 0.05$) among all contrasts.

One hundred seventy five (19 percent) of the captured birds already wore U. S. Fish and Wildlife Service leg bands. Initial banding locations for 170 of the previously banded segment were determined. Twenty-seven (16 percent) were initially banded outside the study area. Twelve originated from seven other Michigan locations, 14 from Ohio, and one from Indiana. The remainder (84 percent) was banded initially within the study area. Band recoveries (1966-1972) from geese harvested by hunters indicate that most geese were taken within the defined study area. Only a few were taken in Canada (2 percent) or south along the Mississippe Flyway (10 percent). It appears that the majority of Canada geese within the study area are year-around residents.

Table 19. Summary of significance tests for measurements by age-sex contrast on Canada geese employing the Bonferroni t-test (Kirk, 1968).

Measurement	Calculated Statistic By Contrast			
	AM-JM	JM-AF	AF-JF	(AM-JF)x(AF-JM)
Culmen length (n=320)	3.96*	1.16	2.80*	4.81*
Culmen width (n=320)	3.00*	2.50*	0.57	2.70*
Tarsus length (n=320)	4.55*	1.56	4.41*	6.28*
Middle-toe length (n=320)	3.30*	3.11*	2.36*	3.45*
Weight (n=206)	2.70*	1.57	3.99*	4.70*

*P < 0.05.

DISCUSSION AND CONCLUSIONS

Prior to the 1950's, nesting Canada geese were scarce throughout southeastern Lower Michigan. Most nests were observed then in southwestern Oakland and southeastern Livingston counties where the flock was originally established. The HRV flock has since expanded its breeding range, but Oakland and Livingston counties no longer contain more nesting geese than other counties surveyed in relation to the availability of wetland habitat in each county. Dispersal of the flock away from the area of establishment may be a function of territoriality (Cooper, 1973:195) and/or intraspecific competition for habitat.

In the past, much attention has been placed on defining habitat preferences of bird species and habitat differences among species with special emphasis focused on passerine species (Whitmore, 1975). Few studies, if any, have shown differences between Canada goose nesting sites and similar unused sites. Without knowledge of what makes a particular nest site type acceptable to nesting geese, an assessment of potential nest site availability is not possible. Among the many physical features associated with nesting sites, Williams and Nelson (1943) and Miller and Collins (1953) together suggested that Canada goose nesting sites should be elevated providing good visibility, afford protection, be in proximity to water, and provide a firm foundation. On the basis of these criteria, appropriate parameters were chosen for the discriminant analysis of utilized versus non-utilized muskrat lodge and island nest sites.

Width of muskrat lodge top achieved the highest discriminatory power between utilized and non-utilized nest sites. This probably explains the high success achieved with artificial nesting platforms in other areas that are managed for nesting Canada geese. The percent of cover around lodges, lodge height above water, and distance from the lodge to open water were the most significant parameters differentiating lodge use types. These four parameters should be considered when evaluating muskrat lodges as potential Canada goose nest sites.

The DF analysis of utilized and non-utilized nesting islands revealed that island percent slope was most distinctive in separating the two island types. Hanson and Eberhardt (1971:8) indicated that Canada geese did not use islands in the Columbia River for nest sites that had low profiles. The density of island vegetation was found to be the next most important in the discrimination being significantly less on utilized nesting islands and at the immediate nest site. Sherwood (1966:179) found that significantly more Canada geese selected islands for nesting that were clear of dense, brushy growths at Seney in Upper Michigan. He speculated that these islands reduced visibility and accumulated more snow which failed to clear less rapidly than more open islands. Barry (1962:24), Cooper (1973:70), and Ryder (1967:22) showed that snow cover on the nesting grounds delayed the onset of nesting in Atlantic brant (*Branta bernicla*), Canada geese, and Ross' geese (*Anser rossii*), respectively.

Assuming a 1974 nesting pair estimate of 526 ± 275 (95% C.I.), 32 percent of the total estimated 1973-74 wintering population of 3,334 (Fig. 1) was involved in nesting. Of 324 geese cloacally examined during the 1974 summer banding operation, 167 (52 percent) were females with 84 (50 percent) being deemed adult (2½ years or older) due to an absence of a bursa. If this ratio was representative of the entire 1974 breeding female population, theoretically then, 864 females of the total wintering population should have been physiologically capable of nesting in 1974. The observed nesting pair estimate was 61 percent of the theoretical estimate. The theoretical estimate was based entirely on the 3-year and older female segment and negated a reproductive contribution of younger females which would have inflated this estimate even more. Several authors (Brakhage, 1965:756; Craighead and Stockstad, 1964:60-61; Cooper, 1973: 200; Sherwood, 1966:69) have documented a significant (30+ percent) reproductive contribution by 2-year old female Canada geese. Hall and McGilvrey (1971) reported the nesting of a yearling female Canada goose whose fertile eggs succumbed to embryonic death. Indirect evidence suggested that a large-scale ingress of non-breeding female molters did not affect the observed adult female ratio because only five percent of the previously banded recaptured females had banding origins outside of Michigan.

The reduced 1974 nesting pair estimate may have been due partly to a sizeable non-breeding component, although no estimates were obtained. MacInnes et al. (1974) found that the minimum non-breeding estimate ranged from 6-22 percent and the maximum from 18-41 percent for small Canada geese (*hutchinsii-parvipes* complex). Brakhage (1965) also provided non-breeding estimates of 13 and 16 percent for 4- and 5-year old female giant Canada geese in Missouri.

The 1974 aerial survey design appears largely responsible for underestimating the actual nesting pair component. Most nesting geese (92 percent) preferred wetlands containing two or more hectares of permanent open water. Much of the survey time was inefficiently spent searching quarter sections with insufficient amounts of open water to attract nesting geese. Exclusion of extremely small wetland areas from future surveys should increase precision in the nesting pair estimate.

An extrapolated life equation representing the reproductive efficiency of 100 HRV Canada goose pairs is presented in Table 20. A total of 183 eggs from 100 clutches were unsuccessful in 1974 which lowered the reproductive potential by 34 percent. As a result, egg success was 66 percent being comparable to the findings of Brakhage (1965:767) and Cooper (1973:270). Primary and secondary agents which contributed to lower the potential were embryonic mortality (12 percent) and egg infertility (9 percent). Hanson (1965:171) concluded that these factors were most significant in suppressing *maxima* production. Nesting success in 1974 for the HRV flock was highest (85 percent) among all other reported *maxima* populations (see review by Cooper, 1973:231), yet hatchability (86 percent) was lower; the reason being mainly high embryonic mortality of which the causes were unknown. The temporal distribution of embryonic mortality showed an early and late peak. Similar patterns have been documented for other Canada goose populations (Table 16).

Table 20. An extrapolated life equation for 100 nesting Canada goose pairs in 1974. The equation omits causes of gosling mortality. Weekly mortality (%) of goslings was obtained from estimates of 23 monitored broods (Table 17).

x	lx	dx F	dx	100 qx
Time	No. Alive at Beginning of x	Factor Responsible for d	Number Dying During x	dx as a Percentage of lx
	560	Embryonic death	66	12
	(mean clutch	Infertile	49	9
	size = 5.6)	Predated	30	5
Nesting Period		Broken	11	2
		Flooded	9	2
		Robbed (humans)	9	2
		Unknown	9	2
			183	34
	370			
Brooding Period				
Week 1	351	Unknown	19	5
Week 2	316	Unknown	35	10
Week 3	294	Unknown	22	7
Week 4	291	Unknown	3	1
Weeks 5-12	282	Unknown	9	3
			88	26
Season Total			271	48

Presumably a total of 370 goslings (Table 20) successfully departed their nests in 1974. Brood size at nest departure averaged 4.4 ± 0.4 in 1974 somewhat lower than the three year average reported by Zicus (1974:80) but he observed a slightly higher average clutch size (5.9 vs. 5.6). Decreased brood size at nest departure was attributed to lower hatchability. Maximum mortality of goslings (10 percent) occurred between the first and second week after hatching. Sherwood (1966:47) recorded highest gosling mortality during the first three to four weeks of life. A 26 percent cumulative loss in total goslings was calculated between nest departure and fledging. Larger broods tended to lose more goslings during this period. Keeping young in aggregate was probably more difficult among larger broods due to fragile family ties early in life as suggested by Sherwood (1966:97).

A 48 percent mortality from the biotic potential of 560 eggs was realized at flight age. Reproductive efficiency (see MacInnes *et al.*, 1974:701) was computed to show what percent of the flock's reproductive potential was achieved. The 1974 reproductive efficiency was 52 percent which indicated, as did the life equation, that 48 percent of the biotic potential was lost by the time goslings fledged. Reproductive efficiency for the HRV flock was eight percent less than the seven year average reported by MacInnes *et al*. (1974:705) for Canada geese of the McConnell River area, Northwest Territories. The HRV flock will produce more offspring per nesting pair due to its higher potential clutch size, but its efficiency in fledging young is less than that of the McConnell River flock.

A short nest establishment period was not evident in 1974 for the HRV flock. The establishment period for 44 first nests encompassed seven weeks (Fig. 8) contrary to highly compressed initiation intervals of near-artic nesting goose and brant populations (Cooch, 1961; MacInnes, 1962; and Barry, 1962). Cooper (1973:76) observed 24 days elapsing from the beginning through the termination of laying. The majority (73 percent) of first nests were initiated during the last two weeks of March. The Huron River Valley occupies nearly the same latitudinal level as does northeastern Illinois where Kossack (1950) observed comparable nest initiation periods beginning 16 April and 24 March of 1944 and 1945, respectively.

The flexible nest establishment schedule suggested that environmental and seasonal barriers were not restricting the onset and prolonged continuance of nest establishment in southeastern Lower Michigan. An absence of less harsh environmental constraints plus a longer growing season than more northern nesting areas probably permitted later hatching young to find sufficient food and attain flight age.

It is commonly observed for geese and brant that large clutches are established earlier than small ones (Barry, 1962:23; Cooch, 1961:77; Cooper, 1973:207; Ryder, 1972:194; and Zicus, 1974:36) possibly insuring maximum time for young development. This phenomenon was not observed for HRV geese in 1974 (Fig. 5) with more than half of the nests, independent of clutch size, being established during 24-30 March. Although the majority (69 percent) of goslings were produced from pairs establishing nests early (17-30 March), their survival to fledging was significantly lower than for goslings from nests established in April.

Koechlein (1971) presented similar survival data for mute swan (*Cygnus olor*) cygnets. Lack (1968:302-304) inferred that most avian breeding schedules are timed so the young can be reared when food resources are most favorable. MacInnes et al. (1974:702) stated that Canada geese of the McConnell River timed their breeding so that the young were growing when protein-rich new vegetative growth was readily available. Undoubtedly, further experimentation regarding the availability and quality of food as it affects the survival of young is needed.

APPENDIX

APPENDIX A

Summarized legal description of the Huron River Valley study area, southeastern Lower Michigan, 1974

Table A1. Legal description of the Huron River Valley study area, southeastern Lower Michigan, 1974.

County	Township	Range	Sections[a]
Jackson	1 south	2 west	1-3, 10-12, 13-15, 17p, 18p, 19-36
	1 south	1 west	1-36
	1 south	1 east	1-36
	1 south	2 east	1-36
	2 south	2 west	1-36
	2 south	1 west	1-36
	2 south	1 east	1-36
	2 south	2 east	1-36
	3 south	3 west	1, 12, 13, 22p-24p, 25-27p, 34p-36
	3 south	2 west	1-36
	3 south	1 west	1-36
	3 south	1 east	1-36
	3 south	2 east	1-36
	4 south	3 west	1-3p, 10p-12, 13-15p, 22p-24, 25-27p, 34p-36
	4 south	2 west	1-36
	4 south	1 west	1-36
	4 south	1 east	1-36
	4 south	2 east	1-36

Table Al - Cont'd:

County	Township	Range	Sections
Oakland	5 north	7 east	1-36
	5 north	8 east	1-36
	5 north	9 east	1-36
	5 north	10 east	1-36
	5 north	11 east	1-36
	4 north	7 east	1-36
	4 north	8 east	1-36
	4 north	9 east	1-36
	4 north	10 east	1-36
	4 north	11 east	1-36
	3 north	7 east	1-36
	3 north	8 east	1-36
	3 north	9 east	1-36
	3 north	10 east	1-30
	3 north	11 east	1-30
	2 north	7 east	1-36
	2 north	8 east	1-36
	2 north	9 east	1-36
	2 north	10 east	5p, 6-8, 9p, 16p-21p, 29-32
	1 north	7 east	1-36
	1 north	8 east	1-36
	1 north	9 east	1-36
	1 north	10 east	5-8, 17-22p, 26p-36p

Table A1 - Cont'd:

County	Township	Range	Sections
Livingston	4 north	6 east	1-4p, 9p-16, 21-28, 33-36
	3 north	3 east	7p-12p, 18-36
	3 north	4 east	18p-21p, 25p-28p, 29-36
	3 north	5 east	25-28, 29p-30p, 31-36
	3 north	6 east	1-4, 9-16, 21-36
	2 north	3 east	1-36
	2 north	4 east	1-36
	2 north	5 east	1-36
	2 north	6 east	1-36
	1 north	3 east	1-36
	1 north	4 east	1-36
	1 north	5 east	1-36
	1 north	6 east	1-36
Washtenaw	1 south	3 east	1-36
	1 south	4 east	1-36
	1 south	5 east	1-36
	1 south	6 east	1-36
	1 south	7 east	1-36
	2 south	3 east	1-36
	2 south	4 east	1-36
	2 south	5 east	1-36
	2 south	6 east	1-36
	2 south	7 east	1-36
	3 south	3 east	1-36

Table A1 - Cont'd:

County	Township	Range	Sections
	3 south	4 east	1-36
	3 south	5 east	1-36
	3 south	6 east	1-13, 27p-28p, 29, 30, 31p, 32p
	4 south	3 east	1-36
	4 south	4 east	1-24, 25p, 26-32, 33p, 34p
	4 south	5 east	1p, 2p, 3-8, 9p, 10p, 16p, 17p, 18, 19p
Lenawee	5 south	1 east	1-36
	5 south	2 east	1-36
	5 south	3 east	1-36
	6 south	1 east	1-36
	6 south	2 east	1-36
	6 south	3 east	1-24, 25p, 26-35, 36p
	7 south	1 east	1-6
	7 south	2 east	1-6
	7 south	3 east	2p, 3-6
Hillsdale	5 south	3 west	1-18, 19p, 20-28, 29p, 33p, 34-36
	5 south	2 west	1-36
	6 south	3 west	1-3, 4p, 9p, 10-15, 16p, 22p, 23-26, 35p, 36
	6 south	2 west	1-36
	6 south	1 west	1-36
	7 south	3 west	1p, 2p
	7 south	2 west	1-5, 6p, 10p, 11, 12, 13p
	7 south	1 west	1-17, 18p

Table A1 - Cont'd:

County	Township	Range	Sections
Lapeer	6 north	9 east	7p, 8-36
	6 north	10 east	7, 8p, 13-36
	6 north	11 east	17-20, 29-32
Ingham	3 north	2 east	13p-15p, 22p, 23-26, 27p, 34p, 35, 36
	2 north	2 east	1, 2, 3p, 10p, 11-14, 15p, 22p, 23-26, 27p, 34p, 35, 36
	1 north	2 east	1, 2, 3p, 10p, 11-14, 15p, 22p, 23-27, 28p-30p, 31-36
	1 north	1 east	27p, 28p, 29p, 31p, 32-36
	1 north	1 west	31-36
	1 north	2 west	28p, 33-36
Genesee	6 north	8 east	7p-10p, 11-36
	6 north	7 east	13, 14p-16p, 18p, 19-36
	6 north	6 east	11p, 12p, 13, 14p, 23p, 24-26, 27p, 34p, 35, 36
	5 north	6 east	1, 2, 3p, 10p, 11-14, 15p, 23-26, 34p, 35, 36
Macomb	5 north	12 east	27-34, 35p
	4 north	12 east	2p, 3-10, 15-22, 27-34
	3 north	12 east	3-10, 15-22, 27-30, 33p, 34
	2 north	12 east	3, 4p
Wayne	1 south	8 east	1-36
	1 south	9 east	1-36
	2 south	8 east	1-36

Table A1- Cont'd:

County	Township	Range	Sections
	2 south	9 east	1-36
	3 south	8 east	1-18
	3 south	9 east	1-11, 12p, 16p, 17p, 18

[a]Section numbers followed by a "p" indicate the inclusion of a portion of that section.

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