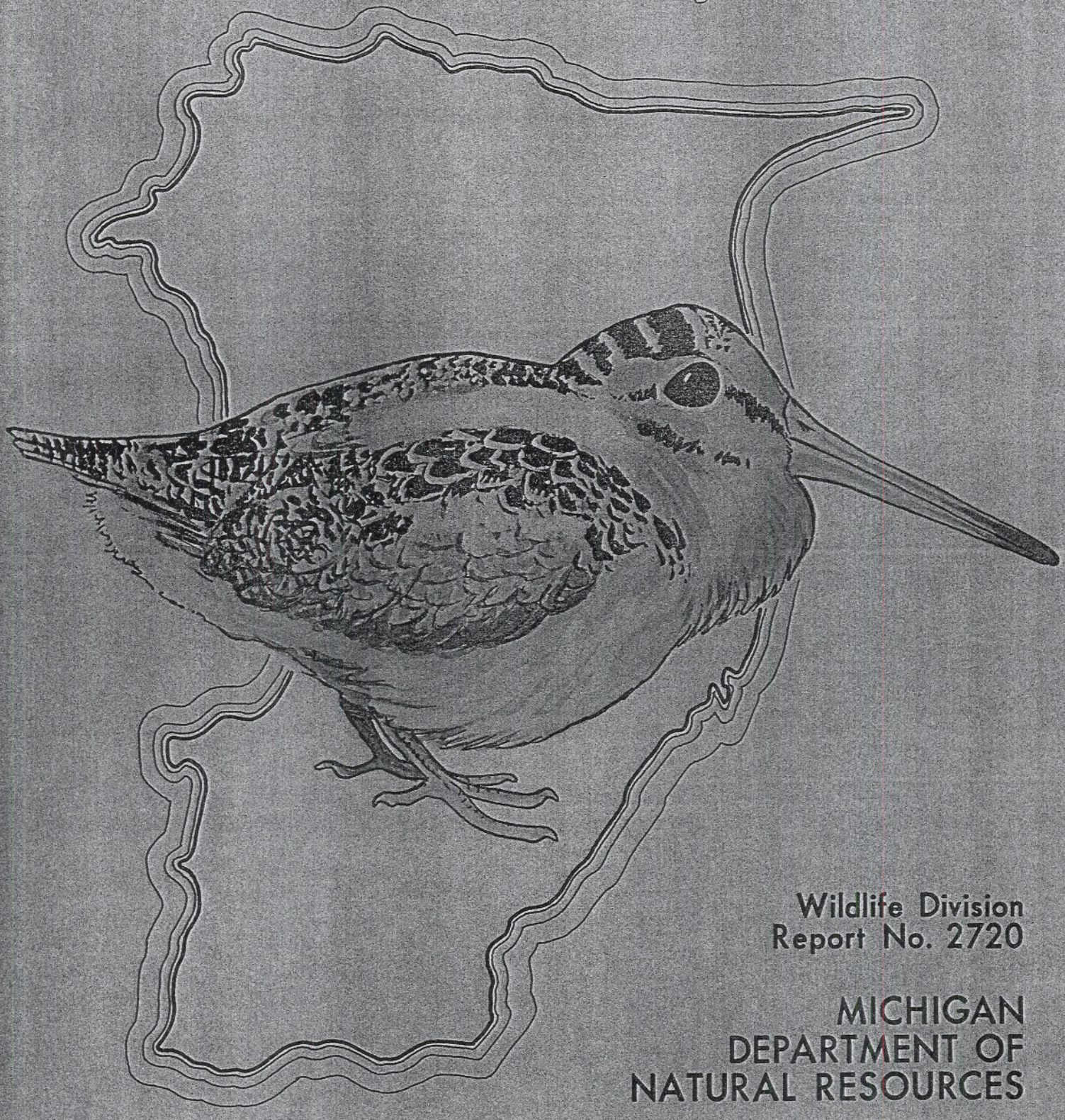
CHARACTERISTICS OF AN INSULAR WOODCOCK POPULATION

Douglas A. Whitcomb



Wildlife Division
Report No. 2720

MICHIGAN
DEPARTMENT OF
NATURAL RESOURCES

ERRORS

Page	
21	In column 8. Column 5 should be divided by the average of column 7, the division sign is missing.
65	There should be a period following (Wright 1965). The rest of the paragraph should be omitted.

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by

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Wildlife Division Report No. 2720

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
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A special thanks is due Beaver Island Forest Fire Officer Bill Wagner for numerous trips to High Island bringing supplies, mail and practical advice.

Lastly, my own family deserves much credit for making the most of somewhat primitive and isolated living conditions and for their patience and help through my graduate years.

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INTRODUCTION

Throughout its range the American woodcock (*Philohela minor* Gmelin) has gained importance as a recreational resource. The 1.4 million birds harvested by U.S. hunters during the 1971-72 season represents a 63 percent increase over a six-year period (Clark 1973). Present trends indicate that future annual harvests of woodcock will soon equal or surpass several heretofore more important game species. Although biologists and administrators have been cognizant of deficiencies in our biological knowledge of the woodcock, the sudden surge in hunter use has focused attention on these deficiencies. Sheldon (1967) and Clark (1969) pointed out specific weak points in our knowledge of the species. Most notable are questions concerning the population dynamics of the species, the role of hunting as a mortality factor, and the interpretation of annual (singing-ground and wing-collection) surveys coordinated by the U.S. Fish and Wildlife Service in order to evaluate the status of the continental woodcock population.

High Island, in northern Lake Michigan, offers unique opportunities to investigate certain aspects of woodcock ecology. The island includes: (1) a discrete block of suitable woodcock habitat which inhibits emigration and immigration during the summer months, (2) an ample population of woodcock that can be monitored from spring through fall, and (3) a situation which allows assessment of hunting effort and kill.

In May 1968, an investigation of the characteristics of the local woodcock population was initiated on High Island. The major objectives of this project included the determination of: (1) dynamics of a heavily exploited local woodcock population, (2) the degree to which singing-ground counts and wing collections may be useful in appraising population status, (3) the effects of hunting on the population, and (4) behavioral characteristics of the population that may limit the population growth or be important in woodcock management.

STUDY AREA

High Island is a 5.5 square mile portion of the Beaver Archipelago which lies in northeastern Lake Michigan (Figure 1). It is located 33 miles northwest of Charlevoix in the Lower Peninsula and 25 miles southwest of Naubinway in the Upper Peninsula of Michigan. It is four miles west of Beaver Island and within 10 miles of several smaller islands. Politically, the island is part of Charlevoix County.

The history of land use on High Island is similar to that of other northern areas in the Great Lakes States--logging, burning, clearing, farming and abandonment have occurred in sequence. By 1920 about 400 acres were under cultivation. High Island was deserted by 1928, except for a few commercial fisherman who remained until the late 1930's. During the mid-1950's a beef cattle business was started but proved to be unsuccessful. The State of Michigan purchased the island in 1957 and it has not been permanently inhabited since then.

About 185 acres in the north-central part of the island still remain as old fields (Figure 2) These openings and the adjacent 1,100 acres of second growth hardwoods and conifers comprise most of the present day woodcock habitat. In addition, several acres surrounding four scattered small clearings in the south half of the island are utilized by woodcock (Figure 3). Nearly 10 miles in linear edge is associated with the clearings. Woody vegetation which is invading all openings includes:

> Staghorn sumac *(Rhus typhina)*, pin cherry *(Prunus pensylvanica)*, aspen *(Populus spp.)*, hazelnut *(Corylus cornuta)*, red-osier dogwood *(Cornus stolonifera)*, willow *(Salix spp.)*, domestic apple *(Pyrus malus)*, white birch *(Betula papyrifera)* and sugar maple *(Acer saccharum)*.
>
> Principle herbaceous ground cover includes several grasses *(Graminea)* wild strawberry *(Fragaria sp.)*, St. John's wort *(Hypericum perforatum)*, milkweed *(Asclepias spp.)*, common yarrow *(Achillea millefolium)* and daisy *(Chrysanthemum leuconthemum)*.

Approximately 240 acres of sugar maple, up to 20 inches in diameter, comprise one portion of the study area. There ground cover consists of hardwood reproduction (primarily sugar maple) and patches of American yew *(Taxus canadensis)*. The remaining 860 acres wooded portion considered to be woodcock habitat is a mixture of white birch, aspen, balsam fir *(Abies balsamea)*, red maple *(Acer rubrum)* and hazelnut.

Soil types on the study area include Onaway sandy loam (wet phase), Kalkaska loamy sand and Munuscong sandy loam. In general, the fields and wooded areas to the north and east are well-drained while the wooded portion south of the fields is poorly drained.

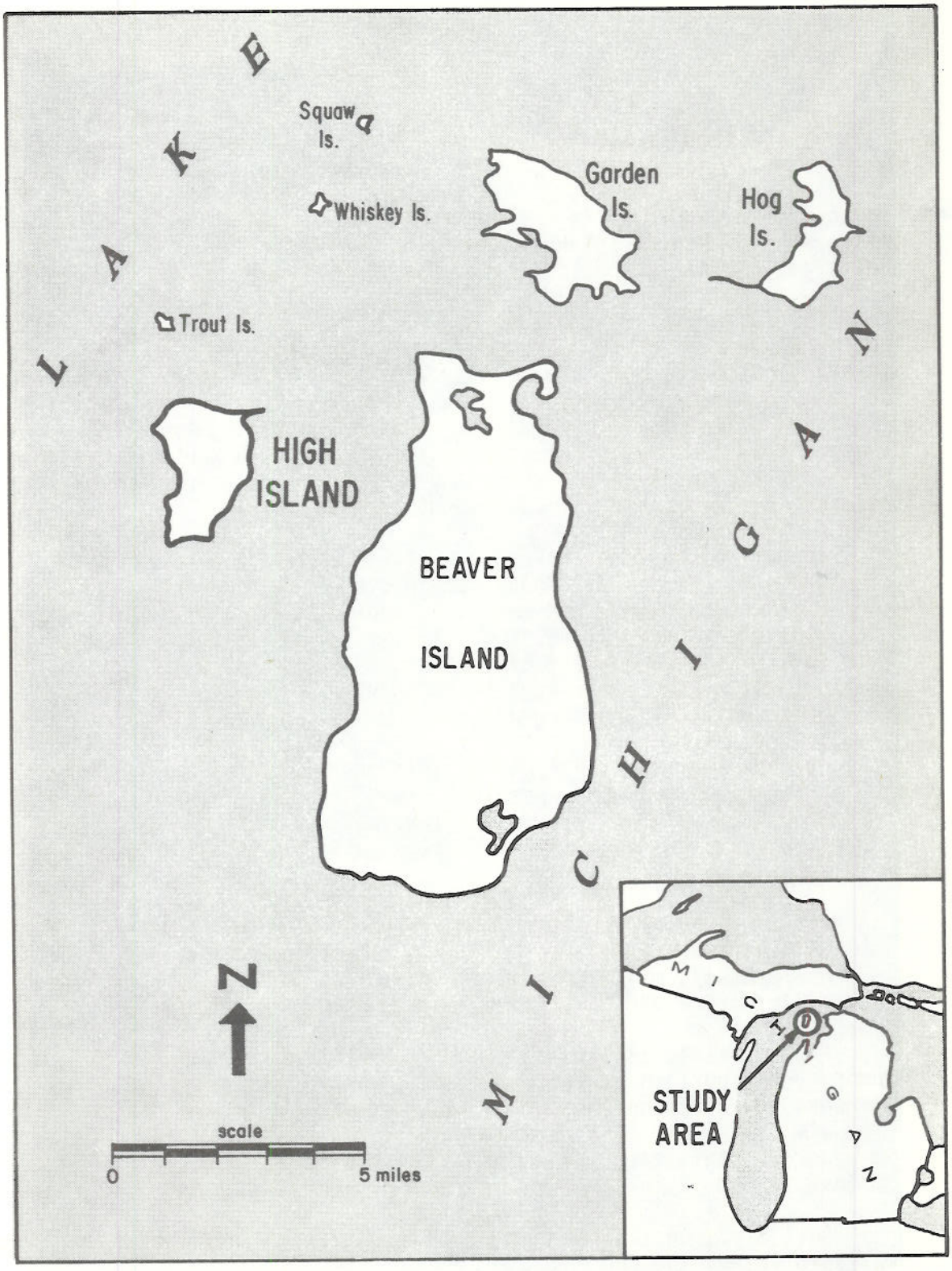

Figure 1. The study area, High Island, and some surrounding islands of the Beaver Archipelago.

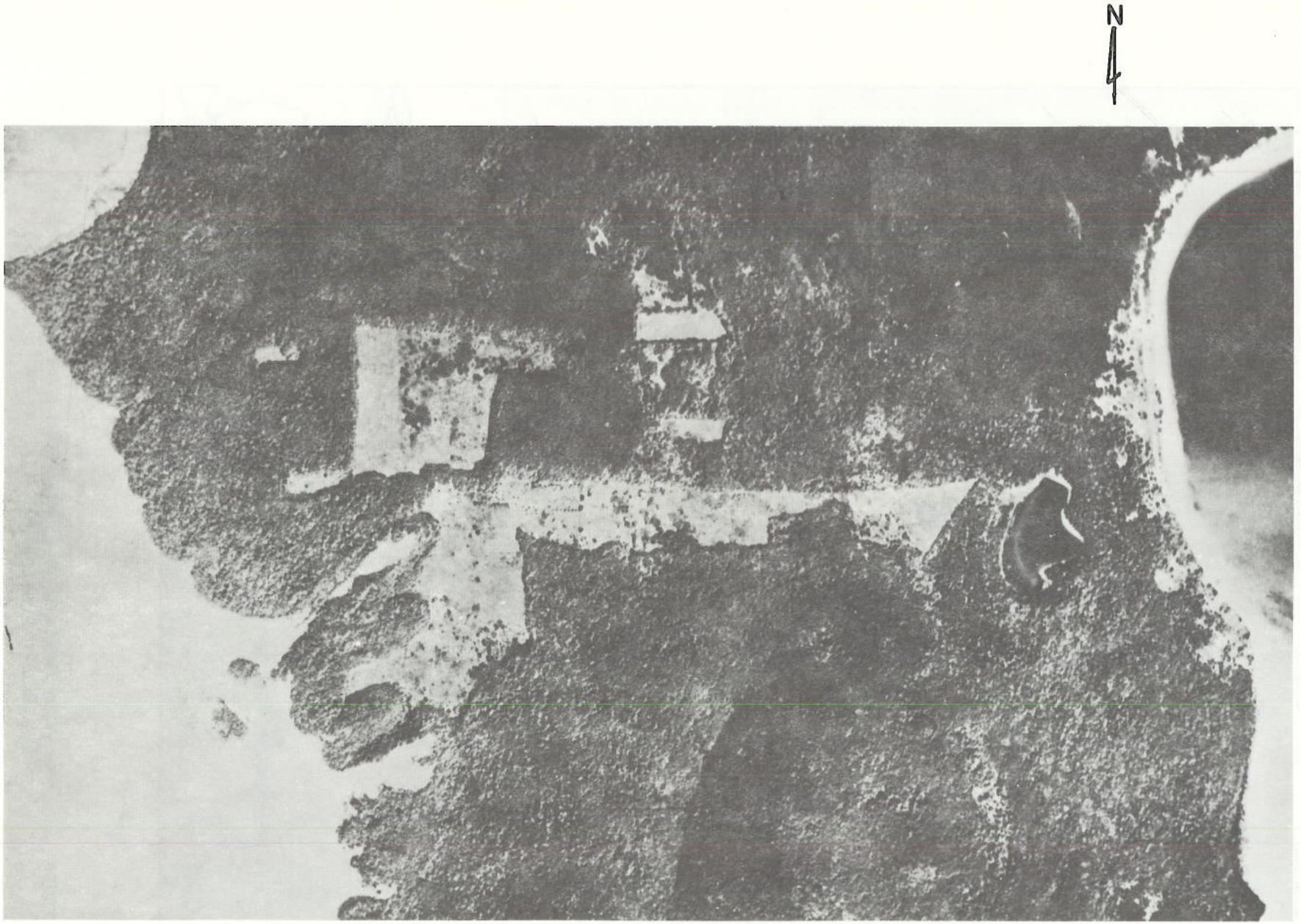

Figure 2. The north half of High Island. The openings appear light gray in color.

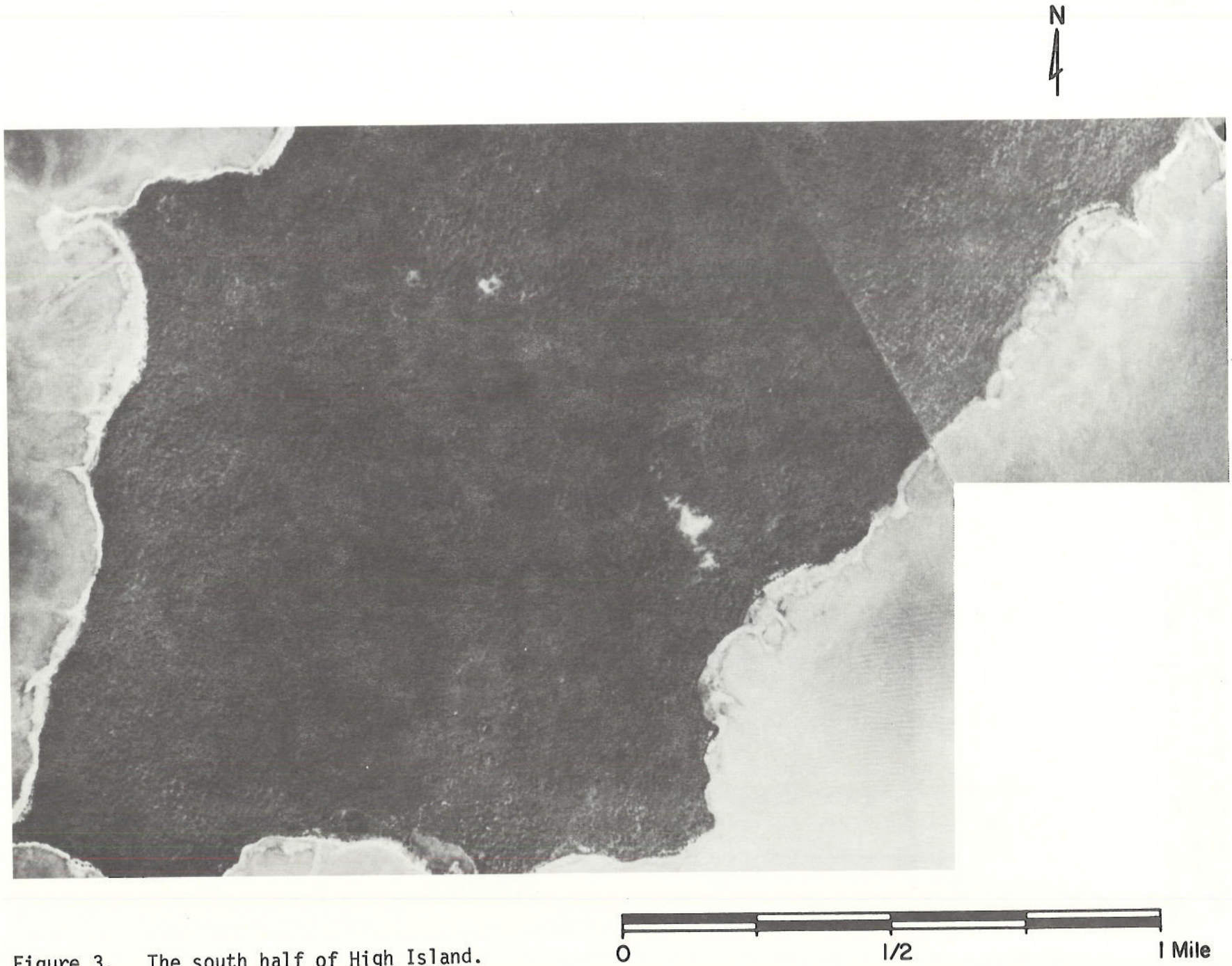

Figure 3. The south half of High Island. Only four small openings occur here.

The remainder of the island consists of sand dunes, sandy or rocky beaches, white cedar *(Thuja occidentalis)* swamps and stands of conifers, mostly balsam fir and red pine *(Pinus resinosa)* on dry uplands. It is generally unattractive to woodcock.

MATERIALS AND METHODS

Singing-Ground Census

A census of occupied singing-grounds was taken each spring from 1968 through 1972. The objective each year was to locate all of the singing-grounds which had active males. The census was conducted by walking through the clearings during the evening and morning performance periods and listening for peenting male woodcock. The location of each active male was marked on a map. If a site was occupied by an active male on at least four different occasions, it was designated as an occupied singing-ground or breeding territory.

Because of their inaccessibility, the four small openings in the south part of the island were censused indirectly. If a concentration of woodcock splashings within the opening could be found and if a bird or birds were flushed nearby, then the site was designated as a probable occupied singing-ground.

Banding Singing Males

In 1969 and 1970 performing male woodcock were captured in mist nets. The netting was done during the breeding season but after an inventory of active singing-grounds had been completed. The technique was similar to that described by Sheldon (1967).

The nets were 12-meter, four tier nylon thrush nets obtained from the Northeastern Bird Banding Association, Inc., West Hartford, Connecticut. Each net was suspended between two three-meter uprights of aluminum conduit which was slipped over the ends of one-meter steel pipes driven into the ground. When unfurled one net presented a vertical web of 36 square meters. Nets were placed on the singing-ground so that the male woodcock would be caught during his courtship performance. Usually one but sometimes two nets were used per singing-ground. The nets on from one to four singing-grounds were unfurled just before the evening courtship period and checked shortly afterward. Captured woodcock were weighed, aged and sexed, banded and released. The age and sex of each woodcock was determined by characteristics of the primaries and secondaries (Martin 1964).

Collecting Singing Males

In 1971 and 1972, some performing male woodcock were collected by shooting. The birds were collected during the breeding season but after an inventory of active singing-grounds had been completed. Breeding territories where males had been removed were checked again for the presence of active males.

Brood and Nest Search

Each spring woodcock broods and nests were searched for with the aid of pointing dogs. This technique, first used in Maine (Mendall and Aldous 1943), has recently been used extensively in Michigan (Ammann 1963).

The usual procedure is for one man with a hand net to work his dog through likely looking brood habitat until the dog comes on point. Generally, the hen and her small chicks stay close together and "freeze" when the dog points. The bander then visually searches the immediate vicinity until a brood or nest is spotted or until he becomes satisfied that it is a false alarm. Banders attempted to capture hens with broods, but not those that were found on nests. The hens that were netted were weighed, aged, banded and released. In any event the chicks were picked up, banded, weighed, their bills were measured and they were released. The age of the chicks (broods) was determined by the length of the bill (Ammann and Whitcomb, in press). Occasionally, second attempts to catch hens were made. Two methods, both utilizing the chicks as "bait" or decoys were tried--ground-trapping and hand-netting. Both techniques and the trap, a modified standard quail trap, are described by Ammann (1963).

A colored vinyl ribbon was used to mark the location of each nest and brood site. The distance of each nest and brood site from the nearest opening was measured.

Effort expended for brood banding varied from year to year depending on the author's arrival date on the island in spring and the availability of extra manpower.

Capturing Woodcock on Summer Fields

Two techniques were used to capture woodcock during the summer months--mist-netting and night-lighting.

Mist-netting techniques were adopted from those described by Sheldon (1967). The nets have been described previously. Mist nets were placed within those portions of fields where observations had revealed woodcock activity to be the greatest. The number of nets used in a particular location varied according to the size of the area and the number of woodcock flying through or landing there.

Mist nets were unfurled at sunset. Those that failed to catch birds after several nights were moved to a different spot. For the most part, netting locations remained the same throughout the investigation. Immediately after the evening flight, captured woodcock were removed from the nets, weighed, aged and sexed, banded and released. The nets were then collapsed for the night but left at the site. One 12-meter mist net operated during the evening flight period constituted a net-night. Nets were operated 211 evenings during the study for a total of 2,581 net-nights.

It was found that by leaving nets up overnight woodcock could also be caught when they left the fields at dawn. On such occasions trapped birds were removed from the nets at sunrise and the nets furled for the day. Mist nets were operated 44 mornings during the investigation for a total of 726 net-mornings.

Mist-netting data were recorded by periods ending on the 15th and final day of each month.

Procedures and equipment used in night-lighting were similar to those reported by Rieffenberger and Kletzly (1967). Night-lighting efforts began one to two hours after sunset and lasted from one to five hours. Teams, consisting of two or three men, walked through the fields searching for woodcock. One member of each team carried a light while the others each carried a long handled net. The light, composed of an automobile headlight for scanning the area and an aircraft landing light for spotlighting a bird once it was located, was powered by a 12-volt motorcycle battery carried in a backpack. Woodcock spotlighted on the ground were approached quietly and caught with the hand net. Flushed birds were kept in the spotlight beam until they became disoriented and returned to the ground, then they were netted. If it became evident that a bird was not going to return to the ground in the immediate vicinity, the light was switched from spot to scan and the banding team walked on.

Captured birds were immediately weighed, aged and sexed, banded and released. The age and sex of each woodcock was determined by characteristics of the primaries and secondaries (Martin 1964). Young of the year were called immatures; all birds one year or older were called adults.

Nocturnal Use of Clearings During Summer

The vegetative characteristics of openings utilized by woodcock on summer nights and the nocturnal behavior of woodcock were more intensely investigated during 1970 and 1971. I established a series of transects through five of the fields. Each transect was arbitrarily chosen so that all vegetation and soil types within each field would be sampled. The combined length of all five transects was 3.18 miles.

Once every six nights from June 29 to August 29 (11 nights) in 1970 and from July 17 to August 16 (six nights) in 1971, I walked these transects. Information recorded included general weather conditions, birds flushed, and time and distance from observer of each flush. In cases where the exact flush site could be determined, numbered flags were placed as markers.

The vegetation at these locations was later analyzed using a procedure proposed by Webb (1942). Circular-nested plots were used

to measure ground cover, shrub layer and tree canopy cover. The size of each plot was .001, .01 and .1 acre respectively. Plant species within each plot were recorded and given a cover density class rating or rank. The cover density classes used were:

(1) Density 1 - leaves cover less than 1/80 of the plot area
(2) Density 2 - leaves cover between 1/80 and 1/3 of the plot area
(3) Density 3 - leaves cover between 1/2 and 2/3 of the plot area
(4) Density 4 - leaves cover more than 2/3 of the plot area

The height range of herbaceous and shrub species and the diameter breast height of tree species was also recorded. One hundred plots were analyzed in this manner in 1970. No analysis of vegetation was made in 1971.

Woodcock Harvest

Woodcock were harvested on High Island by traditional hunting methods each year from 1968 through 1970. Each hunter kept a daily record of his hunt. Data recorded included number of hours hunted and the number of woodcock flushed, number fired at and fate if hit. In addition, flush and kill locations were recorded on maps. The hours of hunting effort during any one week was largely a function of how much help was available. In 1971 an attempt was made to collect all the woodcock on the island. Some males were collected during the spring*. From August 16 to September 15 woodcock were hunted by traditional means during the day and collected at night by mist-netting and by shooting on the summer fields. Later some birds were collected during a short traditional type hunt in October.

All woodcock collected during the fall were weighed, aged and sexed, frozen and sent to the Michigan Department of Natural Resources' Wildlife Pathology Laboratory at Rose Lake.

Lipid Analysis

The total lipid or fat content of 101 woodcock collected in fall 1968 was determined by an ether extraction method. Each bird was weighed. The liver was removed, weighed and a three-five gram portion saved for lipid analysis. A five gram piece of breast muscle was also removed for lipid analysis. In addition, the brain was removed and saved for pesticide analysis.

The remainder of the carcass was minced with scissors and dried in a forced-air oven at 50° C. for one week. The fat was extracted from this material for eight hours with petroleum ether using a Soxhlet apparatus.

*See page 7

Fat from the liver and breast muscle was similarly processed and extracted, but the drying was done at 100° C. for six hours and a Labconco apparatus was used for a four hour extraction.

Results from all three extractions were combined to yield the total fat figure for each bird.

Pesticide determinations were made on the fat from the various materials. Cleanup by partitioning was done by the Mills procedure.

Pesticide Analysis

Chlorinated hydrocarbon pesticide residues of fat samples (see above section) were determined with an F & M Model 400 gas chromograph using an electron capture detector. The four foot glass column was packed with equal portion of 15 percent ZF-1 and 10 percent DC-200 M 80-100 mesh Gas Chrom Q.

POPULATION ANALYSIS

Population Estimates

Point estimates of the number of woodcock in four age and sex categories (adult male, adult female, immature male and immature female) were computed for mid-August of 1968, 1969, 1970 and 1971 (Table 1). Ninety-five percent confidence intervals were computed for each estimate. Because the marked and recaptured samples were relatively small, a modified version of the Lincoln Index formula proposed by Chapman (1951) was used. For a general treatment of the Lincoln Index Method see Overton (1969). For 1968-1970 woodcock captured and banded between July 16 and September 14 formed the marked population and those collected during the hunting season beginning September 15, comprised the recaptured sample. For 1971, woodcock captured between July 16 and August 15 formed the marked population and those collected from August 16 to September 15 and from October 15 to October 18 comprised the recaptured sample.

The Lincoln Index formula yields estimates for the time the population is marked. Thus, population estimates are given here for the midpoint of the marking period, mid-August for 1968-1970 and August 1 for 1971. Data used to compute these estimates are located in the appendix (Table 31).

Relatively few adult woodcock were banded on High Island during the study. These small banded samples are reflected in the extremely wide confidence intervals (average 92 percent) on the point estimates for adults of both sexes for all years. Because of the wide confidence intervals the population estimates for adults are of little use.

The population estimates for immatures appear to be more precise and thus more useful. The confidence intervals on estimates for immatures ranged from 21 to 54 percent and averaged 31 percent of the estimate (Table 1). Point estimates for immature woodcock ranged from 168 to 284 and averaged 227.

Survival Rates for Spring to mid-August

Direct recovery rates were computed for woodcock banded during three time periods through the year: (1) April 15-May 31, (2) June 1-July 15 and (3) July 16 - September 14. Survival rates from the mid-point of period (1) to the midpoint of period (3) were computed by dividing the direct recovery rate for period (1) by the direct recovery rate for period (3). Direct recoveries consisted of those birds collected on the island the same year that they were banded. In

Table 1. Point estimates[a], with approximate .95 confidence intervals[b], of the mid-August[c] woodcock population by age and sex categories computed by the Lincoln Index, High Island, Michigan, 1968-1971.

	1968	1969	1970	1971
Adult Male	80±70	27±24	-[d]	32±50[c]
Adult Female	87±50	102±92	-[d]	53±41[c]
Immature Male	124±26	120±40	85±46	149±36[c]
Immature Female	113±28	98±36	83±36	135±33[c]

[a]Formula from Chapman (1951)

$$N = \frac{(t + 1)\ (n + 1)}{s + 1} - 1$$

[b]Formula from Bailey (1951)

$$S.E. \sqrt{\frac{t^2 n\ (n-s)}{s^3}} \times 2$$

Where:
N = the total population size.
t = the number of members of the population tagged.
n = the number of members of the population subsequently sampled.
s = the number of tagged individuals in the sample.

The sum is added and subtracted from the point estimate.

[c]Population estimate for August 1.

[d]Data insufficient to compute estimate.

Table 2 the banding data were combined for 1968-1971 and average direct recovery rates and survival rates were computed. In Table 3 immature male and female banding data are combined for each year and direct recovery rates and survival rates are given. In both Table 2 and 3 several of the direct recovery rates for period (2) are lower than those for period (1). I can offer no explanation why it occurred as it did. Since the birds banded in period (1) have a longer period in which mortality can take place, fewer should be available to harvest (recover) and direct recovery rates for period (1) should be lower than those for period (2). At any rate for computing survival rates, period (2) banding data has not been used.

Average rates of survival from spring to mid-August for the combined years of 1968-1971 (Table 2) show a higher rate of survival for adult females than adult males. Virtually no difference in survival rates between sexes is indicated for immature woodcock. Rates of survival were greater for immature birds than they were for adults (Table 2).

Again, because so few adult woodcock were banded, I believe that the spring to mid-August survival rates for adults are less reliable than those for immature woodcock. The computed rates appear to be on the low side. If the post-breeding survival rates were so low, an unreasonably high overwinter rate of survival would be required for a population to exist.

When spring to mid-August survival rates for immature woodcock are computed on a yearly basis (Table 3), a difference between years is shown. The survival rates range from .45 to .89 and average .73.

The survival rates were computed for spring to mid-August for 1968-1970 and for spring to August 1 for 1971. Thus a small, but I think insignificant portion of the high rate of survival in 1971 (.89) may be attributed to the shorter time span over which mortality could take place.

The years in which the lowest and highest rate of survival occurred correspond to the years in which the lowest and highest populations of immatures occurred.

Rate of Return to High Island

An average minimum rate at which woodcock reared on High Island returned was determined for each age and sex class (Table 4). Adult and immature rates were computed differently.

For adults, the birds banded between July 16 and September 14 in the years 1968-1970 minus the direct recoveries for those years were totaled. This total was divided into the total number of banded birds recaptured in the first year after banding. Banding data for 1971 was not included because no attempt to capture woodcock in 1972 was made.

Table 2. Average direct recovery rates of woodcock for three banding periods and average spring to mid-August survival rates, High Island, Michigan, 1968-1971.

Age - Sex	Period 1 April 15 - May 31			Period 2 June 1 - July 15			Period 3 July 16 - September 15			Spring to mid-August survival rates ($A_1 \div A_3$)
	Banded b_1	Recovered r_1	Direct Recovery Rate $b_1 \div r_1 = A_1$	Banded b_2	Recovered r_2	Direct Recovery Rate $b_2 \div r_2 = A_2$	Banded b_3	Recovered r_3	Direct Recovery Rate $b_3 \div r_3 = A_3$	
Adult Male	37	5	.14	21	4	.19	32	11	.34	.41
Adult Female	18	4	.22	21	7	.33	51	20	.39	.57
Immature Male	114.5	28	.24	114	26	.23	156	52	.33	.73
Immature Female	114.5	36	.31	66	16	.24	129	56	.43	.72

Table 3. Direct recovery rates of immature woodcock for three banding periods and spring to mid-August survival rates, High Island, Michigan, 1968-1971.

Year	Period 1 Banded April 15-May 31	Period 1 Recovered	Period 1 Direct Recovery Rate (A)	Period 2 Banded June 1-July 15	Period 2 Recovered	Period 2 Direct Recovery Rate (B)	Period 3 Banded July 16-Sept. 15[a]	Period 3 Recovered	Period 3 Direct Recovery Rate (C)	Spring to mid-August[b] survival rate (A ÷ C)
1968	39	8	.21	28	4	.14	118	49	.42	.50
1969	60	14	.23	37	5	.14	82	26	.32	.72
1970	40	6	.15	51	8	.16	45	15	.33	.45
1971	90	36	.40	64	25	.39	40	18	.45	.89
AVERAGE	229	64	.28	180	42	.23	285	108	.38	.73

[a]Banding dates July 16 to August 15.

[b]Rate is spring to August 1 for 1971.

The presumption that immature woodcock returning to High Island should be recovered (in fall) at the same rate as other second year birds banded in spring formed the basis for calculating rates of return for immature birds.

The formula used:

$$N = \frac{\text{Number of immature birds recovered the first year after banding}}{\text{Average direct recovery rate for second year birds banded in spring}} \times 100$$

then:

$$\text{Rate of return} = N \times \frac{\text{Number of banded immatures leaving island}}{100}$$

The average rates at which woodcock that were reared on High Island were estimated to have returned to the island (Table 4) were nearly the same for all age and sex classes, about 31 percent.

Table 4. Estimated rate at which woodcock reared on High Island returned, High Island, Michigan, 1968-1970.

Age and Sex	Rate of Return to High Island
Adult Male	.28
Adult Female	.31
Immature Male	.35
Immature Female	.29

Except for the immature male class, I believe the rates of return to the island are lower than they actually were. The difficulty in catching adults may account somewhat for the low estimates. Too, the rate of return is not necessarily overwinter mortality. The rate at which woodcock "home" is not known precisely, although Sheldon (1967) reported rather high rates for adult males.

Best Estimate of the High Island Woodcock Population

Table 5 is an attempt to depict the High Island woodcock population as I believe it appeared during the study.

With the exception of the spring to fall survival rates for adults, the parameters used to construct the table were computed from the collected data.

I felt that the spring to mid-August survival rates for adults (Table 2) were too low. Arbitrary spring to fall survival rates were set at .67 for adult females and .57 for adult males.

It is assumed also that the ratio of immatures to adult females and that the adult sex ratio in the kill is representative of the population.

The content and explanation of each column is given below.

Column Number	Content and Explanation
5	The point estimates for immature woodcock computed by the Lincoln Index Method (Table 1).
6	The computed rate of survival from spring to mid-August for immature woodcock (Table 3).
7	The actual number of immature woodcock per adult female in fall kill.
8	The estimated number of adult females in fall--computed by dividing Column (5) by the average of Column (7).
9	The estimated number of adult males in fall--computed by multiplying Column (8) by a decimal expression of the ratio in Column (10).
10	The actual ratio of adult males to adult females in the fall kill.
1	The estimated adult male population in spring--computed by dividing Column (9) by a spring to fall survival rate of .57.

Column Number	Content and Explanation
2	The estimated adult female population in spring--computed by dividing Column (8) by a spring to fall survival rate of .67.
3	The estimated number of chicks produced--computed by dividing Column (5) by Column (6).
4	The estimated number of adult females necessary to produce chicks in Column (3).

The proportion of adult females successfully producing young equals the total of Column (4) divided by the total of Column (2).

Generally, I believe that Table 5 represents the High Island woodcock population during the study fairly well. The estimates seem reasonable in light of the number banded each summer (Table 18) and the number harvested (Table 24) each year.

The population estimates for 1971 may be high. The method and time of collecting woodcock that year were different from previous years and may be responsible for this. On the other hand if the survival rates for immatures in 1971 are accurate, it may indicate a higher rate of survival for adults. This would reduce the estimated spring population and make it more reasonable. Population proportion estimates for the first year of the study, 1968, are probably more representative of other woodcock populations. Since the population had a low exploitation rate up to that point.

As a whole, the woodcock population remained steady or increased from 1968 to 1971. The adult male class, however, showed declines each successive year except 1971.

If the survival rates from spring to late summer and fall are close, then considering the exploitation rates (Table 26), immigration of at least female woodcock must have taken place. If such immigration occurred, it would have take place in spring since ratios of banded to unbanded birds in fall (Tables 21-23) showed no change over time.

The average proportion of adult females computed to have produced young (.75) is reasonable.

Table 5. Best estimate of the High Island woodcock population for 1968-1971 and some of the parameters used to make the estimates.

Year	Estimated Spring Population: Adult Male 1 (Col. (9)) ÷ (Surv. Rt.=.57)	Adult Female 2 (Col. (8)) ÷ (Surv. Rt.=.67)	Chicks 3 (Col. (5)) ÷ (Col. (6))	Estimated no. of woodcock necessary to produce chicks in Col. (3) 4 (Col. (3)) Ave. Brood Size in spring=3.51	Estimated No. of Immature woodcock in mid-Aug. from Table 1. 5
1968	104	146	474	135	237
1969	72	134	303	86	218
1970	51	104	373	106	168
1971	83[a]	176	319	91	284
Totals	310	560	1,469	418	907

Proportion of adult females successfully producing young equals total of Col. (4) ÷ total of Col. (2) = .75.

[a]Sixteen adult males, collected in spring, were added to original computation.

Table 5 Con't.

Rate of Survival to mid-Aug. for immature woodcock from Table 3 6	No. of immature woodcock per adult female in fall kill 7	Estimated no. of adult females in fall 8 Col. (5) / Ave. Col. (7)	Estimated no. of adult males in fall 9 Adult Males = (Col. (8)) x Ratio in Col. (10) exp. as a decimal	Ratio of adult males to adult females in fall kill 10
.50	2.12	98	59	60:100
.72	1.83	90	41	45:100
.45	2.68	70	29	41:100
.89	3.17	118	38	32:100
Average	2.41	376	167	

MALE BREEDING ACTIVITY IN SPRING

Singing-Ground Census

The number of occupied singing-grounds decreased from a high of 44 in 1968 to a low of 20 in 1972 (Table 6). One year, 1971, showed an eight percent increase from the previous year, otherwise each year was followed by declines ranging from 19 to 30 percent (Table 6).

Table 6. Number of singing-grounds and percentage change from year to year, High Island, Michigan, 1968-1972.

Year	Singing-Grounds (Actual Count)	Singing Grounds (Probable)	Total No.	Direction & Percentage Change
1968	41	3	44	-
1969	27	4	31	Decrease 30 percent
1970	22	3	25	Decrease 19 percent
1971	25	2	27	Increase 8 percent
1972	19	1	20	Decrease 25 percent

Ratio of Adult Males to Singing-Grounds

The ratio of the total adult male population in spring to the total number of occupied (active) singing-grounds varied from 2.04 to 3.07 and averaged 2.44 (Table 7). The count of singing-grounds having an active male in 1972 is listed for future reference but no estimate of the adult male population in spring 1972 is available.

Table 7. Ratio of adult male woodcock to occupied singing-grounds, High Island, Michigan, 1968-1972.

Year	Estimated Adult Male Male Population in Spring from Table	Singing-Grounds	Ratio Adult Males: Singing-Grounds
1968	104	44	2.36:1.00
1969	72	31	2.32:1.00
1970	51	25	2.04:1.00
1971	83	27	3.07:1.00
1972	No estimate	20[a]	-
Total	310	127	2.44:1.00

[a]deleted from total.

Too few points exist for a correlation between adult males and singing-grounds to be tested. Enough data will be available to test the relationship between the number of adult males and the number of singing-grounds on High Island when Albert Bourgeois' study of the woodcock population is completed in 1975.

Age of Males Captured on Singing-Grounds

From 1969 through 1972, 63 performing male woodcock were recaptured on singing-grounds. Forty-six percent (29) of those caught were two or more years old (ASY) i.e., they were in at least their second breeding season. The ratio of (ASY) birds to those in their first breeding season (SY) varied from .23:1.00 in 1971 to 1.40:1.0 in 1970 and averaged .85:1.00 (Table 8). The age ratio for each year except 1971 are fairly uniform, averaging 1.24:1.00. In 1971 only three of 16 performing males caught were ASY birds (Table 8).

The time during the breeding season that birds were caught may have influenced the age ratio. Prior to mid-May, 72 percent of the males caught were ASY birds but after mid-May only 36 percent of those caught were ASY birds (Table 8).

Table 8. Age and age ratios of performing male woodcock captured on singing-grounds on High Island, Michigan, 1969-1972.

	Before May 15			After May 15			Total			Combined
Year	Number Captured	ASY	SY	Number Captured	ASY	SY	Number Captured	ASY	SY	Age Ratios ASY:SY
1969	18	13	5	10	2	8	28	15	13	1.15:1.00
1970	0	0	0	12	7	5	12	7	5	1.40:1.00
1971	0	0	0	16	3	13	16	3	13	.23:1.00
1972	0	0	0	7	4	3	7	4	3	1.33:1.00
Total	18	13	5	45	16	29	63	29	34	.85:1.00
Percentage	100	72	28	100	36	64	100	46	54	

ASY - two years or older.
SY - one-year old, first breeding season.

Reoccupation of Singing-Grounds

In 1971, from May 16 to June 1, 16 performing male woodcock were collected from 15 different singing-grounds. In addition in 1972, when two evenings (May 17-18) were spent collecting active males, three males were shot from three different singing-grounds.

Only three of the 18 breeding territories failed to have new, active occupants by the next night. One breeding territory was reoccupied immediately after the performing bird was removed. This replacement was apparently already present on the singing-ground. Another singing-ground was reoccupied by the following morning. Other singing-grounds may have also been reoccupied as quickly but no others were checked until the following night. At no time during the study was more than one male observed engaging in courtship performances on a singing-ground at one time.

Sheldon (1967) reported that four singing-grounds on his Massachusetts study area were reoccupied within a week after males were removed. He also cites a Canadian worker that shot 12 singing male woodcock on Manitoulin Island in Lake Huron after the spring migration; the sites from which the males had been removed were reoccupied by other males within a day.

On at least eight occasions I observed another bird on or near a singing-ground where a male was performing. No attempts at mating took place and I believe these extra birds were sub-dominant males. Sheldon (1967) stated that, "There appears to be a drifting opportunistic male population which promptly takes over abandoned singing-sites."

Size of Singing-Grounds and Length of Breeding Season

The size of the territories defended by male woodcock on High Island was highly variable. In one case, three males occupied a 58-acre field. Another opening, about 80 square feet in size along an old trail road was utilized as a singing-ground from 1968 to 1970.

When a decline in occupied singing-grounds occurred, the perimeter of the study area showed the greatest loss (Figure 4). However, specific sites that were used by males did not change appreciably from year to year.

The seasonal length of breeding activity was not the same on all singing-grounds. Some territories were abandoned by mid-May. Breeding activity had ceased by June 2 on all singing-grounds.

Data for singing-grounds in Maine (Mendall and Aldous 1943), Michigan (Blankenship 1956) and Massachusetts (Sheldon 1967) show that the range of sizes and shapes of singing-grounds is tremendous.

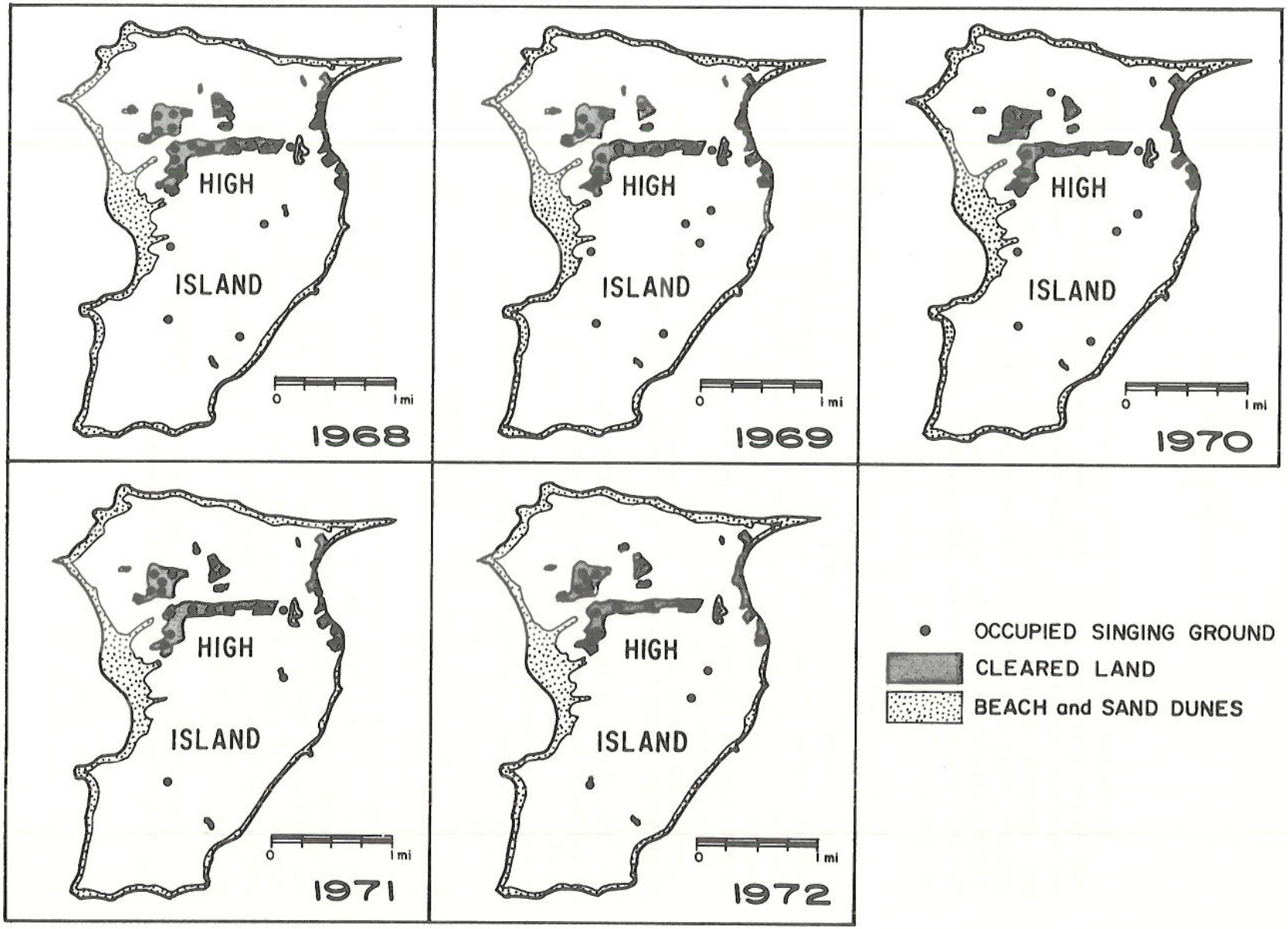

Figure 4. Location of occupied singing-grounds, High Island, Michigan, 1968-1972.

DISCUSSION

Estimates of the adult male woodcock population in spring showed that there were more males than there were occupied singing-grounds. The ratio of total males to total singing-grounds was variable but the variation about the average was not large. Observations revealed, however, that the ratio of actively performing woodcock to occupied singing-grounds was one to one. Thus, on High Island counts of performing male woodcock were indicative of the changing population of adult males.

I believe that there is a definite dominant-subdominant relationship between two or possibly more male woodcock on a breeding territory. If one succumbs, a replacement is ready. In addition there may be a floating group of males as Sheldon (1967) suggested. Birds in this group could move into an abandoned singing-ground if the opportunity existed. The way in which dominant-sub-dominant relationships are established is unknown. The change in age ratios of males captured on singing-grounds as the breeding season progressed suggests that older experienced males dominate breeding activity at first; giving way to young birds toward the end of the breeding season.

The size and location of breeding territories depends on a number of factors, opening size, vegetation, natural barriers, topography, population pressure and many others that we do not know. It is difficult to predict the location that a woodcock will choose for a singing-ground. On the study area several seemingly perfect locations for singing-grounds were never chosen while other seemingly less desirable ones were used each year. Male woodcock, however, consistently picked the exact location that was chosen the previous year.

Quality of brood habitat surrounding an opening may have influenced the desirability of it for a singing-ground and influenced the length of time within the breeding season that males were active. During the investigation the singing-grounds that were deserted first, when the population of males declined, were the same ones where breeding activity stopped by mid-May. Few broods were found near these singing-grounds and the surrounding brood habitat was considered inferior.

Brood habitat was not quantitatively analyzed and its quality was judged by the number of broods located.

NEST AND BROOD SEARCH

During the study, 453 hours were spent searching for woodcock nests and broods. Eighteen nests and 77 broods were located. Twelve of the nests located eventually resulted in a brood being caught and banded. These broods were included in the total of 77. The yearly average hours required to locate a brood varied from 2.9 in 1971 to 10.5 in 1969 and averaged 5.9 hours (Table 9).

Approximately 90 percent of the nest and brood searching effort was spent within 200 yards of the large open fields (Figure 2). Only three broods were not found in this area. Two of the three broods were located in close proximity to one of the small clearings south of the main fields. In each case the clearing was occupied by a singing male. One newly hatched brood and its nest were located along an old trail road nearly .9 miles from the nearest opening.

A highly significant correlation ($P < .001$, df 63) was found between the age of a brood and the distance the brood was found from an opening. Generally, older broods were found farther away from openings than young broods.

Brood Size

The number of woodcock chicks per brood found ranged from one to six. However, most of the broods contained either four young (61 percent) or three young (29 percent) - (Table 10). The average number of chicks per brood varied from 3.33 in 1972 to 3.61 in 1971 and averaged 3.51 (Table 11). If the 1972 data (three broods) is excluded, the average brood size increases slightly in each succeeding year of the study (Table 11).

Twenty-six zero- to six-day old broods hatched before May 15 averaged 3.62 chicks while 16 broods of the same age hatched after mid-May averaged 3.25 chicks per brood.

Blankenship (1956) reported that the size of 28 complete broods in Michigan varied from two to eight with the average size being 3.6 young per brood. The brood of eight was deleted for computing the average. He noted four other instances of broods exceeding four in number, one brood of five and three broods of six.

Clutch Size and Hatching Success

The clutch size for 16 nests that hatched varied from two to four and averaged 3.44 (Table 12). Two other nests, each containing three eggs, were abandoned.

Table 9. Nest and brood searching effort and results, High Island, Michigan, 1968-1972.

Year	Banding Teams	Total Hours	Nests	Broods	Average Hours/Brood
1968	4	75	3	14	5.0
1969	5	200	7	19	10.5
1970	4	88	4	13	6.8
1971	3	80	4	28	2.9
1972	1	10	0	3	3.3
TOTALS		453	18	77	5.9

Table 10. Distribution of woodcock broods by number-classes, High Island, Michigan, 1968-1972.

Number of Chicks in Brood	Broods Found	Percentage in Each Category
1	4	5
2	3	4
3	22	29
4	47	61
5	0	0
6	1	1
TOTAL	77	100

Table 11. Number and size of woodcock broods by year, High Island, Michigan, 1968-1972.

Year	Number of Broods Contacted	Average Number of Chicks per Brood
1968	14	3.36
1969	19	3.47
1970	13	3.54
1971	28	3.61
1972	3	3.33
TOTAL	77	3.51

Table 12. Clutch size and hatching success for woodcock nests, High Island, Michigan, 1968-1971.

Year	Nest Number	Number of eggs	Number Successfully Hatched	Comments
1968	1	4	4	
	2	4	3	1 egg infertile
	3	3	1	2 eggs pipped but chicks died before emerging
1969	1	3	0	Nest abandoned
	2	4	4	
	3	3	1	1 egg infertile, 1 egg pipped but chick died before emerging
	4	4	4	
	5	4	3	1 egg infertile
	6	4	4	
	7	2	2	
1970	1	4	4	
	2	4	4	
	3	4	4	
	4	2	1	1 egg infertile
1971	1	4	4	
	2	2	1	1 chick died in egg
	3	3	3	
	4	3	0	Nest abandoned
Total eggs excluding those from two abandoned nests		55	47	

Average Clutch Size = 3.44 Hatching Success = 85 percent

Eighty-five percent of the eggs hatched successfully. Of the remaining eight eggs (15 percent), four were infertile, three were pipped but the chicks died before emerging, and one contained a chick that died in early incubation.

Clutch size for 31 other Michigan nests ranged from two to six and averaged 3.9 (Blankenship 1956). Sheldon (1967) reported that all 30 nests found or reported to him in Massachusetts contained four eggs.

Very little published data is available on hatching success. In Maine hatching success for 115 nests was 67 percent.

Hatching Dates

The earliest and latest known hatching dates on High Island were April 24 and June 29 respectively. More than half (57 percent) of the broods contacted had hatched during the first two weeks of May (Table 13). Not all of the nests hatching late in the period were the result of renesting. Full clutches of four eggs, indicating first attempts at nesting, hatched as late as June 9 in 1968. In 1969, 1970 and 1971 the latest known full clutches of eggs hatched May 20, June 6 and May 23 respectively.

The chronology of hatching dates on High Island is similar to that in Maine and Massachusetts (Sheldon 1967) and other areas of northern Michigan (Ammann pers. comm.).

When the sexes are combined, woodcock chicks hatched after mid-May had higher direct recovery rates than those hatched before May 15 (Table 14). This indicates a greater chance of survival for those birds hatched after mid-May since the group with the greatest number of birds alive should have the greatest number of birds harvested (recovered).

If there is a real difference in survival rates between the two groups, the possible reasons are confounded by the fact that the first group has lived a month longer.

Table 13. Hatching dates of 77 woodcock broods, High Island, Michigan, 1968-72.

Period	No. of Broods Hatching	Percent
April 24-30	8	10%
May 1-7	24	31%
May 8-14	20	26%
May 15-21	12	16%
May 22-28	4	5%
May 29-June 4	2	3%
June 5-11	5	7%
June 12-18	1	1%
June 19-25	0	0%
June 26-July 2	1	1%
Total	77	100%

Table 14. Direct recovery rates of woodcock chicks hatched before and after mid-May, High Island, Michigan, 1968-1971.

		Hatching Period					
		April 24 - May 14			May 15 - July 2		
		Number Banded (1)	Recovered (2)	Direct Recovery Rate (2 1)	Number Banded (1)	Recovered (2)	Direct Recovery Rate (2 1)
1968-1971	Males	81*	17	.21	31.5*	11	.35
	Females	81*	27	.33	31.5*	9	.29
1968-1971	Sexes Combined	162	44	.27	63	20	.32

*Assume even sex ratio.

NOCTURNAL BEHAVIOR OF WOODCOCK DURING SUMMER

Evening flights of woodcock into the fields began about one-half hour after sunset and lasted approximately 15 minutes. Another flight period took place 30 to 60 minutes before sunrise. In 85 hours of observing fields at night between sunset and sunrise no woodcock were seen or heard flying except during the regular crepuscular flight periods. During night-lighting operations birds were flushed from the clearings until dawn. Thus, at least some woodcock remained on the fields throughout the night, apparently roosting.

On 13 occasions a woodcock was observed for 15 to 30 minutes just after it had landed in a field. Ten of these birds began probing and exhibiting characteristic feeding behavior after alighting and the other three remained still throughout the periods that they were observed. Among the 10 birds the length of time spent feeding ranged from 30 seconds to 10 minutes and averaged approximately three minutes. Of seven woodcock observed for 10 to 40 minutes prior to the time that they left the fields at dawn, five moved about and probed for about two minutes each just before they flew while the other two left with no preliminary activity. The type or quantity of food items ingested during the periods that birds were observed was not determined. Many of the woodcock netted during the evening had damp soil on their bills suggesting that they had fed just prior to leaving their diurnal coverts. The crops of four birds killed during night-lighting operations between 10 p.m. and 2 a.m. were empty.

It was estimated that 85 to 90 percent of approximately 3,500 woodcock observed making crepuscular flights during the investigation flew alone. The remaining birds flew in groups of two or three. The relationship between birds flying together was not determined.

Nearly 87 percent of a sample of 175 woodcock flushed from the clearings at night were determined to be alone, i.e., there were no other birds within an arbitrary distance of five meters.

All through the summer, vocalizations resembling feeble peent calls were emitted and aerial flights similar to those of courting males in spring were performed, although the musical chirping song was not given.

Five birds descending from such flights were caught in nets, all were immature males. These displays, both at dusk and at dawn, took place during the regular flight periods. Such activity was most prevalent from mid-June to mid-July.

The starting time and the duration of crepuscular activity periods during summer on High Island did not vary from those reported by Sheldon (1967) or Krohn (1971) and Dunford and Owen (1973) for birds

in Massachusetts and Maine, respectively. Sheldon (1961), as I did in this study, found that both the male courtship flight in spring and the summer flight of woodcock began about 30 minutes after sunset. Glasgow (1958) also found in Louisiana that wintering birds arrived on fields about a half-hour after sunset. Pettingill (1936), Mendall and Aldous (1943) and other early workers noted that a specific light intensity is correlated with the beginning and ending of male courtship performances in spring. Apparently, similar intensities prompt woodcock to initiate and cease flights during summer.

Reports from the northern breeding range of the woodcock have shown that courtship-like performances during the summer are common. Birds netted after completing such flights both on High Island and in Massachusetts (Sheldon 1967) proved to be immature males. Sheldon (1967) also described observations made by William Nutting where a pair of woodcock judged to be male and female engaged in antics similar to pre-copulatory behavior on a summer field in Massachusetts.

The importance of feeding in attracting woodcock to fields in summer is not clear. Quantitative data were not obtained in this study but most of the locations used as nocturnal habitat by woodcock appeared to have a dearth of invertebrate animal life. Krohn (1970) reported that few woodcock foods were found in soil samples located randomly and at sites on Maine summer fields where woodcock were flushed. He stated that birds had not selected sites where soil invertebrates were concentrated and that no substantial amount of food was found to have been eaten by woodcock that remained on the fields throughout the night. Krohn (1970) concluded that food was not an important consideration for woodcock using fields during summer.

Few data on the diurnal feeding pattern of woodcock are available. Captive woodcock were seen to feed at dawn, or just before mid-day and late in the evening (Sheldon 1967). Radio-equipped immature woodcock in Maine were active throughout the day but very little activity was recorded after they moved to nocturnal sites (Dunford and Owen 1973). Damp soil found on the mandibles of birds netted as they entered fields both during the present study and by Krohn (1970) indicated that woodcock feed prior to leaving their diurnal coverts. The short periods in which woodcock were observed to feed on High Island suggest that this activity in unimportant as a reason for visiting fields at night.

Summer Activity Pattern

On High Island, by early June, courtship activity has ceased and about 90 percent of the broods have hatched. Evening flights of woodcock into the fields were observed to begin during the first week of June.

Evening netting data (Figure 5) revealed that the use of fields was relatively high during June and July. Woodcock utilization of fields declined during August but increased to pre-August levels in September. Evening capture rates were higher than morning rates (Figure 5) but seasonal trends in capture rates were similar.

Four immature woodcock, one from each of the four different known-age broods, were captured in mist nets when they were between 31 and 33 days of age. Although woodcock can fly well when 18 days old, broods were found to remain together at least during the day until 29 days of age. Based on sample hatching dates plus 30 days for development (Figure 6) 10 percent of the woodcock broods dispersed prior to June 1. During the first week of June, 31 percent of the broods disbanded and 41 percent of the island's immature woodcock probably had begun visiting fields at night. (Figure 6). By July 15,during the period of highest activity (Figure 5) 98 percent of the broods had dispersed (Figure 6) leaving only late-nesting hens with broods. The sample of known age broods indicates that none of the broods on High Island remained together after August 1.

The number of woodcock using the fields on a given night was not determined accurately. Counts obtained by tallying birds seen during night-lighting operations did indicate, however, that the number varied greatly. Flush rates varied from a high of 25 birds per hour to a low of less than one bird per hour.

Sheldon (1967) reported that evening flights to summer fields began after breeding activities had ceased and Krohn (1971) stated that, "The initiation of summer field usage in mid-June apparently coincides with the time most young birds would reach full flight capabilities." Evidence found during this investigation indicated that woodcock broods dispersed about 30 days after hatching. The use of summer fields by these immatures then began. Thus, the initiation of summer crepuscular flights in a particular area is directly related to the time and length of that area's nesting season. On High Island, about two months elapsed between the time that immatures from the earliest and the latest hatching broods first began making crepuscular flights (Figure 6). The majority of young birds, however, began the use of clearings during June. This coincided with the peak of the hatch plus one month. Apparently, 10 percent of the immature woodcock began flying into the fields before summer crepuscular flights were noted and prior to capture efforts being made (Figure 6). Presumably all adult males and most adult females also began using clearings in June.

Evidently, a declining use of fields in late summer occurs throughout the range of the woodcock. Sheldon (1967) found that the most successful netting was during June and early July, and that evening flights were erratic after that. Two fields in Maine, censused regularly during the summers of 1968 and 1969, generally contained fewest birds during August (Krohn 1971).

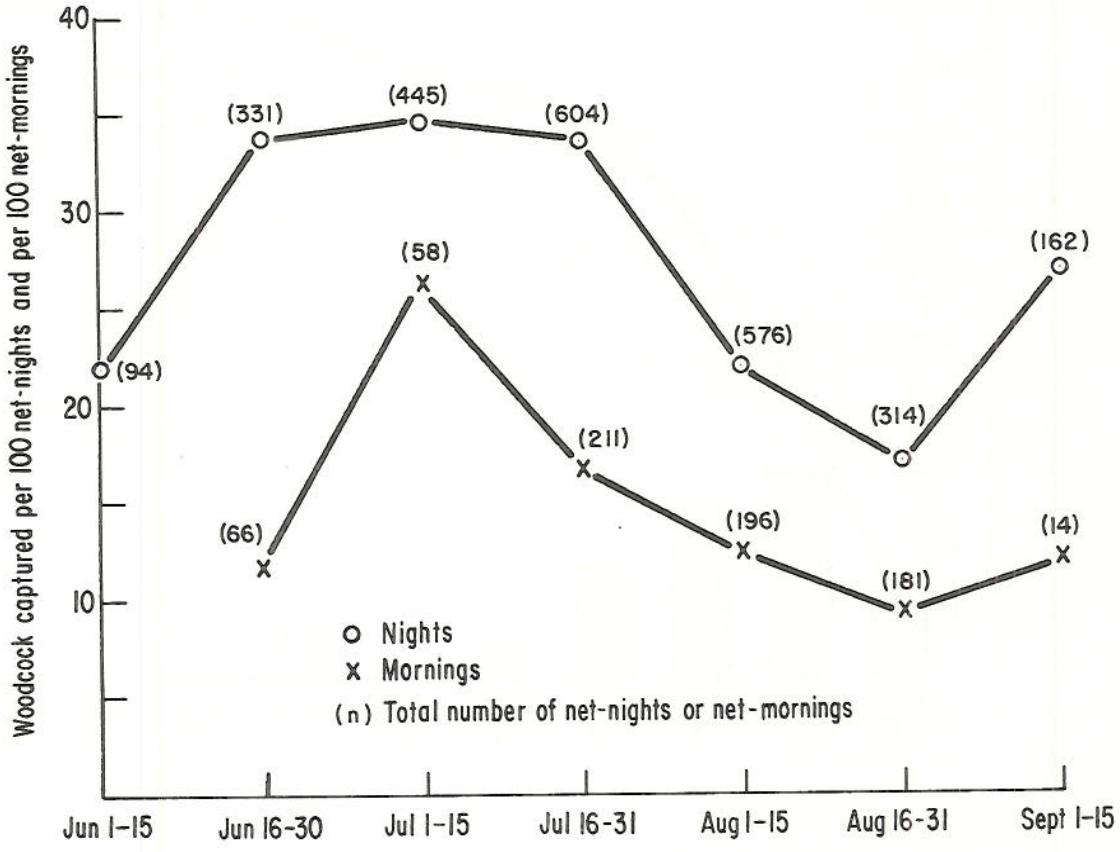

Figure 5. Summer mist-netting capture rates, High Island, Michigan, 1968-1971.

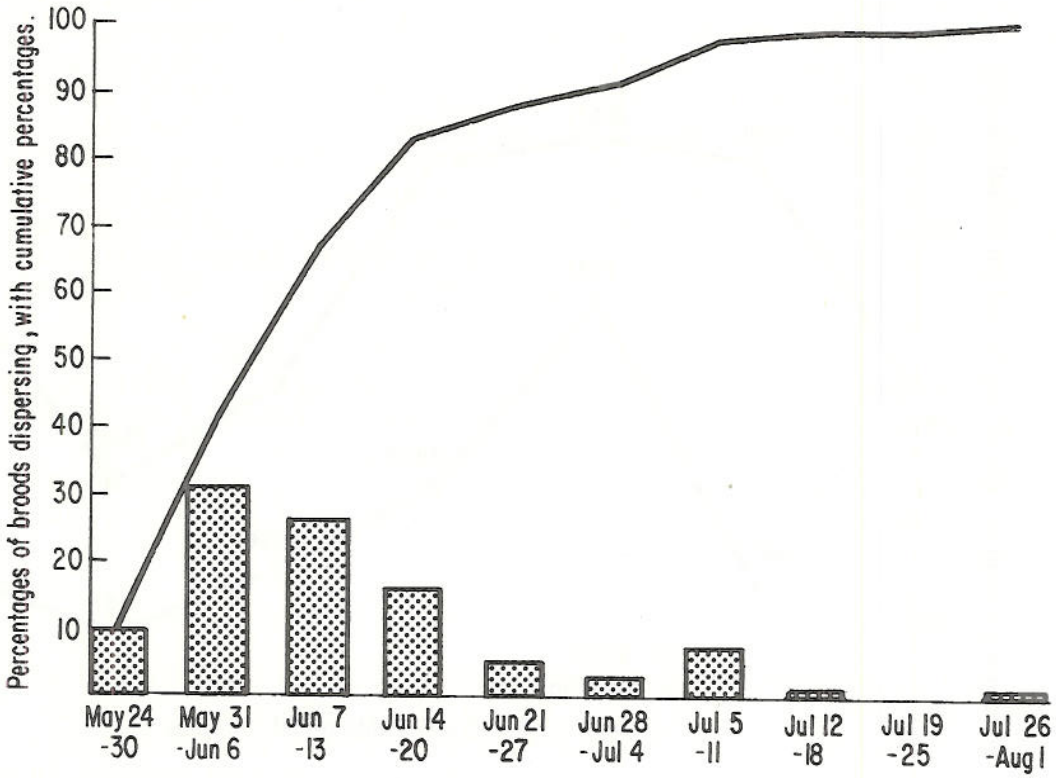

Figure 6. Hatching dates plus 30-day developmental period for 77 broods, indicating dates that immature woodcock begin summer flights, High Island, Michigan, 1968-1972.

Sheldon (1961) and Clark (1966) believed that continuous mist-netting caused a reduction in the number of woodcock flying into summer fields. Sheldon (1967) mentioned that several years of weather records failed to reveal any positive correlation between weather conditions and bird activity. He did state, however, that extremely hot days followed by late afternoon thundershowers and a windless, humid evening constituted consistently successful netting conditions. In Maine, use of blueberry fields and similar clearings by woodcock declined significantly when drouth conditions prevailed (Clark 1966). Gregg (1972) also noted a decrease in capture rates when rainfall was below normal. On High Island precipitation seemed to stimulate flight activity particularly in the latter half of the summer, but no correlation was found between rainfall and mist-netting capture rates.

Insight into the regularity at which woodcock, at least immature birds, visit fields was provided by Dunford and Owens' (1973) behavioral study of radio-equipped immature woodcock in Maine. They reported that males moved to nocturnal locations on 93 percent of 74 woodcock nights and females moved on 94 percent of 74 woodcock nights.

Vegetation on Summer Fields

The vegetation found at sites where woodcock were flushed at night was variable. However, a typical site consisted of short, sparce herbaceous plants interspersed with shrubs and small trees. Grasses, wild strawberry and St. John's wort were each present in at least 90 of the 100 plots (Table 15). Wild Rose was the most common shrub found, it occurred in 76 of the plots (Table 16). Pin cherry, a typical old-field invader species, was found in more plots (35) than other tree species (Table 17). Perhaps of more importance is the frequency at which woody vegetation occurred. Some species of shrub was present in 99 of the plots while some tree species occurred in 66 of the sites. Lists of all plant species found at roosting sites are in the appendix (Tables 32-34).

Soils at 89 of the flush sites were dry, well-drained sand. The remaining sites varied from moderately drained to wet sandy loam.

Vegetative cover may be the most important factor governing the distribution of woodcock on summer fields. Krohn (1971) reported that, "Woodcock preferred small pockets of short vegetation surrounded by taller cover." Woodcock utilizing clearings during summer in West Virginia were evidently attracted to strips of short cover which biologists had created by mowing (Rieffenberger, pers. comm.). In Louisiana, Ensminger (1954) concluded that vegetative cover was more important in the selection of feeding sites by wintering woodcock than the abundance of earthworms. On the study area, the fact that birds were frequently flushed from near puddles in the roads but not from naturally occurring wet areas suggests that the profuse vegetation growing in the latter areas restricted their use as nocturnal habitat.

Table 15. Frequency at various ranks, total frequency, average rank and height range of the 15 most common herbaceous[a] species found at woodcock roosting-sites, High Island, Michigan, 1970.

	Species	Frequency at Various Ranks 1	2	3	4	Total F	Average Rank	Range Height
(1)	Grasses	4	22	50	21	97	2.9	4"-17"
(2)	Strawberry	37	54	4	0	95	1.7	3"-6"
(3)	St. John's-Wort	62	27	1	0	90	1.3	3"-24"
(4)	Wild Rose	40	18	0	0	58	1.3	1"-11"
(5)	Mint	55	3	0	0	58	1.1	3"-11"
(6)	Yarrow	57	1	0	0	58	1.0	3"-12"
(7)	Daisy	43	12	0	0	55	1.2	1"-14"
(8)	Milkweed	33	8	0	0	41	1.2	6"-26"
(9)	Thimbleweed	40	1	0	0	41	1.0	3"-16"
(10)	Red Clover	36	1	0	0	37	1.0	3"-16"
(11)	Sheeps-Sorrel	31	3	0	0	34	1.1	2"-7"
(12)	Goldenrod	16	17	0	0	33	1.5	8"-30"
(13)	Smooth Aster	16	11	1	0	28	1.5	6"-15"
(14)	Wild Lettuce	22	0	0	0	22	1.0	2"-18"
(15)	Moss	7	12	0	0	19	1.6	1"-2"

[a]Any plant less than one foot in height.

Table 16. Frequency at various ranks, total frequency, average rank and height range of the 10 most common shrub[a] species found at woodcock roosting-sites, High Island, Michigan, 1970.

Species	Frequency at Various Ranks 1	2	3	4	Total F	Average Rank	Range Height
(1) Wild Rose	29	46	0	1	76	1.6	1'-1.5'
(2) Red-osier Dogwood	18	17	3	0	38	1.6	2'-5'
(3) Staghorn Sumac	8	23	6	0	37	1.9	1'-4'
(4) Choke Cherry	18	15	1	0	34	1.5	1'-5'
(5) Apple	24	10	0	0	34	1.3	2'-6'
(6) Pin Cherry	9	22	0	0	31	1.7	1.5'-7'
(7) Black Ash	16	3	0	0	19	1.2	2'-2.5'
(8) Sand Cherry	17	2	0	0	19	1.1	1'-3'
(9) Northern Bush Honeysuckle	4	8	2	2	16	2.1	1'-3'
(10) Buffalo Berry	6	6	0	0	12	1.5	1'-5'

[a]Woody plant less than 10 feet in height.

Table 17. Frequency at various ranks, total frequency, average rank and d.b.h. range of the 10 most common tree species found at woodcock roosting-sites, High Island, Michigan, 1970.

	Species	Frequency at Various Ranks 1	2	3	4	Total F	Average Rank	DBH Range
(1)	Pin Cherry	18	16	1	0	35	1.5	2"-4"
(2)	Apple	11	14	1	0	26	1.6	2"-6"
(3)	White Birch	14	9	2	0	25	1.5	2"-13"
(4)	June Berry	10	1	0	0	11	1.1	1"-3"
(5)	Sugar Maple	5	5	0	0	10	1.5	1"-8"
(6)	Aspen	7	2	1	0	10	1.4	1"-5"
(7)	White Cedar	10	0	0	0	10	1.0	2"-5"
(8)	Willow	3	6	0	0	9	1.7	1"-1.5"
(9)	Mountain Ash	8	0	0	0	8	1.0	3"-8"
(10)	Black Ash	6	1	0	0	7	1.1	1"-6"

Age-Sex Composition of Woodcock Captured on Summer Fields

During the investigation 721 different woodcock were captured at night on summer fields. The age-sex composition of woodcock caught by mist-netting and by night-lighting was not significantly different from each other ($P > .05$, Chi-square) and the data are combined (Table 18). There was no significant difference ($P > .05$, Chi-square) between years either (Table 18)

Except for the immature female class there was a marked disparity between the age-sex composition of the captured sample and that of the island's estimated woodcock population (Table 19). On the average, immature males comprised 32 percent of the population but composed 47 percent of the captured sample. Immature females averaged 30 percent of the population and 32 percent of the captured birds. Adult males and females were estimated to average 12 and 26 percent of the woodcock population but only 9 and 12 percent respectively of those birds caught in the fields.

Frequency of capture of each age and sex category is presented in Table 20) . Immature woodcock were recaptured more times than were adults. Over one-half of the immature males and one-third of the immature females were recaught one or more times. Only seven percent of the adult females were retaken compared to 20 percent of the adult males. A high percentage (64-82) of recaptures took place in a field different from that of the previous capture (Table 20).

Immature males were also netted most frequently in Massachusetts (Sheldon 1967) and in Maine (Krohn 1971). Dunford and Owen (1973) concluded that the great percentage of males caught on summer fields may be related more to east of capture than to differences in field usage.

Table 18. Number of woodcock[a] of each age and sex category captured on summer fields on High Island, Michigan, 1968-1971.

Year	Adult Males		Adult Females		Immature Males		Immature Females		Totals		Combined Total
	Mist-netting	Night-lighting	Mist-netting	Night-lighting	Mist-netting	Night-lighting	Mist-netting	Night-lighting	Mist-netting	Night-lighting	
1968[b]	18	0	24	0	105	0	68	0	215	0	215
1969[c]	12	2	17	4	70	12	53	6	152	24	176
1970[c]	13	4	10	8	55	10	40	9	118	31	149
1971[c,d]	6	4	12	4	80	5	57	13	155	26	181
Totals	49	10	63	16	310	27	218	28	640	81	721

[a]Repeats are excluded.
[b]No night-lighting was done.
[c]No significant difference ($P > .01$ Chi-square) in age-sex composition between those captured by mist-netting and by night-lighting in any year.
[d]16 males were collected from population in spring.

Table 19. Sex and age proportions for birds captured on summer fields compared with the total woodcock population, High Island, Michigan, 1968-1971.

Year	Adult Males		Adult Females		Immature Males		Immature Females	
	Estimated proportion of population	Proportion of summer captures	Estimated proportion of population	Proportion of summer captures	Estimated proportion of population	Proportion of summer captures	Estimated proportion of population	Proportion of summer captures
1968	.15	.08	.25	.11	.31	.49	.29	.31
1969	.12	.08	.26	.12	.34	.47	.28	.33
1970	.11	.11	.26	.12	.32	.44	.31	.33
1971	.09	.06[a]	.27	.09[a]	.34	.47[a]	.31	.39[a]
Averages	.12	.09	.26	.12	.32	.47	.30	.32

[a]Data excluded from averages.

Table 20. Frequency of capture of four age and sex categories of woodcock and the proportion of recaptures that took place in fields different than that of the previous capture, High Island, Michigan, 1968-1971.

Age and Sex Category	Number of Woodcock Captured: One Time = f_1	Two Times = f_2	Three Times = f_3	Four Times = f_4	Total No. of Individuals Cap. = $\sum_{1}^{4} f$	Proportion of Birds Recap. at least once	Proportion of Recap. in fields other than previous capture
Adult Male	49	9	1	0	59	.20	.82
Adult Female	74	4	1	0	79	.07	.67
Immature Male	215	105	13	4	337	.57	.64
Immature Female	186	54	5	1	246	.32	.64
	f_1=524	f_2=172	f_3=20	f_4=5	$\sum_{1}^{4} f$=721		

WOODCOCK COLLECTED ON HIGH ISLAND

1968, 1969 and 1970

The combined hunting seasons of 1968, 1969 and 1970 yielded a kill of 381 woodcock. There was no significant difference ($P > .05$, Chi-square) in the age and sex composition of the harvest from year to year nor was there a significant difference ($P > .05$, Chi-square) in the age and sex composition of the harvest between the first half of each season and the second half (Tables 21-23).

In all three years more females were shot than males in both age classes (Table 24).

The reported crippling loss was very low, only four birds or one percent of the total kill.

The ratio of adult males to adult females in the harvest decreased steadily in each subsequent year of the study (Table 25).

The ratio of immature males to immature females in the harvest was identical in 1968 and 1970 and in 1969 and 1971 (Table 25). The average ratio of males to females in the immature age class was 84:100.

The estimated proportion of woodcock collected each year or rate of exploitation is reported in Table 26 . Each year 28 to 48 percent of age and sex class was harvested before migration took place.

The number of woodcock flushed per hour on a weekly basis was highly variable ranging from .44 to 3.37 and averaging 1.98 (Table 27). Slightly more than nine out of every ten woodcock harvested on High Island was shot in edge cover within 50 feet of an opening.

Only small changes took place from week to week in the percent of harvested birds that were banded (Tables 21-23). This indicates that immigration to the island in fall was minimal.

Nearly all the woodcock reared on High Island had migrated by October 20.

1971 Harvest

A known total of 200 woodcock were collected on High Island in 1971. This is a minimum figure because the kill was not monitored during most of the hunting season. But since few hunters normally hunt on the island it is probably close to the true kill.

The harvest was composed of 29 adult males (including those collected in spring), 41 adult females, 64 immature males and 66 immature females. I estimated that at least 45 percent of the woodcock population was collected.

Table 21. The age and sex composition and banding status of woodcock shot during hunting season, High Island, Michigan, 1968

Week	Adult Male		Adult Female		Immature Male		Immature Female		Total Shot	Percent Banded
	Unbanded	Banded	Unbanded	Banded	Unbanded	Banded	Unbanded	Banded		
1 Sept. 14-20	8	1	10	3	3	17	11	12	65	49
2 Sept. 21-27	2	0	13	2	4	4	3	10	38	42
3 Sept. 28-Oct. 3	2	2	3	1	0	1	4	0	13	31
4 Oct. 4-10	3	0	1	0	0	1	0	3	8	50
5 Oct. 11-17	3	1	4	2	2	2	6	2	22	32
6 Oct. 18-24	3	1	2	2	2	1	1	2	14	43
TOTAL	21	5	33	10	11	26	25	29	160	44
Percent of Total	16		27		23		34			

Banded adults - banded and/or handled in the same year--could have been banded in a previous year.

Banded immature - banded in summer, chicks banded in spring and caught again in summer.

Table 22. The age and sex composition and banding status of woodcock shot during hunting season, High Island, Michigan, 1969.

Week	Adult Male		Adult Female		Immature Male		Immature Female		Total Shot	Percent Banded
	Unbanded	Banded	Unbanded	Banded	Unbanded	Banded	Unbanded	Banded		
1 Sept. 13-19	3	0	13	4	8	4	4	8	44	36
2 Sept. 20-26	3	2	1	0	1	2	3	0	12	33
3 Sept. 27-Oct. 2	3	1	7	0	0	4	3	3	21	38
4 Oct. 3-9	1	0	3	3	1	2	4	4	18	50
5 Oct. 10-16	2	1	4	1	8	2	3	2	23	26
6 Oct. 17-23	2	0	4	0	0	4	3	0	13	31
TOTAL	14	4	32	8	18	18	20	17	131	36
Percent of Total	14		31		27		28			

Banded adults - banded and/or handled in the same year--could have been banded in a previous year

Banded immatures - banded in summer, chicks banded in spring and caught again in summer.

Table 23. The age and sex composition and banding status of woodcock shot during hunting season, High Island, Michigan, 1970.

Week	Adult Male Unbanded	Adult Male Banded	Adult Female Unbanded	Adult Female Banded	Immature Male Unbanded	Immature Male Banded	Immature Female Unbanded	Immature Female Banded	Total Shot	Percent Banded
1 Sept. 15-21	3	1	11	0	7	5	8	6	42	29
2 Sept. 22-28	2	0	3	1	3	2	0	2	14	38
3 Sept. 29-Oct. 4	0	0	0	0	0	0	0	0	0	0
4 Oct. 5-11	3	0	5	0	4	2	12	4	29	21
5 Oct. 12-18	0	0	2	0	0	0	3	0	5	0
TOTAL	8	1	21	1	14	9	23	12	90	26
					(+1)* in week #2					
Percent of Total	10		24		27		39			

*One bird shot at close range - the age and sex was determined but not the banding status

Banded adults - banded and/or handled in the same year--could have been banded in a previous year.

Banded immatures - banded in summer, chicks banded in spring and caught again in summer.

Table 24. Number of woodcock in each age-sex category collected on High Island, Michigan, 1968-1971.

Year	Adult Male	Adult Female	Immature Male	Immature Female	Total
1968[a]	26	43	37	54	160
1969[a]	18	40	36	37	131
1970[a]	9	22	24	35	90
1971[b]	16[c]	41	64	66	200
TOTAL	66	146	161	192	565

[a]Collection period - September 15 - Oct. 31
[b]Collection periods - August 16 - September 16 and October 15-18
[c]Collected in spring

Table 25. Sex ratios of adult and immature woodcock and number of immatures per adult female in fall kill, High Island, Michigan, 1968-1971.

Year	Ratio of Adult Males to Adult Females in Kill	Ratio of Immature Males to Immature Females in Kill	Immature Woodcock per Adult Female in Kill
1968	60:100	69:100	2.12
1969	45:100	97:100	1.83
1970	41:100	69:100	2.68
1971	32:100	98:100	3.17
AVERAGE	45:100	84:100	2.41

Table 26. Estimated proportion of woodcock collected each year or rate of exploitation, High Island, Michigan, 1968-1971.

Year	Adult	Immature	
	Male and Female	Male	Female
1968	.44	.30	.48
1969	.44	.30	.38
1970	.31	.28	.42
1971	.33	.43	.48

Table 27. Hunting season data by weeks including hours hunted, flush rates, total kill and kill rates, High Island, Michigan, 1968-1970.

Week No.	Hours Hunted			Birds Flushed Per Hour			Birds Killed			Kill Per Hour		
	1968	1969	1970	1968	1969	1970	1968	1969	1970	1968	1969	1970
1	102.5	121	61.75	2.94	1.18	2.25	65	34*	42	.63	.28	.68
2	51.0	29.25	27.25	3.24	1.29	2.28	38	12	14	.75	.41	.51
3	47.5	25.75	0	1.39	1.94	0	13	21	0	.27	.82	0.0
4	19.5	42.5	31.5	1.69	1.98	3.37	8	18	29	.41	.42	.92
5	51.25	42.0	13.5	2.15	2.0	1.11	22	23	5	.43	.55	.37
6	31.0	34.5	0	1.32	1.25	0	14	13	0	.45	.38	0.0
7	0	18.75	0	0	.44	0	0	0	0	0.0	0.0	0.0
TOTAL	302.75	313.75	134.0	2.37	1.44	2.40	160	121* (131)	90	.53	.39	.67

*+10 collected at night.

OFF-ISLAND RECOVERIES

To date 15 off-island recoveries of woodcock that were banded on High Island have been reported (Table 28). All but one was shot by hunters. The remaining bird was mist-netted and released by a bird bander in Tennessee during spring.

Table 28. Location of woodcock banded on High Island but recovered elsewhere, 1968-1973.

No.	Age	Sex	Date Banded	Recovery Location	Date	Approximate elapsed time
1	Immature	Male	7-19-68	Kalkaska, Michigan	10-30-68	3 months
2	Immature	Male	7-27-68	Johannesburg, Mich	10-24-68	3 months
3	Immature	Male	6-20-69	West Laurel, Mississippi	1-? -70	7 months
4	Immature	Female	7-31-69	Beaver Island, Michigan	10-10-72	40 months
5	Immature	Female	8-5-69	Malden, Missouri	11-11-70	16 months
6	Immature	Male	8-13-69	30 miles S.E. Lake Charles, Louisiana	11-30-69	3.5 months
7	Immature	Female	7-8-70	Tobermory, Ontario Can.	10-15-71	15 months
8	Immature	Male	8-11-70	Beaver Island, Michigan	10-24-70	2.5 months
9	Adult	Female	9-2-70	Mandeyville, Louisiana	1-2-71	4 months
10	Chick	Unknown	5-9-71	Cheboygan, Michigan	10-10-71	5 months
11	Immature	Male	7-4-70	Sheffield, Massachusetts	11-11-72	28 months
12[a,b]	Immature	Male	7-27-71	Nashville, Tennessee	3-7-73	7.5 months
13	Immature	Female	7-9-71	Wexford County, Michigan	10-8-73	27 months
14	Adult	Female	7-16-70	Frederic, Michigan	1-21-73	39 months
15	Immature	Male	7-27-71	Anna, Ohio	Hunting Season '73	27 months

[a]Only non-hunting recovery.

[b]Number 12 and 15 are the same bird.

WOODCOCK WEIGHTS

Weight gains for woodcock appear to be linear for about the first 19 days of life and curvilinear afterward although few data points are available for the 19 to 37 day age class (Figure 7). Hatching-day weights ranged from 9 to 18 grams and averaged 12 grams. A regression equation of weight gain for woodcock between 1 and 19 days of age shows an increase of 5.75 grams daily (Figure 7).

Adult male weights in spring showed a steady increase as the breeding season progressed but the sample of adult females was too small (10) to show weight changes during the incubation and chick-raising period (Table 29).

Adults lost weight after mid-July but showed steady gains from mid-September through October (Table 29).

Immature woodcock showed a slight loss of weight in the last half of August but otherwise weights remained steady or increased slightly through the summer months (Table 29). By mid-September immatures weighed as much or more than adults of the same sex and weight gains during fall were similar (Table 29).

Weight gains in fall correspond with increases in body fat (Figure 8), which is necessary for migration.

Very few weights of woodcock chicks have been published. Weights of chicks from one brood that Pettingill (1936) located on a small island are considerably lower than those I found for chicks of the same age. I found that birds from broods that were recaught several times did not gain weight at the same rate as undisturbed young.

Changes in weight for adult woodcock in spring, and all woodcock in summer and fall were similar to those found by Sheldon (1967) in Massachusetts and Owen and Krohn (1973) in Maine.

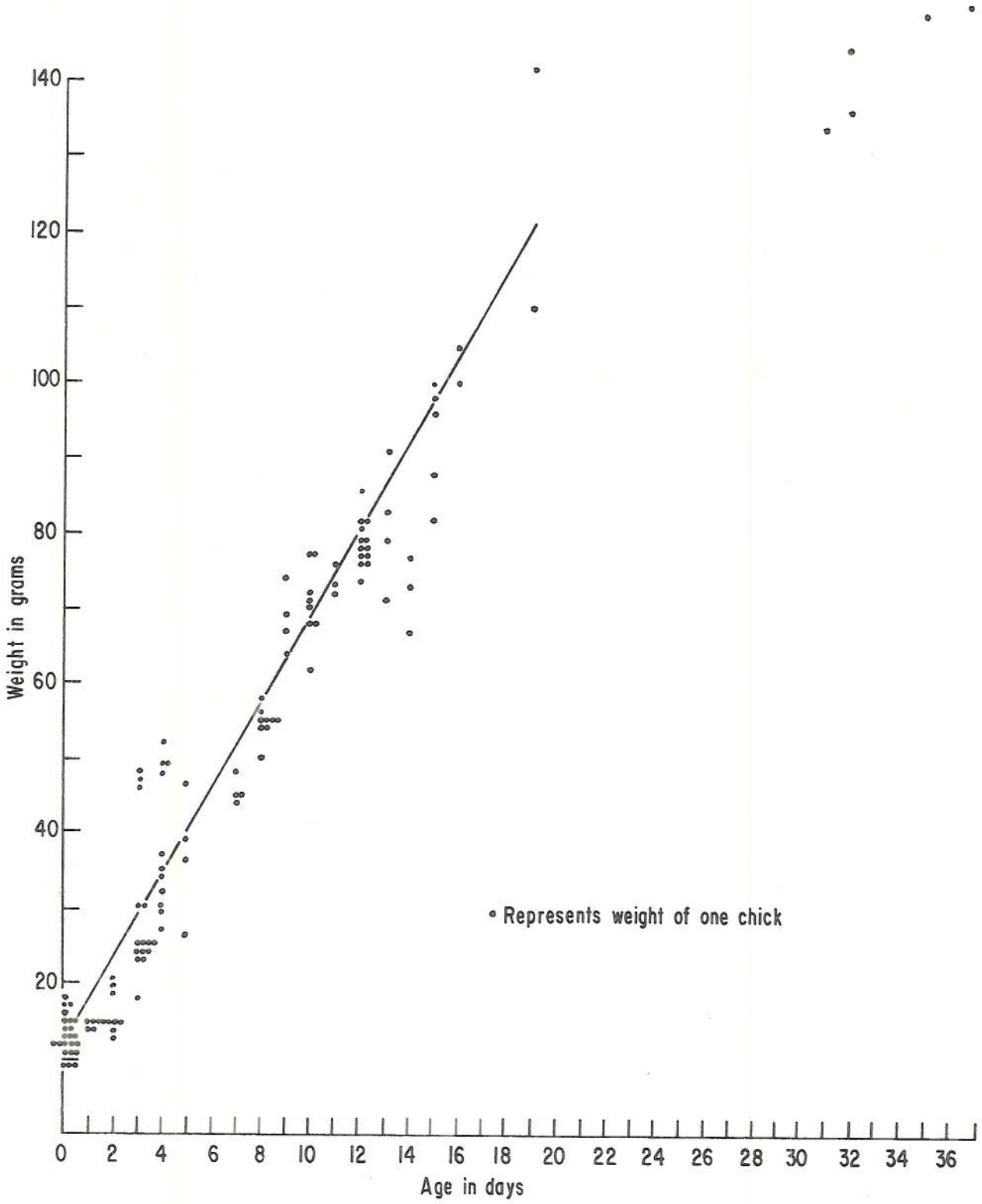

Figure 7. Weights of woodcock chicks zero to 36 days of age, High Island, Michigan, 1968-1972.

Table 29. Mean weight in grams of woodcock captured on High Island, Michigan, 1968-1972.

Date	Adult Male SY	Adult Male ASY	Adult Female	Immature Male	Immature Female
April 15-30	118(1)[a]	127±8.4[b](5)	Periods combined 184±14.9(10)		
May 1-15	125±8.5(3)	130±5.8(8)			
May 16-31	136±7.7(26)	133±8.1(17)			
June 1-15[c]			200±5.6(2)	146±6.7(8)	174±11.2(7)
June 16-30	156±13.4(10)		200±16.1(5)	146±8.1(57)	178±11.4(36)
July 1-15	160±4.2(2)		200±9.8(8)	145±9.9(38)	179±16.2(35)
July 16-31	153±14.2(5)		193±9.2(13)	147±9.1(42)	184±12.5(47)
August 1-15	159±1.7(3)		188±10.8(6)	149±4.7(28)	184±12.9(31)
August 16-31	141±9.3(4)		185±6.2(5)	147±11.0(16)	179±15.0(8)
Sept. 1-15	144(1)		185±1.0(2)	153±10.9(8)	192±16.4(6)
Sept. 16-30[d]	147±8.8(29)		187±11.4(62)	153±11.0(62)	189±10.9(79)
Oct. 1-15	154±15.0(10)		198±15.6(25)	154±11.5(21)	198±10.3(37)
Oct. 16-30	163±15.9(9)		204±16.8(10)	161±10.2(8)	205±13.7(12)

[a]Sample size.
[b]Standard error of the mean.
[c]Adult male age group combined after June 1.
[d]Sample consists of collected birds after mid-September.

FAT DEPOSITION

The sample of woodcock analyzed shows that the pattern of fat accumulation through the fall is similar for each age and sex category (Figure 8). The combined data (Figure 9) shows a steady increase in percentage of fat from five percent in mid-September to 17 percent in late October.

Detailed data on fat deposition for individual birds, including percentage of fat in the liver and muscle is listed in the appendix (Tables 35-38).

In Maine, Owen and Krohn (1973) obtained a fat index for 116 woodcock by recording the estimated degree of deposition, ranging from 0 (no fat) to 3 (very fat) on seven areas and averaging the values. They found that fat was deposited during the fall by adult and immature woodcock at about the same rate.

If the deposition of fat triggers migration, the data from High Island for 1968 does not suggest a differentiation in time of migration between ages or sexes.

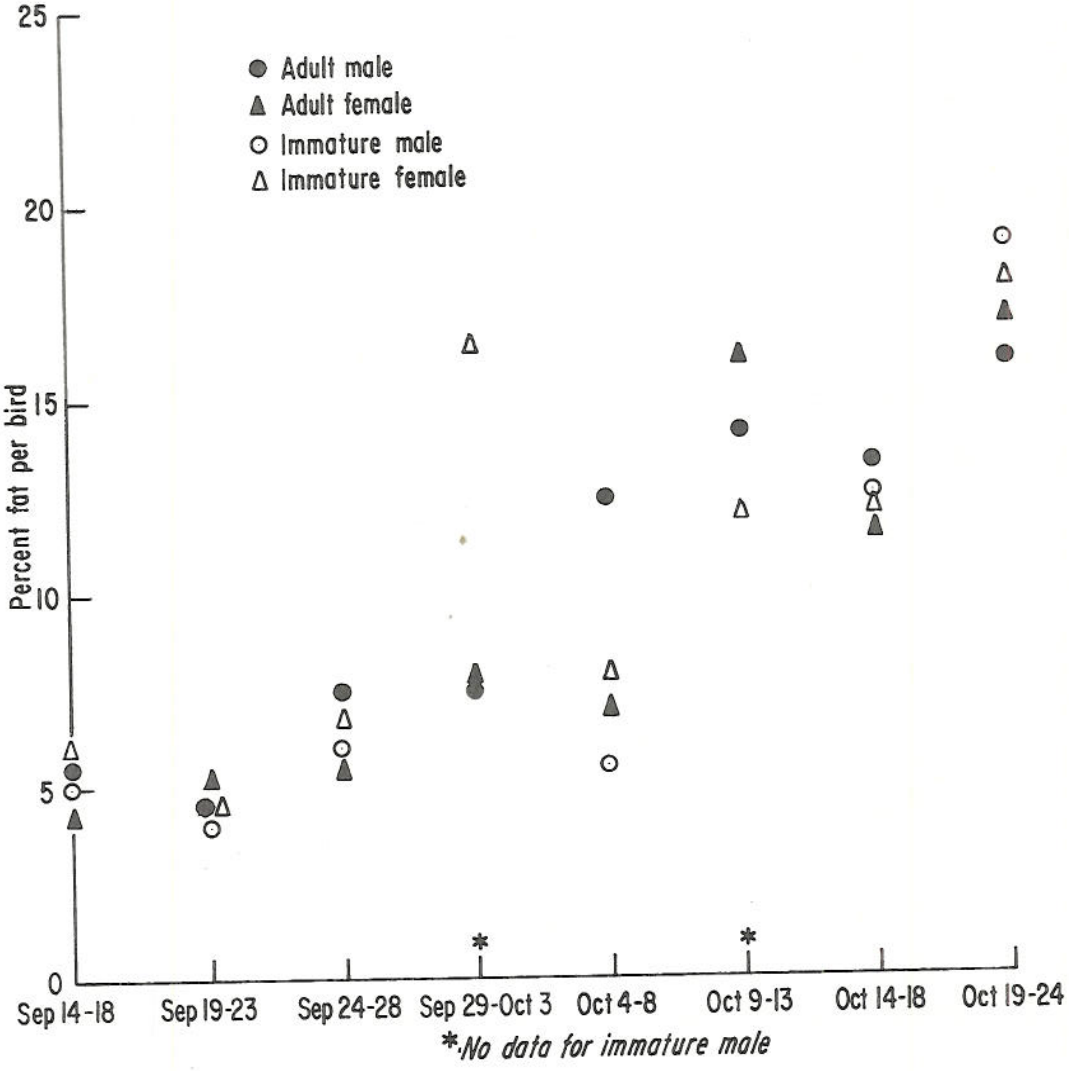

Figure 8. Percent fat of four age and sex categories of woodcock collected in fall, High Island, Michigan, 1968.

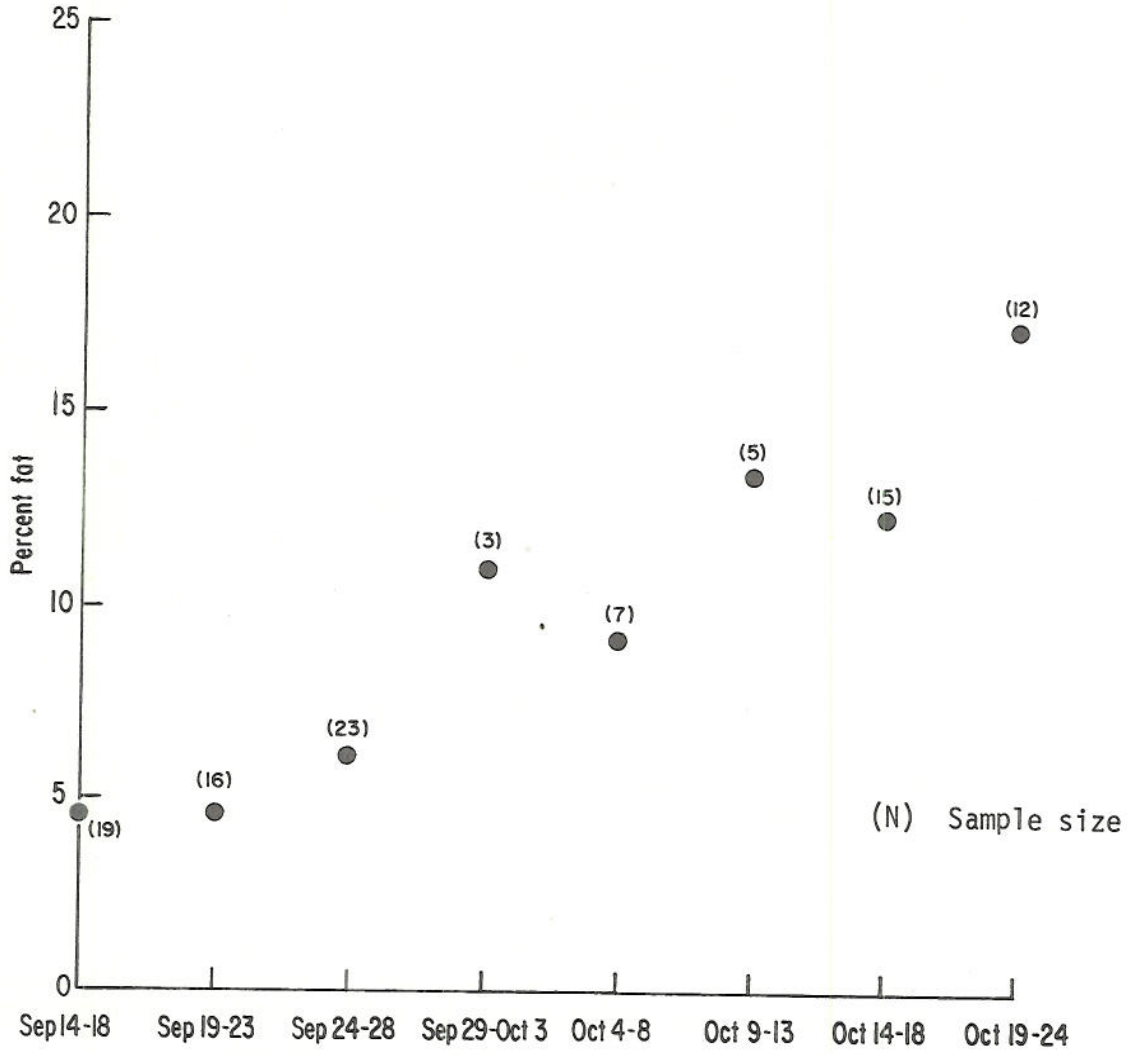

Figure 9. Percent fat of woodcock (ages and sexes combined) collected in fall, High Island, Michigan, 1968.

PESTICIDE ANALYSIS

A summary of chlorinated pesticide residues found in woodcock collected on the study area during fall of 1968 is presented largely as a reference point for future pesticide analyses. With the exception of work done in New Brunswick with DDT and heptachlor, few data have been published on pesticide residues for woodcock collected in the wild. Also, the significance of organochloride residues to woodcock populations is uncertain.

Levels of DDT were generally lower in woodcock from High Island than levels in New Brunswick where spraying for spruce budworm (*Choristoneura fumiferana*) took place (Wright 1965) but apparently the source (the bird's wintering grounds) is the same for both groups of birds.

The average DDT content of woodcock meat (breast muscle) was well below the 7 ppm acceptable level set for commercial meat by the Food and Drug Administration but the average methoxychlor content was just below the 3 ppm acceptable level set for that pesticide (Table 30).

Heptachlor and its epoxide both have a zero tolerance level in commercially sold meat. The sample of woodcock breast muscle that was analyzed contained 2.03 ppm and 1.72 ppm of heptachlor and heptachlor epoxide respectively.

Table 30. Summary of chlorinated pesticide residues in woodcock collected between September 15 and October 24 on High Island, Michigan, 1968.

Tissue	Category	Heptachlor	Heptachlor Epoxide	DDE	Dieldrin	op-DDT*	DDD	pp.DDT**	Methoxy-chlor	DDE +DDD +DDT
Brain	Highest	6.853[a](10)[b]	2.043(6)	5.530(150)	4.189(116)	10.221(160)	3.177(60)	11.725(132)		20061(133
	Lowest	0	0	0	0	0	0	0	0	0
	Average	3.427	1.022	2.765	2.095	5.111	1.589	5.863		10.031
Liver	Highest	20.095(116)	3.343(66)	33.097(116)	4.695(102)	4.667(35)	15.205(54)	8.274(116)	7.404(150)	41.548(11
	Lowest	0	0	0	0	0	0	0	0	0.219(10
	Average	10.048	1.672	16.549	2.348	2.334	7.603	4.137	3.702	20.889
Muscle	Highest	4.052(85)	3.473(85)	7.721(50)	3.432(50)	1.457(56)	9.333(107)	4.134(50)	2.564(126)	16.691(50)
	Lowest	0	0	0	0	0	0	0	0	0
	Average	2.026	1.737	3.861	1.716	0.729	4.667	2.067	1.282	8.346

[a]Parts per million
[b]Sample size
*Ortho-para-DDT
**Para-para-DDT

SUMMARY

The adult male population declined when subjected to extreme exploitation. The overall population, however, continued to be maintained. Considering the high mortality rates and low rates of return to the island, it is almost certain that some immigration took place. Since adult male and adult female mortality rates were not greatly different most of the immigrants must have been females.

The apparent high rate of natural mortality and the low rate of reproduction leads me to believe that a population of woodcock can only sustain relatively low rates of exploitation.

It was not determined if the ratio of immature woodcock to adult females in the kill was indicative of reproductive success.

I believe that counts of performing (peenting) male woodcock (synonymous with counts of occupied singing-grounds in this study) measured the trend in the adult male woodcock population. However, two more years of data are needed to indicate the relationship between number of adult males and singing-ground counts.

The importance of openings to the existence of a woodcock population cannot be overemphasized. Breeding, nesting, brood-raising and summer activities took place in and around openings within the forest. Without openings a population of woodcock simply cannot live.

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Table 31. Data used in computing population estimates, High Island, Michigan, 1968-1971.

	Birds Banded[a] July 16 - Sept. 14	Birds Collected[b] Sept. 15 - Oct. 31	Banded Birds in Collected Sample
1968			
Adult Male	17	26	5
Adult Female	21	43	10
Immature Male	88	37	26
Immature Female	61	54	29
1969			
Adult Male	6	18	4
Adult Female	14	40	5
Immature Male	61	36	18
Immature Female	46	37	17
1970			
Adult Male	10	9	1
Adult Female	11	22	1
Immature Male	35	23	9
Immature Female	27	35	12
1971			
Adult Male	6	13	2
Adult Female	8	41	6
Immature Male	79	66	34
Immature Female	68	66	33

[a] In 1971 the banding period was from July 16 to August 15.
[b] In 1971 the collection period was August 16 to Sept. 16 and October 15 - 18.

Table 32. The herbaceous species identified on summer field vegetation plots, High Island, Michigan, 1970.

Common Name	Scientific Name*
Common Yarrow	*Achilleamillefolium* L.
Agrimony	*Agrimonia gryposepala* Wallr.
Thimbleweed	*Anemone virginiana* L.
Pussy's Toes	*Antennaria fallax* Greene
Spreading Dogbane	*Apocynum androsaemifolium* L.
Sarsaparilla	*Aralia nudicaulis* L.
Common Milkweed	*Asclepias syriaca* L.
White Aster	*Aster ericoides* L.
Smooth Aster	*Aster laevis* L.
Rattlesnake Fern	*Botrychium virginianum* L.
Sedge	*Carex* sp.
Indian Paintbrush	*Castilleja coccinea* (L) Spreng.
Field Daisy	*Chrysanthemum leucanthemum* L.
Wild Carrot	*Daucus carota* L.
Fireweed	*Epilobium angustifolium* L.
Field Horsetail	*Equisetum pratense* Ehrh.
Daisy Fleabane	*Erigeron philadelphicus* L.
Wild Strawberry	*Fragaria virginiana* Duchesne
Purple Avens	*Geum rivale* L.
Gention	*Gention puberula* Michx.
Clammy Everlasting	*Gnaphalium macounii* Greene
Orange Hawkweed	*Hieracium aurantiacum* L.
King Devil	*Hieracium florentinum* All.
St. John's-Wort	*Hypericum perforatum* L.
Wild Lettuce	*Lactuca canadensis* L.
Hoary Puccoon	*Lithospermum canescens* (Michx.) Lehm.
Club Moss	*Lycopodium* sp.
Wild Lily-of-the-Valley	*Maianthemum canadense* Desf.
White Sweet Clover	*Melilotus alba* Desr.
Mint	*Mentha arvensis* L.
Wild Bergamot	*Monarda fistulosa* L.
Evening-Primrose	*Oenothera biennis* L.
Ground-Cherry	*Physalis heterophylla* Nees

Table 32 Continued.

Common Name	Scientific Name*
Silverweed	*Potentilla anserina* L.
Heal-all	*Prunella vulgaris* L.
Bracken Fern	*Pteridium aquilinum* L.
Common Buttercup	*Ranunculus acris* L.
Sheeps Sorrel	*Rumex acetosella* L.
Bouncing Bet	*Saponaria officinalis* L.
Bladder Campion	*Silene cucubalus* Wibel
Solomon's Seal	*Smilacina* sp.
Yellow Goat's-Beard	*Tragopogon major* Jacq.
Yellow Clover	*Trifolium agrarium* L.
Red Clover	*Trifolium pratense* L.
Common Mullein	*Verbascum thapsus* L.
Violet	*Viola* sp.
Golden Alexanders	*Zizia aurea* (L.) W.D.J. Koch
Grasses	
Moss	
Unknowns (2)	

*Smith (1966) was used for identification and scientific names.

Table 33. The shrub species identified on the summer-field vegetation plots, High Island, Michigan, 1970.

Common Name	Scientific Name*
Juneberry	*Amelanchier* sp.
Bearberry	*Arctostaphylus uva-ursi* (L.) Spreng.
Silky Dogwood	*Cornus obliqua* Raf.
Red-osier Dogwood	*Cornus stolonifera* Michx.
N. Bush Honeysuckle	*Diervilla lonicera* Mill.
Michigan Holly	*Ilex verticillata* (L.) Gray
Dwarf Juniper	*Juniperus communis* L.
Trailing Juniper	*Juniperus horizontalis* Moench.
Smooth Honeysuckle	*Lonicera dioica* L.
Hairy Honeysuckle	*Lonicera hirsuta* Eat.
Sand Cherry	*Prunus pumila* L.
Choke Cherry	*Prunus virginiana* L.
Wild Rose	*Rosa* sp.
Poison Ivy	*Rhus toxicodendrun* L.
Staghorn Sumac	*Rhus typhina* L.
Blackberry	*Rubus allegheniensis* Porter
Red Raspberry	*Rubus idaeus* L.
Willow	*Salix* spp.
Buffalo Berry	*Shepherdia canadensis* (L.) Nutt
Snowberry	*Symphoricarpos albus* (L.) Blake
American Yew	*Taxus canadensis* Marsh.

*Petrides (1958) was used for identification and scientific names.

Table 34. The tree species identified on the summer field vegetation plots, High Island, Michigan, 1970.

Common Name	Scientific Name*
Balsam Fir	*Abies balsamea* (L.) Mill.
Red Maple	*Acer rubrum* L.
Sugar Maple	*Acer saccharum* Marsh.
White Birch	*Betula papyrifera* Marsh.
Black Ash	*Fraxinus nigra* Marsh.
White Spruce	*Picea glauca* (Moench) Voss
White Pine	*Pinus strobus* L.
Balm-of-Gilead	*Populus gileadensis* Rouleau
Aspen	*Populus tremuloides* Michx.
Pin Cherry	*Prunus pensylvanica* L.
Mountain Ash	*Pyrus americana* (Marsh.) DC
Apple	*Pyrus malus* L.
Red Oak	*Quercus rubra* L.
Willow	*Salix* sp.
White Cedar	*Thuja occidentalis* L.

*Petrides (1958) was used for identification and scientific names.

Table 35. Fat analysis data for 19 adult male woodcock collected in fall, High Island, Michigan, 1968.

Date Recovered	Bird Number	Wt* of Bird	Wt* of Fat Total	% Fat/ Bird	Wt. of Liver	% Fat/ Liver	% Fat/ Muscle
9-14-68	2	144.87	10.75	7.42	4.80	4.75	-
9-14-68	10	146.20	6.62	4.53	4.32	2.65	1.86
9-15-68	35	131.35	5.96	4.54	3.99	3.16	2.11
9-20-68	62	138.64	6.55	4.72	3.12	3.86	1.93
9-27-68	101	137.32	9.04	6.58	-	-	2.46
9-28-68	105	142.02	12.09	8.51	4.17	4.28	2.63
9-29-68	111	142.61	10.39	7.29	3.25	4.96	2.67
10-4-68	115	145.17	15.83	10.91	3.01	5.91	2.79
10-7-68	119	143.82	16.78	11.67	2.43	5.59	4.10
10-7-68	120	153.67	22.95	14.94	-	-	3.33
10-9-68	124	164.11	23.18	14.12	-	-	2.93
10-15-68	133	152.65	14.98	9.82	-	-	2.57
10-16-68	135	138.39	13.62	9.84	-	-	2.85
10-18-68	141	151.95	16.85	11.09	3.70	5.02	2.26
10-18-68	144	157.65	34.27	21.74	3.21	8.86	4.66
10-19-68	148	170.04	24.93	14.66	5.49	5.99	3.03
10-23-68	153	183.95	36.52	19.85	4.53	4.25	6.67
10-24-68	159	147.27	18.52	12.33	2.99	7.01	4.03
10-24-68	160	159.73	24.96	15.63	3.47	7.15	5.42

*In grams.

Table 36. Fat analysis data for 34 adult female woodcock collected in fall, High Island, Michigan, 1968.

Date Recovered	Bird Number	Wt.* of Bird	Wt.* of Fat Total	% Fat/ Bird	Wt.* of Liver	% Fat/ Liver	% Fat/ Muscle
9-14-68	14	174.69	6.91	3.96	4.13	2.45	2.02
9-15-68	38	182.49	7.17	3.93	3.43	4.01	2.19
9-15-68	43	190.33	10.87	5.71	3.99	3.23	1.62
9-16-68	56	190.00	8.56	4.50	4.56	3.05	1.60
9-17-68	58	160.40	6.18	3.85	-	-	1.53
9-18-68	59	170.56	8.28	4.86	2.53	4.48	2.25
9-20-68	60	174.40	8.26	4.74	3.42	3.84	1.71
9-21-68	67	145.54	8.82	6.06	2.24	4.22	3.05
9-21-68	68	173.57	10.91	6.29	4.34	5.61	2.12
9-21-68	69	166.41	9.28	5.58	3.35	3.66	2.12
9-21-68	70	172.46	4.41	2.56	5.01	2.85	1.34
9-21-68	72	197.78	12.55	6.34	3.57	4.38	2.05
9-22-68	74	162.99	7.58	4.65	-	-	1.56
9-22-68	77	176.99	8.78	4.96	4.26	6.49	2.01
9-24-68	81	176.53	6.85	3.88	3.94	4.36	1.61
9-24-68	85	169.26	8.84	5.22	3.16	3.86	1.20
9-25-68	90	173.60	13.37	7.70	3.15	3.98	2.30
9-26-68	92	173.33	9.45	5.45	-	-	2.07
9-27-68	96	187.71	11.24	5.99	3.17	4.78	1.94
9-27-68	102	158.52	3.49	2.20	4.87	3.50	1.08
9-27-68	103	183.58	15.19	8.27	3.87	4.93	2.42
9-28-68	106	173.88	12.95	7.45	4.78	4.89	1.21
9-28-68	107	185.85	10.88	5.85	5.29	4.24	1.75
10-3-68	113	184.50	14.29	7.74	2.49	4.81	2.21
10-8-68	122	176.33	12.13	6.88	3.40	4.60	1.77
10-12-68	126	205.12	36.75	15.97	-	-	2.94
10-14-68	129	228.21	44.01	19.28	2.15	4.64	4.14
10-14-68	130	183.08	21.53	11.76	3.89	6.37	3.18
10-15-68	132	173.15	12.99	7.50	3.47	3.54	2.58
10-17-68	136	194.57	16.78	8.62	3.05	5.43	2.66
10-18-68	146	171.65	15.28	8.90	3.36	6.62	3.18
10-19-68	147	230.15	32.14	13.97	7.34	7.39	2.71
10-23-68	154	208.51	36.67	17.59	4.40	6.28	3.80
10-23-68	156	198.62	38.90	19.59	4.26	7.38	3.83

*In grams.

Table 37. Fat analysis data for 18 immature male woodcock collected in fall, High Island, Michigan, 1968.

Date Recovered	Bird Number	Wt.* of Bird	Wt.* of Fat Total	% Fat/ Bird	Wt.* of Liver	% Fat/ Liver	% Fat/ Muscle
9-14-68	5	142.03	11.21	7.88	4.04	3.68	3.32
9-14-68	7	135.52	5.83	4.30	4.60	3.61	2.02
9-14-68	31	144.66	7.59	5.25	3.68	4.69	3.00
9-15-68	37	132.25	6.33	4.78	3.25	4.60	1.94
9-16-68	57	125.03	3.91	3.13	4.09	2.33	1.57
9-20-68	64	128.67	3.75	2.92	2.90	4.07	1.75
9-21-68	66	150.97	6.05	4.01	4.19	3.00	1.59
9-21-68	71	159.60	7.26	4.55	4.30	3.56	1.96
9-22-68	76	147.54	7.93	5.38	5.03	3.79	1.90
9-24-68	82	142.05	8.41	5.92	2.87	4.95	2.31
9-25-68	89	112.75	6.80	6.03	1.96	5.44	1.99
9-27-68	95	150.47	7.08	4.70	3.16	5.46	1.80
9-28-68	104	134.83	10.70	7.94	4.16	3.80	2.36
10-5-68	117	125.24	7.01	5.60	-	-	1.85
10-14-68	131	143.41	7.61	5.30	-	-	2.72
10-17-68	137	157.13	30.24	19.24	3.67	4.74	4.20
10-23-68	155	170.77	34.96	20.47	4.89	2.52	6.91
10-24-68	158	166.09	28.87	17.38	2.58	6.40	5.15

*In grams.

Table 38. Fat analysis data for 30 immature female woodcock collected in fall, High Island, Michigan, 1968.

Date Recovered	Bird Number	Wt.* of Bird	Wt.* of Fat Total	% Fat/ Bird	Wt.* of Liver	% Fat/ Liver	% Fat/ Muscle
9-14-68	6	170.32	14.45	8.48	4.06	4.34	3.69
9-14-68	15	164.09	8.48	5.17	4.87	2.50	2.09
9-16-68	50	176.21	11.11	6.31	4.71	4.01	3.47
9-16-68	54	168.21	8.14	4.84	5.39	3.17	1.38
9-16-68	55	186.20	9.16	4.92	5.71	2.76	1.55
9-20-68	63	182.67	7.95	4.35	3.53	2.80	1.26
9-22-68	75	166.24	6.03	3.63	4.32	3.31	1.51
9-22-68	78	179.81	10.17	5.66	5.57	2.81	1.96
9-24-68	79	171.65	7.33	4.27	-	-	2.08
9-25-68	88	174.75	6.82	3.90	4.62	4.15	1.69
9-26-68	91	173.36	13.92	8.03	3.16	5.41	2.45
9-26-68	93	175.55	16.99	9.68	3.77	5.78	3.69
9-27-68	94	164.73	5.59	3.39	5.29	3.13	1.61
9-27-68	97	181.21	20.88	11.52	3.55	4.41	3.50
9-27-68	99	179.46	8.82	4.91	3.69	3.23	2.13
9-28-68	109	199.52	7.83	3.93	8.50	2.90	1.71
10-2-68	112	194.96	32.80	16.82	4.42	11.27	3.15
10-4-68	114	178.89	13.97	7.81	3.47	4.29	2.86
10-8-68	123	175.92	13.10	7.45	1.24	4.63	2.93
10-12-68	125	200.57	31.15	15.53	6.45	4.27	4.42
10-12-68	127	181.78	14.84	8.16	5.24	5.95	2.53
10-12-68	128	188.84	22.75	12.05	6.49	6.47	4.12
10-16-68	134	183.07	15.26	8.34	3.73	3.52	1.78
10-17-68	140	188.43	19.78	10.50	5.78	9.80	2.50
10-18-68	142	216.01	39.84	18.44	5.39	6.15	6.24
10-18-68	143	207.93	38.95	18.73	5.89	7.69	3.83
10-18-68	145	163.90	6.48	3.94	4.48	4.57	2.32
10-20-68	150	193.65	26.80	13.84	4.22	5.12	3.33
10-21-68	151	219.64	54.54	24.83	4.90	13.86	4.92
10-24-68	157	210.57	30.29	14.39	2.87	8.20	4.66

*In grams.