INVESTIGATIONS OF THE AMERICAN WOODCOCK IN MICHIGAN

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Lytle H. Blankenship

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This is to certify that the

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INVESTIGATIONS OF THE AMERICAN WOODCOCK IN MICHIGAN

by

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ABSTRACT

Investigations of the American woodcock in Michigan were made for the purpose of developing and improving management techniques involving the bird. Phases especially investigated were (1) migratory habits, annual production, and population levels, (2) extent of present utilization of the resource, and (3) factors influencing the distribution, abundance, and activities of the bird.

Woodcock arrived in Michigan during late winter. By the last of April, spring migration was completed. Movements thereafter were restricted to local activites until late summer when fall migration began. Most woodcock moved through Regions I and II by October 20 while in Region III some birds had moved out and others moved in by that date.

The major part of the breeding season occurred between April 15 and May 15 in the Lower Peninsula and between April 25 and May 25 in the Upper Peninsula. Singing-ground counts were made during these periods. Data obtained on these counts were used to determine factors affecting observations and woodcock activity, population trends, number of times a route should be run, and number of routes to be run in the state.

Woodcock breeding activity was affected by light intensities, rain, temperature, wind, and other animals, particularly man. Major factors affecting observations were wind and noise interference.

Singing-ground routes usually were run two or three times each but a statistical analysis of data from one route indicated that the

route would need to be run at least 27 times to obtain confidence limits 25 per cent of the observed mean. Economically, a route should be run twice the first year and once each year thereafter.

A comparison of bill lengths and the total width of the outer three primaries was considered a reliable criterion of sex. A comparison of the total width and total length of the same primaries was used also for sexing birds. Leg color was used tentatively as a criterion of age.

Sex and age data in conjunction with nesting success, brood sizes, and kill figures were used to determine survival and mortality and to analyze the extent of harvest. Data indicated woodcock are not being over-harvested in Michigan.

Major factors influencing the distribution, abundance, and activities of woodcock were vegetation, food, weather, and soil. Minor factors included competition, predation, diseases and parasites, and accidents.

Vegetation was important in restricting distribution as well as serving as an indicator of the habitat type. The availability of earthworms was a critical factor determining whether or not woodcock used certain areas as feeding or loafing sites. Weather, including temperature, wind, and precipitation, influenced local activity and migration. The remaining factors were of little importance except in local situations.

For managing the woodcock population two methods seemed promising. First, improvement of habitat by vegetation controls should be used on singing grounds and feeding areas. Second, a change in hunting season

dates to correspond more closely to migratory movements might be helpful for increasing the harvest of woodcock.

Future studies should emphasize the relationship between woodcock populations and habitat changes, practical methods for determining seasonal occurrence of birds, increased vegetation control by various means, and better techniques for determining population trends. In the meantime, banding operations and singing-ground counts should be continued and increased when possible.

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INTRODUCTION

The American woodcock (Philohela minor) is a favorite bird of many people. To some bird watchers the male's courtship flights during the spring are a sight to behold. To photographers the well-camouflaged nesting female provides a perfect model as she sits so closely on the nest that she may be removed by hand. And yet, to others the seemingly quick and darting shadow of a bird is a target for the gun. To these latter people the woodcock, though small in size, is a favorite game bird, even though most hunters consider the timberdoodle only a welcome addition to a mixed bag of game. Regardless of its appeal to the human, many hours have been spent by interested persons searching the woodcock's domain for sight or sound of the bird. In addition, many rounds of ammunition regularly are expended on the diminutive game bird, causing a considerable income for arms manufacturers and dealers. Thus, the woodcock is a bird of economic as well as esthetic value.

Although a member of the Order Charadriiformes, the woodcock is primarily an inhabitant of wooded swales and stream bottoms. More specifically, it is a member of the Family Scolopacidae which includes such relatives as the snipe, sandpipers, curlews, and willets. The family is divided further into three subfamilies one of which is the Scolopacinae to which the woodcock belongs. Generally this group is recognized by the three following characters: (1) eyes located in the upper part of the head, (2) a long and membranous bill, and (3) ear far below the eye and possibly a little forward. There are ten genera

in the North American Scolopacinae. The American woodcock is distinctive in having the three outer primaries narrowly attenuated and shorter than the next two primaries which are the longest of the primaries (Pettingill, 1936). A close relative, and Old World counterpart, the European woodcock, Scolopax rusticola, is found in the British Isles, Europe, Asia, and northern Africa.

The American woodcock is confined primarily to the deciduous forests of eastern United States and southern Canada. Although the bird breeds generally throughout this region, the primary breeding range includes southern Ontario and Quebec, the Maritime Provinces, and the area south to the 40th parallel. The main wintering range includes portions of the southern Atlantic and Gulf Coastal states from Maryland to Texas with the major concentration being in Louisiana.

Since the major wintering and breeding grounds are widely separated, the life cycle of the woodcock includes a biannual migration. In late winter and early spring most birds leave their wintering range for the northern breeding areas. A movement in the opposite direction occurs during the fall.

When woodcock return to the breeding grounds the males locate relatively open sites, referred to as "singing grounds," on which they perform their courtship display (Plate 1). Throughout the day birds remain in diurnal coverts, occasionally moving and sometimes feeding if the coverts are located suitably. Then a few minutes after sundown (15± minutes, depending on cloud coverage) the male seems to become sexually excited and often starts to sound off with a call of nasal-like quality described as a "peent." After a few

minutes of rather consistent "peenting," the bird leaves the covert and proceeds to the singing ground which usually is within 300 feet. It may fly directly to the site, make a short, circling flight first, or even walk to the singing ground. After reaching the area the male usually spends several minutes peenting before starting the aerial display. This display normally commences with the bird taking off into the wind. It ascends in spirals to a height of at least 200 feet and then descends rapidly in a series of zig-zags and j-shaped loops until about 30 feet from the ground. From this level it glides in and lands at or near the spot of its departure. During the flight, which lasts about 60 seconds, an aerial song may be heard. This song begins with a whistle of the wings, and the wing trilling may be heard intermittently through most of the flight. The vocal twittering or chipping is not added until near the apex of the flight, probably as the bird begins to descend. Then the vocal and wing noises seem to occur alternately. All sounds end as the male glides in for a landing. After reaching the singing ground the bird peents for a minute or so before taking off on another aerial display. This alternate ground and aerial activity continues usually between 30 and 45 minutes each evening. Occasionally a female will enter the male's domain, at which time copulation may take place.

When the evening activity has ended, the male may remain on the singing ground awhile; eventually it leaves to feed. It may return to the "ground" several times during the night, especially on a bright moonlight night, but another major period of display does not take place until around daybreak. After this morning period of activity

PLATE 1

A. A typical singing ground located on the Rose Lake Wildlife Experiment Station. The site most frequently used is indicated by the arrow.

B. A singing ground situated in Indian grass and small shrubs near Vermillion Creek on the Rose Lake Wildlife Experiment Station. The singing ground is indicated by the arrow.

on the singing ground, the male retires to the diurnal coverts again.

Status of Woodcock Research

One of the first detailed accounts of the American woodcock was published in the eighteenth century by Lawson (1714). This was some years prior to the formal description by Pennant (1785) who gave the bird the name of "Little Woodcock." The first Latin name was Scolopax minor, given by J. F. Gmelin in the thirteenth edition of the Systema Naturae of 1788. George Robert Gray, in his 1841 edition of A List of the Genera of Birds, changed the generic name to Philohela. Other than the taxonomic studies and general observations little scientific work was done on the species until recent years when Pettingill (1936) published on an intensive study of the woodcock's life history. In addition to data gathered through his own studies in Maine and New York, Pettingill compiled many findings from questionnaires and publications.

A later book, written by Mendall and Aldous (1943), was based on an investigation of the ecology and management of the woodcock in Maine. The present widely-used methods for spring breeding-ground counts were introduced by them.

A large part of the most recent and intensive studies on woodcock, including those of William Sheldon in Massachusetts, Stephen Liscinsky in Pennsylvania, and Leslie Glasgow in Louisiana, have not been published except in state and federal (Pittman-Robertson

Projects) progress reports.

In Michigan, investigations of woodcock have been confined primarily to observations regarding distribution and general life history notes. The writings of Barrows (1912) and Wood (1951), on the birds of Michigan, included most of the published references to woodcock in the state and information from a few observations of their own.

For many years the American woodcock has been a major game bird in the northeastern states. In the Great Lakes region, especially Michigan, the importance of this bird has not been emphasized until recently. There have been many woodcock hunters but the major harvest of the bird has been by the ruffed grouse hunter. This incidental harvest has been sufficient to place Michigan as the state with the largest annual kill. The present study was instigated during the spring of 1953 to learn more concerning the "timberdoodle" in Michigan. Field work continued until the fall of 1955. The primary objectives of the investigation were to determine:

(1) Annual production, population levels, and migratory habits.

(2) The extent of the present utilization of the resource.

(3) Factors influencing the distribution, abundance, and activities of the woodcock.

(4) Management practices necessary to improve conditions for the woodcock.

During the first year most of the time was spent getting acquainted with the woodcock habitat in the state and doing basic work in preparation for future activities. The major part of the work was accomplished in the following two years with most of the spring data

being gathered on the Rose Lake Wildlife Experiment Station and the Gratiot-Saginaw Game Area, while summer and fall research was carried on in the vicinity of the Pigeon River Trout Research Station near Vanderbilt, Michigan (Plate 2).

For clarity, certain terms are defined at this time. A "route" or "singing ground route" constituted the area of woodcock habitat traversed for the purpose of counting the number of breeding males which could be heard. "Cooperators" were the people who assisted in running singing ground routes, keeping records on hunting success and migration, or collecting woodcock parts for sex and age data. Regions I, II, and III are state administrative divisions used by the Michigan Department of Conservation. Region I is the Upper Peninsula; Region II includes the northern half of the Lower Peninsula; and Region III includes the southern half of the Lower Peninsula (Plate 2). Other terms are considered as being self-explanatory or are defined in the section in which they are used.

Acknowledgments

The investigation was undertaken under a contract between the Michigan Department of Conservation and Michigan State University. This study was designated as Pittman-Robertson Research Project 90-R of the Game Division, Michigan Department of Conservation.

The writer wishes to express his appreciation to Dr. Donald W. Douglass, Game Division, Michigan Department of Conservation, and

PLATE 2

A map of Michigan showing the regional divisions, study areas, and many other locations mentioned in the text.


EAGLE RIVER
HOUGHTON
ONTONAGON
BARAGA
MARQUETTE
EWEN
GOGEBIC
IRON
CRYSTAL FALLS
DICKINSON
DELTA
ESCANABA
MENOMINEE
CUSINO WILDLIFE EXP. STA.
ALGER
SCHOOLCRAFT
LUCE
NEWBERRY
CHIPPEWA
PARADISE
SAULT STE. MARIE
DUNBAR
BLANEY PARK
MACKINAC
MORAN
STRAITS OF MACKINAC
MACKINAW CITY
EMMET
CHEBOYGAN
PIGEON RIVER AREA
CHARLEVOIX
EAST JORDAN
ATLANTIA
CRAPO LAKE
GRAND TRAVERSE
KALKASKA
CLIMPORD
OSCODA
ALCONA
HARRISVILLE
REGION II
RIFLE RIVER AREA
HOUGHTON LK. EXP. STA.
GREENWOOD
MASON
LAKE
OSCEOLA
CLARE
GLADWIN
OCEANA
NEWAYGO
MECOSTA
ISABELLA
MIDLAND
BAY
BAD AXE
OSCODA
AUSABLE
MONTCALM
GRATIOT
GRATIOT-SAGINAW GAME AREA
GENESEE
LAPEER
SAINT CLAIR
OTTAWA
GRAND RAPIDS
IONIA
CLINTON
ROSE LAKE EXP. STATION
LANSING
MACOMB
ALLEGAN
BARRY
EATON
LIVINGSTON
OAKLAND
KELLOGG BIRD SANCTUARY
WATERLOO RECREATION AREA
ANN ARBOR
GROSSE PTE.
KALAMAZOO
BATTLE CREEK
REGION III
BERRIEN
CASS
ST. JOSEPH
BRANCH
HILLSDALE
LENAWEE
MONROE
PETERSBURG

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The writer is grateful to Dr. William H. Marshall, Professor of Wildlife Management, University of Minnesota, for the use of woodcock specimens taken in Minnesota and to Dr. William Murchie of Thiel College, Pennsylvania, for his identification of earthworms taken

from study areas. Allen Duvall, U.S. Fish and Wildlife Service, Patuxent, Maryland, furnished banding records.

Facilities for summer and fall studies were made available at the Pigeon River Trout Research Station by the Institute for Fisheries Research of the Michigan Department of Conservation. Thanks go to Edward Bacon and Gerald Myers for their cooperation at the station.

Gratitude must be expressed to the writer's wife, Margaret, who spent many hours assisting in field studies and in typing reports.

Last but not least, grateful acknowledgment is given two top-notch woodcock dogs, Lady and Pixie, both Brittany Spaniels. Without the aid of these fine dogs in locating woodcock, much of the information would never have been gathered. Appreciation is expressed too for the many hours of company they provided in the solitude of extensive untenanted woods as well as the enjoyment received from watching them work.

DISTRIBUTION AND MOVEMENTS

Distribution in Michigan

During this study woodcock were observed by the writer, other Department of Conservation personnel, and singing ground cooperators in every county except Alcona, Benzie, Branch, Cass, Hillsdale, Ionia, Missaukee, Osceola, Ottawa, and Wexford.

Reports of breeding birds were received from 40 counties as a result of singing-ground counts between 1953 and 1955. Records from the other counties were of one or more active singing grounds. In all probability woodcock nest in every county of Michigan.

In 28 counties where breeding woodcock had been observed by the writer, birds were found in the summer. In 15 other counties where breeding woodcock had been reported, the writer saw summer residents. Hunting records since 1938 revealed that woodcock, whether local or migrant, had been shot in every county.

Because of the large acreage of farmland and the scarcity of wooded streams and swales, the woodcock is not as abundant in the southern half of the Lower Peninsula as in the northern half of the Lower Peninsula and the Upper Peninsula.

Movements

Spring.

Path of migration. The best information available concerning the relationship between the breeding and wintering grounds of Michigan woodcock is from banding records (Table 1). Since some of the banded woodcock were killed near their singing grounds, it is likely that many woodcock remain in the vicinity of the breeding ground from the time of arrival in the spring until departure in the fall. If this is the case then fall band returns should be useful in determining the origin and destination of woodcock. With these data and the

supposition that birds travel somewhat in a direct path from the wintering grounds to the breeding range, the general direction of migration between Louisiana and Michigan is shown in Plate 3.

Other paths of migration must involve other states as indicated by a band recovery in Georgia from a woodcock banded in Antrim County, Michigan. This bird lived almost two years; so it is probable that it had made one return trip to Michigan between the banding and recovery dates. That woodcock frequently return to the same area each year was demonstrated by banding operations. Several male birds were re-trapped on the same singing ground three years in a row. Other workers found that male woodcock frequently returned to the same singing ground or to that vicinity (Mendall and Aldous, 1943, and Sheldon, 1953).

Time of Migration. The time of the major movement of woodcock from their wintering grounds is probably during February although records in the literature are scarce. Knight (1946), in an article which was based on information gathered by others, mentioned that before two-thirds of February is gone most of the woodcock have departed from the wintering grounds. Glasgow, of Louisiana State University, is planning to publish a manuscript soon regarding the migration of woodcock (personal letter).

Woodcock arrive in Michigan at various times depending on the part of the state under consideration. The Lower Peninsula is approximately 290 miles long. Usually much of the northern half of this area is still under snow when woodcock first reach the southern half. Most of the Upper Peninsula is still farther north and has a

Table 1. Banding records concerning woodcock banded or recovered in Michigan

Band No.	Banding Data Age	Sex	Date	Location	Retake Data Date	Location
024 53673	-	M	4/11/37	Racine, Wisc.	12/26/40	Big Rapids, Mich.
				"Louisiana"		
373 40925	-	-	1/12/39	Lottie	10/27/44	Osceola Co., Mich.
493 03575	A	-	1/13/50	Ravenswood	10/11/52	Iosco Co., Mich.
503 01557	A	F	1/ 6/51	Ravenswood	10/18/51	4 mi. SE Mikado, Mich.
503 66437	A	F	12/20/51	Sherburne	10/ /52	Peck Lake, Newaygo Co., Mich.
503 66446	A	-	12/20/51	Lottie	10/25/53	Ortonville, Oakland Co., Mich.
503 66470	A	M	12/20/51	Lottie	10/22/53	Faithorn, Menominee Co., Mich.
503 67886	A	F	12/19/51	Grosse Tete	11/ 3/53	Grand Haven Twshp., Ottawa Co., Mich.
523 31070	A	M	12/29/51	Red Cross	11/ 2/52	Midland Co., Mich.
523 31186	-	F	12/30/51	Lottie	10/21/53	7 mi. E. Clare, Clare Co., Mich.
523 08623	A	F	1/15/52	Ravenswood	10/ 9/52	Ann Arbor, Washtenaw Co., Mich.
523 31289	A	F	1/ 3/52	Sherburne	10/ 3/52	4 mi. E. Alger, Arenac Co., Mich.
523 31393	A	M	1/ 9/52	Ravenswood	10/ 4/53	Au Gres River, Iosco Co., Mich.
523 93083	-	F	12/19/52	Lottie	10/21/54	7 mi. N. Ann Arbor, Washtenaw Co., Mich.
523 94042	-	-	12/ 9/52	Guerin's Grosse Tete	10/ 4/53	Selkirk, Ogemaw Co., Mich.
493 62633	A	F	1/26/52	Lottie	10/20/55	Cheboygan Co., Mich.
533 00122	A	-	1/27/52	Swayzee Lake	10/18/55	Black Lake, Cheboygan Co., Mich.
523 08301	A	-	12/11/53	Brusly	10/ 4/54	1 mi. W. Dighton, Osceola Co., Mich.
523 08468	A	M	12/28/53	Grosse Tete	3/23/54	S. Howell, Livingston Co., Mich.
523 08500	A	-	12/28/53	Grosse Tete	10/28/54	Benzie Co., Mich.
523 08595	A	M	12/29/53	Grosse Tete	4/13/54	Cedarville, Mackinac Co., Mich.
523 94556	-	F	1/23/53	Little Alabama	5/20/53	Riga, Lenawee Co., Mich.
523 94700	-	-	12/28/53	St. Charles Parish	10/30/54	Bay Co., Mich.
523 08927	A	-	1/10/54	Grosse Tete	10/20/54	3 mi. E. Bradley, Allegan Co., Mich.
523 93312	-	-	1/ 9/54	Krotz Springs	10/15/54	NE corner Eaton Co., Mich.
553 35504	A	F	1/22/55	Grosse Tete	10/15/55	Otsego Co., Mich.
				"Michigan"		
493 09702	L	-	5/30/51	Jackson	10/ 6/51	Jackson, Jackson Co., Mich.
513 96901	L	-	5/10/53	Alba, Antrim Co.	2/19/55	Barnesville, Lamar Co., Georgia
513 96910	A	M	5/20/55	Shiawassee Co.	11/ 7/55	Rose Lake Exp. Sta., Shiawassee Co., Mich.
523 33507	-	M	7/ 7/55	Cheboygan Co.	10/18/55	Elk Hill, Otsego Co., Mich.
523 33519	-	M	8/ 4/55	Cheboygan Co.	11/ 2/55	CCC Camp, Cheboygan Co., Mich.
523 33547	-	F	9/ 5/55	Otsego Co.	10/ 3/55	Elk Hill, Otsego Co., Mich.
523 33549	-	M	9/28/55	Otsego Co.	10/ 5/55	Tin Bridge, Cheboygan Co., Mich.
553 38002	A	M	4/28/55	Otsego Co.	10/21/55	Pigeon River Sta., Otsego Co., Mich.
523 33515	-	M	7/29/55	Cheboygan Co.	10/ 2/55	12 mi. E. Wolverine, Cheboygan Co., Mich.

PLATE 3

Relationship between banding and recovery sites of 29 woodcock, with postulated paths of migration.

correspondingly longer winter. Woodcock may not reach parts of that area until mid-spring.

The earliest arrival date in Michigan recorded recently was for Kalamazoo. Here a cooperator (Mrs. Gladys Hall) observed one on February 28, 1955. For the Lansing area, March 9, 1955, has been the earliest date of arrival observed recently (Victor Janson, Department of Conservation). Eugene Kenaga observed woodcock on March 24, 1948, and March 27, 1953, near Midland. Lawrence Ryel, game biologist at the Ogemaw State Game Refuge, reported woodcock in Roscommon County during the latter part of March, 1955. In 1954 and 1955 woodcock were observed during the first week of April at the Pigeon River area. No recent records are available for the Upper Peninsula.

Older records show that first arrival dates have continued to be about the same through the years. Gibbs (1885) in discussing birds of the Kalamazoo area mentioned that woodcock usually appeared in early March but often arrived in late February. According to Cook (1893), the birds were common from March, rarely February, to October or November. The earliest date of arrival at Petersburg was March 2, 1887, and the average was March 17 (Cooke, 1912). In reviewing past works, Bent (1927) found that woodcock had been recorded as early as March 9 at Battle Creek and March 17 at Ann Arbor. Pettingill (1936), through literature review and questionnaires, found that woodcock had arrived at Ann Arbor by March 2, 1918, and Blaney Park, Schoolcraft County, by April 5, 1931.

Although the average arrival of woodcock at the Rose Lake Experiment Station during the past three years has been March 12, the

last evident flights have been three or four weeks later. In 1953, the last flight passed before singing ground routes were started on April 20 (Figure 1). The data for 1954 (Figure 2) did not show any definite migration peaks but the greatest number of occupied singing grounds occurred between April 14 and 22. The route was not run prior to April 3, but one or more flights may have passed through earlier inasmuch as observations at two sites in the Rose Lake area on March 22, 1954, showed three or more birds present at each place.

In 1955 the Rose Lake route was run earlier in the spring and more frequently than in 1954. The fluctuations in number of occupied singing grounds (Figure 3) indicated migrants were passing through the area up to mid-April. The last peak apparently occurred about April 13, which would correspond to the postulated peak for 1953 and 1954.

The Gratiot-Saginaw route was run fewer times and many migrants could have been missed. In 1953 one flight of spring migrants seemed to be present when the singing-ground counts were started on April 11 (Figure 1). Since another count was not made until April 19, a possible flight may have passed unnoticed. About the same may be said for the 1954 route (Figure 2). Since only three counts were made during the migration period, the true migration pattern is probably not shown by the available data. Migrants may have passed through prior to April 9 when the route was first run or before April 23 when the next count was taken.

Data for 1955 revealed a clearer picture of the possible migration routine. The Gratiot-Saginaw route was run only a few times but

the observer happened to be in the right place at the right time. On April 16 and May 1, 19 active woodcock were counted while only 11 were heard on April 23 (Figure 3). A study of these counts might leave the impression that two waves of migrants passed through the area. However, May 1 is past the normal migration period for Region III and the low count on April 23 probably resulted from high wind conditions which prevented the observer from hearing all active woodcock. On the basis of the above data and explanation the birds counted on April 16 could not be considered as migrants. And yet, on the evening of the 16th it was evident that migrants were present in large numbers. While the route was being traversed woodcock were seen flying across and sitting in the road. Some of these birds may have been local females, but at no other time did such a large number of woodcock appear as on that evening. At least 31 woodcock were seen or heard along the route.

As a result of the above observations it is believed that for the two areas discussed the regularly-used singing grounds were occupied throughout much of the migratory period. As this period of migration progressed, some singing grounds were established as permanent breeding areas by residents while other sites were used as temporary grounds by migrants. Consequently, some woodcock moved in and stayed while others moved on, thus giving the impression of successive waves of spring migrants with the last wave usually being the greatest. By the time the last flight came through, most of the regularly-used grounds were taken so that the count made on April 16, 1955, included most of the residents plus some migrants.

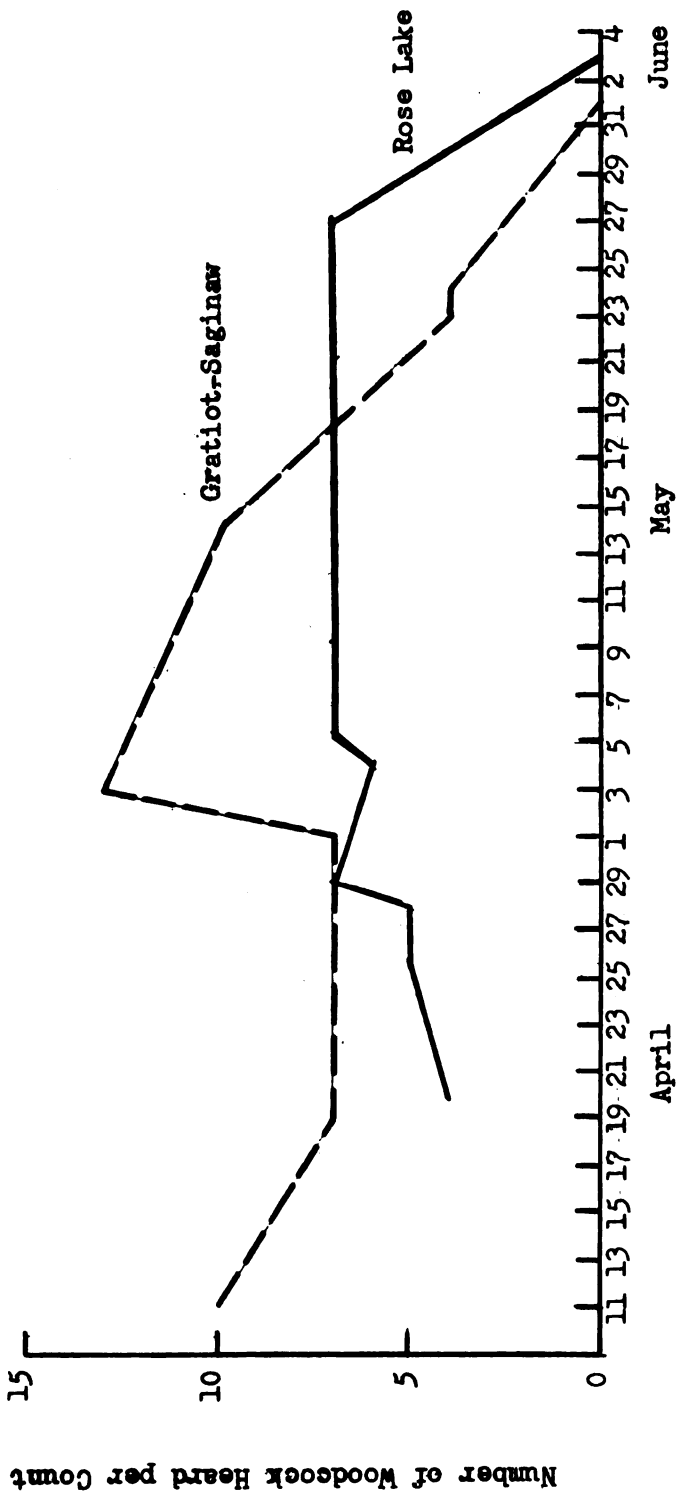


Figure 1. Fluctuations in the number of active males on the Rose Lake and Gratiot-Saginaw routes - 1953.

Figure 2. Fluctuations in the number of active males on the Rose Lake and Gratiot-Saginaw routes - 1954.

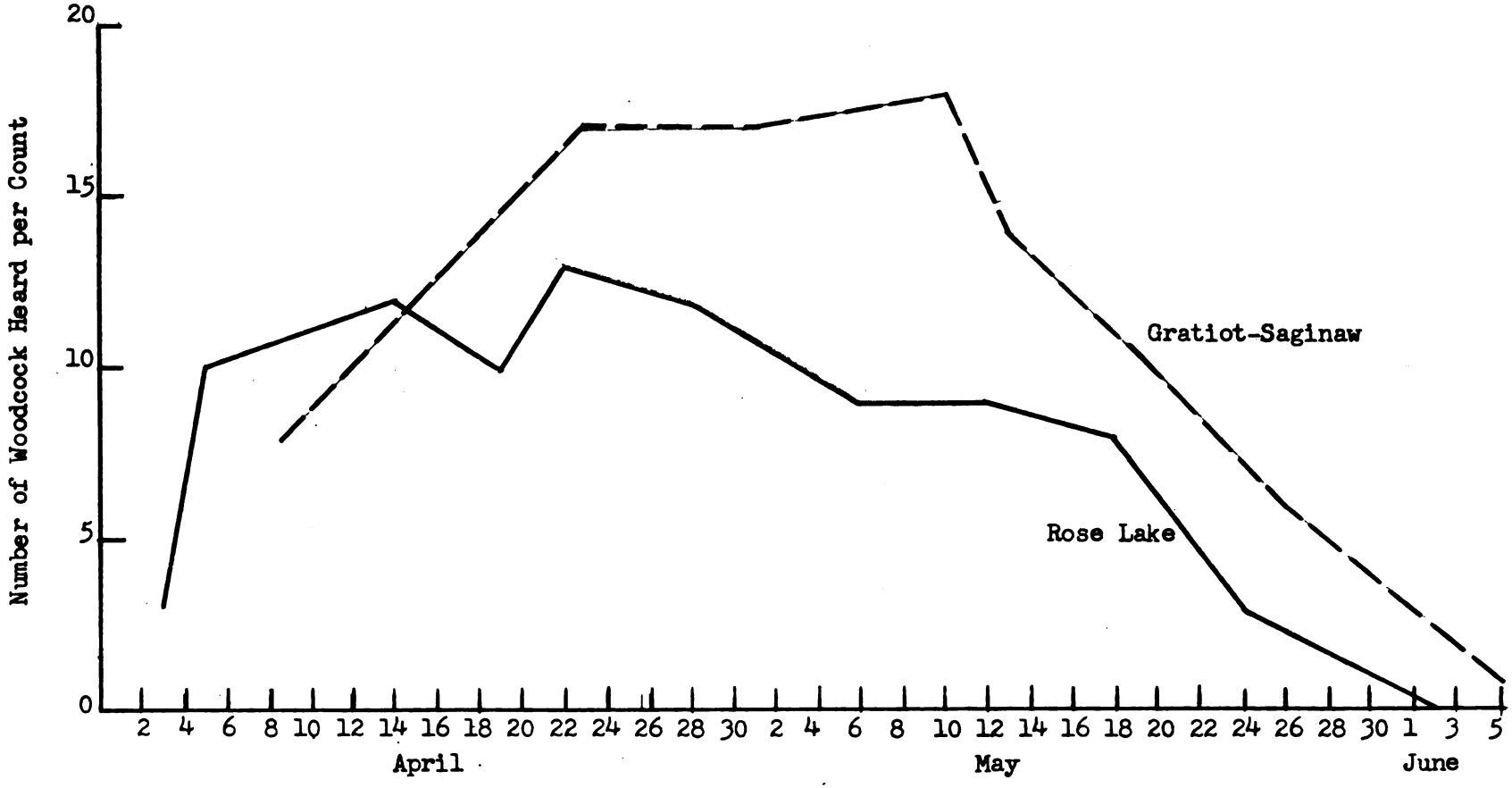
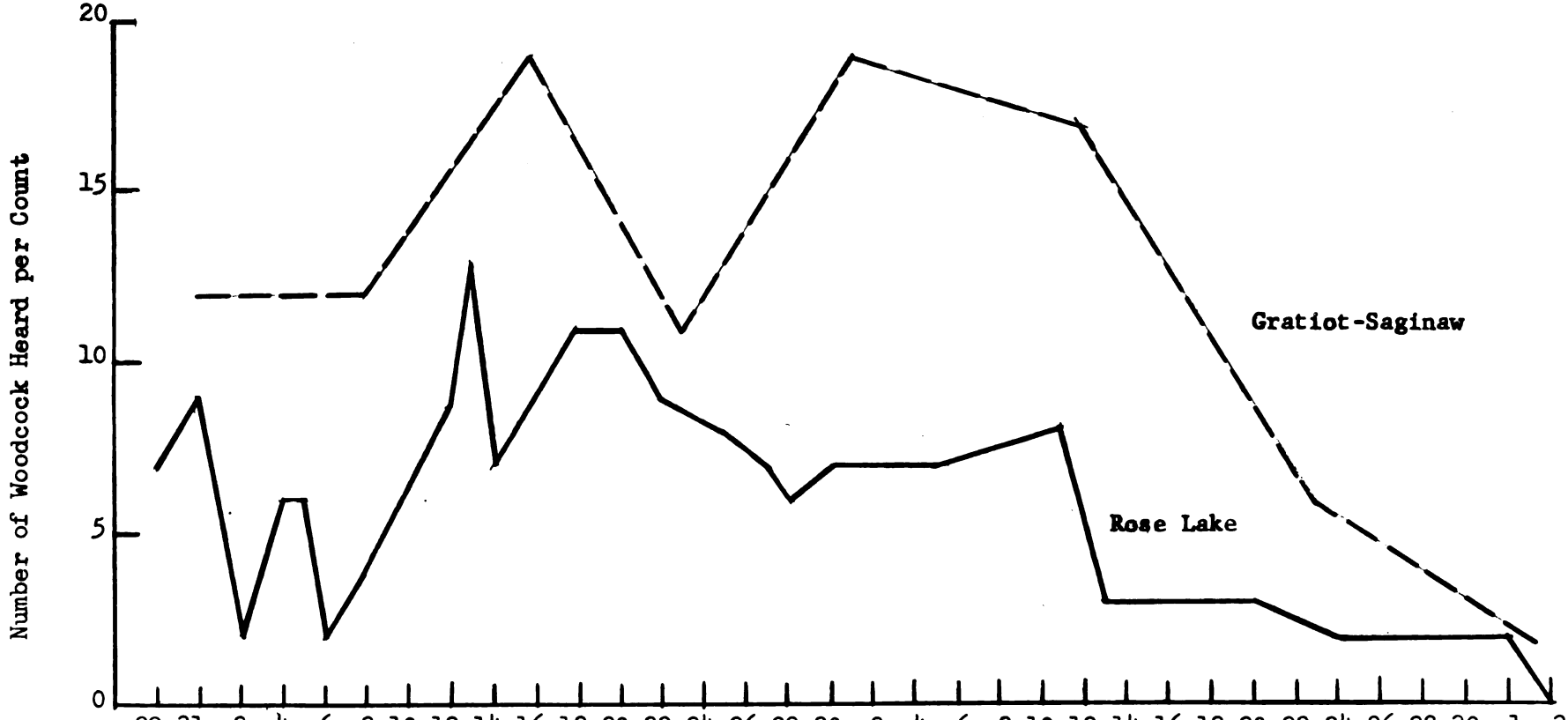


Figure 3. Fluctuations in the number of active males on the Rose Lake and Gratiot-Saginaw routes - 1955.



Summer.

In late spring and early summer, woodcock apparently began to move from the typical breeding sites into moister situations. Dry, open sites frequently used for singing grounds were no longer occupied by the birds and the adjoining edges commonly used for diurnal coverts often were abandoned. Also, since many moist areas became restricted, woodcock had to concentrate nearer to more permanent wet sites such as stream bottoms. Often the hillsides overlooking such areas were used during the day.

Woodcock seem to remain in or near these more permanent sites of moist soil throughout most of the summer. If the summer has plentiful precipitation, the woodcock are more dispersed.

In late summer there was some indication of a complete population movement from certain locations. On several occasions during August, 1955, in the West McMaster Creek area of Cheboygan County, as many as 15 woodcock were flushed in 30 minutes. In the same month and area, 12 woodcock were banded. But after September 1, no woodcock could be found in the area. The birds had moved but their new location could not be determined. Reports were received of an increase in numbers of birds near Atlanta during the week ending September 3. At the same time an increase in woodcock was reported in southern Otsego County near Crapo Lake. Similar instances of woodcock movements will be more fully discussed in the following section.

Fall.

Pre-season movements. This period included the 30 days preceding

the October 1 opening of the woodcock hunting season in Regions I and II. Most of the information gathered was based on daily field observations.

The movements observed in parts of Cheboygan, Otsego, and Montmorency counties were mentioned above.

Another definite record of a large number of woodcock, seemingly on the move in September, was turned in by a member of the Department of Conservation who saw 100 woodcock one evening on a road in Ontonagon County (western part of Region I).

On September 28, David Arnold, District Game Supervisor at Escanaba, with an observer, flushed 15 woodcock in 1½ hours on a special study area. This was the peak for that location during the fall season. The greatest number of birds seen thereafter was 7 in 1 3/4 hours.

It is not known whether these movements were definite southward migrations or local wanderings. The population fluctuations noted around September 1 in Region II could have been a southward migration since the number of woodcock seemed to decrease in southern Cheboygan County but increased southward in the vicinity of Atlanta and Crapo Lake. If this viewpoint is taken, it is difficult to account for one woodcock which was banded at West McMaster Creek in August, 1955, and shot November 2, 2½ miles due south. Soil moisture never became a critical factor for the presence of woodcock at West McMaster Creek since a beaver pond maintained a high soil water table. Food could have been the important factor at that site since the earthworm population was small.

Another cause for movement, especially in the Region II area being discussed, could have been the weather. August had been generally hot and dry, but a frost occurred on September 1, followed by a few cool days. The sudden change could have caused the population fluctuations in the West McMaster Creek area; similar weather conditions may have been effective at other sites. However, woodcock were present in many other areas checked regularly in the Pigeon River area of Otsego and Cheboygan counties.

There is a theory that woodcock may move north before finally heading south. This could be, but if they do it seems likely that they return via the same route, since seven banded woodcock were recovered in 1955 in the vicinity of banding. Mendall and Aldous (1943) had banding records which showed a preseasonal movement of woodcock northward as far as 40 miles.

Regardless of why woodcock move and where they go when they do move, some areas become empty of woodcock during September while other sites have an increase in population.

Hunting season movements. The movements discussed in this section refer to those which took place during the hunting season. This season lasted from October 1 to November 1 in Region I, from October 1 to November 9 in Region II, and from October 20 to November 9 in Region III. The major emphasis was placed upon data from Regions I and II. Methods of studying these movements included:

(1) Splashing counts

(2) Area observations at Pigeon River

(3) Daily observations by woodcock observers

(4) Records from game bird hunters

(5) Banding operations

Splashing counts were undertaken to determine whether such counts were feasible as an indication of migration (splashings are chalky-colored fecal droppings of woodcock). The plan was to set up several plots in different areas and to check these plots regularly for evidence of splashings. It was hoped, if splashings did indicate a population fluctuation, a method for determining dates of migration could be devised for use by field personnel.

This method was started during the fall of 1953 when plots were set up in two different localities in the Rifle River and Pigeon River areas. The localities were chosen on the basis of known previous use by woodcock. The plots were one-hundredth acre in size. Five were set up in each of two areas located along Rifle River, six plots were located at Tin Bridge (Pigeon River Area), and eight plots were set up near the Pigeon River Experiment Station. Upon each visit to the plots, splashings were counted and erased. In addition, notes were taken on the number of woodcock seen on and off the plots, the number of splashings near plots, and weather conditions. These plots were checked only on weekends in 1953.

In 1954, plots at the Rifle River Area were dropped and efforts were concentrated in the vicinity of the Pigeon River Experiment Station. Only two areas (Tin Bridge and Experiment Station Flats) used in 1953 were used again, and the number of quadrats was reduced to four for each area because of time limitations. However, since fall headquarters for the project was at the Pigeon River Station, the

plots were visited more frequently. The same type of data as was recorded in 1953 was gathered.

The same procedure was followed in 1955 except that three areas were used. Besides the Tin Bridge site which was the only old locality retained, two new areas were set up, at West McMaster Creek and the Old Grant School. All three sites were located in southeastern Cheboygan County (Plate 4). Ten plots were set up in each location. These plots were checked frequently throughout the fall, and again the same type of information was taken.

In addition, another method of observing splashings was undertaken in 1955. This method was a line transect projected through each of the three sites discussed above. Splashings were counted on a strip covering five feet on each side of the line.

The data for 1953 were not used as much as later information in an analysis of population fluctuations since the areas were visited only on weekends and consequently often represented a week's accumulation of splashes. Therefore, data from the 1954 and 1955 seasons (Table 2) were used to determine the population fluctuations. In 1954 the areas were visited more frequently than in 1955 and the amount of time spent on the areas was less in 1955 because more plots and transects were involved and other phases of study were started. However, data from the fall of 1955 were as reliable as those of 1954 since at each check both old and new splashings were counted and the age of splashings considered. Moisture was considered since it hastens the deterioration of splashings. However, moisture did not eliminate any splashings before they were counted.

The 1954 data regarding splashings correlated more closely with other information regarding times of migration than the 1955 data. A large number of splashings often occurred on the Tin Bridge plots at the same time a peak in actual number of birds occurred in the Pigeon River Area. More often, however, when a peak in the number of woodcock was observed, splashings were not found on any plots.

Little correlation was seen between the number of woodcock flushed and the number of splashings recorded from plots and transects in 1955. Fewer woodcock were seen in the Tin Bridge area than in 1954. The decrease in woodcock in that area may have accounted for the splashings being less indicative of population fluctuations.

Data gathered incidental to regular plots emphasized the necessity of a great number of sample areas and plots and thus the probable impracticality of the method. Specific instances illustrate this conclusion.

On October 1, 1954, at Tin Bridge no splashings were found on the four plots, but eight woodcock were flushed on an acre enclosing two of the same plots. Four days later in the same area no splashings were seen on plots, but 15 were found a few feet from one plot. In 1955, on October 14, only one splashing was found on plots at Grant School while a great number of splashings were found near the plots. At the same time, seven woodcock were flushed in and adjacent to the plot area.

During the three years only eight woodcock were flushed from the quadrats. Two of these birds were flushed in 1953 and the other six were flushed in 1955. Four of the latter woodcock were moved from

PLATE 4

Detailed map of the Pigeon River Area showing the location of study areas and distinguishing landmarks.

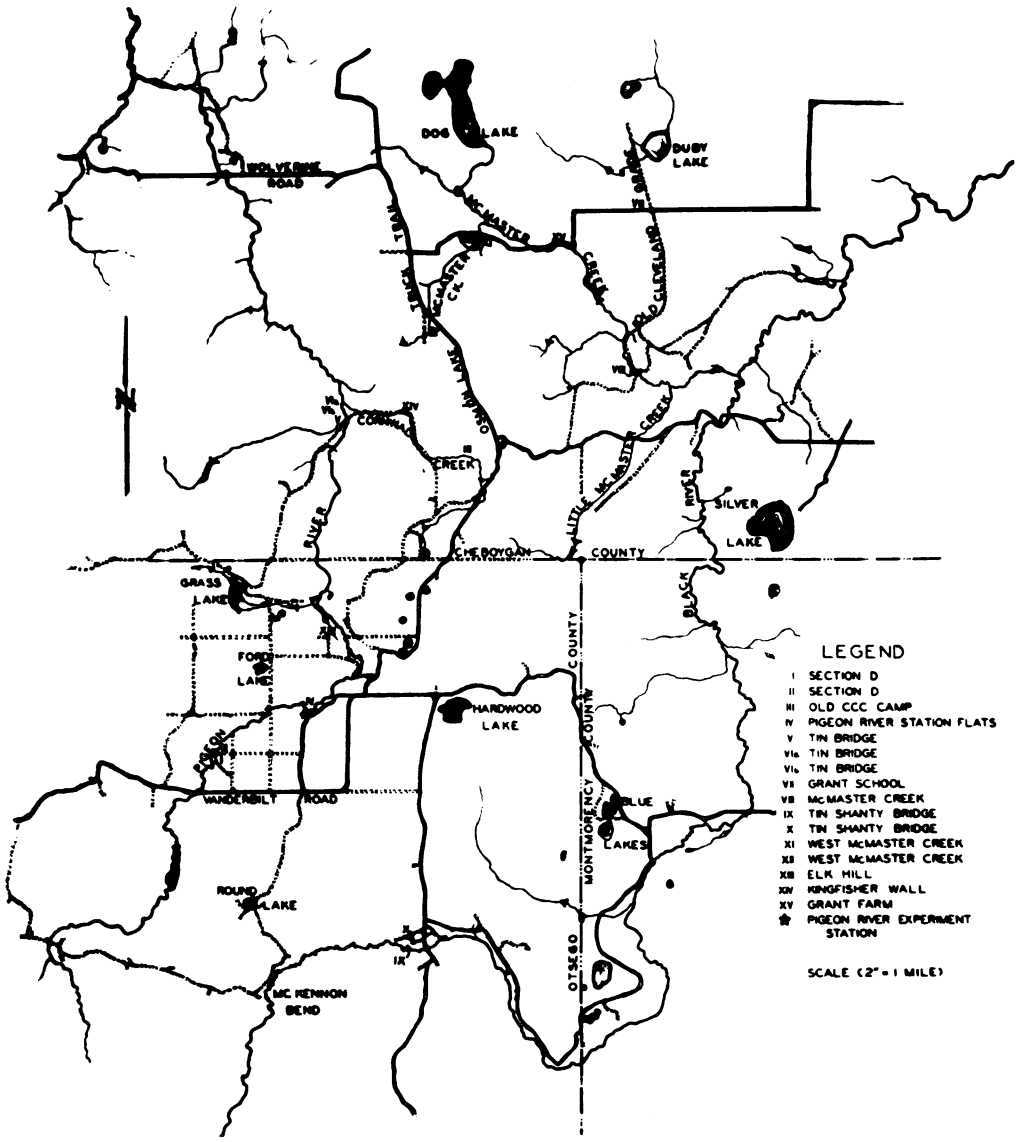

DOG LAKE
DUSTY LAKE
WOLVERINE ROAD
McMASTER CR.
OLD CLEVELAND TRAIL
McMASTER CREEK
OSMUN LAKE
CORWITH CREEK
LITTLE McMASTER CREEK
SILVER LAKE
CHEBOYGAN COUNTY
GRASS LAKE
FORD LAKE
HARDWOOD LAKE
MONTMORENCY COUNTY
BLACK RIVER
VANDERBILT ROAD
BLUE LAKES
ROUND LAKE
McKENNON BEND
OTSEGO
LEGEND
I SECTION D
II SECTION D
III OLD CCC CAMP
IV PIGEON RIVER STATION FLATS
V TIN BRIDGE
Va TIN BRIDGE
Vb TIN BRIDGE
VII GRANT SCHOOL
VIII McMASTER CREEK
IX TIN SHANTY BRIDGE
X TIN SHANTY BRIDGE
XI WEST McMASTER CREEK
XII WEST McMASTER CREEK
XIII ELK HILL
XIV KINGFISHER WALL
XV GRANT FARM
PIGEON RIVER EXPERIMENT STATION
SCALE (2" = 1 MILE)

Table 2. Number of woodcock splashings found per area

Date	1953 Plots			1954 Plots		1955 Plots			1955 Transects		
	Tin Bridge	Pigeon R. Station	Rifle River	Tin Bridge	Pigeon R. Station	Tin Bridge	West McMaster	Grant School	Tin Bridge	West McMaster	Grant School
Sept. 28							5	21	6	1	10
29						12					
30				0							
Oct. 1				0	0	3		7	0		3
2				1	8		0			0	
3	0	6	12	0	0						
4	0	0	0	0	0						
5				0	0	0			0		
6				0	0			8			6
7				0	0		8			1	
8				33	4						
9				16	0	0			0		
10	1	1	33	0	0		0	7		0	0
11	0	0	1	0				0			0
12				1	5			0			0
13				0		5	0		1	0	
14				8	0			1			2
15				2				0			0
16				0							
17	5	0	2	0	0	0			0		
18	5	0	0	7	0	5	9		0	4	
19				0	0			0			0
20				0		0	0	0	0	6	0
21				0							
22				0	0		0	0		0	0
23				0	0						
24	11	1	40	0	0	0			0		
25	0	0	0	0			0	0		0	6
26											
27				0			0	0		0	0
28				0							
29					0						
30							0	11		0	2
31	0	0	0			0			2		

along the transects.

The splash-plot method has not proven worth while as a means of determining migration. The major difficulties involved are: (1) the great number of sample areas and quadrats needed which raises the time, effort, and cost, (2) the variation in use of an area by woodcock from year to year as well as between seasons, and (3) the variation of use within an area.

Another method employed in the Pigeon River Area for determining population fluctuations was the use of bird dogs on special study areas. In 1954, two such areas were set up, one of which was near the Tin Bridge and the other at Kingfisher Wall on Cornwall Creek. The areas were checked primarily in October, the critical period for observations. Record was kept of the number of hours spent in the area and the number of woodcock flushed (not counting reflushes when such could be determined).

Ten study areas were located for the 1955 fall observations. All ten were in southeastern Cheboygan County and northeastern Otsego County. Observations were terminated on November 3 because of a heavy snowfall.

All sites used were known woodcock areas, being used either during preceding falls or the summer just prior to the fall observations.

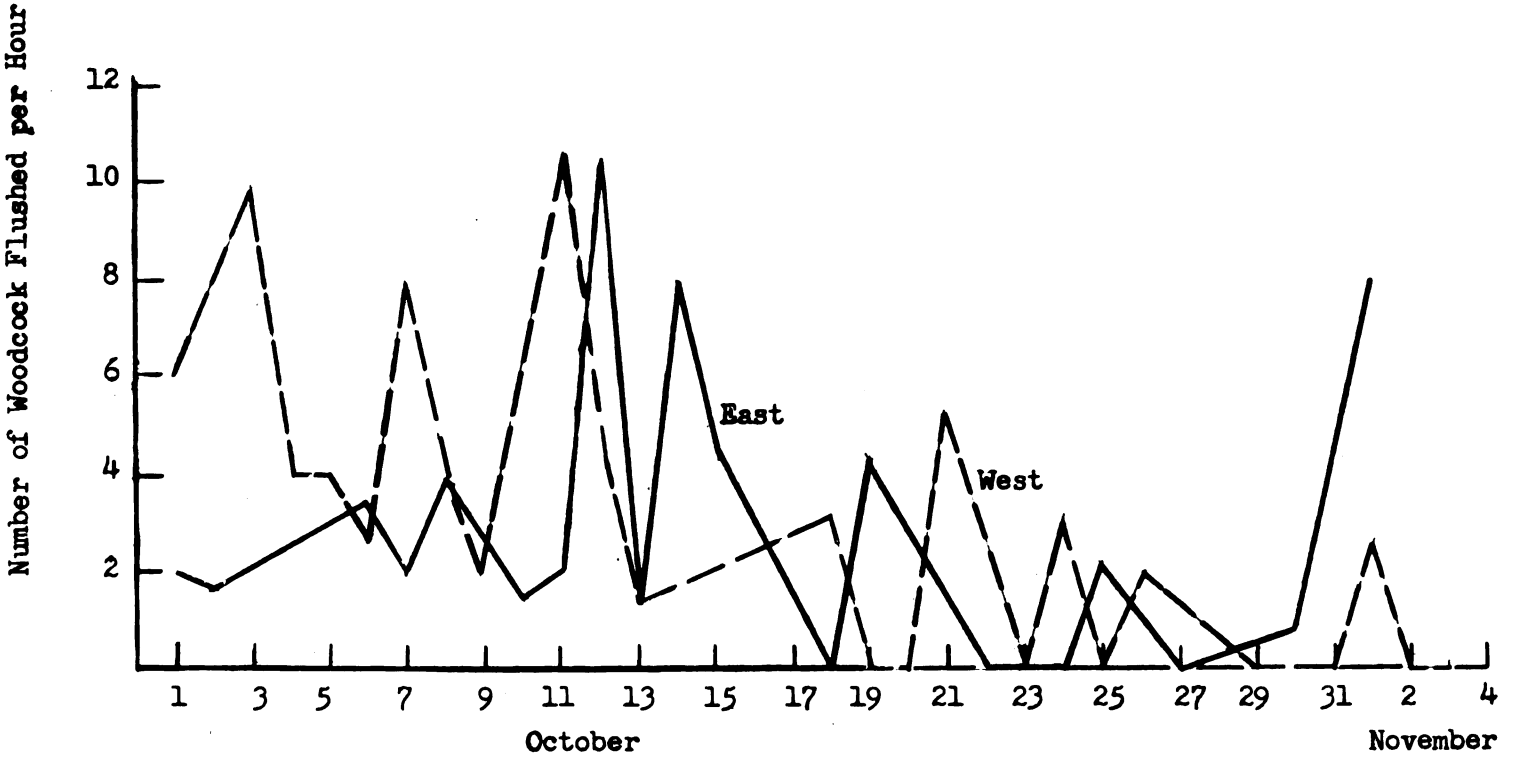
For the Tin Bridge and Kingfisher Wall areas there was a definite time during October when birds were moving. In both years the greatest number of woodcock were found during the first three days of October. Some of these woodcock could have been migrants but it is

likely most of them were residents since both areas harbored high summer populations. The decrease after the first few days of hunting probably was not a result of migration but a result of birds being hunted and consequently killed or dispersed. In both years another increase, though smaller, occurred around October 7. Another peak was on October 12 although the number of woodcock seen was greater in 1954. The next peak for 1954 came on October 19 which was two days later than the next high for 1955. The last prominent increase took place on October 22 in 1954 and October 24 in 1955.

In 1955 the Pigeon River Area was separated into east and west sections. This division was made to determine if the population fluctuated differently between the two sections. The east section was composed of those five areas (Grant School, Grant Farm, Duby Lake, West McMaster Creek, and McMaster Creek) located east of the Osmun Lake Truck Trail. The west section included those sites (Tin Bridge, Kingfisher Wall, Elk Hill, and Pigeon River Station Flats) located west of the truck trail and primarily along the Pigeon River.

Population peaks never occurred at the same time in the two sections although occasionally they nearly coincided (Figure 4). These data indicated woodcock came into one area one time and the other area the next time. An analysis of variance was made to see if any consistent difference existed in the population fluctuations between the two areas. The resulting variance ratio (F) of 0.11 was not significant at the 1 per cent level, indicating no evidence of such consistent differences between times or places.

Figure 4. Population fluctuations as indicated by hunting records from the East and West Divisions of the Pigeon River Area - 1955.



Population peaks were evident when observation records for all of the Pigeon River Area were considered (Figures 5 and 6). The 1954 curve contained records primarily from the two study areas while the 1955 curve was constructed with data from nine study areas mentioned above, plus records from Tin Shanty Bridge. This study area was not included in the east-west division since it would not fit into the separation.

For both years population peaks occurred about the same date, in some cases on the exact date. Such a fluctuation could mean that migratory flights, even though small in numbers, did occur in the Pigeon River Area and that they came about the same date each year. In addition woodcock were present most of the hunting season with the greater part of the migratory population passing through by mid-season. A total of 169 woodcock were seen in the Pigeon River study areas in 1954, and of these, 113 were seen prior to October 20. In 1955, 219 woodcock were seen and 163 of these were seen before October 20. Most of the population in the latter half of the hunting season was represented by one last wave of migrants near the season's end.

Three major difficulties were involved in analyzing data from the Pigeon River Areas. First, low counts on certain dates could have been a result of less time in the field rather than actual population fluctuations. For instance, on October 16, 1954, only 1/4 hour was spent in the field. No woodcock were seen during that brief period but several could have been on the study area visited or at some other site.

Figure 5. Population fluctuations in the Pigeon River Area as indicated by hunting records - 1954.

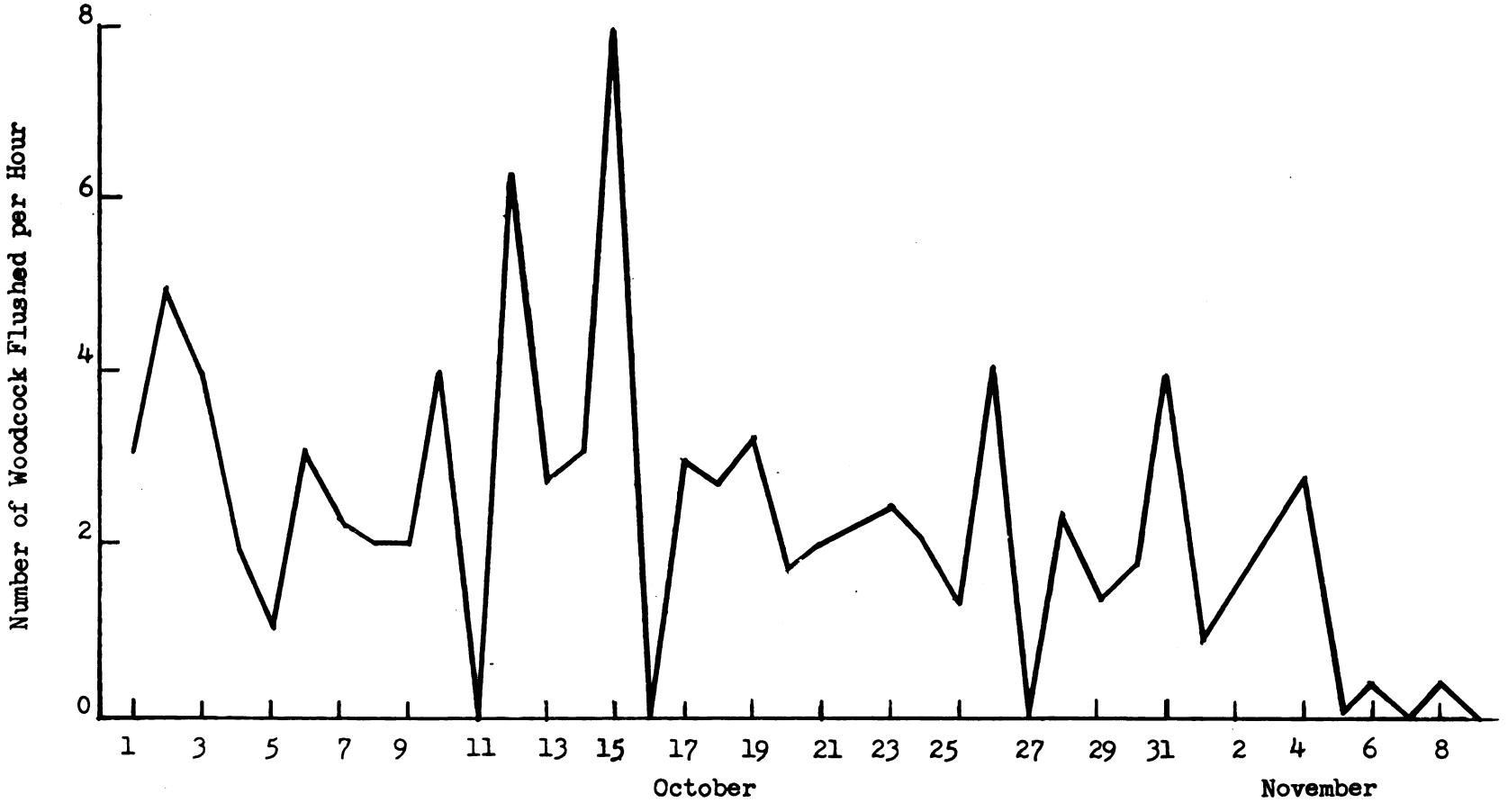
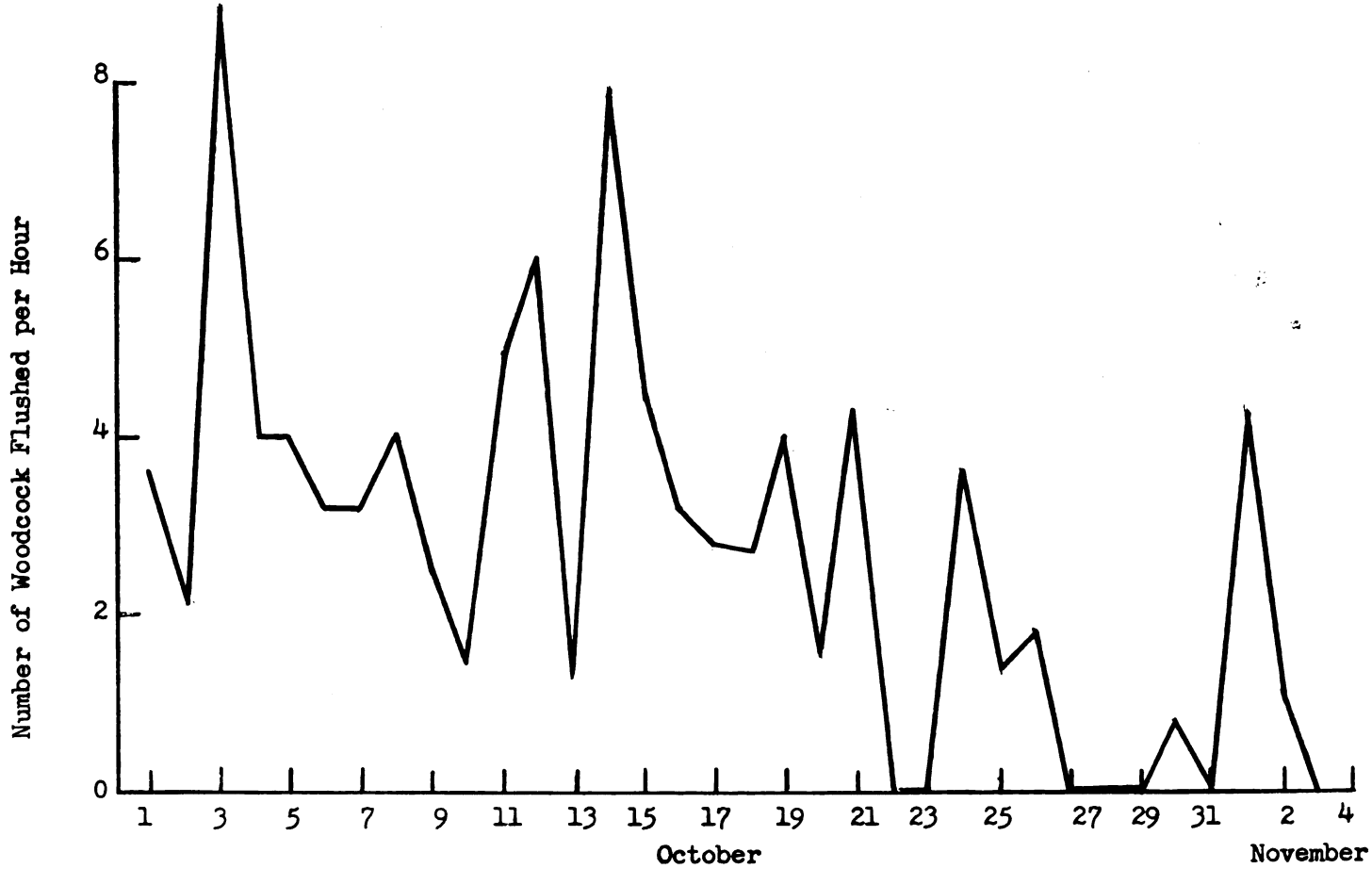


Figure 6. Population fluctuations in the Pigeon River Area as determined by hunting records - 1955.



Another factor was that the number of areas checked varied from day to day. Thus the Pigeon River population may not have fluctuated so consistently if a more systematic method of checking each area had been used.

The third point is that many of the areas often were hunted by other persons. Therefore, observations often were made on a study area after some hunter had passed through.

The third method used for studying population fluctuations involved the assistance of observers located at various points in the Upper Peninsula and at Mackinaw City. These observers were instructed to check special areas several days a week. Some observers spent six days a week on study sites while others averaged every other day. Records were kept of the number of hours spent in the area looking for woodcock, number of woodcock seen, and weather conditions.

The purpose of this method was not only to determine migration times and routes but also to determine if woodcock were moving across Lake Superior from Canada.

In 1954, observations were made at sites near Dunbar, Marquette, Eagle River, Crystal Falls, Escanaba, and Moran in the Upper Peninsula and Mackinaw City in Region II (Plate 2). One area near Marquette and three near Eagle River were chosen with the idea that if any woodcock crossed Lake Superior the population in those areas would show increases. Two sites near Dunbar were used to observe population fluctuations caused by birds moving across the St. Marys River from Canada. The remaining three areas, located in the southern part of the Upper Peninsula, were used to observe fluctuations caused by woodcock moving

out and others moving in from more northern parts of the region.

The single Region II area at Mackinaw City was selected to observe movements in that area in relation to the other areas. Since Mackinaw City is located on the south side of the Mackinac Straits where two land masses are separated by a narrow stretch of water (five miles), the area was considered a good place to check woodcock movements.

In 1955, observation areas were set up in the general locations used the previous fall. However, the study areas near Dunbar were moved closer to Sault Ste. Marie and a new location was chosen near Paradise. Two observation areas each were set up near Sault Ste. Marie, Marquette, Crystal Falls, Escanaba, and Mackinaw City while three such areas each were set up at Paradise, Eagle River, and Moran.

Only a few birds were seen at any one time in the northern Upper Peninsula observation areas. Small increases in number of woodcock seen from one day to another could have been a result of birds moving across Lake Superior but more likely the increases represented woodcock moving in from adjacent areas. Mac Frimodig, Manager of Fort Wilkins State Park in Keweenaw County, reported that he normally flushed five or six woodcock near the park during the course of a hunting season, but that in 1954 no woodcock were flushed by him and five other hunters hunting in the area.

Definite records exist of woodcock crossing Lake Superior from the direction of Isle Royale. Davis J. Smith, a worker on a Great Lakes ore boat, found two dead woodcock on the boat during the latter part of April, 1950. The boat was about half-way between Isle Royale and the Keweenaw Peninsula. Two woodcock landed on the boat in

mid-October, 1951, near the same location. These woodcock could have been residents on the island since breeding birds have been found there. Other woodcock possibly moved into the Upper Peninsula from Canada, but it seems doubtful that the numbers were great.

Data gathered on study areas near Sault Ste. Marie did not indicate that birds were moving in from Canada. But since there was a large breeding population in the Algoma District of Ontario in 1955, many woodcock probably entered Michigan from that area. These woodcock probably accounted for the large populations often recorded near the Straits of Mackinac.

Population peaks were evident at Moran and Mackinaw City probably because this area served as a funnel and received migrants from parts of the Upper Peninsula farther north and from Canada. Increases in woodcock numbers occurred about the same time for both places, indicating that woodcock were coming into the Straits area in large numbers and dispersing rather generally.

Data gathered from observation areas located in the southern part of Region I could not be correlated with the northern part, except that occasionally a decrease in the woodcock population on the Marquette areas was followed by an increase in the population on study areas near Escanaba.

The length of time when woodcock were present was greater in 1955 than in 1954. Except for one large peak in the Mackinac Straits area between October 26 and 29 most birds deserted the observation areas by October 20 in 1954. Birds were observed on the last checking date on many areas in 1955, but most woodcock were seen before October 20.

Records from woodcock hunters were collected and analyzed to determine population fluctuations. Two sets of records are represented. One set includes information received from hunters who at times hunted only woodcock, while the second set came from hunters who were requested to check a favorite hunting spot at least three times a week. Hunters who gathered the first set of records were part of a group of sportsmen chosen to keep records of all their gamebird hunting activities, but were requested to keep separate the hours which were spent in woodcock cover.

Few hunters looked for woodcock or kept separate records; hence, the area covered and the number of hours represented were not very large. Figures 7 and 8 show results obtained for the three regions. There is little correlation between the different regions in regard to number of birds and time of flights. In 1954 some woodcock were still present in Region II at the end of hunting season. There was little day-to-day fluctuation for the region even though extreme local population fluctuations occurred.

The 1955 data for Region II showed much the same variation except that the population definitely decreased after October 24. The fluctuations could have resulted from a lack of data on certain dates, or from local variations.

In Region I, the data indicated that woodcock population fluctuations were prominent; however, the peak on October 15, 1955, was the result of one hunter's observations. Only 45 minutes were spent in one location near the Straits. Data from two hunters accounted for the peak on October 21, 1955. Thus the records indicated local more

Figure 7. Population fluctuations as determined by records from woodcock hunter cooperators - 1954.

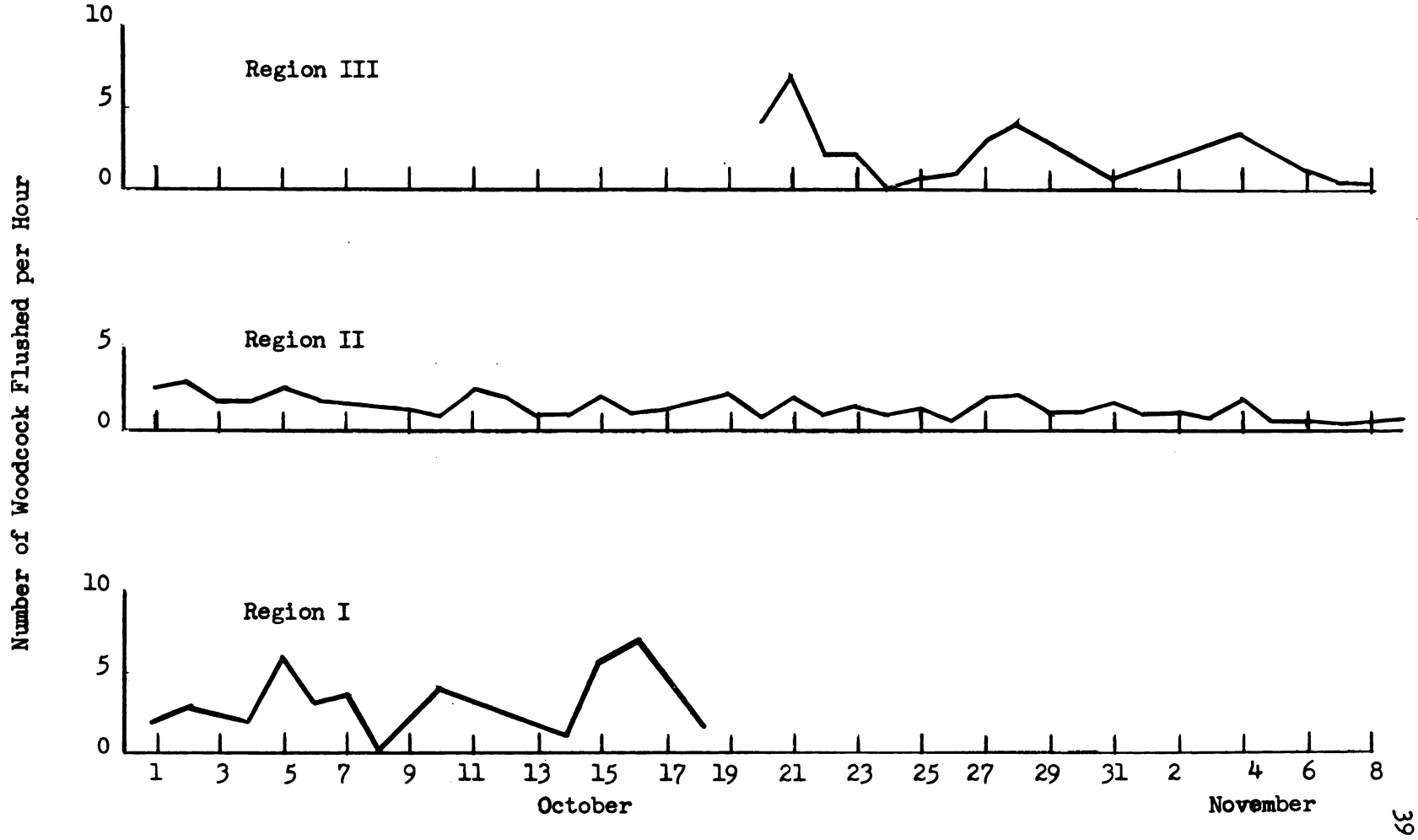
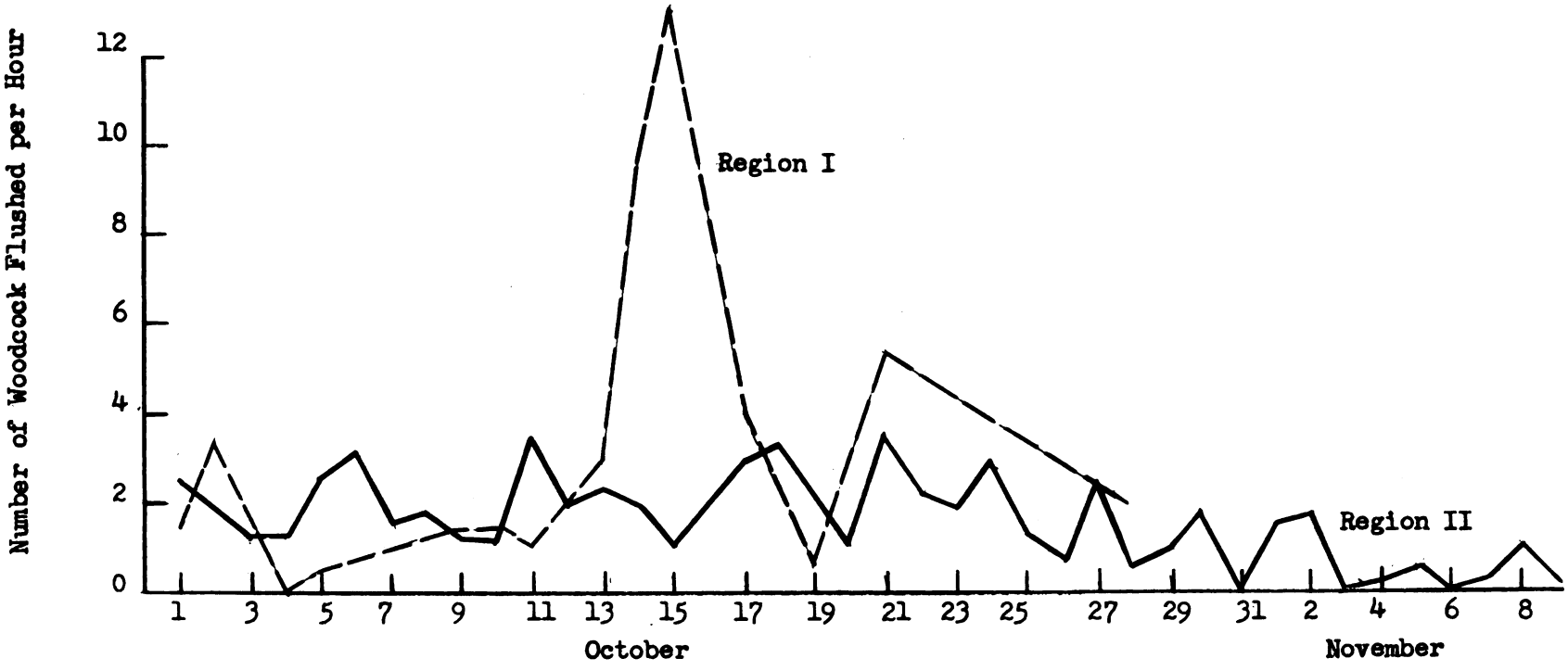


Figure 8. Populations fluctuations as determined by records from woodcock hunter cooperators - 1955.



than regional population fluctuations.

There was a high woodcock population in many locations on opening day of hunting season in Region III. This was noticeable on the southern game areas where much of the hunting took place. The population curve (Figure 7) for 1954 showed the highest peak at the beginning of the season. On opening day, one hunter reported 20 woodcock flushed in 1½ hours in the Gratiot-Saginaw Game Area. This area had a high breeding population in 1954 and possibly the birds had concentrated in the site which was hunted; however, only a few splashings were observed, indicating that most birds had just moved into the area.

Hunter reports in 1955 indicated a high population near the opening day. In the Deford Game Area, 36 woodcock were killed for 719.5 hours in the field. This population was not large for the amount of hours recorded; however, hunters were after all types of small game. At no other time during the season was a comparable ratio obtained.

Woodcock were present in Region III throughout the season. On October 25, one hunter flushed 14 woodcock in 3 1/4 hours in the Stanton Game Area. On November 9, 16 woodcock were flushed in 2 hours from approximately three acres in the Waterloo Game Area.

When records from the hunters who were checking favorite spots were analyzed, definite trends in the woodcock population were noted (Figure 9). The 1954 reports showed major fluctuations occurring during the first half of the season. Also, the trend of the population size was downward from the first part of the season. In 1955, the reports indicated the main fluctuations occurred about mid-season.

In a further attempt to determine if hunting records could be used as an indication of woodcock migration, reports received from game bird hunters were analyzed. The report forms, which included places to record counties, dates, different species seen, and species bagged, had been mailed to approximately 100 hunters prior to the 1954 and 1955 fall seasons.

Population fluctuations were evident for both years in Regions I and II. These records showed that the number of woodcock flushed per hour remained comparatively high throughout the season in both regions, particularly Region II where most of the data were collected. Two major peaks occurred in Region I and four in Region II (Figure 10).

Population peaks were more evident in data gathered for 1955. Three major peaks were noticed in the Upper Peninsula, while several population highs occurred in Region II (Figure 11). The number of woodcock flushed per hour varied between one and two birds most of the season indicating a rather constant woodcock population for the region.

There was an alternating population fluctuation between the two regions in 1955; that is, a population peak in Region I usually preceded a peak in Region II. The similarity was less pronounced for the 1954 data.

A final criterion for studying fall migration concerned band returns. Different methods were involved in capturing woodcock (Table 3). Most woodcock caught during the spring were taken by a singing-ground decoy trap patterned after one used in Massachusetts by Sheldon (1955). This trap was set for both evening and morning flights. Normally, two traps were set on the same singing ground

Figure 9. Population fluctuations as determined from reports of woodcock hunters checking favorite hunting spots.

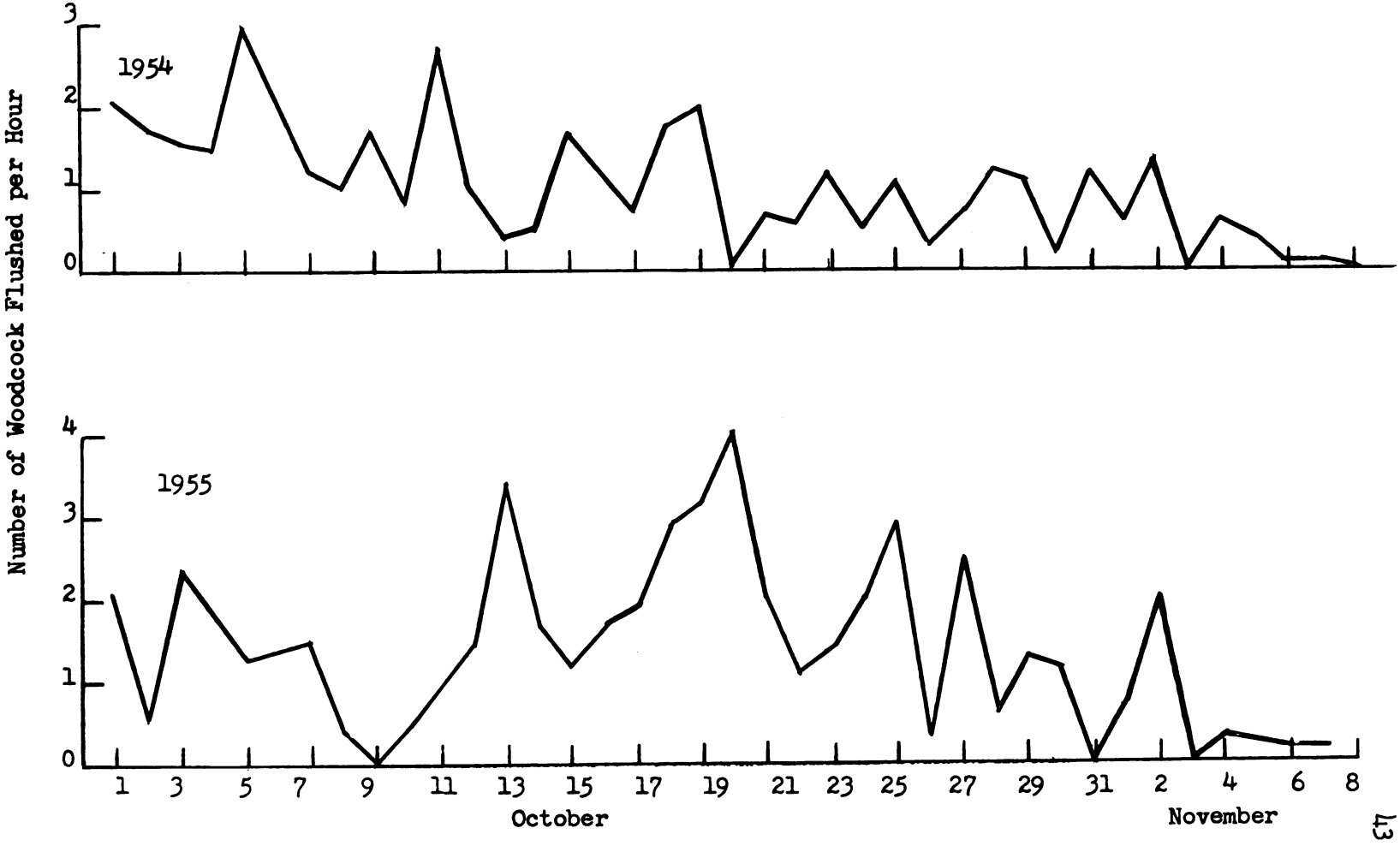


Figure 10. Population fluctuations as determined from records of game bird hunter cooperators - 1954.

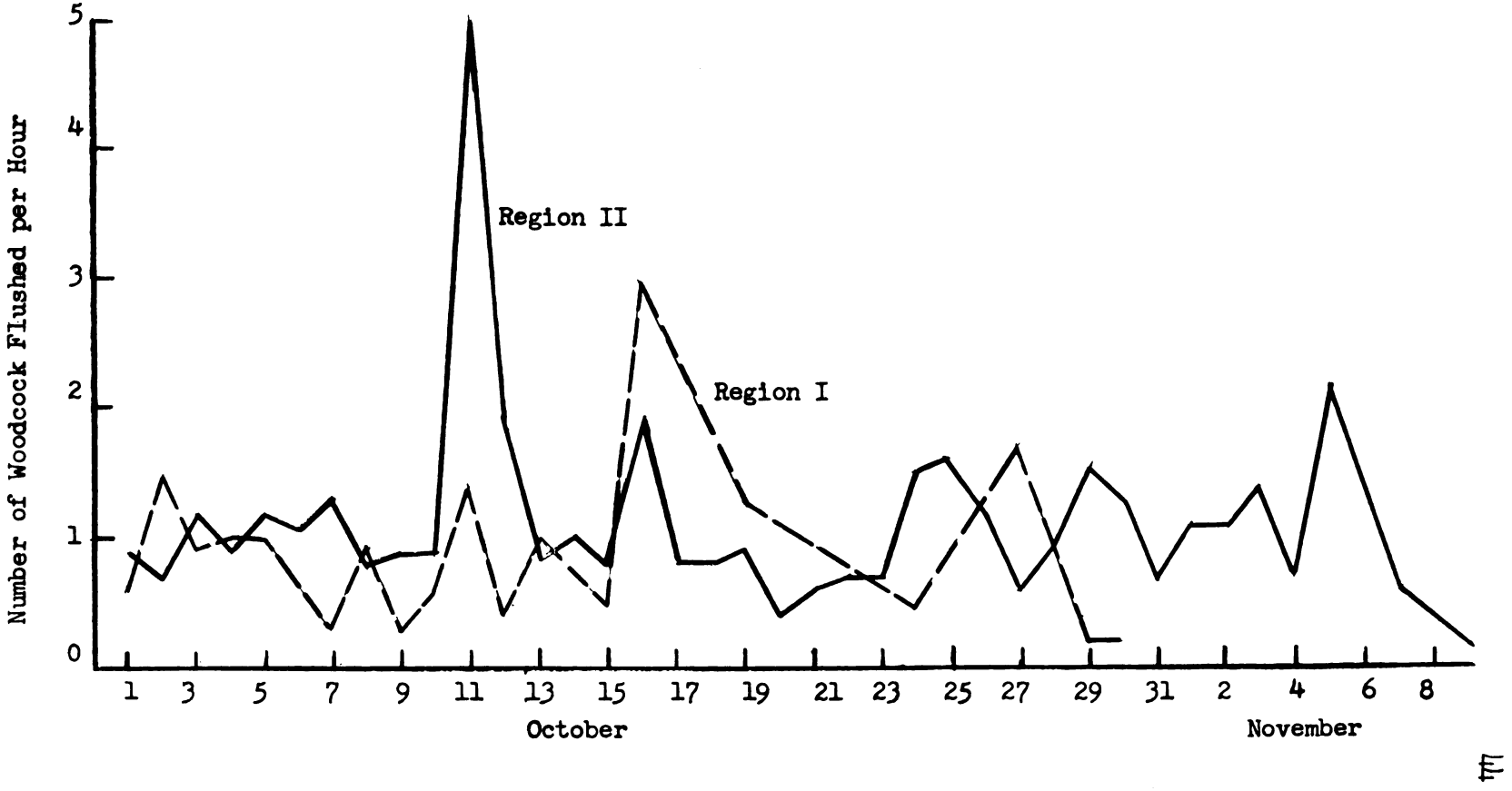


Figure 11. Population fluctuations as determined from records of game bird hunter cooperators - 1955.

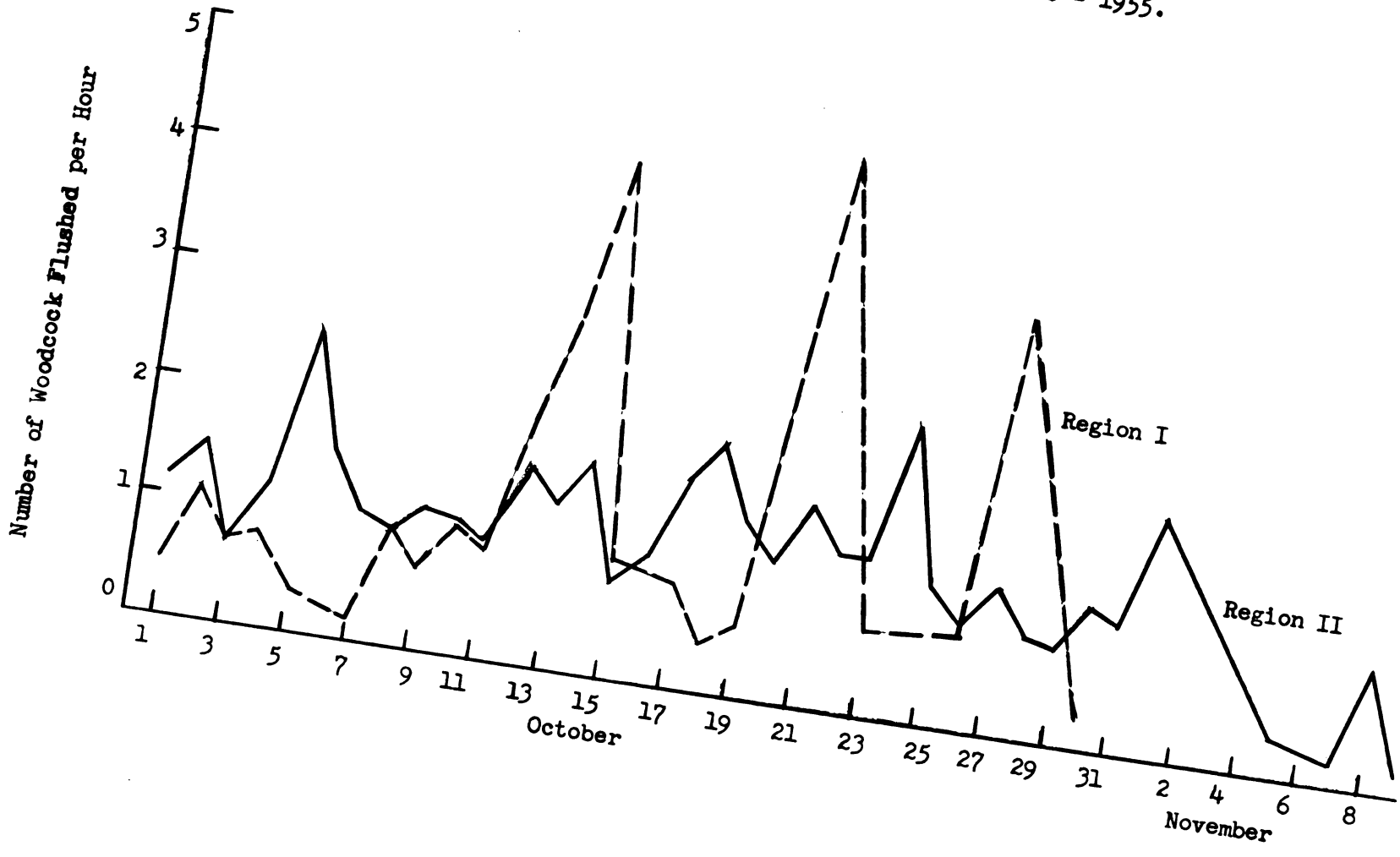


Table 3. Number of woodcock caught by various methods used in banding operations.

Year	Methods					
	Decoy Trap	Hand Net	Chicks	Mist Net	Clover-leaf Trap	Totals
1953			3			3
1954	7	3	2		4	16
1955	8		4	14	20	46
Totals	15	3	9	14	24	65

Table 4. Banding and recovery records showing the extent of travel and the tendency of some resident woodcock to remain late in the fall.

	Banding Records		Banding Returns	
Band No.	Date	Location	Date	Location
513-96901	5/10/53	5 mi. N. Alba, Antrim Co.	2/19/55	Barnesville, Ga.
553-38002	4/28/55	Pigeon River Exp. Sta., Otsego Co.	10/21/55	Pigeon River Exp. Station
513-96910	5/20/55	Rose Lake Wild. Exp.Sta., Clinton Co.	11/ 7/55	Rose Lake Exp. Station
523-33507	7/ 7/55	Tin Bridge (Pigeon R.), Cheboygan Co.	10/18/55	Elk Hill, Otsego Co.
523-33515	7/29/55	Old Grant School, Cheboygan Co.	10/ 2/55	Old Grant School, Cheboygan Co.
523-33519	8/ 4/55	W. McMaster Creek, Cheboygan Co.	11/ 2/55	Old CCC Camp, Cheboygan Co.
523-33547	9/ 5/55	Elk Hill, Otsego Co.	10/ 3/55	Elk Hill
523-33549	9/28/55	Elk Hill, Otsego Co.	10/ 5/55	Tin Bridge, Cheboygan Co.

(Plate 5). In the evenings, a painted plastic decoy (Plate 6) was set on one trap while the other remained blind (without a decoy). For morning flights both traps were left blind. The blind traps set for morning flights proved most successful, especially those traps which had held a decoy on the preceding evening. Perhaps woodcock were caught more often on these blind traps because the performing male "remembered" the decoy being there. It can not be said that the traps were successful because they were set on the main performing spots; on the contrary, they usually were set to one side. Apparently more woodcock were caught in the morning since the traps seemed better hidden when activity was beginning at a period of decreasing darkness.

Another method of catching breeding birds was the mist net. At first, regular Japanese mist nets of one-inch square mesh were used but these were unsuccessful. Eventually, a net was constructed which was successful for the few times used on singing grounds. This net was nylon gill netting of 2½-to three-inch stretched mesh constructed as a mist net and dyed black. To capture a woodcock the net was stretched vertically along the edge of a singing ground on the windward side.

A long-handled net (12-foot bamboo pole) and a six-volt headlight were used several times but their success was limited. Difficulties involved were too much dry vegetation on the "grounds" and the excitability and nervousness of birds during their breeding season.

Several chicks were caught and banded. Most of these were found with the aid of bird dogs, but some were found by systematic searches near singing grounds.

PLATE 5

A. Two decoy traps set on one singing ground at the Rose Lake Experiment Station. Both traps were set blind for the morning flight and each trap caught a woodcock.

B. A close-up of one of the above decoy traps showing the male woodcock which was caught.

PLATE 6

A. A singing ground in the Gratiot-Saginaw Game Area on which a woodcock (513-96916) was active three successive years. The bird was attracted once by the plastic decoy shown in the lower picture.

B. A plastic decoy set on a camouflaged trap in the Gratiot-Saginaw Game Area.

During the summer and early fall woodcock nets were used again. The nets were stretched across back trails and streams where birds had been seen flying at dusk (Plate 7). Since the woodcock only flew about 10 to 15 minutes in the evening, nets were erected prior to that time and removed immediately afterwards.

Another method used for taking woodcock in the summer was a clover-leaf trap (Plate 8). Trap specifications were received from Stephen Liscinsky of the Pennsylvania Game Commission. To use this trap feeding or diurnal concentration areas had to be located. Once an area was found, the trap was set and either two or three leads were erected (Plate 9). Traps were checked each morning and occasionally in late afternoon.

Band returns indicated that some woodcock stayed most of the fall season (Table 4). Since information presented in previous graphs showed that woodcock populations were fluctuating most of the season, it is possible that some or most of the resident birds in the Pigeon River and Rose Lake areas stayed in the vicinity throughout the season while migrants dropped in for a short stay before moving southward. Mendall and Aldous (1943) observed many resident birds present during the latter part of the migration period in Maine even though migrants were still passing through.

Of the eight banded woodcock which were recovered in the past three years, seven were shot near the banding site. The other woodcock was taken in Georgia. There have been a number of woodcock banded in Louisiana and shot in Michigan as described previously (Plate 3). Assuming that woodcock return to the same wintering

PLATE 7

A. The Tin Bridge Road crossing the Tin Bridge of the Pigeon River. Evening flights of woodcock were seen at this site almost every evening during the summer and fall. Nets were stretched across the road and the river.

B. Two woodcock caught in a net stretched across the Pigeon River at the Tin Bridge.

PLATE 8

A. A clover-leaf trap showing the relation of the leads to the trap. Notice the woodcock to the left of the far entrance. This trap was set at West McMaster Creek.

B. A close-up of the clover-leaf trap showing an entrance, the gathering cage on the right, and a woodcock.

PLATE 9

A. A fifty-foot wire lead going to a clover-leaf trap located near Elk Hill in the Pigeon River Area.

B. A close-up of a clover-leaf trap showing the gathering cage connected to the trap. This trap was located in the McMaster Creek study area of the Pigeon River Area.

grounds each year, the fall path of migration between Michigan and Louisiana would be similar to the one described for the spring migration.

Conclusions regarding fall movements. Most of the fall movement of woodcock in Regions I and II took place prior to October 20, although large numbers frequently were observed through the first week of November. A few woodcock remained even longer. This fall movement appeared to start as early as September 1 in some localities, and by October 1 many woodcock had left their summer range. By October 20, migrants were present in Region III. However, band returns indicated that some woodcock in Regions II and III stayed in the same area much of the fall season. Therefore, the population fluctuations occurring in many areas probably were a result of migrants coming in from more northern locales, staying awhile, and then moving on south. Birds in the northern part of the breeding range possibly were stimulated to move earlier because of weather and decreasing light conditions.

The characteristics of the movements were quite varied. Some woodcock were observed in what appeared to be southward flights in the twilight hours of morning and evening, and at night prior to 11:00 p.m. Although an occasional large "flight" of twenty or more woodcock was seen in an area, the birds generally moved through in small numbers. In some locations woodcock could be found every day during the hunting season while in other spots woodcock were found only once or twice. The population of birds in some coverts remained at a peak for as long as a week while other coverts "held" birds for only a day.

Winter.

Even though woodcock depend primarily on areas of soft, moist soil where they can probe for earthworms, some birds may be found in Michigan long after most of these areas are frozen. These woodcock are usually found in sites where spring waters keep the ground soft.

Records indicated a number of woodcock have been seen in Michigan during the winter. Gibbs (1885) reported that woodcock were taken in all months in Kalamazoo County. According to Cook (1893), R. H. Wolcott found a woodcock on January 1, 1888, at Grand Rapids when there was a foot of snow present. F. F. Tubbs, of the Department of Conservation, observed a woodcock December 1, 1940, along a spring-fed creek off Harrison Road near Lansing. On January 10, 1952, Bert Stoll, an outdoor writer, took a picture of two woodcock feeding in the bottom of a drained trout pond at the Cedarbrook Trout Farm near Harrisville (Alcona County). This area contained running spring water. The most recent record of wintering woodcock was reported by Martin Pollok (Michigan Department of Conservation), who observed two woodcock several times during December, 1955, along a stream in southern Ingham County.

Since most, if not all, of these woodcock were in good condition it is doubtful that the birds remained because of an inability to travel. No reason can be given at this time for their apparent lack of the migratory urge so strongly characteristic of woodcock.

POPULATION STUDIES

Singing-Ground Activities

The singing ground serves as the center of a woodcock's breeding activity. Because such a definite site exists and since the male bird visits this site rather regularly most of the spring, the singing ground has become the basis for the spring breeding counts. These counts are used purely as an index to population fluctuations from year to year.

Factors Affecting Woodcock Activity.

Activity on the singing grounds begins shortly after woodcock arrive in the spring. Some birds may even begin courtship displays before leaving the wintering grounds or while they are on the northward trip. In 1954, however, the first woodcock were reported for the Rose Lake Area on March 9, but the first sign of display on a singing ground did not occur until March 13.

The main portion of the breeding activity occurred between April 15 and May 15 in the Lower Peninsula and between April 25 and May 25 in the Upper Peninsula.

The time when most of the woodcock activity on singing grounds was terminated in different parts of Michigan in 1954 and 1955 is shown in Tables 5 and 6.

Some records were obtained regarding woodcock courtship displays in the fall, but no evidence was presented to indicate actual attempts

at breeding.

Two factors which are difficult to separate and discuss individually are the time of day and light conditions; therefore, the two are combined.

The evening performance usually began about 15 minutes after sundown, but varied from 5 to 30 minutes depending on light conditions. When a clear sky prevailed birds began courtship displays about 20 to 30 minutes after sundown, but on a dark, heavily clouded day the activity started as early as 5 minutes after sunset. Variable starting times existed for different percentages of cloud cover between the two extremes. On a hazy day when light conditions were affected, birds commenced activity slightly earlier than on a clear day.

There was a correlation between the time of day, light conditions, and commencement of woodcock activity. As the season progressed the sun set later and thus the woodcock activity began later. A regular photographic exposure meter was not sensitive enough to record accurate readings of conditions at that time of the day. Some readings taken by an exposure meter showed from two to five foot-candles of light apparent when evening activity started on the singing grounds. A much more sensitive meter was tried in Michigan, but details for operation of the instrument had not been completely mastered and further tests are desirable.

Morning activity began shortly before daybreak in almost complete darkness and continued for a similar length of time as the evening activity. The performance, however, seemed to be more variable in intensity and length.

Table 5. Date of last singing-ground activity observed in various locations in Michigan in 1954.

Route Locations	Direction and Distance from Lansing (miles)	Date*
Kellogg Bird Sanctuary	SW - 45	May 30
Rose Lake Exp. Station	ENE - 10	June 3
Gratiot-Saginaw Game Area	N - 40	June 1
Houghton Lake	N - 105	June 5
Cusino Exp. Station	NNW - 260	June 20

Table 6. Date of last singing-ground activity observed in various locations in Michigan in 1955.

Route Locations	Direction and Distance from Lansing (miles)	Date*
Kellogg Bird Sanctuary	SW - 45	May 30
Rose Lake Exp. Station	ENE - 10	June 3
Gratiot-Saginaw Game Area	N - 40	June 6
Greenwood (Ogemaw County)	NNE - 100	June 10
Pigeon River Area	N - 165	June 16
Cusino Exp. Station	NNW - 260	June 9-28**

* The peak of activity passed long before this time.
** One woodcock was heard on June 9 but another count was not made until June 28.

Light produced by the moon often affected the activity of performing males. This effect was most pronounced on a bright moonlight night. When such conditions existed the courtship display became more irregular. The male bird started later, continued longer, displayed erratic periods of peenting and flying, or performed at intervals most of the night. The erratic display may have resulted because the bright light made birds feel less protected. Woodcock approached on such nights were more wary. When approached the bird often ceased all sounds and flushed more quickly than on a dark night. Probably the bird could see the intruder more clearly, but even when the intruder remained hidden the woodcock was more wary of noises on a bright night.

Such erratic display did not take place in the full moon period when a heavy cloud coverage existed. In Michigan, especially the Lansing area, the average cloud cover was 50 per cent or more for the spring months. Thus the effect of bright moonlight often was eliminated.

Weather was one of the most, if not the most, important factor controlling activity on the singing ground. This does not mean all activity ceased under adverse weather conditions but it became more erratic and sometimes lessened depending on the situation. All woodcock were not affected similarly.

Weather data were collected from several sources and by several methods. General climatic conditions were reported by singing-ground cooperators, while more detailed information was taken from daily reports accumulated by the East Lansing Weather Bureau. In addition records were kept on time of day, per cent of cloud coverage, phase

of moon, wind velocity, amount and type of precipitation, and temperature, for the Gratiot-Saginaw Game Area and Rose Lake Experiment Station routes each time a count was made. Thermometers were placed near several singing grounds for the 1955 spring season. Readings were taken at the time the count was made at that stop on the route. A recording thermograph and a hygrograph were set up on one singing-ground at Rose Lake. Temperatures were taken at ground level and at 10 feet with these two instruments and the thermometers.

Temperature was one of the critical weather factors. Woodcock activity was more consistent and persistent on warm, clear nights. On cold nights the performance of singing males decreased considerably. However, this does not mean that the activity was directly proportional to all temperature changes. Once the minimum temperature had been exceeded, subsequent increases did not insure increased numbers of active males. This minimum temperature occurred near 35 degrees Fahrenheit, although the Fish and Wildlife Service recommended that no singing ground counts should be made when the temperature fell below 25 degrees. On three different routes run in 1953 and one in 1954, the number of birds heard per count was below the mean whenever the temperature was below 35 degrees. In no instance was the count above the mean when the temperature was colder.

Wind was another important factor affecting woodcock activity in the spring. The most consistent performance occurred on calm nights or when the wind was below 10 miles per hour, assuming other factors were suitable. When the wind velocity reached 13-18 miles per hour, activity became erratic. The male bird made fewer flights than normal

and spent more time on the ground peenting between flights.

Rain and snow definitely influenced the activity of singing males. On rainy nights the courtship display started earlier than on a dry, cloudy night since darkness came earlier. Also, the activity became erratic and shortened, even when a light drizzle occurred. As the intensity of the precipitation increased, activity seemed to decrease. Observations were made on some rainy nights when almost no singing grounds were occupied by performing males. If a rain occurred during the day but stopped before sunset woodcock seemed more active.

Snow caused the same trend toward an erratic and shortened activity; however, the erratic tendency was less pronounced. On April 19, 1953, a singing ground count was made in the Gratiot-Saginaw Area during a snow storm (about three inches fell). The night was calm and the temperature was 35 degrees. Seven woodcock were heard on the first half of the route but none on the last half where three to five birds usually were heard -- the mean count for the route was 11 birds. The seven woodcock were as active as on any other night, but their enthusiasm ended quickly. Another incident of woodcock activity in a snowstorm was observed in 1956. Again activity was quite normal but shortened.

Relative humidity and barometric pressure seemed to show little correlation with the amount of breeding activity displayed by a male woodcock. Since these two factors were studied only slightly, further investigations might be warranted.

Performing males were influenced occasionally by activities of other animals. Man and his activities exerted the greatest influence.

On one instance a singing ground was burned over and the male was forced to vacate the area for the evening display. Often, farming activity, continuing late into night and passing near or through a singing ground, caused the male to move. Occasionally, the movement of observers near a "ground" caused an erratic display. At other times and on the same or other singing grounds birds were not bothered by farming practices or movements of observers near the "ground." Nearby car traffic, low-flying planes, and building construction did not cause the male to stop performing.

Other animals were not observed to affect the male woodcock's display to any extent. Stray dogs often could be heard barking nearby, but the noise did not influence the bird's actions. If a dog chanced to run near the singing ground while the woodcock was peenting, the bird would either pause momentarily or take off into a flight display. One night a fox was seen within 50 feet of a singing ground but the animal's presence either was not noticed or was ignored by the bird. Often deer and elk walked through or near singing grounds in the Pigeon River Area; again the bird's reaction was either to ignore the animal if it was not too close, take off in a flight display, or sit quietly until the creature passed. Other birds, particularly song and game birds, did not produce any effect on a male woodcock and his courtship display.

Factors Affecting Observations.

There are several groups of factors which may prevent the gathering of suitable data on a route. Of these, weather is very important.

However, only the wind is critical to the observer. Fewer woodcock usually are heard as the velocity increases beyond a certain point. The direction of the wind becomes important when the wind is blowing about 10 miles per hour; woodcock on the leeward side are difficult to hear. If the wind exceeds 15 miles per hour, it becomes increasingly difficult to hear woodcock from any direction.

Low temperatures may be uncomfortable but cold does not affect the hearing, except psychologically. Also, it is uncomfortable to make a count in rain or snow but it would be unusual to make a count under such conditions. Snow does not affect the hearing ability of the observer, but rain makes so much noise that an observer would not be able to hear all active woodcock.

Another group of factors would include noises of other animals, again including man. When a route is selected it should be in an area free of such interference, but it is seldom possible to escape every cause of distraction. Even on trails, another car often is encountered. Occasionally, if a route is set up as far as two miles from a black-top road, the noise of vehicles, especially trucks, still may cause a certain amount of interference to the observer. If part or all of a route is along a paved road, passing cars make it impossible to get an accurate count.

Other human or man-made disturbances include airplanes, tractors, construction, trains, motor boats, and playing children.

Other animals which affected observations at varying intensities, depending on the number, distance, or vocal capacity of the animals, were frogs, dogs, birds, and insects. Stops near low wet areas were

omitted some nights due to the chorus of frogs. Noise, more than similarity of the sounds of some frogs to the peent of a woodcock, was the disturbing factor. Barking dogs running loose or at nearby residences often caused too much noise interference. Some birds, such as the whip-poor-will, Wilson's snipe, killdeer, and great horned owl, were too active at some stops to allow gathering of accurate counts. Whip-poor-wills, especially, were pests since they frequently landed near the car and continually called.

Insects, particularly mosquitoes, made it uncomfortable to observe woodcock along some routes. The observer was unable to concentrate on counting woodcock on such occasions.

Another source of difficulty in obtaining a set of reliable observations is the individual variation between observers. Some people are capable of hearing woodcock performing farther away than others and obtain higher counts along the same route. The sounds made by the bird may not be loud enough or may be pitched in a frequency range which some people can not hear. Carney (1954) found such a variation between observers making crowing-cock pheasant counts.

Marked Woodcock.

Methods involved in banding woodcock were discussed in a previous section. In addition, in 1955, several woodcock were marked on a wing with a spray-glo paint. The paint was sprayed on the wings and allowed to dry before the bird was released. Different colors were used for each woodcock. This marking was done so that subsequent trappings to

identify birds would not be necessary.

Banding operations, recaptures, and some marked-bird observations revealed several pertinent facts which should be considered in the analysis of singing-ground activities.

First, many male woodcock returned to the same singing ground each year. Three woodcock were recaptured in 1955 at the exact spot where they were first taken the previous year (Table 7). In addition, some singing grounds which were occupied each spring were being used every night by the same male bird. One male was recaptured at a stop on the Gratiot-Saginaw Game Area route on April 16, 1955. One wing of the bird was sprayed with a bright red paint. Only this bird was observed using that site the remainder of the season.

Often several males used one singing ground. On May 2, 1955, a male bird was caught on a singing ground at Rose Lake during the evening flight. The following morning another male was recaptured on the same singing ground. Another singing ground at Rose Lake seemed to be an "open-house" site. At least three different males used the site in 1954. In 1955 one of them returned, and at least two others shared the site. Sheldon (1953), with a greater number of trapped birds, found many instances of one singing ground serving more than one male.

One male often used more than one singing ground on the same or subsequent nights. In a number of instances a woodcock was seen landing at different spots, sometimes 300 feet apart, during the display of one evening. On May 3, 1954, a woodcock was taken from a singing ground at Rose Lake. One wing of the bird was colored.

Table 7. Recapture data

Band Number	Age	Sex	Banding Date	Banding Location*	Recapture Date	Recapture Location*	Distance Between**
513-96916	A	M	5-15-54	Gratiot-Saginaw #10	4-16-55	Gratiot-Saginaw #10	0
513-96915	A	M	5-11-54	Rose Lake #11	5- 3-55	Rose Lake #11	0
513-96923	A	M	5-30-54	Rose Lake #3	5- 5-55	Rose Lake#1	.4 mi.
					5-13-55	Rose Lake#3	.4 mi.
513-96913	A	M	5- 3-54	Rose Lake #2	5-24-54	Rose Lake #1	.4 mi.
553-38005	J	F	5- 5-55	Rose Lake #3	6- 2-55	Rose Lake #20	1.0 mi.
553-38006	J		5- 5-55	Rose Lake #3	5-13-55	Rose Lake #3	40 yds.
523-33507		M	7- 7-55	Tin Bridge	7-25-55	Tin Bridge	0
523-33518	A	M	8- 3-55	W.McMaster Ck.	8- 9-55	W.McMaster CK.	0
					8-18-55	W.McMaster CK.	0
523-33520		F	8-11-55	W.McMaster Ck.	8-22-55	W.McMaster Ck.	0
523-33526		M	8-18-55	Elk Hill	8-20-55	Elk Hill	0
523-33540"		F	8-20-55	Elk Hill	8-26-55	Elk Hill	0
					8-28-55	Elk Hill	0

* The numbers represent the singing ground on which the bird was banded or near which the bird was banded.

** The distance between the site of banding and the site of recapture. "0" indicates that the bird was retaken at the same spot.

" This bird had a broken bill resulting from an injury received in the trap. The bill was mended by the time of the first recapture and the bird was feeding at the time of the second recapture.

Three weeks later the same male was shined on a singing ground 0.4 mile away. Another woodcock was first taken on a singing ground at Rose Lake in 1954. In 1955 this bird was recaptured twice, once at another singing ground and again at the original site of capture (a distance of 0.4 mile separates the two grounds). Banding operations by Sheldon (1953) showed that one woodcock was caught at one site on Tuesday and 3½ miles away on the following Thursday. But, the distance between first capture and recapture sites exceeded 0.5 mile for only 20 per cent of the repeats.

Records also showed that some females return to the same breeding area. One female was taken in a blind decoy trap on May 2, 1955, on the Rose Lake Area. On May 8, 1956, this bird was taken in the same manner at the same spot. This singing ground was peculiar in that it was located in a tamarack swamp and was only six by ten feet in dimension.

Recapture of a young woodcock gave an opportunity to observe juvenile birds. Three young birds, about ten days old, were caught and banded on May 5, 1955. Four weeks later one of them was taken in a mist net set on a singing ground one mile west. New measurements were taken and it was found that the weight of the bird had tripled. The young bird weighed more than most adult females in spring. The bill had grown from 34 to 65 millimeters and the bird was feathered completely.

Activities such as those discussed above tend to make it impractical to use data gathered on singing-ground counts for anything but an index to population trends.

Singing-ground Counts.

The only method devised and used with any consistency to determine breeding population trends has been singing-ground counts. Generally, this method involved setting up a route at least two miles long, establishing stops at least 0.4 mile apart, running the route during the time of evening activity, and making two-minute interval counts of different woodcock heard at each stop. Complete instructions for running a woodcock route as set forth by the U.S. Fish and Wildlife Service for spring, 1956, are included in the Appendix. A few changes in the instructions have been made since 1953; the major change was the suggestion to run two or more routes in an area once each instead of running one route two or three times.

When such counts were begun in Michigan in 1951 only 12 routes were run. Gradually, a better coverage of woodcock habitat was obtained, and in 1955, at least 56 routes were in operation (Plate 10). Many routes have been run by non-department personnel, but the present policy is to depend more upon Game Division employees. It has been more difficult and expensive to locate and train people not connected with the Conservation Department than members of the Department. The present group of cooperators should be retained, however, since they are reliable and familiar with procedures.

Data which have been accumulated since 1953 were used to analyze fluctuations of spring populations. From these data an attempt was made to answer the following pertinent questions regarding singing-ground counts: (1) How many times should a route be run during the breeding season to obtain a reliable count of active woodcock along

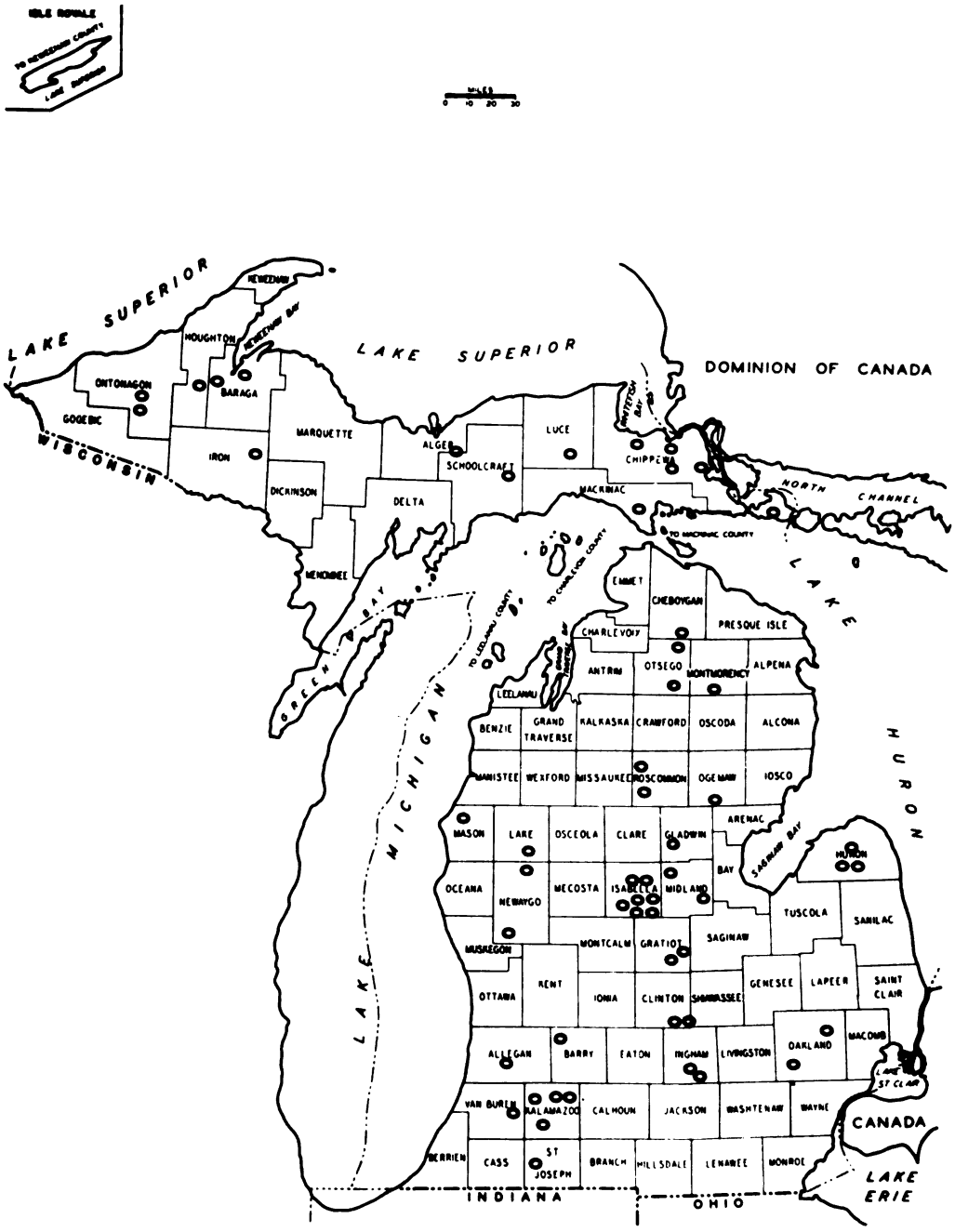
that route? (2) How many routes should be run in Michigan to obtain a reasonable coverage of woodcock habitat? (3) What are the practical aspects or limitations of singing-ground counts?

Earlier instructions by the U.S. Fish and Wildlife Service, based upon findings of Mendall and Aldous (1943), recommended that each route be run at least three times during the main part of the breeding season. The reason for three or more counts was to determine the number of singing grounds used regularly and to obtain a mean figure. Subsequent investigations by workers in Pennsylvania (Norris, et al., 1940) and Massachusetts (Sheldon, 1953) showed that the male woodcock was promiscuous and that it often used more than one singing ground. Consequently, repeated running of one route is not as important as was formerly believed. When Kozicky, Bancroft, and Homeyer (1954) made a statistical analysis of data obtained by cooperators over a five-year period in the Northeastern States they concluded there was little advantage to running one route more than once. They recommended that a more complete stratification, based on habitat types, be investigated and that a minimum of two routes should be selected at random from each stratum. It was felt that it should be possible for the same expenditure of funds and time to increase the number of routes and decrease sampling error.

Before the analysis of Michigan singing grounds was started data were examined to see if the singing ground counts were distributed in a normal fashion. A comparison of a frequency distribution, formed from results from 56 routes scattered through Michigan in 1955, with that expected with a normal distribution with the same mean and

PLATE 10

Location of singing ground routes which were run in 1955.


ISLE ROYALE
TO HOUGHTON COUNTY
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BARAGA
GOGEBIC
IRON
MARQUETTE
ALGER
SCHOOLCRAFT
LUCE
CHIPPEWA
DETROIT RIVER
DICKINSON
DELTA
MACKINAC
TO MACKINAC COUNTY
NORTH CHANNEL
MENOMINEE
GREEN BAY
TO DELTA COUNTY
TO CHARLEVOIX COUNTY
EMMET
CHEBOYGAN
PRESQUE ISLE
CHARLEVOIX
ANTRIM
OTSEGO
MONTMORENCY
ALPENA
LEELANAU
BENZIE
GRAND TRAVERSE
KALKASKA
CRAWFORD
OSCODA
ALCONA
MANISTEE
WEXFORD
MISSAUKEE
ROSCOMMON
OGEMAW
IOSCO
ARENAC
MASON
LAKE
OSCEOLA
CLARE
GLADWIN
SAGINAW BAY
HURON
OCEANA
NEWAYGO
MECOSTA
ISABELLA
MIDLAND
BAY
TUSCOLA
SANILAC
MUSKEGON
MONTCALM
GRATIOT
SAGINAW
OTTAWA
KENT
IONIA
CLINTON
SHIAWASSEE
GENESEE
LAPEER
SAINT CLAIR
ALLEGAN
BARRY
EATON
INGHAM
LIVINGSTON
OAKLAND
MACOMB
LAKE ST CLAIR
VAN BUREN
KALAMAZOO
CALHOUN
JACKSON
WASHTENAW
WAYNE
CANADA
BERRIEN
CASS
ST JOSEPH
BRANCH
HILLSDALE
LENAWEE
MONROE
LAKE ERIE
INDIANA
OHIO

standard deviation revealed no evidence of a statistical difference, using a chi-square test (Table 8). Therefore, no transformation was considered necessary in the statistical analyses presented in subsequent discussions.

Information compiled from frequent runnings of routes on special study areas in the present study revealed that the estimated population fluctuated considerably during the breeding season. The population along the Gratiot-Saginaw Game Area route varied less than that along the Rose Lake Experiment Station route; however, the latter route was run more frequently (Figure 3).

Counts from the Rose Lake route were used to determine how many times a route had to be run to obtain various degrees of precision at the 95 per cent level of confidence. These sample sizes were computed using the formula (1): $n = t^2 s^2/(d \bar{x})^2$ (Snedecor, 1946). Only counts were considered that were taken on nights which fell within prescribed limitations set forth by the Fish and Wildlife Service instructions for running routes. According to these data, which had a standard deviation of 2.2 and a mean of 7.2 calls, the route analyzed would need to be run 27 times to obtain confidence limits extending either side of the observed mean for 25 per cent of its value. The same route would have to be run 170 times to obtain confidence limits 10 per cent of the observed mean.

The number of times a route should be run were investigated further in light of sampling theory, using data gathered from routes scattered through Michigan. An analysis of variance of counts obtained from routes run at least twice for each of the three years

Table 8. Data used in a chi-square test to determine if woodcock counts were distributed normally.

Average Number of Woodcock Heard per Stop	Number of Routes on Which Counts Were Made
.00 - .195	2
.20 - .395	2
.40 - .595	9
.60 - .795	10
.80 - .995	11
1.00 - 1.195	10
1.20 - 1.395	3
1.40 - 1.595	5
1.60 - 1.795	1
1.80 - 1.995	2
2.00 - 2.195	0
2.20 - 2.395	1

(1953, 1954, and 1955) yielded a pooled estimate of variance (Table 9).

Table 9. Pooled estimate of variance for singing-ground counts (1953-1955).

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares
Among routes	91	67.1	.737
Within routes	170	11.2	.066

Since the number of times a count was made varied with the route, an average number was needed to estimate the various components. This average was obtained by use of the formula from Snedecor (1946):

$$k_o = 1/n-1 \ (Sk - Sk^2/Sk) \qquad (2)$$

where,

k_o = average number

k = number of times a route was run

n = number of routes run

The average number was determined to be 2.8. With the aid of this average $\underline{k}$ and the mean square (s^2) of the pooled estimate (Table 9) figures in Tables 10 and 11 were compiled.

The formula,

$$s^2_{\bar{x}} = 1/n \ (s^2_b + s^2_w / k) \qquad (3)$$

used in the compilation of data for Table 10 is a restatement of formula 10.3 (Cochran, 1953) which was used to predict the variance expected for other subsampling ratios. In the formula as it is used here:

$s^2_{\bar{x}}$ = variance of the mean

n = number of routes to be run, or sample size

Table 10. Variance of the mean (s^2_k) showing the relationship between the sampling (n) and subsampling (k) sizes.

n	Routes run: One Time	Two Times	Three Times
1	.306	.273	.262
2	.153	.137	.131
4	.077	.068	.066
8	.038	.034	.033
16	.019	.017	.016
32	.010	.009	.008

Table 11. Number of singing ground routes required for a given precision.

Precision*	Routes run: One Time	Two Times	Three Times
.50	.6	.5	.5
.40	.9	.8	.8
.30	1.6	1.4	1.4
.25	2.3	2.1	2.0
.20	3.6	3.2	3.1
.15	6.4	5.7	5.5
.10	14.5	12.9	12.4
.05	58.0	51.6	49.6

* or confidence semi-interval as proportion of the mean (.92)

k = number of times each route is to be run, or subsample size

s_b^2 = variance between routes (here, .240)

s_w^2 = variance within routes (here, .066).

Data in both tables reveal there is little benefit gained by running a route more than once. These results substantiate the conclusion drawn by Kozicky, et al. (1954) that there seems to be little gain in precision from running the same route two or more times in the same year.

From the practical or financial view it may be more economical to run a route twice during the first season in terms of information per dollar spent. This conclusion is reached by examining the present set of data according to the methods presented by Cochran (1953) for determining the optimum number of items in a subsample for surveys where, as in the present study, a subsampling method is used. The optimum number is

$$k_{opt} = s_w/s_b \sqrt{c_u/c_e} \qquad (4)$$

where,

k_{opt} = optimum number of times a route should be run

s_w = standard deviation within routes

s_b = standard deviation between routes

c_u = cost for locating and setting up a route

c_e = cost for running a route after it is set up

The required information on costs may be derived from records kept during the present study and estimations based on experience. The experience represented in this study may be illustrated by

mentioning the efforts involved in establishing new routes. Since only 13 singing ground routes were run in Michigan the first year of the study a better coverage of the state was desired. To get this increase approximately 100 people were contacted by letter or in person. Those persons who expressed interest were again contacted by a biologist.

To determine the optimum number of times a route should be run, considering economic aspects, the costs involved in setting up a route as compared to the cost of running a route after it was set up were considered. In determining the average cost of setting up a route the following points were included for 25 routes: correspondence, round-trip mileage from Lansing to the area, mileage involved in locating a route, mileage involved in traveling to and from the route and running the route in a preliminary way, number of hours involved, and room and board. No expense was attributed to non-department personnel since the time of such people was donated. The hours spent by department personnel were not included since in most instances their time was not taken from the regular working day. Considering these various aspects the average cost of setting up a route was computed as $25.25, a minimum figure.

To run these routes after they were set up cost comparatively little. In determining the average cost of running 25 routes the major consideration was the local mileage to and from the census area and mileage of the route. Again the expense of non-department personnel was not included, but the mileage of department personnel was since they would be reimbursed for use of their cars (or would use state-

owned vehicles). Time used by department personnel was not figured, as discussed above. A certain per cent of loss had to be considered for those routes which were set up and for some reason were not continued by the cooperators. Thus the average cost for running these routes was $2.10, again probably a minimum figure.

Substituting the proper values in formula 4, the optimum $\underline{k}$ becomes 1.82 or 2. Thus in early stages of accumulating a number of routes it is more practical to run each route twice. However, the second year there is no cost associated with setting up an already established route, and it should therefore be run only once. Throughout the years the number of new routes will become smaller. In addition, experienced observers may set up additional routes without costly outside aid, and more observers will be located throughout the state, available to assist new personnel thus reducing the cost of new routes. As a working rule, therefore, it is suggested that new routes be run twice the first year and only once in each year thereafter, increasing the number of routes as the budget permits.

Reviewing the field experience and data in 1955 when 56 routes were run from one to three times each, confidence limits of the mean value of .92 birds heard per stop were computed as being between 1.04 and .80, or about 13 per cent of the mean. The mean value for each route was used above regardless of the number of times run.

As shown by data in the above tables and by subsequent discussions, there is a practical limit to the number of routes to be run. Once a certain sample size has been reached the precision increases relatively little for additional routes. Thus it may be financially

practical to reach and maintain a certain sample size, realizing that stratification, as suggested by Kozicky, et al. (1954) might further reduce sampling error.

Nesting

A study of nesting habits and success was a minor phase of the investigations. Such information was gathered incidentally to other phases of activity. The discussion represents an accumulation of data gathered from personal observations, use of bird dogs, cooperator reports, and Game Division files.

Reports of only 31 nests were available. The clutch-size for those nests ranged from two to six eggs with an average of 3.9. Mendall and Aldous (1943) found an average clutch in Maine to contain 3.94 eggs.

Of those Michigan nests known to have produced young every egg hatched. Knight (1946) mentioned that few infertile eggs are found in woodcock nests and that normally there is a 95 per cent success. Mendall and Aldous (1943) found the fertility to be 98.4 per cent.

Seven of the Michigan nests were destroyed later (Plate 11). Man and his activities were the cause of destruction for three nests. Two nests were lost to mammalian predation (red fox or skunk); the remaining two nests were deserted. One of the latter may have been due to adverse weather conditions since the nest was found when snow was still present. Many nests built soon after birds arrive in Michigan probably are unsuccessful because of adverse weather.

The length of the nesting period is quite long in Michigan since about 400 miles separate the southernmost part of the state from the northern edge. One of the earliest nest records was reported near Grosse Pointe by G. A. Abbott on March 27, 1918 (Wood, 1951). On March 31, 1954, Walter Lemmein, in charge of the Kellogg Forest near Battle Creek, found a woodcock nest, containing two eggs, surrounded by snow. The latest nesting recorded was June 11, 1936, near Ann Arbor reported by G. A. Ammann, (Wood, 1951). On June 9, 1955, a woodcock nest containing six eggs was located in Roscommon County. These records give some idea of the length of nesting season.

The major nesting effort during the present study occurred during the last two weeks of April and the first two weeks of May. The period was somewhat later in Region I and the northern part of Region II. In Maine, Mendall and Aldous (1943) found that most woodcock began nesting about the third week of April and that most young emerged from eggs between May 11 and 25. They also concluded that toward the northern limits of the breeding range most nests are constructed during the latter part of April and the first part of May.

Broods

Observations of broods also were limited during the study. Emphasis was placed on finding young birds in order to band them. Notes were taken on habitat types, which will be discussed later, and certain life history aspects. Additional observations regarding broods were made by various Department of Conservation field personnel, and other data was taken from Game Division files.

PLATE 11

A. Site of a woodcock nest beneath overhanging branches of a tamarack. The nest location is indicated by the arrow.

B. A close-up of the above-mentioned nest showing the results of mammalian predation.

Brood searches were made in wooded areas near singing grounds. Bird dogs were used much of the time but some broods were found without their aid.

The size of 28 complete broods varied from 2 to 8 with the average size being 3.6 young per brood. The brood with the 8 young was observed by F. M. Baumgartner (1938), then with the Michigan Department of Conservation. He suggested that this brood may have been the result of two females laying in one nest or one female taking over two broods. Since it is most unlikely that one woodcock would lay and could incubate 8 eggs, this brood was not included in the determination of the average brood size. There were four other instances when the brood size exceeded four. One brood of five young was found and three instances of six young per brood were observed.

A division of the broods into two age classes ("less than 7 days" and "7 days plus") showed that for the younger age class the average brood size was 3.6 and for the older age class the average was 3.4 young.

In Michigan, apparently, most young are hatched during May. Of the 31 broods, 17 were hatched in May and 16 of these emerged from the eggs during the first three weeks of the month. The earliest hatching record was April 24, 1955, near Bad Axe. Seven broods came off after June 1, and one of these hatched about July 6 in Alger County according to Department of Conservation Biologist Carl Dubovsky. Most of the June reports were probably of renesting attempts.

Because of their rapid development, young woodcock from renestings are probably not much handicapped by their late birth. A young

woodcock grows so rapidly that within a month it can make long flights. One banded juvenile in Michigan had developed so much in a month that it would have been mistaken for an adult if it had not been ringed. Pettingill (1936) and Mendall and Aldous (1943) agreed that by 25 days of age the young bird is practically "full grown."

Sex and Age Statistics

An accumulation of data from specimens during the past three hunting seasons has provided considerable information concerning the sex and age composition of fall woodcock populations. Most specimens were collected in the Pigeon River Area, particularly during 1954-55. Others were received from various hunters throughout the state. Department of Conservation employees were especially helpful. Information from these specimens included date, location where killed, cover, type, sex, age, weight, various measurements of the bill and the outer three primaries, notes pertaining to molting patterns, kinds of external parasites and diseases if any, and miscellaneous notations. Gastro-intestinal tracts were saved for study of food habits and internal parasites.

Sex and Age Determination.

Techniques for sex and age determination involved external measurements. The internal method for sexing was primarily an examination of carcasses for the presence of testes or an ovary. If the gonads had been destroyed a search was made for an oviduct. Occasionally, the latter method was successful in determining the sex.

The presence or absence of the bursa of Fabricius was the main criterion for distinguishing between adults and birds of the year. In addition, the width of the oviduct in females was greater in old birds than in young as determined by visual examination.

A determination of useful external criteria for sexing and aging woodcock was one objective of the study. Several criteria have been developed and used by other workers. Pettingill (1936) observed that the female woodcock usually was larger in most measurements, including weight. Tufts (1940) indicated that bill length was a more reliable criterion for sexing than weights but that such measurements were not conclusive. Later Mendall and Aldous (1943) studied the relationships of body weight, wing length, and bill length to sex. They concluded that too much overlap occurred with weights and wing lengths to use either of these criteria, but that bill length was quite reliable. In 1953, Greeley's studies on fall-shot woodcock were published. In addition to repeating some measurements previously tried by others, he used the width of the outer-most primary (number 10) at a point two centimeters from the tip. With this measurement he reduced the overlap error considerably. Harris (1953) proposed the use of the bill length with the combined widths (two centimeters from the tip) of the outer three primaries as a method for sexing fall-shot woodcock in Minnesota.

In examining Michigan specimens in the present study (80 in 1953, 147 in 1954, and 189 in 1955) emphasis was placed upon the measuring of weights, bill length, and widths and lengths of the outer three

primaries. The woodcock were weighed as soon as possible after being killed. Measurements were made to the nearest gram on a dietetic scale. Six birds were weighed immediately upon being shot and at various temperatures and intervals of time up to 24 hours with weight losses varying only between zero and two grams. Linear measurements were made to the nearest tenth of a millimeter with a Vernier caliper.

Bill length was measured from the base of the nares to the tip of the bill as suggested by Greeley (1953). Measurements were made also from the anterior part of the nares to the tip in 1953, but this measurement was discontinued when a statistical "t" test showed no evidence of a variable difference between the two measurements.

Four different measurements were made on each of the three outer primaries of the specimens examined in 1953. One of these, the width, was made two centimeters from the distal end of each primary. Both wings were used the first year but when a "t" test showed no evidence of a difference between the primary measurements of the two wings the procedure was changed. Subsequent measurements were made only on the primaries of the right wing unless the feathers were deformed, in which event the left wing was used.

In addition to width, three measurements were made on the length of each primary. One length ("intact") was obtained with the primary in place. This measurement was made from the web of the wing to the distal end of the feather. Then the feather was removed from the wing and two more measurements made: the length of the vane and the total length of the primary. The total length measurements were easiest to make and data in Table 12 and 13 show those measurements to be as

accurate as the others. Therefore, only total lengths of primaries were measured in subsequent years.

Table 12. Length data computed from primaries 8, 9, and 10 of female woodcock specimens collected in 1953.

	Intact				Vane				Total			
	$\bar{x}$	n	s^2	s	$\bar{x}$	n	s^2	s	$\bar{x}$	n	s^2	s
8	82.3	38	3.85	1.96	74.2	38	4.78	2.19	95.5	38	4.92	2.21
9	79.1	37	4.46	2.11	73.1	37	4.55	2.13	91.2	37	5.75	2.40
10	74.6	38	4.09	2.02	70.9	38	4.48	2.12	84.2	38	4.14	2.03
Sum	236.2	36	34.84	5.90	218.3	37	39.23	6.26	271.0	37	37.09	6.09

Table 13. Length data computed from primaries 8, 9, and 10 of 29 male woodcock specimens collected in 1953.

	Intact			Vane			Total		
	$\bar{x}$	s^2	s	$\bar{x}$	s^2	s	$\bar{x}$	s^2	s
8	74.8	3.43	1.85	67.9	3.10	1.76	87.2	4.44	2.11
9	72.4	3.24	1.80	67.5	3.11	1.76	83.6	4.13	2.03
10	69.2	3.51	1.87	66.1	3.08	1.75	78.3	4.12	2.03
Sum	216.3	27.72	5.26	201.6	25.27	5.03	249.1	34.77	5.90

Weights of woodcock were considered as a possible sexing method since female birds frequently were observed to be much heavier than males. During the three hunting seasons 345 woodcock for which the sex

was known were weighed, and although the average weight of females exceeded that of males, the region of overlap was too great to allow practical use of weight as a sex criterion. Pettingill (1936), Tufts (1940), and Mendall and Aldous (1943) all made the same observation and concluded that weight could not be used for sex differentiation with any success.

Throughout this discussion "overlap" refers to the actual overlap while "per cent of overlap" means the calculated per cent to be expected assuming normal distributions of the observed means and standard deviations. Overlap refers to the proportion of mis-identified animals. This is determined by first setting up a point of discrimination between the two sexes. Then the measurements which fall beyond this discrimination point represent the fraction of individuals which can not be identified.

An analysis of the weights of Michigan woodcock indicated the weight criterion to be less reliable than feather and bill measurements, as determined by the much larger standard deviations and coefficient of variability of weights (Table 14).

Table 14. Analysis of weight records of woodcock specimens collected during the hunting seasons (1953-1955).

Sex	Number of Birds	Weights* Range	Average	s	CV
Female	155	162-252	207	17.8	8.58
Male	148	129-201	164	13.6	8.28

* In grams.

A progressive weight increase was exhibited by woodcock from spring through the fall season (Table 15). The weight increase during the fall is more evident than in other seasons. At the beginning

Table 15. Progressive weight increases of woodcock in 1953, 1954, and 1955.

	Males		Females	
Season	Number of Birds	Average Weight*	Number of Birds	Average Weight*
Spring	18	129	3	167
Summer	22	147	8	176
Fall	148	164	155	207

* In grams.

of the hunting season no fat or very little was found on woodcock specimens. As the season progressed the amount of fat increased (Plate 12). This fat deposition probably accounted for the progressive weight increase noted in Michigan woodcock (Table 16). A similar weight increase was noted for woodcock collected in Nova Scotia (Mendall and Aldous, 1943).

Table 16. Fall weight variations of woodcock collected in the Pigeon River Area (1954-1955).*

	Males			Females		
Periods	Number of Birds	Weight Range	Average Weight	Number of Birds	Weight Range	Average Weight
Oct. 1-15	55	134-187	158	49	162-232	196
Oct. 16-31	32	150-189	172	28	190-245	216
Nov. 1- 9	8	174-201	183	8	216-246	231

* Weights are in grams.

PLATE 12

Two pictures showing the distribution and amount of fat on woodcock late in the fall season.

Measurements considered to be most important and accurate as criteria of sex were bill length and total width and total length of the outer three primaries (Table 17).

Table 17. Comparison of criteria of sex for fall-shot woodcock in Michigan (1953-1955).

	Bill Length		Primary Width		Primary Length	
	Male	Female	Male	Female	Male	Female
n	179	213	181	199	179	198
Range	56.4-64.2	61.6-72.8	8.1-12.4	12.6-17.4	232.7-262.9	257.4-291.3
$\bar{x}$	60.1	66.9	10.3	14.6	248.9	271.7
$s_{\bar{x}}$	.135	.151	.054	.061	.408	.398
s	1.80	2.21	.73	.87	5.46	5.60
CV	2.99	3.30	7.09	6.00	2.19	2.06
% Overlap	4.46		0.36		1.97	

On the basis of data obtained by Mendall and Aldous (1943) and Greeley (1953), the bill length was considered as a possible criterion of sex. However, according to the conclusions of these same investigators, as well as judging by a statistical analysis of data from Michigan woodcock (Table 17), the bill length alone was not considered to be sufficiently accurate for use. Because bills are easy to obtain from hunters and since simple and rather accurate measurements may be taken from the bills, the use of the organ is desirable.

To increase the accuracy of determining sex (or to reduce the amount of overlap or proportion of animals "mis-sexed") the widths of

the outer three primaries were considered, following Harris (1953). He found that with specimens he examined in Minnesota a combination of bill length and total width of the outer three primaries was a very accurate method for determining the sex of woodcock. In addition, in the present study the total length of the outer three primaries was examined. The totals of the widths and the lengths of all three outer primaries were used rather than width and length of one feather, because the per cent of overlap was less for the combined measurements compared to any one of the three primaries.

A scattergram is presented for each two-way comparison (bill length vs. primary width in Figure 12, primary length vs. primary width in Figure 13, and bill length vs. primary length in Figure 14). In Figure 12 it may be noted that a considerable amount of overlap occurred in the bill lengths but that none existed for the primary widths. When the two characters were plotted on the scattergram a blank space extended diagonally between the two clusters of points. An eye-fitted diagonal line drawn through the middle of this space represents a separation point for these data. Any dot plotted below the line represents a male and any plotted above the line represents a female.

In Figure 13, some overlap is shown between the primary lengths but this overlap is less than that shown for bill lengths in Figure 12; hence the distinction between sexes seems more evident. As in the above scattergram a diagonal was drawn between the two clusters of dots to represent the separation point between sexes.

Figure 12. Relationship between bill length and total width of outer three primaries.

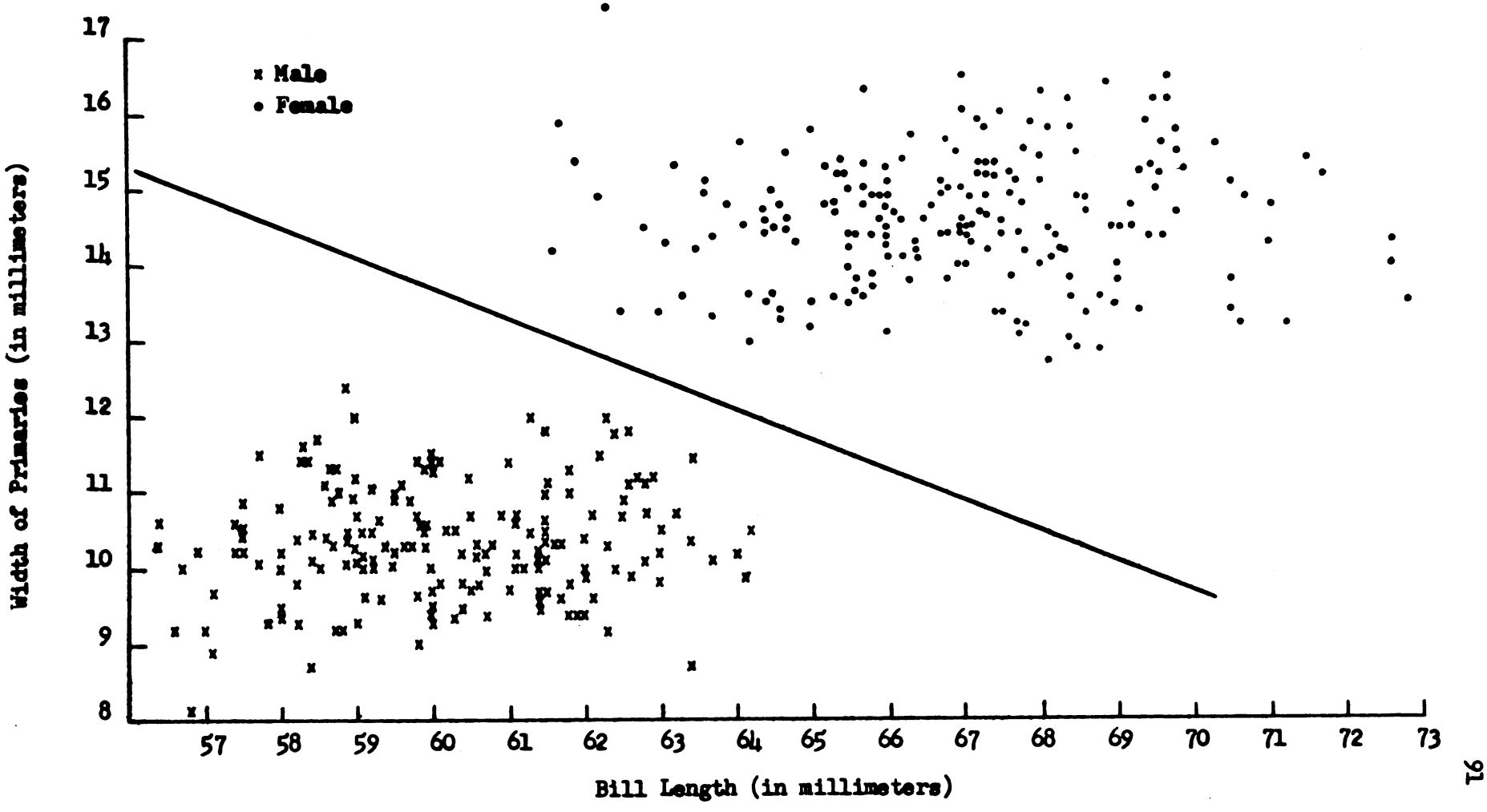


Figure 13. Relationship between total width and total length of outer three primaries.

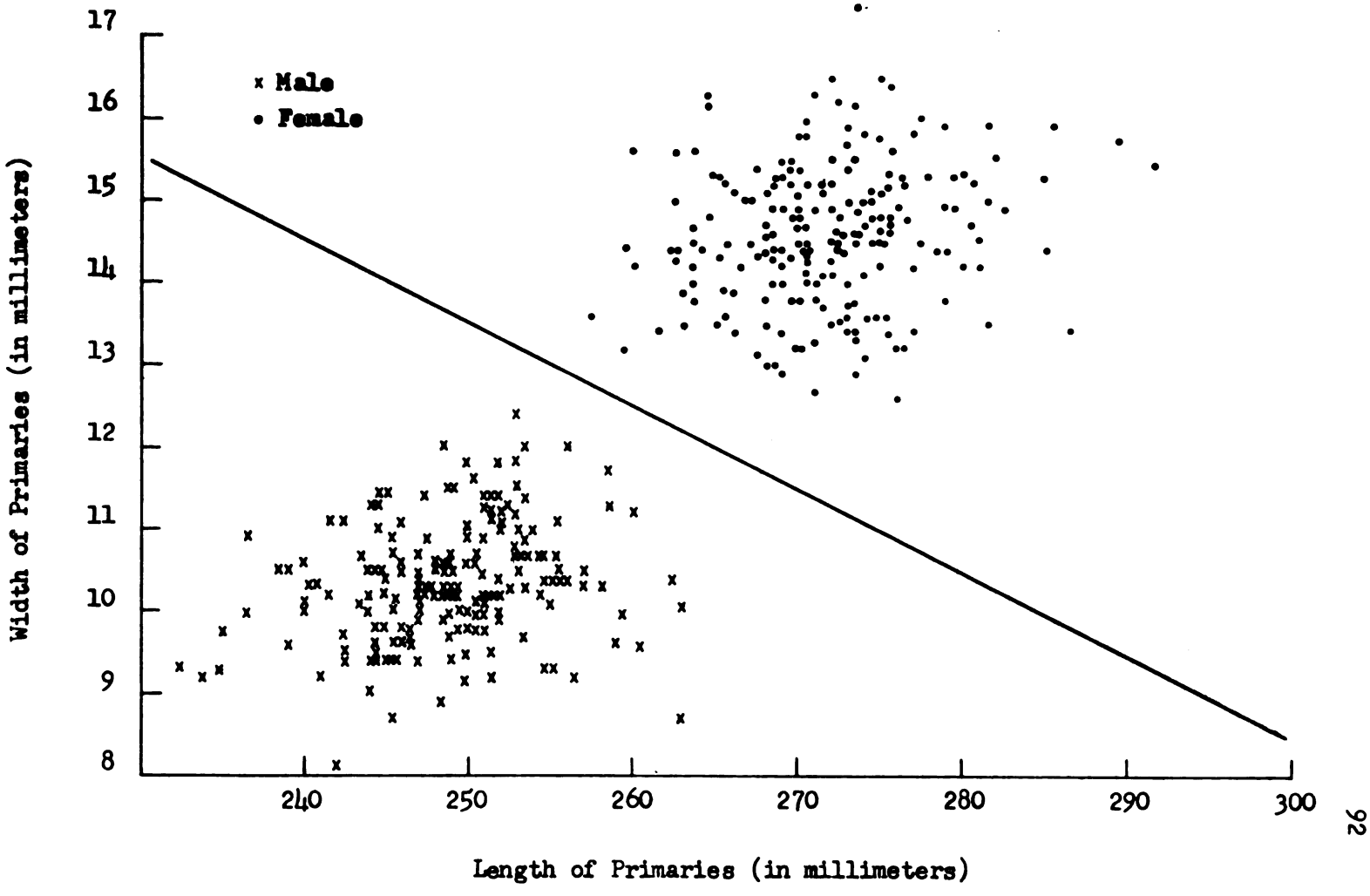
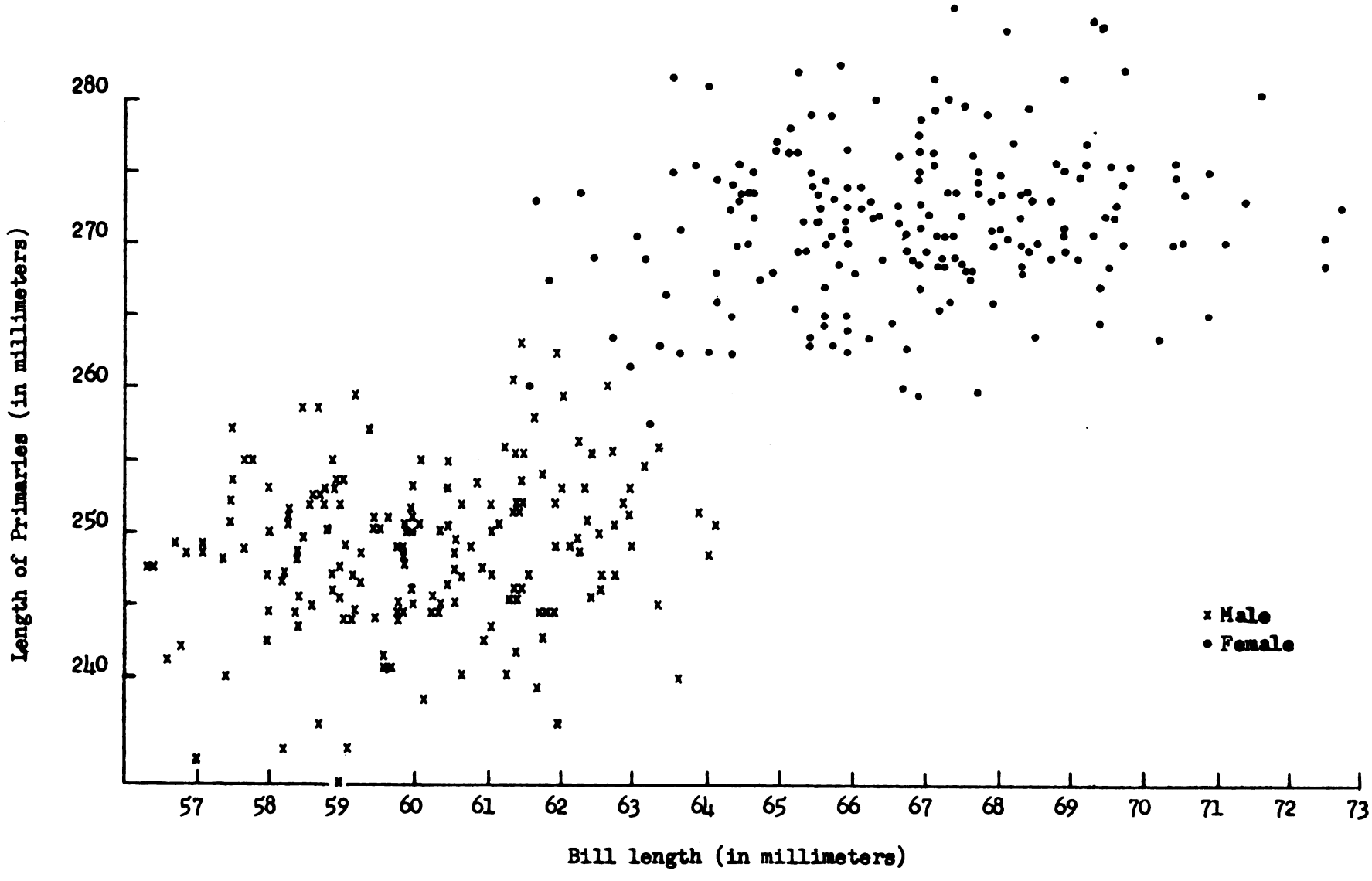


Figure 14. Relationship between bill length and total length of outer three primaries.



For the third comparison of two characters (primary length vs. primary widths, Figure 14) no such separation line could be easily designated since the overlap occurred in two directions. This latter two-way comparison apparently is not suitable for use in distinguishing sex even though the actual overlap for the 370 specimens was only about six per cent.

Of the three comparisons the first two were sufficiently accurate to be considered as sexing methods. Naturally the methods will need to be checked with future sets of data from woodcock of known sex. As the data appear now no overlap exists and the per cent of overlap seems insignificant. The amount of overlap decreases and the accuracy greatly increases by using a combination of two factors. However, the amount of work involved in making measurements increases also. The measuring of the widths and lengths of primaries takes time, yet it appears that the increased accuracy is worth the effort.

Instead of using the scattergram it might be preferable to have a table of critical measurements which separate sexes. Tables 18 and 19 show these numbers, up to a certain point, calculated from the diagonal lines of separation. Table 18 was determined by the formulae, female: $W + B/2.5 > 37.7$ and male: $W + B/2.5 < 37.7$, where,

W = primary width
B = bill length
1/2.5 = slope of line in Figure 12

The sex of a woodcock is determined from Table 18 by looking up first the bill length and then the corresponding primary width; both criteria are important in the separation; e.g., if a bill is measured as being 60 millimeters long the woodcock is a male if the primary

width is less than 13.7 and is a female if the width is more than 13.7 millimeters.

Table 18. Critical measurements necessary for sexing woodcock as determined from a comparison of bill lengths and primary widths.*

Bill Length	Primary Width	Bill Length	Primary Width
50	17.7	63	12.5
51	17.3	64	12.1
52	16.9	65	11.7
53	16.5	66	11.3
54	16.1	67	10.9
55	15.7	68	10.5
56	15.3	69	10.1
57	14.9	70	9.7
58	14.5	71	9.3
59	14.1	72	8.9
60	13.7	73	8.5
61	13.3	74	8.1
62	12.9	75	7.7

* All measurements in millimeters.

Table 19 was determined by the formulae, female: $W + L/10 > 38.5$ and male: $W + L/10 < 38.5$, where,

L = length of primaries
1/10 = slope of line in Figure 13.

Again the width of the primary is the critical measurement; e.g., if the primary length is 250 millimeters and the primary width is less than 13.5 millimeters the bird is a male, but if the width is more than 13.5 millimeters the bird is a female.

Following the method adopted by Harris (1953) the succeeding three schedules for sexing woodcock were determined from data on the scattergrams.

Table 19. Critical measurements necessary for sexing woodcock as determined from a comparison of primary lengths and primary widths.*

Primary Length	Primary Width	Primary Length	Primary Width
230	15.5	260	12.5
231	15.4	261	12.4
232	15.3	262	12.3
233	15.2	263	12.2
234	15.1	264	12.1
235	15.0	265	12.0
236	14.9	266	11.9
237	14.8	267	11.8
238	14.7	268	11.7
239	14.6	269	11.6
240	14.5	270	11.5
241	14.4	271	11.4
242	14.3	272	11.3
243	14.2	273	11.2
244	14.1	274	11.1
245	14.0	275	11.0
246	13.9	276	10.9
247	13.8	277	10.8
248	13.7	278	10.7
249	13.6	279	10.6
250	13.5	280	10.5
251	13.4	281	10.4
252	13.3	282	10.3
253	13.2	283	10.2
254	13.1	284	10.1
255	13.0	285	10.0
256	12.9	286	9.9
257	12.8	287	9.8
258	12.7	288	9.7
259	12.6	289	9.6

* All measurements in millimeters.

1. If bill length is 61 mm. or less the bird is a male.
   If bill length is 65 mm. or more the bird is a female.
   If the length is between 61 mm. and 65 mm., measure the width of the outer three primaries and add the values.
   If wing value is 12.0 mm. or less the bird is a male.
   If wing value is 13.0 mm. or more the bird is a female.
   If wing value is between 12.0 mm. and 13.0 mm. and bill length is between 61 mm. and 65 mm. the sex can not be determined externally.

2. If total length of outer three primaries is 255 mm. or less the bird is a male.
   If length is 265 mm. or more the bird is a female.
   If length lies between 255 mm. and 265 mm. then measure width of outer three primaries and add the values.
   If width value is 12.0 mm. or less the bird is a male.
   If width value is 13.0 mm. or more the bird is a female.
   If width value is between 12.0 mm. and 13.0 mm. and primary length is between 255 mm. and 265 mm. the sex can not be determined externally.

3. If bill length is 61 mm. or less the bird is a male.
   If bill length is 65 mm. or more the bird is a female.
   If bill length is between 61 and 65 mm. measure length of outer three primaries and add the values.
   If primary length is 255 mm. or less the bird is a male.
   If primary length is 265 mm. or more the bird is a female.
   If primary length is between 255 and 265 mm. and bill length is between 61 and 65 mm. the sex can not be determined externally.

Inspection of the present sets of data suggest that a three-variable method for distinguishing sex could probably be devised if the methods using two variables are found to fail. This method would include the bill length, primary lengths, and primary widths.

Throughout studies on fall-shot woodcock no external measurement was found which would separate birds-of-the-year from adults. But, during the fall of 1955, a close examination of legs and feet from freshly-killed woodcock indicated a color difference between specimens. Of 123 birds examined, 66 had light or flesh-colored legs. Sixty-four of these birds were adults while only 2 were juveniles. Fifty woodcock had legs and feet which were of a dusky-grey coloration, and of these, 48 were juveniles. The color or age was questionable for 7 birds. Most woodcock of doubtful age were taken during the latter part of the season; this fact might suggest that the bursa had been absorbed on some birds-of-the-year by that time while the leg color may or may not have changed.

These results imply that young birds have darker legs than adults during the fall. The colorations should be checked another year to determine if such a method may be reliable. In a letter from Dr. William Sheldon of the Massachusetts Wildlife Cooperative Unit he mentioned that neither he nor Dr. Fred Greeley could observe any consistency in color variation of woodcock legs they had examined.

Sex and Age Ratios.

There were 381 specimens collected for which the sex and age were determined. For one year, this number of specimens seemed sufficient but once the specimens were separated year by year and into four component parts (adult male, adult female, juvenile male, and juvenile female) usefulness of the data decreased greatly. Numbers and ratios are presented to make the data available to other investigators.

Over half of the woodcock specimens were taken in the Pigeon River Area in 1954 and 1955. These specimens were handled separately from those taken at various other locations over the state, but when the chi-square test of homogeneity showed no significant differences in sex or age ratios between years or areas, the data for the two areas were combined for further analysis (Table 20).

Table 20. Sex and age ratios of woodcock collected in Michigan.

	Adult			Juvenile			
Year	Male	Female	Male-Female Ratio	Male	Female	Male-Female Ratio	Adult Female-Juvenile Ratio
1953	18	23	78:100	13	17	76:100	1:1.39
1954	29	38	76:100	30	31	97:100	1:1.63
1955	43	56	77:100	45	38	118:100	1:1.48
Total	90	117	77:100	88	86	102:100	1:1.51

When the data were combined for all three years the sex ratio of juveniles approached the hypothetical 1:1 ratio. The adult male:female ratio of 77:100 was comparable to ratios found for fall-shot woodcock by several other investigators. Mendall and Aldous (1943) reported a sex ratio of 75 males:100 females, but this ratio included all ages. The ratio of 86:100 given by Harris (1953) was also for all ages. Greeley (1953) gave a sex ratio of 80 males:100 females in both adults and young.

Production.

Rates of increase, using the formula: $r = 1 + fy$ (Kelker, 1949) where,

f = proportion of females in adult population
y = average number of young per adult female

were determined for the three years. These rates are shown in Table 21 along with estimates of the spring breeding population and the fall ratio of young per adult female. (Data for the spring breeding population and broods were discussed earlier).

Table 21. Population levels for different periods.

Category	1953	1954	1955
Rates of increase	1.73	1.91	1.84
Spring breeding levels*	.80	1.04	.92
Young/adult female	1.39	1.63	1.48

* Woodcock heard per stop per route.

Survival rates were determined as 0.75 for the 1953-1954 period and 0.46 for the 1954-1955 period by the formula: $S = P_2/P_1 r$ (Petrides, 1949) where,

P_1 = population for one year
P_2 = population for second year
r = rate of increase

The survival rate of 0.75 seemed rather high but it could be possible that mortality, including hunting kill, was reduced for reasons unknown during that period. The spring breeding counts for Michigan showed an increase in the breeding population from 1953 to 1954. Half of the other states reporting woodcock counts also had an increase according to Aldrich (1955). If this increase did occur in Michigan it could have resulted from the low mortality indicated above, from an increased production in 1953, or from both.

A definite decrease in the number of young occurs from the nest to the fall season as determined by information from this study. The table below shows this decrease as it occurred.

	Average Clutch-size	Average Brood-size 0-7 days	8-14 days	Young/adult female (fall)
Number	3.9	3.6	3.4	1.5

The figure of 1.5 young per adult female is comparable to the ratio of 1.4 young per adult female which Greeley (1953) found to exist in fall-shot woodcock in Wisconsin. The low ratio indicates that the greatest number of woodcock died during the first five months of life, before the birds were even subjected to hunting pressure. In many species of birds this mortality is expected before the fledgling stage is reached. Here the greatest mortality, in numbers of birds, is indicated as occurring after the fledgling stage. Mendall and Aldous (1943) noted that the rate of mortality up to three weeks of age did not exceed 10 per cent, but they did not indicate

what the rate of mortality might be from that period to the fall season. A recent method devised by Allen J. Duvall of the Fish and Wildlife Service for aging woodcock by plumages during the summer may be useful in determining what per cent of the mortality occurs in each month. For the data to be reliable a large number of woodcock will need to be caught, and the birds must not show a differential sex or age vulnerability to the trapping technique employed.

Assuming that no mortality occurs in the adult group up to the hunting season then mortality of the total population between that time and the next spring breeding season should not exceed 54 per cent if the breeding population of the previous year is to be maintained at the same level. This conclusion is based on the assumption that the spring breeding population levels represent the true trends in the population. For 1954 and 1955 when the survival was determined as 46 per cent the spring population remained almost constant (1954 - 1.04, 1955 - 0.92).

From Fish and Wildlife Service banding records the writer determined that the average length of life for 41 woodcock banded as young birds in the spring and later recovered was approximately 10.6 months (Appendix). Of the 41, only 12, or less than 30 per cent, lived long enough to breed. Twenty-seven of the birds were recovered in the fall season of the year of banding. These records imply that as in most species the younger animals comprise the greater part of the hunting kill.

There is a considerable difference indicated between the mortality rate determined by population data from Michigan and the band

returns received from the Fish and Wildlife Service. This difference could be due to one or more of several reasons. First, as frequently is the case, the data are lacking. Second, the woodcock population in the northeastern states on which the band records were primarily obtained, could be different in population characteristics from the birds in Michigan. Third, the woodcock, being more concentrated in the northeast, could be subjected to a heavier local hunting pressure. Also juveniles may be less vulnerable to hunting pressure, although this would be contrary to the usual higher vulnerability of young birds. Finally, the method of using spring breeding levels to determine survival might not be appropriate since these levels are indicative only of trends.

Extent of Kill

Although the northeastern states have long been considered the land of "dyed-in-the-wool" woodcock hunters, Michigan has reported the greatest annual kill. This leadership in woodcock kill may have resulted from a combination of more woodcock habitat and a larger population of birds or a greater number of hunters in the woods.

For several years, kill of woodcock in Michigan has been determined on the basis of hunter report cards. In the later years these report cards were supposed to be given to hunters when they purchased a small-game hunting license (at first they were a part of the license). And though the law required hunters to send in the cards

after the season ended, the return usually was small, especially in the later years (Table 22).

In 1954, a new method of determining the kill of many game species, including woodcock, was started. This method was the polling of a group of hunters whose names had been chosen by a systematic sampling, the start of which was randomized. Approximately 4400 cards were mailed. If the hunter failed to return the card as many as four follow-ups were made if needed.

Of these two methods the post card survey was considered most reliable since it was based essentially on a random sample. The reliability of hunter report cards had long been questioned for several reasons. One such reason is bias due to a probable tendency for the more successful hunters to report in higher proportions. However, data from these reports have been somewhat useful as an indication of the trends involved. As shown in Table 22 the average number of woodcock bagged by hunters reporting on woodcock kill varied between 2.47 and 2.74. The largest kills came when the greatest number of hunters were in the woods.

A brief examination of the computed woodcock kill in Table 22 might leave the impression that the woodcock population showed a cyclic trend. However, the lows and highs of the kill were a result of the lows and highs of hunting pressure as shown by the straight-line relationship in Figure 15.

In general the various data pertaining to hunting records and population levels are too contradictory to set forth any definite conclusions. Although the data presented in Table 21 show that the

Table 22. Woodcock kill data from hunter report cards and post card surveys.

"Hunter Report Cards"

Year	Total No. of Hunters	Percent Return	Computed Woodcock Hunters	Computed Woodcock Kill	Average No. of Woodcock per Hunter Reporting	Percent Hunting Woodcock
1938	515,522	19.4	21,807	55,156	2.53	4.23
1939	538,026	39.6	22,337	60,081	2.69	4.15
1940	537,630	32.8	16,259	40,690	2.50	3.02
1941	610,000	25.1	13,882	35,553	2.56	2.28
1942	573,837	20.1	11,734	31,905	2.72	2.04
1943	510,000	13.4	13,208	32,938	2.49	2.59
1944	546,680	10.8	11,882	30,020	2.53	2.17
1945	547,204	10.3	15,107	37,258	2.47	2.76
1946	685,500	12.4	25,513	69,049	2.71	3.72
1947	535,927	11.0	21,223	58,249	2.74	3.96
1948	582,000	9.0	29,588	77,871	2.63	5.08
1949	626,941	9.5+	34,291	92,110	2.69	5.47
1950	620,192	9.0+	30,418	78,095	2.57	4.90
1951	640,010	9.2+	31,785	79,762	2.51	4.97
1952	664,728	7.2	32,903	84,197	2.56	4.95
1953	705,000	5.8	26,823	67,264	2.51	3.80
1954	714,000	5.0	21,488	54,701	2.55	3.01
1955	727,874	3.4	25,216	57,985	2.30	3.74

"Post Card Survey"

1954	662,920	94.0	29,150	49,320	1.69	4.40
1955	677,370	95.4	33,700	46,230	1.37	4.99

rates of increase, survival, and spring population levels for 1954 were the highest of the three years, most records show that fewer woodcock were killed in that year (Tables 22, 23, 24, 25, and 26). The post card survey (Table 22) showed a higher kill for 1954 than for 1955, but no comparison could be made to the 1953 harvest.

This hunting pressure, in addition to natural mortality, has not reduced the woodcock population to a critical level. If the population were being harmed it is unlikely that most of the hunting records would have shown an increase in kill in 1955 over that in 1954. The limit to which woodcock may be harvested can not be given. However, since the hunting success has remained relatively constant and the kill has continued to increase as the hunting pressure increased the point of overharvesting has not been reached.

It is likely that the woodcock may become more popular as a game bird in the southern states as a greater demand is placed upon wildlife as a source of recreation. If this additional harvest starts in the South then probably bag limits may need to be reduced in order to decrease the kill per hunter in Michigan and other northern states. The same number of hunters or more can still hunt woodcock but at a lower daily bag limit.

There could be a greater surplus to harvest if natural mortality could be reduced in juveniles. Of the current crop only 1.5 young per adult female, or about 38 per cent of the young, live to the fall.

Figure 15. Relationship between hunting pressure and woodcock kill (1938-1955).

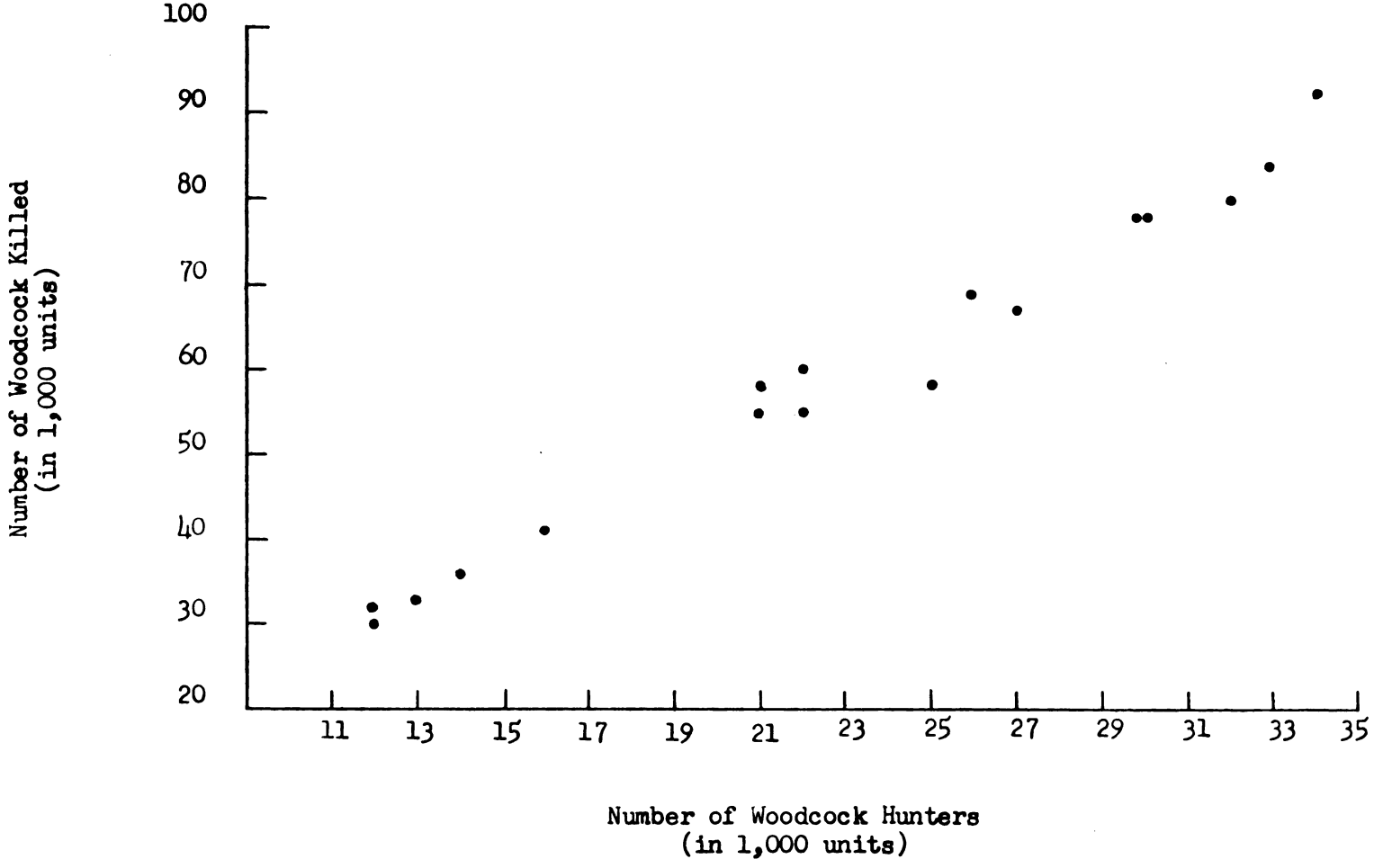


Table 23. Compilation of reports from those hunter cooperators who flushed woodcock.

Year	Number of Hours	Number of Woodcock Seen	Number of Woodcock Shot	Woodcock Seen per Hour	Woodcock Shot per Hour
1953	1389	1544	412	1.11	.30
1954	1135	1008	266	.89	.23
1955	1109	1284	340	1.16	.31

Table 24. Compilation of reports from those cooperators who hunted only woodcock.

Year	Number of Hours	Number of Woodcock Seen	Number of Woodcock Shot	Woodcock Seen per Hour	Woodcock Shot per Hour
1954	660.75	1019	274	1.54	.41
1955	510.50	956	279	1.87	.55

Table 25. Compilation of records from all ruffed grouse hunters reporting.

Year	Number of Hours	Number of Woodcock Seen	Number of Woodcock Shot	Woodcock Seen per Hour	Woodcock Shot per Hour
1953	4238	1544	435	.36	.10
1954	3598	1246	322	.35	.09
1955	3069.5	1568	437	.51	.14

Table 26. Compilation of hunter reports from the Rifle River Area.

Year	Number of Hunters	Number of Woodcock Seen	Number of Woodcock Shot	Woodcock Seen Per Hunter	Woodcock Shot Per Hunter
1954	66	146	13	2.21	.20
1955	121	443	65	3.66	.54

ECOLOGICAL FACTORS AFFECTING DISTRIBUTION, ABUNDANCE, AND ACTIVITIES

Vegetation

Plant cover seemed to be a major factor limiting the use of an area by woodcock in many instances. Whether the amount and type of vegetation was the limiting factor or whether vegetation was indicative of a combination of other factors which actually determined the use of an area was not always clear. It was probable, however, that both relationships existed, either separately or together, at various times.

Information pertaining to vegetation was gathered in several ways. Most data taken in relation to singing grounds, diurnal coverts, nests, and broods were based on a general examination of the immediate area. Records were made of the major species which occurred and the relative abundance of each. The summer and fall coverts were analyzed more systematically; the methods used will be discussed under those categories.

Breeding Areas.

Such areas included three primary niches: singing grounds, diurnal coverts, and feeding sites. Which of the three was most important was difficult to say, but it was probable that the singing ground and feeding site played comparable roles in determining whether or not a woodcock would be in the general area. A stand of trees

without any suitable openings was not used by a male woodcock regardless of the abundance of food. Nor was an area of suitable openings normally used if a scarcity of food prevailed for several miles.

At least 98 singing grounds were checked over the three-year period. Of these, 43 were examined closely to determine species composition, relative density, and the height of herbaceous and woody types. Since all three of these characters changed as the breeding season progressed, it was hard to characterize a singing ground for the entire spring. Generally, when the first woodcock returned to Michigan the ground was relatively bare, the only noticeable vegetation leafless shrubs and trees and dead herbaceous plants. Sometimes dead plants played an important part in determining the exact site to be used by a male bird. If the herbaceous growth had been extremely luxuriant in the previous year, and nothing had occurred to remove the greater part of it, then the dead stems remained dense and bothersome to the woodcock. Normally however, spots with relatively little cover were present on sites chosen for singing grounds. As the season progressed new plants started growing, and often by the first week of May herbaceous vegetation on some singing grounds was from 6 to 12 inches high. Usually one or more spots had shorter vegetation so woodcock continued using the singing ground; however, the rapid growth of herbs on some "grounds" undoubtedly shortened the use of those sites by woodcock.

The density of herbs progressed in much the same manner as height. But, on many of the "grounds" the prevalent forbs and grasses were of the low-growing type, such as strawberry, pussy's-toes, panic

grass, and blue-grass, and never reached 6 inches until late in the season. Even though the density may have been heavy, as was the case by May 1 for 32 of the "grounds," the plants averaged about 4 to 6 inches in height, and usually some spots were present which had shorter plants, or none. When a combination of heavy densities and average heights of about 8 to 12 inches occurred use of the site was terminated.

In any one season the density and height of woody plants changed very little. The ideal situation regarding woody plants seemed to occur when the plants were scattered sparsely over the general location and less than 6 feet high (Plate 13). Dangler and Marshall (1950) found that the cover on 14 out of 17 singing grounds was not higher than 5 feet.

Species composition as given in Tables 27 and 28 was confined primarily to new plants. The dead plants which were present on singing grounds when the breeding season began included primarily grasses, goldenrods, asters, and fleabanes. As indicated by the tables a variety of species, both herbaceous and woody, was found; more forb species could have been added if some "grounds" had been checked later in the season. The variety was increased somewhat by including singing-ground records from both the Lower and Upper peninsulas.

In summarizing, it may be said that the singing grounds observed in Michigan most often occurred in areas where an opening existed near woods. These openings occurred most frequently on such places as abandoned farms, cut-over land, old burns, and seldom-used roads. Generally, the herbaceous cover did not become important as a limiting factor until the breeding peak was passed. The most important

PLATE 13

A. The upper picture shows a singing ground which has been used several years by woodcock. Notice the height and distribution of shrubs which are encroaching upon the opening.

B. The lower picture shows an opening just opposite the one above. Woodcock were never observed in the site. Notice the absence of woody vegetation.

Table 27. Vegetation observed on singing grounds.

"Herbaceous Plants"

Species	Frequency*	Species	Frequency*
Grasses	40	Milkweed	4
Goldenrods	30	Cinquefoil	4
Strawberry	19	Alsike clover	3
Pussy's-toes	18	Bracken fern	2
Nut grass	11	Bastard-toadflax	2
Mosses	8	Groundsel	2
Orange hawkweed	8	Crowfoot	2
Aster	8	Wintergreen	2
Yarrow	7	Bulrush	2
Sorrel	6	Red clover	1
Chamomile	6	Vetch	1
Smartweed	5	Purple avens	1
Lichen	5	Common thistle	1
Dandelion	4	Violet	1
Wormwood	4	Wood-fern	1
Hawkbit	4	Mint	1

"Woody Plants"

Willow	15	Jack pine	1
Quaking aspen	11	Bush clover	1
Spiraea	6	Black ash	1
Black cherry	6	Common juniper	1
Staghorn sumac	5	Buffalo berry	1
Hawthorn	4	Bearberry	1
American elm	4	Canadian Juneberry	1
Blackberry	4	Dewberry	1
Red osier	3	Wild-raisin	1
Grey dogwood	2	Swamp birch	1
Chokecherry	2	Raspberry	1
Currant	2	Pin cherry	1
Sweet fern	2	Sugar maple	1
Poison sumac	1	Witch hazel	1

* The number of singing grounds on which the plant was observed.

Table 28. Vegetation enclosing singing grounds.

Species	Frequency*	Species	Frequency*
Willow	26	White oak	1
Quaking aspen	25	Multiflora rose	1
Black cherry	9	Indian grass	1
Red pine	7	Raspberry	1
Blackberry	6	Honeysuckle	1
Red osier	6	Chokecherry	1
Spiraea	6	Buckthorn	1
American elm	6	Bush clover	1
Staghorn sumac	6	Sugar maple	1
Speckled alder	6	Black spruce	1
Hawthorn	4	White spruce	1
Swamp birch	4	Buffalo berry	1
Grey dogwood	4	Large-toothed aspen	1
Apple	3	Chestnut	1
Tamarack	3	Yellow-barked oak	1
Poison sumac	3	Silky dogwood	1
Sweet fern	3	Witch hazel	1
White pine	3	Balsam fir	1
Jack pine	2	White cedar	1
Pin cherry	2	Currant	1
Black ash	2	Scotch pine	1

* The number of singing grounds on which the plant was observed.

PLATE 14

A. Site of a singing ground where staghorn sumac and scattered pine trees have served to break the continuity of an opening.

B. Site of a singing ground where bush clover (Lespedeza) has served as a substitute for early stages of woody vegetation succession.

vegetational characteristic seemed to be that plant succession on the openings was in the early woody or low shrubby stage. However, anything which seemed to break the continuity of an opening seemed to suffice. Some apparent substitutes for the early woody stage of succession were staghorn sumac, Indian grass, and bush clover (Plate 14).

While examining singing grounds for information on vegetation, records were kept on other possible characteristics such as soil, size, shape, exposure, and distances to water, nests, and diurnal coverts. The influence of soil will be discussed later. In regard to the next three factors, little importance could be placed on any of them because of the great variations between singing grounds. Some singing grounds contained approximately 25 square feet, the minimum noted by Mendall and Aldous (1943) in Maine. Normally, a male would restrict activities to a small portion of a much larger area which sometimes was as large as 40 acres. These smaller portions were distinctive parts of the overall clearing. One male was known to use several landing sites of various dimensions on about 3 acres. It seemed impractical to compute an average size since it was too difficult to define the actual limits of a singing ground.

Shapes of the clearing and the more restricted area of activity were of all possible forms. Because of the variation no significance was noted for this factor. Neither were the exposures considered important since all possible types were observed.

Distances to water, nests, and diurnal coverts were recorded for most singing grounds. The average distances to each respectively were

300, 320, and 285 feet. The range varied considerably: Water was found adjacent to singing grounds or as far as 925 feet distant. This water was of the type (streams and marshes) which might influence the surrounding area and thus determine the presence of food. Actually, the nearest permanent water supply was often as far as one-half mile.

Nests ranged from 25 to 660 feet from the nearest singing ground. It was not determined whether these singing grounds were ones which the female visited. Mendall and Aldous (1943) reported the average distance to the nearest "ground" to be only 115 yards, which was comparable to the 320 feet mentioned above.

Diurnal coverts were often in woods adjacent to the singing ground or as far as 750 feet away. Two males were observed using the same diurnal cover (Plate 15). One of these males went 45 feet to a singing ground while the other flew 730 feet. The average distance of 300 feet could be compared to the distance given by Mendall and Aldous (1943). They concluded territories over 100 yards were the exception rather than the rule.

Diurnal coverts and feeding areas were often at the same location. As indicated by Pettingill (1936), the diurnal territory is the principal abode of the male during breeding season; consequently, much of the feeding must take place in day-time cover. During the present study, however, in several instances other feeding areas were located where male woodcock went after the evening performance. These areas were soft, moist sites nearby. Birds may have gone much farther, but such movements could not be followed.

PLATE 15

A clump of tamaracks, on the Rose Lake Wildlife Experiment Station, which served as a diurnal covert for two male woodcock, a nesting site for a female woodcock for two years, and a singing ground for a male woodcock. The singing ground was located on the edge of the clump of trees (marked by arrow).

Since diurnal and feeding covers were frequently the same a list of major woody plants observed in those areas is included in Table 29.

Table 29. Woody plants found in diurnal coverts.

Species	Frequency*	Species	Frequency*
Quaking aspen	35	Large-toothed aspen	3
American elm	15	White pine	3
Willow	14	Black locust	2
Speckled alder	12	Viburnum	2
Red osier	10	Juneberry	2
Grey dogwood	9	Red pine	2
Tamarack	9	White birch	2
Oak	6	Jack pine	1
White spruce	6	Hawthorn	1
Black ash	5	Buffalo berry	1
Maple	5	Staghorn sumac	1
Black cherry	4	Chestnut	1
Poison sumac	3	Hickory	1
Spiraea	3	Highbush cranberry	1
Balsam fir	3	Ninebark	1
Balm-of-Gilead	3	Blackberry	1

* The number of diurnal coverts in which the plant was found.

Nesting Cover.

Although more than 30 woodcock nest reports were received, only 12 had cover types included. The immediate nesting cover was varied as would be expected with the numerous vegetative types which exist in Michigan. Generally, most nests were located in relatively open cover or at the edge of clearings.

Five nests were found in relatively young and open second-growth woods. Four of these nests were in upland woods consisting primarily of quaking aspen with an occasional white birch, juneberry, white

spruce, or balsam fir. The other nest was in a river valley consisting of a mixed growth of quaking and large-toothed aspens, white and jack pines, and white spruce.

Five other nests were situated at or near the edge of openings. Three were in a tamarack swamp on the edge of groves which consisted mostly of tamarack, grey dogwood, hawthorn, poison sumac, red osier, and elm. Two of the nests in the swamp were near the end of overhanging branches of tamaracks while the other was at the base of a hawthorn (Plate 11). Of the remaining two nests, located near openings, one was in a strip of willow, quaking aspen, and grey dogwood between an old field and a sedge marsh. The other nest was under a dead quaking aspen on the edge of an opening bordering a stand of aspen and speckled alder (Plate 16).

Two nests were built in fields. One nest was under a planted jack pine in an upland field while the other was in an open fallow field of grass and forbs.

In no instance was a nest well-concealed. Most of the immediate cover was dead vegetation and small green herbs (Plate 17). The birds seemed to depend upon their concealing coloration for protection rather than a dense vegetative stand.

Brood Habitat.

Since brood movements were not traced, the complete vegetative cover used by woodcock could not be determined. Only that vegetation in which broods were found once was analyzed. For 11 records, the general habitat type was the edge of relatively open woods adjacent

PLATE 16

A. The location of a woodcock nest beneath a fallen aspen at the edge of an alder-aspen stand.

B. A close-up of the above mentioned nest showing the eggs and nest construction.

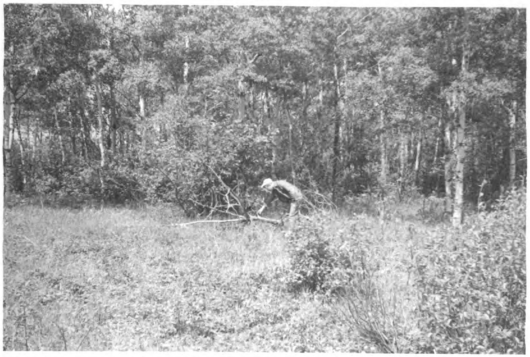


PLATE 17

A. A female woodcock on a nest, illustrating the lack of cover and type of vegetation present at that time of the year.

B. A picture of the above nest showing the eggs and again the lack of cover.

to clearings. Only one of the broods was in a dense stand of woods, and those woods were bordered on one side by a road.

Of the 11 broods found, 9 were in stands of quaking aspen. These stands included other such plants as blackberry, elm, grey dogwood, black ash, maple, willow, oak, hawthorn, red osier, or juneberry. Another brood was seen in a narrow strip of willow, quaking aspen, and grey dogwood which grew adjacent to a clearing. The last record concerned a brood found in a patch of timothy on Isle Royale.

Normally, the ground cover was heavier than the cover in which nests were located, but it was doubtful if the birds sought the heavier vegetation for cover. Probably by the time most broods were off, the ground cover was more dense due to new spring growth. Several broods were located in woods which had rather sparse ground cover (Plate 18). Two broods were found in dense stands of grass, but these stands had several open bare spots. Every brood was found in or near wet sites.

Summer.

In most places in Michigan the summer habitat of woodcock appeared to be similar to diurnal and feeding coverts used during the spring. Occasionally, woodcock moved to other places, but when they did the change usually was caused by a decrease in soil moisture within the regularly-used habitat. This decrease in soil moisture restricted feeding areas and thus was a major factor in causing woodcock concentrations. Such concentration areas were the ones analyzed for vegetational composition.

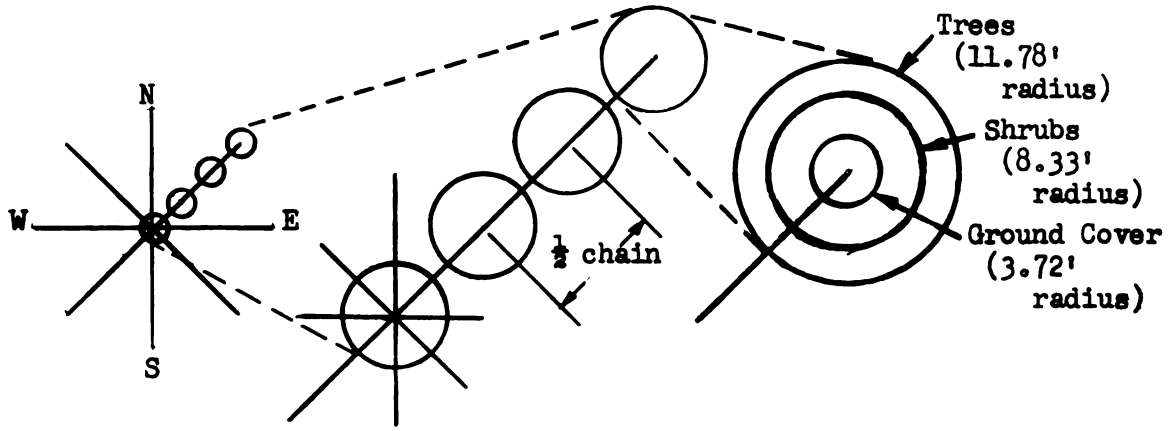
PLATE 18

Two young woodcock, in center of picture, illustrating the concealing coloration and the sparsity of the surrounding ground cover.

These concentration areas were classified tentatively as feeding or loafing places according to the general appearance of habitat, moisture content, location, and food availability. Loafing sites normally were in dry upland situations overlooking low moist feeding grounds. Earthworms were few in comparison to the number found in feeding areas.

Evidently, little feeding if any took place in loafing sites, but feeding areas provided both loafing and feeding cover. In most places used as feeding grounds, woodcock could be found any time during the day. At twilight more woodcock could be seen moving into these areas from adjacent hillsides or slopes and from seemingly greater distances.

During 1954 and 1955, nine feeding areas and four loafing areas were studied. The methods used in 1954 to determine species composition and density of vegetation was a modification of one proposed by Webb (1942). This modified method consisted of locating the approximate center of activity in the area to be analyzed. From this point, compass readings were taken to locate the eight principal directions. One circular plot was laid out and analyzed at the center point. Then 24 other plots (three on each of the eight lines) were analyzed in the defined area. The center of each plot was on the line, and the distance between the centers of two successive plots on a line was one-half chain (see following diagrams - top of next page).



Twenty-five was chosen arbitrarily as the number of sample plots per area. Then at the end of field work in 1954, the data were analyzed and it was believed that additional plots would not improve the precision enough to warrant the extra time involved. The following tabular information was used to construct Figure 16 which illustrates the reason for considering 25 plots a sufficient sample size.

Table 30. Data necessary to determine coefficient of variability of the mean or precision desired for various subsample sizes of vegetation in woodcock habitat.

	Trees		Shrubs		Ground Cover	
	Feeding Areas	All Areas	Feeding Areas	All Areas	Feeding Areas	All Areas
$\bar{x}$*	2.20	2.09	1.30	1.33	2.74	2.43
s	.59	.68	.57	.63	.45	.56

* Average density of the vegetation in the sampled areas.

Each plot was composed of three concentric subplots, one each for ground cover, shrubs, and trees. The radii for each of these subplots were 3.72, 8.33, and 11.78 feet respectively (see preceding diagram). Ground cover included all herbaceous plants and any woody

plant 1 foot high or less. Shrubs included any woody plant between 1 foot and 10 feet high. Woody plants higher than 10 feet were considered as trees.

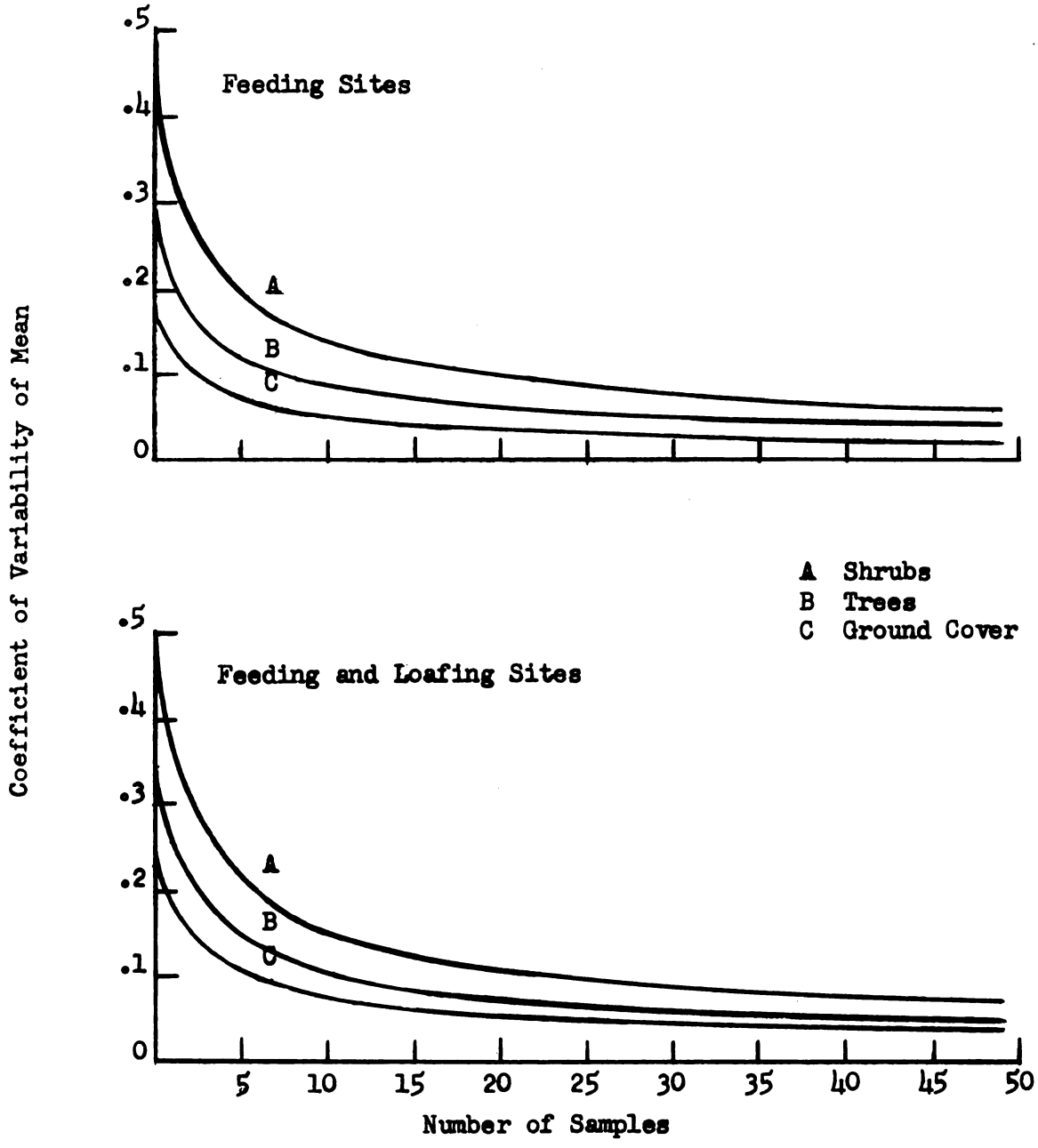
The density measurements recommended by Webb (1942) were used because of their apparent simplicity and because measurements are reproducible by other workers. Following are those measurements:

Trace - leaves cover less than 1/80 of the subplot area.
One - leaves cover between 1/80 and 1/3 of the subplot area.
Two - leaves cover between 1/3 and 2/3 of the subplot area.
Three - leaves cover more than 2/3 of the subplot area.

As the above described method was being used in 1954, it became apparent that a center of major activity was difficult to define and that too many plots were being located toward this so-called center. In 1955, the old method of locating plots was discarded but the system of plots, subplots, and density measurements was retained. The new method located plots at random. First, the approximate boundaries of the area being frequented by woodcock were located and a starting point designated. Then two numbers were chosen from a sheet of random numbers. The first number represented the distance from the starting point in one direction, or the first ordinate, and the second number represented the second coordinate perpendicular to the first. At the point located a plot was set up and analyzed if the plot fell within the defined boundaries. If the plot was outside the area it was ignored. Twenty-five such plots were analyzed for each area.

Data gathered from these plots and areas were analyzed by the method, prescribed by Webb, of giving each plant a rating. This rating depended on the frequency of occurrence and the total density as

Figure 16. Number of vegetation samples required to gather data which will give various degrees of reliability.



indicated by the formula: $R = P \times D \times K$, where,

R = rating
P = number of plots on which the species was found
D = average density computed by dividing the summation of the densities (E) by the number of plots on which the species was found (P).
K = a constant as long as the total number of plots remained the same. Its use made the maximum rating 100. Determined by: 100/total plots x 3.

Since $D = E/P$, then $R = EK$.

In analyzing the data three points were considered: (1) differences between the results obtained from two methods of collecting information, (2) characteristics of feeding and loafing areas, and (3) costs involved in gathering data.

To determine if the data obtained by the two methods of selecting sample plots could be combined, a "t" test was made for each of 15 major species of trees, shrubs, and herbs found in the feeding areas, comparing means of data collected by the two methods. Since no significant difference between the two methods could be detected by the test, data gathered by the two methods were combined.

Although certain plants seemed to the investigator to be characteristic of either feeding or loafing sites, judging by their abundance at one type of site and scarcity at the other, it was difficult to test statistically for these apparent differences. Except for the few most common species of plants, the fraction of plots with zero occurrence was high, producing a clearly non-normal distribution, and making use of the "t" test of doubtful value.

Several other reasons accounted for the difficulty in differentiating between kinds of areas statistically. First, too few data were available since in comparing kind of area, each area (25 plots)

Table 31. Relative abundance of plant species found in woodcock habitat.

"Feeding Areas"*

Trees	No.of Areas	No.of Plots	Total Density(E)	Rating
Speckled alder	9	204	251.67	37.50
Quaking aspen	8	123	153.32	22.84
Spruce	7	57	62.99	9.39
Balsam-fir	5	53	53.00	7.90
Willow	9	55	42.00	6.26
Balm-of-Gilead	7	51	38.99	5.81
White birch	8	43	35.33	5.26
American elm	5	37	28.67	4.27
Black cherry	5	34	26.67	3.97
Black ash	5	29	25.66	3.82
Tamarack	3	21	24.67	3.68
Nannyberry	3	14	10.67	1.59
Juneberry	2	9	4.34	.65
Pin-cherry	3	9	3.00	.45
White pine	1	3	3.00	.45
Red maple	2	4	2.66	.40
Yellow birch	1	2	2.00	.30
Red osier	2	2	1.33	.20
Choke-cherry	2	2	1.33	.20
White cedar	1	2	1.33	.20
Highbush-cranberry	2	2	.66	.10
Wild-raisin	1	1	.33	.05
Shrubs				
Speckled alder	9	203	187.33	27.91
Red osier	9	156	87.67	13.06
Raspberry	9	109	69.33	10.33
Nannyberry	5	49	30.33	4.52
Currant and Gooseberry	7	69	27.01	4.02
Black cherry	5	47	25.67	3.82
Wild-raisin	2	30	24.33	3.63
Willow	6	42	23.33	3.48
Spruce	5	38	23.33	3.48
Buckthorn	6	42	22.99	3.43
Spiraea	8	44	20.01	2.98
Balm-of-Gilead	5	38	17.33	2.58
Balsam-fir	5	26	15.33	2.28
Highbush-cranberry	7	28	12.66	1.89
Honeysuckle	6	23	9.67	1.44
Quaking aspen	8	29	9.66	1.44

Shrubs (cont....)	No.of Areas	No.of Plots	Total Density(E)	Rating
Choke-cherry	6	17	7.00	1.04
Ninebark	3	12	6.00	.89
Beaked hazel	1	8	6.00	.89
Virgin's-bower	5	13	5.66	.84
Pin-cherry	2	14	5.33	.79
American elm	2	12	4.67	.70
Red maple	4	14	4.66	.69
Blueberry	2	6	4.33	.65
Fly-honeysuckle	1	9	4.33	.65
Tamarack	1	8	3.33	.35
Swamp-fly-honeysuckle	3	7	2.33	.35
Swamp-birch	2	5	2.33	.35
Black alder	1	3	2.33	.35
Juneberry	3	7	2.33	.35
Black ash	5	6	1.99	.30
White birch	4	6	1.99	.30
White cedar	3	5	1.66	.25
Bush-honeysuckle	3	5	1.66	.25
Common elder	2	2	1.33	.20
White ash	1	2	.67	.10
Poison ivy	1	2	.67	.10
Wild honeysuckle	1	1	.33	.05
Hairy honeysuckle	1	1	.33	.05
Rose	1	1	.33	.05
Ground Cover				
Grasses	9	196	196.99	29.45
Sedge	9	185	179.33	26.72
Goldenrods	8	150	111.00	16.54
Strawberry	9	141	96.34	14.35
Dwarf raspberry	7	107	88.00	13.11
Violet	9	51	73.33	10.93
Asters	7	102	62.66	9.34
Bedstraw	9	130	58.67	8.74
Purple meadow-rue	7	87	53.67	8.00
Orange hawkweed	7	57	50.01	7.45
Bracken	4	36	46.66	6.95
Bishop's-cap	9	58	34.00	5.07
Bunchberry	6	38	28.32	4.22
Lettuce	9	73	24.34	3.63
Raspberry	8	52	22.34	3.33
Crowfoot	6	42	20.67	3.08
Lady fern	4	29	20.01	2.98
Spotted touch-me-not	3	35	19.66	2.93
Crested wood-fern	4	31	19.00	2.83
Bugle weed	3	34	17.34	2.58
Sensitive fern	2	13	16.33	2.43
Field mint	5	31	15.67	2.33

Ground Cover (cont....)	No.of Areas	No.of Plots	Total Density(E)	Rating
Red osier	8	46	15.33	2.28
Common thistle	7	35	15.32	2.28
Joe-Pye-weed	6	30	14.66	2.18
Mad-dog skullcap	3	27	14.33	2.14
Equisetum litorale	3	29	13.67	2.04
Currant and Gooseberry	7	41	13.67	2.04
Fringed polygala	7	35	13.66	2.04
Virgin's-bower	6	28	13.32	1.98
Common skullcap	3	29	13.00	1.94
Loosestrife	4	28	12.67	1.89
Avens	8	26	11.99	1.79
Sow-thistle	5	34	11.33	1.69
Alsike clover	3	22	11.33	1.69
Watercress	1	14	10.67	1.59
Balsam-fir	5	28	10.66	1.59
Black cherry	4	30	10.00	1.49
Twinflower	3	12	10.00	1.49
Lycopus rubellus	1	19	9.67	1.44
Wood-horsetail	2	22	9.33	1.39
Shinleafs	6	13	8.65	1.29
Wild sarasparilla	6	17	8.32	1.24
Poison ivy	3	12	7.33	1.09
False lily-of-the-valley	5	20	7.32	1.09
Goldthread	2	17	7.00	1.04
Blue flag	4	10	6.66	.99
Speckled alder	7	19	6.33	.94
Blueberry	2	9	6.33	.94
Viburnum	3	18	5.99	.89
Spruce	3	17	5.67	.84
Grape-fern	2	16	5.34	.80
Spike-rush	2	7	5.33	.79
Meadow-sweet	4	14	4.67	.70
Milkweed	2	12	4.66	.69
Daisy-fleabane	2	10	4.66	.69
Willow	2	11	4.34	.65
Pearly everlasting	3	9	4.33	.65
Moonwort	5	13	4.32	.64
American elm	2	12	4.00	.60
Juneberry	1	11	3.67	.55
Lycopus americanus	3	9	3.66	.55
Thimbleweed	2	10	3.33	.50
Honeysuckle	3	10	3.33	.50
Yarrow	3	8	3.33	.50
Yellow cress	1	8	3.33	.50
Marsh-bellflower	4	10	3.32	.49
Anemone	2	9	3.00	.45
Blazing-star	1	9	3.00	.45
Broad-leaf anemone	2	7	3.00	.45
Foamflower	4	9	2.99	.45

Ground Cover (cont....)	No.of Areas	No.of Plots	Total Density(E)	Rating
Buckthorn	4	9	2.99	.45
Ninebark	2	8	2.67	.40
Wing-stem monkey-flower	3	6	2.67	.40
Teaberry (wintergreen)	1	4	2.67	.40
Pin-cherry	3	8	2.66	.40
Quaking aspen	3	8	2.66	.40
Stinging nettle	2	6	2.66	.40
Red maple	3	7	2.33	.35
Dogbane	2	7	2.33	.35
Common sorrel	1	7	2.33	.35
Dwarf dandelion	1	7	2.33	.35
Choke-cherry	4	6	2.00	.30
White birch	2	6	2.00	.30
White cedar	1	6	2.00	.30
Star-flower	2	4	2.00	.30
Selfheal	3	4	2.00	.30
Duckweed	1	1	2.00	.30
Partridge-berry	2	6	2.00	.30
Balm-of-Gilead	3	6	1.99	.30
Bush-honeysuckle	2	5	1.67	.25
Groundsel	1	5	1.67	.25
Square-stem monkey-flower	1	5	1.67	.25
Beaked hazel	1	5	1.67	.25
Marsh-marigold	2	2	1.33	.20
Wormwood	1	4	1.33	.20
Highbush-cranberry	2	4	1.33	.20
Swamp-birch	1	2	1.33	.20
White lettuce	2	2	1.33	.20
Red baneberry	2	2	1.33	.20
Silvery spleenwort	1	2	1.33	.20
Rue-anemone	3	4	1.33	.20
Nightshade	1	2	1.33	.20
Toadflax	1	2	1.33	.20
Bulrush	1	1	1.00	.15
Corn-lily	2	3	1.00	.15
Cardinal-flower	1	3	1.00	.15
Water-mat	2	3	1.00	.15
Blackberry	2	3	1.00	.15
Beech	2	3	1.00	.15
Plantain	1	3	1.00	.15
Wood-betony	1	1	1.00	.15
Fringed loosestrife	3	3	.99	.15
Dandelion	1	2	.67	.10
Arrowhead	1	2	.67	.10
White snakeroot	1	2	.67	.10
Black ash	2	2	.66	.10
Trillium	2	2	.66	.10
Fragile fern	1	1	.33	.05
Northern green orchis	1	1	.33	.05

Ground Cover (cont....)	No.of Areas	No.of Plots	Total Density(E)	Rating
Poor Robin's plantain	1	1	.33	.05
Painted-cup	1	1	.33	.05
Tamarack	1	1	.33	.05
False Solomon's-seal	1	1	.33	.05
Turtlehead	1	1	.33	.05
Stick-tight	1	1	.33	.05
Common elder	1	1	.33	.05
White sweet clover	1	1	.33	.05
Common mouse-ear chickweed	1	1	.33	.05
Trailing arbutus	1	1	.33	.05
Wild columbine	1	1	.33	.05
Soft rush	1	1	.33	.05
White pine	1	1	.33	.05
Old-field-cinquefoil	1	1	.33	.05
Pussy's-toes	1	1	.33	.05
Wild bergamot	1	1	.33	.05
Blunt-leaf orchis	1	1	.33	.05

"Loafing Areas"**

Trees	No.of Areas	No.of Plots	Total Density(E)	Rating
Quaking aspen	4	77	107.00	35.63
Red maple	3	44	51.00	16.98
Spruce	1	23	25.67	8.55
White pine	3	31	22.67	7.55
Jack pine	3	30	20.67	6.88
Red pine	3	26	18.00	5.99
Large-toothed aspen	3	18	15.33	5.10
White birch	3	17	13.33	4.44
Balsam-fir	2	14	10.67	3.55
Pin-cherry	3	15	9.66	3.22
Black cherry	4	13	8.99	2.99
Juneberry	3	6	4.00	1.33
Red oak	2	3	1.67	.56
Willow	1	5	1.67	.56
Choke-cherry	1	3	1.67	.56
Speckled alder	2	2	.67	.22
Balm-of-Gilead	1	2	.67	.22
Beaked hazel	1	1	.33	.11
Shrubs				
Blackberry	3	64	67.33	22.42
Sweet-fern	2	31	26.66	8.88
Beaked hazel	3	35	25.99	8.65

Shrubs (cont....)	No.of Areas	No.of Plots	Total Density(E)	Rating
Black cherry	4	42	18.67	6.22
Quaking aspen	4	39	16.33	5.44
Willow	4	20	13.67	4.55
Blueberry	4	20	12.67	4.22
White pine	3	16	8.66	2.88
Red maple	3	14	6.00	2.00
Spruce	2	9	5.66	1.88
Bush-honeysuckle	2	6	2.66	.89
Red pine	2	6	2.66	.89
Pin-cherry	2	5	2.34	.78
White birch	1	7	2.33	.78
Large-toothed aspen	3	7	2.33	.78
Speckled alder	2	3	2.33	.78
Spiraea	2	4	2.00	.67
Choke-cherry	2	3	1.66	.55
Jack pine	2	3	1.66	.55
Juneberry	2	2	1.33	.44
Raspberry	1	3	1.00	.33
Honeysuckle	2	2	.66	.22
Balm-of-Gilead	2	2	.66	.22
Red osier	1	1	.33	.11
Balsam-fir	1	1	.33	.11
Wild-raisin	1	1	.33	.11
Rose	1	1	.33	.11
Ground Cover				
Bracken	4	96	172.33	57.39
Grass	4	96	89.67	29.86
Strawberry	4	84	54.32	18.09
Goldenrods	4	67	37.67	12.54
Teaberry (wintergreen)	3	45	30.00	9.99
Asters	4	71	29.66	9.88
Blackberry	3	53	26.33	8.77
Blueberry	4	22	17.66	5.88
Black cherry	4	39	12.99	4.33
Beaked hazel	3	38	12.67	4.22
Sweet-fern	2	28	10.00	3.33
Orange hawkweed	4	23	9.67	3.22
Fringed polygala	2	17	9.66	3.22
Sedge	2	13	8.67	2.89
Violet	3	22	8.00	2.66
Red maple	2	20	6.67	2.22
Bush-honeysuckle	2	19	6.34	2.11
Lettuce	4	18	6.01	2.00
Dogbane	4	16	5.34	1.78
Balsam-fir	3	16	5.33	1.77
Alsike clover	3	15	5.00	1.67
Shinleafs	4	12	4.67	1.56

Ground Cover (cont....)	No.of Areas	No.of Plots	Total Density(E)	Rating
Pin-cherry	2	14	4.67	1.56
Dwarf raspberry	1	6	4.67	1.56
Quaking aspen	4	13	4.33	1.44
Ground-cherry	1	6	4.00	1.33
White pine	2	11	3.67	1.22
False lily-of-the-valley	2	9	3.66	1.22
Honeysuckle	3	8	3.33	1.11
Bedstraw	2	10	3.33	1.11
Wormwood	1	4	2.67	.89
Daisy-fleabane	2	7	2.33	.78
Pearly everlasting	2	7	2.33	.78
Wild sarsaparilla	1	5	2.33	.78
Cow-wheat	1	6	2.00	.67
Wood-betony	1	3	1.67	.56
Common sorrel	2	4	1.33	.44
Foamflower	2	3	1.00	.33
Willow	2	3	1.00	.33
White birch	1	3	1.00	.33
Red osier	1	3	1.00	.33
Cinquefoil	1	1	1.00	.33
Cirsium Hillii	1	1	1.00	.33
Bunchberry	1	2	.67	.22
White lettuce	1	2	.67	.22
Virgin's-bower	1	2	.67	.22
Large-toothed aspen	1	2	.67	.22
Blazing-star	1	2	.67	.22
Spruce	2	2	.66	.22
Moonwort	2	2	.66	.22
Partridge-berry	2	2	.66	.22
Pussy's-toes	2	2	.66	.22
Viburnum	2	2	.66	.22
Anemone	1	1	.33	.11
Balm-of-Gilead	1	1	.33	.11
Sow-thistle	1	1	.33	.11
Milkweed	1	1	.33	.11
Raspberry	1	1	.33	.11
Purple meadow-rue	1	1	.33	.11
Yarrow	1	1	.33	.11
Buckthorn	1	1	.33	.11
Lady fern	1	1	.33	.11
Crowfoot	1	1	.33	.11
Trailing arbutus	1	1	.33	.11
Juneberry	1	1	.33	.11
Star-flower	1	1	.33	.11
Late coral-root	1	1	.33	.11
Ground-pine	1	1	.33	.11

Ground Cover (cont....)	No.of Areas	No.of Plots	Total Density(E)	Rating
Rose	1	1	.33	.11
False beech-drops	1	1	.33	.11
Common hound's tongue	1	1	.33	.11
Hieracium Gronovii	1	1	.33	.11

* A total of 9 areas and 223 plots were analyzed in woodcock feeding habitat.

** A total of 4 areas and 100 plots were analyzed in woodcock loafing habitat.

made up a single datum. More than twice as many feeding areas were studied as compared to loafing sites. Second, these two types of area frequently were adjacent to each other with a zone of overlap (Plate 19). It was difficult to draw a definite line separating the two areas; consequently, some species were recorded for both types of habitat when a random sample fell in those overlapping zones. Finally, judgments of the writer based on personal experience may have been biased.

A possible way of differentiating between areas, using vegetation, could be by the combined results from several species. If a correlation existed between certain species or among several these plants could be used as an entity to describe an area. Then if one species was missing from the entity in one area the absence would not be critical. Also the entity might be included in statistical tests. Such a method was not explored during this study.

The frequency of occurrence and the rating did indicate certain plants to be characteristic of feeding and loafing covers. Most plants which were found on the areas were listed in Table 31. A few unidentified plants were not included. This list shows the great variety of plants which do exist in woodcock habitat and those plants which were most abundant. The scientific names are included in the Appendix.

The most common species occurring in each plant category were found most frequently in certain types of environment. That is, such plants as speckled alder, red osier, sedge, and some violets normally were found in low moist sites of relatively heavy soils and hence on

PLATE 19

A picture of woodcock habitat used during the spring, summer, and fall. The lower area of alder, which serves as a feeding site, blends into the upper habitat of aspen-conifer which is used as a loafing area. A zone of overlap is formed where the two sites blend together.

feeding sites. Other plants like red maple, blackberry, and bracken fern were prevalent in the dry upland and well-drained soils and therefore found in loafing areas. However, some species such as quaking aspen, grasses of different species, and strawberry were almost as common in one kind of area as on the other.

Since the average density of plants was hidden in the rating, the following table was included to show the relative density for each category for the 13 areas analyzed. The maximum density as discussed previously was 3.0.

Class	Feeding Area	Loafing Area
Trees	2.09	1.88
Shrubs	1.29	1.25
Ground Cover	2.24	2.11

Ground cover appeared to be dense, but actually sufficient bare or low-density spots occurred to allow feeding and freedom of movement. In many sites where the ground cover was dense the foliage was short enough to allow movement over the plants or tall enough to allow movement beneath. Strawberries were a good example of the first type of foliage and ferns an example of the latter (Plate 20). Some sites were so densely vegetated that freedom of movement and feeding must have been difficult for the birds. In such areas few woodcock were found and when they were present they used the more open sites. Some areas observed were disappearing as woodcock coverts; such places have been considered in more detail in the section on habitat control.

Trees and shrubs were open enough to allow freedom of flight although the amount of cover overhead frequently covered two-thirds of

PLATE 20

A. A view through an aspen-birch-conifer stand showing the apparent density of bracken fern. Woodcock were still quite abundant in this area.

B. A close-up showing the flushing site of a woodcock. Bracken fern, although dense above, is sparse enough at the ground level to allow freedom of movement by woodcock.

Table 32. Woodcock summer cover as based on vegetation at 222 flushing sites.

Plant	Frequency
Speckled alder	158
Quaking aspen	117
Spruce	56
Balm-of-Gilead	36
Willow	34
Balsam fir	33
White birch	22
Black cherry	20
Tamarack	16
Red maple	16
Elm	15
White cedar	11
White pine	11
Black ash	11
Large-toothed aspen	8
Jack pine	5
Red pine	4
Nannyberry	4
Bracken fern	3
Juneberry	3
Ninebark	2
Red osier	2
Viburnum	1
Spiraea	1
Beaked hazel	1
Pin cherry	1
Basswood	1
Highbush cranberry	1
Green osier	1

the area.

In addition to the systematic sampling, information was collected on the dominant overstory at the site where a woodcock was flushed. Usually, this overstory consisted of trees, but frequently shrubs were dominant and on three occasions bracken fern was the only cover (Table 32). Again the species which occurred most frequently were speckled alder and quaking aspen.

In summary, a feeding area seemed to be covered with those plant species characteristic of low moist sites. However, all such sites were not used by woodcock, probably because the density of the vegetation was too great or food availability was too low. Some areas used by woodcock could have had a very different plant composition since vegetation varies to a certain extent between sections of the state. The plant composition of a typical loafing area was also characteristic of many areas which never were used by woodcock. Thus, a loafing area was characterized, not only by certain plants, but also by its relationship to feeding sites.

Previously it has been pointed out that a sample of 25 plots per acre gave relatively accurate data by which a particular area might be characterized. However, the economics and practical aspects involved in gathering the data were not considered; so an estimate of the cost involved in locating and analyzing woodcock cover was obtained in order to determine the optimum number of plots per area.

Since speckled alder was the dominant species found in many areas, the ratings for that plant were used to determine a mean square or variance required for a cost analysis. An arc sine transformation was used on the original densities because of the percentage nature of

the data and the apparent relationship between the means and variances. Resulting data were included in the following tabulation based on 1955 data:

Source of error	Degrees of Freedom	Sum of Squares	Mean Square
Between areas	4	4,328.8	1082.2
Within areas	120	22,441.2	187.0

An estimate of the cost for locating areas was based upon travel expense and time required to survey the area. Twenty such areas were located and checked. The cost was $13.83 per area. To estimate the cost of analyzing an area, which included travel expense and actual time spent examining the cover, data from 14 areas were used. That cost was $43.13 per area or $1.72 per plot.

Using formula 4 and substituting the necessary cost figures and variances, the optimum number of plots per area was computed as being 6.5. Thus it seems that it would be more practical and economical to locate more areas and analyze fewer plots per area.

Since many areas analyzed in 1954 and 1955 were known beforehand the average cost for locating an area was reduced. Future areas to be studied would be expensive to find since presumably the location of such areas would not be known. Consequently, the ratio between cost of locating and cost of analyzing an area would be greater than the present 8.03 and thus the optimum number of plots would increase. A sample of at least 10 plots per area should be considered if such an analysis of vegetation is continued. With the reduced sample per area presumably more areas could be analyzed.

Fall.

In most cases the areas studied during the summer were used by woodcock in the fall (Plate 19). Consequently, plant characteristics discussed for the summer period remained much the same. The exceptions were that the composition of cover species changed in regard to abundance of live plants. Most of the same species remained, but in many cases they prevailed as dead or dying plants. With the dying of plants many sites became more open. The composition of trees and shrubs remained the same, but the density of the overstory decreased because deciduous species lost their leaves. Generally, the major difference between summer and fall cover was the decrease in density.

Records were made of dominant woody plants which were found at 224 flushing sites of woodcock in the fall (Table 33). Again speckled alder and quaking aspen were observed most frequently, indicating that most woodcock were flushed in low moist sites or adjacent to such places.

Land-use.

Openings used as singing grounds resulted from various causes. To determine these causes, two state-owned land tracts, the Rose Lake Wildlife Experiment Station and the Gratiot-Saginaw Game Area, were chosen for study. These areas were selected because of the availability of historical records and their nearness to spring headquarters. Information regarding past land-use practices was obtained from those records and from persons familiar with the history of the area. Present land-use practices on the area also were determined. Twenty-one

Table 33. Woodcock fall cover as based on vegetation found at 224 flushing sites.

Plant	Frequency
Speckled alder	161
Quaking aspen	160
Willow	60
Spruce	48
Elm	17
Balm-of-Gilead	15
Black cherry	14
Red osier	13
White cedar	7
White birch	5
Grey dogwood	5
White pine	4
Tamarack	4
Highbush cranberry	4
Red pine	3
Balsam fir	3
Black ash	3
Red maple	1
Hawthorn	1
Basswood	1
Spiraea	1
Black locust	1

singing grounds at Rose Lake and 29 at Gratiot-Saginaw were included in the study.

Of the 21 singing grounds examined on the Rose Lake Experiment Station, 2 were in food patches while 19 were on land lying idle. However, 4 "grounds" were adjacent to food patches and 4 others were in areas that had been planted to pines and staghorn sumac.

Ten singing grounds were located in sites farmed prior to 1946, while 2 other "grounds" were in areas cleared and broken about 1938 for farming but never used except for pasturing. Nine other places were pastured until about 1940. One of the areas farmed had been a fruit orchard earlier. When the above areas were purchased by the Department of Conservation, most of them were taken out of cultivation of any sort except for a few food patches and the scattered pine and shrub plantings already mentioned.

Since most of the areas have remained idle for ten or more years some woody vegetation has returned. In most of the old pastures and farms, where plant succession has been slow, only scattered shrubs and small trees have reappeared. In two portions of the tamarack swamp which were cleared for farming, the invasion of woody plants has eliminated most open sites.

For the Gratiot-Saginaw Game Area the history of most of the original clearings has been primarily one of fires. In 1871, at the time of the great Chicago fire, many fires were flaring up over much of the Lower Peninsula. On October 10 of that year, the Saginaw Valley was swept with fire and four days later fires were reported increasing in Gratiot County (Mitchell and Robson, 1950). Other large

fires in 1894 and 1940 swept much of the area, while smaller fires between the 1871 and 1940 fires were scattered through the area.

Much of the merchantable timber was removed by lumber companies. One of the early lumber mills (Potter's Mill) and a small community were located in a clearing which still exists. One edge of this clearing has been used as a singing ground at least for the past four years.

Some farming was attempted in various parts of the area, so a few of the clearings were maintained or reopened by farmers. Eight singing grounds were found on sites which were cleared and farmed prior to 1940. Eight other "grounds" were located on tracts of land which had been pastured at some time. One of these tracts of about 20 acres, which was broken prior to 1950 for farmland but was used only for pasture, contained three singing grounds.

Most state land involved was obtained through purchases or tax reversion in 1941; a few forties were added in 1942, 1943, and 1947. Since the land was taken over by the state, it has remained idle except for a few food patches and occasional pine plantings. Three singing grounds were located adjacent to food patches and at least seven "grounds" were in or near sites of scattered pine plantings.

Agricultural practices and fires in the Rose Lake and Gratiot-Saginaw areas were responsible for clearings which developed into suitable sites for woodcock breeding activity. These clearings, in most cases idle for a decade or so, have retained their open aspect because of slow woody-plant succession. Decreased availability of soil nutrients, and plant competition probably have been the major

factors causing the slow succession.

Agricultural practices and fires accounted for many clearings used by woodcock throughout the state, but other factors have been equally or more important in restricted areas. Lumbering operations opened many sites which were maintained as clearings by fires, various agricultural usages, loss of soil fertility, etc. Other clearings were caused by mining operations, road construction (including railroads), power and gas lines, and natural stream erosion.

Soil

A great variety of soil textures were found in habitat occupied by woodcock. These ranged from sandy soils to organic soils of muck and peat. Because of this variety soil types alone could not be considered as a limiting factor to abundance and distribution of woodcock.

At least 156 sites being used by woodcock were checked for soil texture (Table 34). A large portion of these soil types were identified by Cash Wonser, land-use specialist of the Game Division, Department of Conservation. In the remaining sites the soils were identified on the basis of descriptions presented in soil survey reports.

— Breeding grounds were located primarily on well-drained soils such as Rubicon and Roselawn sands, Hiawatha fine sandy loam, Oshtemo loamy sand, and Onaway loam. Of the 80 singing grounds checked, 42

Table 34. Types of soil on which woodcock were found.

	Type of Site				
	Singing ground	Nesting	Brood	Feeding	Loafing	Totals
Sand	29	1	1	0	6	37
Loamy Sand	10	1	0	1	4	16
Sandy Loam	16	3	3	8	6	36
Loam	17	0	1	6	0	24
Clay Loam	0	1	0	0	0	1
Silt Loam	0	0	0	1	0	1
Muck	2	1	3	14	1	21
Peat	6	3	0	11	0	20
Totals	80	10	8	41	17	156

were on such soils. Imperfectly-drained soils, including Newton sand and loamy sand, Saugatuck sand, and Brady sandy loam, were the site of 27 other "grounds." Three singing grounds were located on moderately-drained Berrien loamy sands, while the remaining 8 grounds were on poorly-drained soils such as Rifle peat. During the past three years at least 5 active "grounds" have been observed each year in a large area of Rifle peat on the Rose Lake Experiment Station. One of these "grounds" has been occupied all three years.

Of ten nesting sites analyzed, 5 were on well-drained soils, 1 on an imperfectly-drained soil, and the other 4 were on poorly-drained soils. Three of those nests on the latter type of soil were in the Rifle peat area discussed above and thus near singing grounds. Evidently, females did not show any preference for soil textures.

Broods remained on or near the heavier and wetter soils, probably because of feeding habits. Four broods were found on undrained muck and loam soils while three others were on the imperfectly-drained Brady sandy loam.

Feeding areas studied were on moist soils. Thirty-three of the 41 feeding sites occurred in poorly-drained situations which included such soils as Rifle peat, Carbondale peat and muck, Lupton and Kerston muck, Griffin loam, and Munuscong sandy loam. Of the remaining 8 sites, 4 were on moderately-drained soils, 3 on imperfectly-drained soils, and 1 on a well-drained soil.

Occasionally, woodcock were reported feeding on dry upland sites considerable distances from moist areas. The soils on such sites, though unchecked, probably were of the sandy types. If woodcock were

feeding on those areas they undoubtedly were after insects and not earthworms.

Loafing sites were more difficult to define since woodcock frequently used one area for both a feeding and loafing site. However, some places were used strictly as loafing areas. These places usually were dry upland sites adjacent to feeding sites. Ten so-called loafing sites were on well-drained sandy soils, 6 were on imperfectly-drained sandy soils, and 1 was on a moderately-drained soil of thin muck over sand. Woodcock could be seen flying from those places in the evening to adjacent moist sites of poorly-drained soils.

The type of soil found in an area was not by itself a restricting factor to the presence of woodcock. Factors associated with the soil such as moisture content, earthworm abundance, and relation to other soil textures were more important. As a result of the extensive glaciation which occurred in Michigan, the soil types within an area are quite varied and provide most of the necessary combinations of soil factors required by woodcock.

Soil moisture was a factor which determined where most of the activity would be. A majority of the singing grounds were on drier sites while most feeding areas were on poorly-drained soils. If an area became too wet, birds vacated that location. Likewise, as discussed above, birds concentrated near or in the more moist situations in the summer and fall when drought conditions existed.

Soil p^H was not recorded for most areas examined, and many descriptions in soil survey reports omitted the chemical aspects. However, soils ranged from strongly acid to slightly alkaline with acidic

soils predominant. Of 62 soil samples taken from 13 loafing and feeding sites in the Pigeon River Area, only 5 samples had a pH greater than 7.00. Eleven samples had a pH of 6.90 or greater. As shown in Table 35 there seemed to be little correlation between pH, and the type of area and abundance of earthworms.

Vegetation did not become a limiting factor to the presence of woodcock unless the stands became too dense or old. Usually, the types of vegetation occurring on a site was a result of the soil factors. Thus vegetation was often a good indication of the soil type which existed at that location.

Food

The diet of woodcock which were examined consisted primarily of animal food, particularly earthworms. Pettingill (1936) found earthworms more frequently in woodcock stomachs than any other food. Approximate percentages given by Pettingill (1939) were: earthworms 86, arthropods 10, and seeds 4. Other reports have placed the percentages of earthworms above 85 per cent (Aldous, 1939, and Mendall and Aldous, 1943). Sperry (1940) reported that for 261 specimens taken from March through December, earthworms constituted 68 per cent of the total food content. The lowest percentage of earthworms in the diet occurred in December -- 48. In October, 82 per cent of the food was earthworms. The seed content increased to 28 per cent in September while insects were found in greatest numbers in August.

Table 35. Relationship between earthworms, soil pH*, and woodcock habitat.

Area	Date	Type of Site	pH Range	Avg. pH	Earthworms Per Sq.Ft.**	Species of Earthworm
I	8/13/54	Loafing	5.7-6.4	6.0	1.1 ± 1.4	Lumbricus rubellus
II	9/ 1/54	Loafing	5.5-5.6	5.5	1.5 ± 2.0	Lumbricus rubellus
V	8/21/54	Feeding	7.2-7.3	7.2	6.5 ± 4.3	Lumbricus rubellus
VIa	8/18/54	Loafing	6.4-6.7	6.5	1.6 ± 2.0	Lumbricus rubellus
VIb	8/19/54	Feeding	6.4-6.6	6.5	9.3 ± 5.9	Lumbricus rubellus
VII	11/12/54	Feeding	5.2-6.9	5.9	22.7 ±12.4	Lumbricus rubellus
VIII	11/13/54	Feeding	6.4-6.7	6.6	.2 ± ---	Lumbricus rubellus
IX	7/22/55	Feeding	6.0-7.0	6.4	8.2 ± 6.1	Lumbricus rubellus
X	7/25/55	Loafing	5.6-6.0	5.8	1.6 ± 1.8	Lumbricus rubellus
XI	8/ 4/55	Feeding	6.8-7.1	6.9	3.8 ± 3.9	Lumbricus rubellus
XII	8/ 5/55	Feeding	6.6-6.9	6.8	2.2 ± 2.8	Lumbricus rubellus
XIII	8/30/55	Feeding	5.0-6.9	6.0	19.8 ±19.0	Lumbricus rubellus and Bimastos tenuis
XIV	9/17/55	Loafing	5.0-6.2	5.8	1.0 ± 1.1	Lumbricus rubellus

* pH was determined with a Beckman pH meter.
** Based on twelve samples in each area.

Although a large number of woodcock specimens were collected in the Michigan study and the gastro-intestinal tracts were preserved, a detailed analysis has not been made of the food content. Generally, the stomach contents included earthworms, insects, seeds, and vegetative parts of plants. Earthworms composed the greatest volume; this was especially evident when worms were found in the esophagus and proventriculus. If earthworms had reached the stomach, digestive processes had destroyed much of the body structure. The same was true for other soft-bodied animals such as insect larvae.

Insects, particularly beetles, were found frequently, but the volume was small compared to the abundance of earthworms. Other animal forms included sow bugs and spiders.

Plant material was as abundant as any other item, but it is doubtful that the material was always taken as food. Seeds, which in some cases were numerous and of a variety of species, could have been taken intentionally. It was believed that, in many instances, plant material, including seeds, was taken unintentionally while the bird was probing.

Grit occurred in the stomach of every specimen examined for parasites. This grit could have been taken unintentionally also as the bird probed for food or it may have come from earthworms. However, woodcock were observed on several occasions picking up small particles, evidently grit, in roads and trails during the twilight hours.

Earthworm availability studies were made to determine differences between loafing and feeding areas. Several methods were used to

determine the availability and abundance of earthworms. These methods included various dosages of potassium permanganate, mechanical vibrations, electric currents of varying intensities, and the digging of circumscribed plots. All but the last method were discarded early in the study since most soil situations required different dosages, boundaries of the area affected could not be determined, and earthworms could have gone down or to the sides as well as to the surface.

Some earthworms probably went downward as soon as the soil was disturbed by a shovel, but more worms were found when plots were dug than with any other method. The plot was one foot square and three inches deep. Only three inches was removed since most woodcock could not probe beyond that depth. Twelve plots, chosen on the basis of the random number sampling technique employed with vegetative plots, were dug in each area analyzed.

For five loafing sites the average number of earthworms per square foot was 1.4, while the average for seven feeding sites was 10.4, a significant difference as indicated by a "t" value received when a comparison of the two types of areas was made. The data for Area VIII were not included because the sample taken from the area was not representative. An analysis of that area could not be made until after a high water level which flooded the site subsided. The water in combination with freezing temperatures may have affected the distribution of worms. Plots dug adjacent to the sampled area, and where high water did not reach, contained a higher earthworm population.

Earthworm counts for Area XI and XII seemed too low for a feeding site, especially when compared to the counts from the other feeding

places. However, woodcock were seen feeding at the two locations during the day, other birds were seen flying into the areas at twilight, and probings were numerous throughout. The areas were not the most productive sites for earthworms, but much of the ground was soft and birds could probe with ease. Even though counts were low, more earthworms were found there than in any loafing site.

Weather

Of the many weather factors the following affected the distribution, abundance, or activity of woodcock during the summer and fall: temperature, wind, precipitation, and light intensities. Information regarding these factors was taken from general field observations and records maintained by the U.S. Weather Bureau.

Temperature.

Heat was not known to affect woodcock directly, although it may have been a factor causing minor local movements. Indirectly, heat helped determine the distribution and activity of many birds by drying up some areas.

Cold had a greater effect on woodcock. Even in the summer months twilight flights preceding evening feeding were reduced in length of time and number of birds participating when temperatures fell below 45° F. In late summer and fall cooler temperatures affected local movements and migrations. One reason given for the woodcock movement

from the West McMaster Creek area in early September (1955) was the sudden decrease in temperature. The average daytime temperatures remained approximately the same as in August, but night temperatures dropped sufficiently to cause frost conditions. Such a sudden change could have caused some woodcock movement.

Although occasional population increases in the Pigeon River Area and Region II preceded or followed a cold front, more often the increase occurred on the same day as the lowered temperature. Temperature and precipitation data from Sault Ste. Marie, Newberry, Mackinaw City, Pigeon River Research Station, and East Jordan were used to indicate critical weather conditions for the eastern part of the Upper Peninsula and the northern half of Region II (data included in the Appendix). Since the distance between the extreme locations was only about 100 miles, population fluctuations in Regions I and II could have been caused by the same cold spell.

As autumn progressed, increasingly colder temperatures seemed to have less effect on woodcock. Several birds were present in the Pigeon River Area in the latter part of the 1954 hunting season even though temperatures fell as low as 14° F.; whereas, earlier in the season population decreases were noticed when temperatures dropped to 40°. Toward the end of both the 1954 and 1955 hunting seasons, a definite flight occurred in the Pigeon River Area, indicating that some woodcock had remained farther north regardless of the lower average temperatures.

Wind.

Periods of northerly winds or of no wind favored woodcock migration; whereas, moderate or strong southerly winds seemed to hold back

movements. As indicated above, movements occurred most frequently just prior to or during periods of decreasing temperatures. These periods of decreasing temperatures and the northerly winds occurred at the same time. Some population fluctuations took place when temperatures were mild and light southerly winds prevailed.

Imhoff (1953) showed that during spring migrations in the south, clear warm days with moderate southerly winds were most favorable to migrants while cold fronts were most unfavorable. Others have deduced from various studies and observations that in general spring migration was related to the movement of air masses (Lowery, 1951; Bullis, 1954; and Douglass, 1955). In fall migration, birds in the north should be affected similarly by opposite conditions. Mazzeo (1955) reported that birds seemed to arrive at Matinicus Rock, Maine, regardless of the wind's direction, but that the greatest numbers arrived during very strong northwest winds. His observations were made from August 27 to September 11, 1949.

Woodcock activity during the evening and morning flights of summer and fall were correlated with wind conditions. If the wind, regardless of direction, exceeded 10 miles per hour, fewer woodcock were seen flying; when the wind exceeded 15 miles per hour very few, if any, woodcock were observed. Strong winds during the day had no effect on woodcock since birds remained on the ground most of the time.

Precipitation.

Rain and snow also affected the distribution, activity, and movements of woodcock. The effect on distribution and activity was more

evident on local populations. During the summer and fall normal precipitation helped maintain many feeding sites by keeping the soil moist. Below-normal precipitation caused a decreased moisture content in many places and thus caused woodcock concentrations. Above-normal precipitation caused a wider distribution of woodcock since more moist areas were available as feeding sites.

Much rain fell in the Pigeon River Area in the latter part of the 1954 summer. As a result, much woodcock habitat, especially feeding areas, was flooded. Consequently, woodcock were found scattered along the edge of flooded sites and in swales of adjacent areas. In the same period of time in 1955, less rainfall occurred and woodcock were more concentrated. Similar situations occurred in many other locations.

The effect which precipitation had on the flushing distance of woodcock varied. Some birds flushed more quickly and at greater distances when the vegetation was moist or when it was raining. Generally, however, woodcock were more difficult to flush during rainy conditions, their ascent was less lively, and the distance of flight was shorter.

Evening and morning flights definitely were influenced by rain. A light sprinkle had less effect on woodcock activity than a rain, but even with the light precipitation fewer woodcock were seen flying in the areas observed at Pigeon River. A heavy downpour or a slow steady rain were most effective in preventing woodcock flights. Very few birds, and frequently none, were seen if a lapse in the rainfall occurred during the normal flight period. Evidently, the wet vegetation, high humidity, or dark cloudy sky influenced flight activity even though rain was not falling.

Precipitation produced the same results in regard to migration; that is, woodcock did not move during rains. If birds were found in an area one day and then it rained that night, birds could be expected in that area the following day. If they were not there then they probably had moved just before the rain. The major precipitation often followed the change in temperature by one or more days. Therefore, the population fluctuations discussed previously in relation to temperature decreases and northerly winds took place prior to the precipitation which often was a result of the changes in other weather conditions. However, the population did not always decrease prior to a heavy precipitation. On several occasions the population was at a peak during the rainy spell, which would tend to substantiate an earlier statement that woodcock did not move during rainy weather.

Nebulosity and Light Intensities.

Woodcock activity, especially evening and morning flights, was influenced by light intensities. When skies were clear, woodcock began their evening flights shortly after sundown. Morning flights were begun shortly before dawn. But on days when the percentage of cloud cover was high, flights started earlier in the evenings and later in the mornings. The relationship between woodcock activity, cloud cover, and light intensities was similar to that discussed for the breeding population except that the moon was less important. Evening flights did not last any longer when bright moonlight conditions existed.

Woodcock populations fluctuated regardless of the cloudiness or

light intensities, not including periods of precipitation. Birds may have moved more on moonlight nights, but there was no indication of such activity at Pigeon River. Areas were found empty of woodcock following a cloudy night as well as a clear moonlight night. No comparative data, other than incidental observations, were available.

Barometric Pressure.

During the fall, fluctuations in woodcock populations at Pigeon River seemed to be correlated with changes in barometric pressure. These population fluctuations occurred at or near the time of pressure changes but not necessarily in the same direction. Sometimes the population seemed to increase as the pressure increased and at other times under similar pressure trends the population decreased; the population fluctuated similarly with high pressure conditions.

Even though the woodcock population did seem to fluctuate with pressure changes, the number of birds present in the Pigeon River area did not seem to be any greater with one pressure condition than the other. In case of the European woodcock, Schenk (1931) reported that in the spring this bird generally appeared in Hungary when a low atmospheric pressure existed over England; however, such a relationship was not evident for the fall migration.

Other Factors

Competition.

All intraspecies competition observed occurred in the spring breeding season. At that time some territorialism was displayed on

the singing grounds. The strong territorial system and defense common to many other birds was not evident among the woodcock observed.

Although no actual combats were seen, a few observations were made of certain actions which simulated defense of an area. A male bird was performing on a singing ground at Rose Lake when another woodcock flew directly over. The performer arose and darted after the passing bird for a short distance before returning to assume the courtship display. During the short defense a rough cackling noise was uttered by the defender.

On another occasion a male was observed pursuing another bird which had entered the area being occupied. Both birds flew directly upward with the defender literally "on the tail" of the intruder. The two birds appeared as butterflies flitting upward with the defending bird making consistent and continual passes at the other one. Finally, the intruder faded off in the direction of another singing ground. The intruding bird may have been the occupant of a singing ground less than 100 yards away since no activity was heard in that direction while the two birds were in the air.

Several singing grounds were located close enough for the male birds to overlap in their flights, but only a few cases of antagonistic action were seen. William Goudy made an interesting observation one evening on a singing ground when he attempted to imitate the peent of a performing male. This bird immediately rushed toward the sound, making low cackling noises and ruffling its feathers. This display was repeated each time an imitation peent was given.

Mendall and Aldous (1943) reported on several observations concerning defense of the breeding area. They felt that males were very jealous of their display site and seemed to be more disturbed by the presence of other male woodcock than by human intruders. Pitelka (1943) observed frequent instances of territorial defense and competition. However, much intraspecific tolerance was noted by Sheldon (1953) in studies on woodcock in Massachusetts.

Even though singing grounds were defended at times by male birds, defense of diurnal coverts was not observed. Two male birds used the coverts illustrated in Plate 15 consistently in 1954. Frequently these two birds were flushed almost together, and on several occasions both were heard peenting in the coverts prior to their departure for individual singing grounds. Two other similar small and compact diurnal coverts were found being used jointly by at least two males.

No information was gathered pertaining to nesting territories, but Mendall and Aldous (1943) found little evidence of territorial instincts in females. Some nests were found only 25 feet apart though the usual distance seemed to be at least 200 yards.

Territorial displays were not observed among woodcock on feeding areas. In fact, woodcock concentrated in certain places to feed during the summer and fall. In such places there could have been a direct competition for the available food supply. Several people have mentioned the voracious appetite of woodcock (Audubon, 1835--cf. Pettingill, 1936; Forbush, 1925; and Robert Whiting, 1954 -- personal interview). However, an analysis was made of the abundance of earthworms in several places and a large number of worms were still available

after birds had deserted the site. Thus the woodcock must not hav been seriously affected by any intraspecific competition for food.

The major interspecies competition involved man. In no instance was any other animal observed in competition with woodcock for space or food. But man and his activities often affected woodcock either directly or indirectly. Such activities as farming, construction, etc., mentioned earlier, often interrupted singing ground displays or removed the "grounds" entirely from further use by woodcock. Fires, lumbering, agricultural practices, and other land uses destroyed diurnal and feeding coverts. The period of time for which some sites would be usable by woodcock was decreased by shrub and tree plantings. However, such activities as those above were not unduly detrimental to the species, except in local situations, since other sites were available or being made available by similar or other man-influenced enterprises.

Predation.

Predation was not found to be a restriction to the distribution and activity of woodcock. In the three years of field work only a few cases of predation were recorded. The destruction of two nests by red fox or skunks has been mentioned. The only other records of predators catching woodcock concerned birds taken from clover-leaf traps. A weasel entered one trap and caught a woodcock, while another woodcock was taken by a raccoon. Two ruffed grouse were eaten in the same trap by a raccoon. The predation at that site ended when the raccoon was caught and removed.

A bobcat partially destroyed a trap one night in an unsuccessful attempt to catch a woodcock in the trap. No other signs of a wildcat were observed again in the vicinity of trapping operations.

That a variety of animals do prey upon woodcock has been shown by the studies of Pettingill (1936) and Mendall and Aldous (1943). Such mammals as the domestic cat, red squirrel, fox, weasel, skunk, and dog were listed as actual predators. The domestic cat was responsible for 18 of 42 woodcock listed by Mendall and Aldous as being taken by predators. They considered the cat as the most serious predator on woodcock.

Birds of prey listed by Mendall and Aldous included the great horned owl, long-eared owl, sharp-shinned hawk, goshawk, marsh hawk, duck hawk, pigeon hawk, and red-shouldered hawk. A compilation of the food of predaceous animals by Latham (1950) also included a record of one woodcock taken by a Cooper's hawk in Pennsylvania.

Two reptiles, the black snake and a snapping turtle, were mentioned by Pettingill as preying on woodcock. Two blue racers were observed consistently on two singing grounds at Rose Lake. Neither snake influenced the activity of the singing male although the bird landed within a few feet of the reptile.

Diseases and Parasites.

Diseased woodcock seldom were noticed. Such a condition may not have been common or it may have gone unnoticed because such specimens were not handled. Diseased or dead birds were not found in the woods. Two specimens were collected which exhibited a diseased condition.

One bird had a fungus or tumorous growth on the breast beneath the right wing. The other bird had scattered tumors in the body cavity involving the intestinal tract or the peritoneum and mesenteries. Neither of the two diseases was identified.

Parasites were much more common; in fact, the percentage of internally parasitized birds was high. No detrimental effects were observed as a result of such parasitism.

In 1954, 50 birds were examined, 46 of which were parasitized with one or more of the three major types of internal parasites: cestodes, nematodes, and trematodes. Of the 65 specimens examined in 1955, 63 had internal parasites. In 1954, only the readily apparent parasities were removed from the specimens, while in 1955 an attempt was made to take all parasites from the intestinal tracts.

The above rate of infestation was greater than that observed by Aldous (1937) and Mendall and Aldous (1943). In the former publication, Aldous reported that no parasites were found in 100 specimens studied. In the latter writing, 93 of 258 specimens were mentioned as being parasitized at a rate of one to twenty parasites per bird.

Woodcock were more severely parasitized during the first part of the hunting season. In 1955 specimens, approximately 63 parasites were found per bird during the first 15 days of October, while an average of 37 parasites were found per bird the remaining part of the season.

Nematodes occurred more frequently than flukes or tapeworms, but the latter two (tapeworms especially) were more abundant when they did occur (Tables 36 and 37). Tetrameres was the parasite responsible

for the high frequency of occurrence of nematodes. Forty-three of the 85 woodcock with roundworms had Tetrameres. Frequently, two or more of the major types of parasites were found in one bird (Table 36).

Parasites occurred most commonly in the small intestine (Table 38), although almost as many were found in the stomach (proventriculus and gizzard). The parasites found in the gizzard, particularly the tapeworms and flukes, normally do not live there. These animals probably moved into that organ after the bird was dead. Some parasites found in other organs also could have been out of their normal habitat; this was true especially of the roundworms found in the body cavity.

Since species identification of most parasites could not be made, specimens were forwarded to the Agricultural Research Service at Beltsville, Maryland. Some parasites were identified tentatively before the specimens were sent.

Of the cestodes, only the genus Hymenolepis was identified as being in the woodcock; however, at least three different species seemed to be present. Of these species, two were microscopic in size. Aldous (1938) reported finding cestodes of Hymenolepis in woodcock taken in Maine and New Brunswick. Some other tapeworms reported for the American woodcock have been Anomotaenia variabilis (Ransom, 1909, and Rankin, 1946) and Anomotaenia stentorea (Fuhrmann, 1932).

Nematodes found in Michigan woodcock included the aforesaid Tetrameres sp. (both males and females) and Dispharynx spiralis from the proventriculus. Capillaria sp. was found in the small intestine. Roundworms of the super-family Filaroidea were taken from the body

Table 36. Frequency of parasitization in the woodcock.

Number of woodcock	1954	1955	Total
Examined	50	65	115
With trematodes	18	41	59
With cestodes	18	45	63
With nematodes	36	49	85
With other parasites	1	1	2
Without parasites	4	2	6
With one type of parasite	24	16	40
With two types of parasite	17	22	39
With three types of parasite	5	25	30

Table 37. Abundance of parasites taken from 1955 specimens.

	Trematodes	Cestodes	Nematodes
Total number	898	2222	301
Maximum number in one woodcock	188	472	24
Minimum number in one woodcock	1	1	1
Average number per woodcock	13.8	34.2	4.6

Table 38. Occurrence of internal parasites in woodcock.

Location	1954 (50 woodcock)			1955 (65 woodcock)			Totals (115 woodcock)		
	Flukes	Tape-worms	Round-worms	Flukes	Tape-worms	Round-worms	Flukes	Tape-worms	Round-worms
Esophagus	0	0	3	0	2	11	0	2	14
Proventriculus	0	0	26	6	6	32	6	6	58
Gizzard	1	3	7	15	14	4	16	17	11
Small intestine	17	16	11	36	41	19	53	57	30
Large intestine	0	1	4	6	1	2	6	2	6
Caeca	0	0	0	0	0	0	0	0	0
Meckel's diverticulum	0	3	1	0	3	0	0	6	1
Bursa	0	0	0	1	0	1	1	0	1
Cloaca	0	0	1	6	0	1	6	0	2
Body cavity	0	0	4	0	0	0	0	0	4

cavity, cloaca, large and small intestines, and stomach. The large intestine and Meckel's diverticulum held nematodes of the superfamily Trichostrongyloidea. Records of nematodes in the American woodcock were difficult to find. Aldous (1938) merely mentioned finding members of the family Acuariidae in the woodcock he studied.

The trematodes belonged in two families, Strigeidae and Echinostomatidae. Only a few birds had echinostomes; all were in the small intestine. The echinostome which Rankin (1946) reported finding was in the duodenum.

The remaining flukes were of the strigeid group and especially of the subfamily Cotylurini which according to Dubois (1938) included such genera as Cotylurus, Cardiocephalus, Pseudapatemon, and Nematostrigeia. Trematodes from several woodcock may have belonged to the genus Nematostrigeia, but most, if not all of the others, belonged to the genus Pseudapatemon. In a recent letter, Dr. Allen McIntosh indicated specimens of the latter genus may include more than one species. McIntosh (1940) described a new species, Pseudapatemon aldousi, from woodcock furnished by Aldous (1938). The genus Nematostrigeia was reported as being present in woodcock by Rankin (1946).

Other internal parasites included sarcosporidia and an arthropod-like animal. The species of Sarcocystis was found in one woodcock in 1954. These organisms were noted in leg and breast muscles, not only superficially but throughout the muscles. No previous record was found of Sarcocystis sp. occurring in the woodcock, American or European species, but Erickson (1940) and Scott (1943) reported Sarcocystis

rileyi in the Wilson's snipe, Capella delicata.

The arthropod-like animal was taken from the intestinal tract of a woodcock shot on October 17, 1955. The animal may have been taken unintentionally by the woodcock while feeding or it may have been a parasite.

Fecal samples from twelve woodcock were examined but no coccidia were found. Thirty-three blood slides were studied but no blood parasites were seen. These slides were made primarily from fall-shot woodcock which have less chance of being infected with blood parasites than birds in the spring.

External parasites were found on woodcock during the spring but not on woodcock taken in the fall. These parasites were lice of the order Mallophaga. At least two different species were collected. Forty per cent of the birds examined on spring breeding grounds had the smaller species. Only two woodcock had the larger louse.

The heavy infestation of parasites in some woodcock (Table 37) indicated that detrimental effects of parasites were insignificant, since most birds examined were in good condition. One juvenile female collected in 1954 had its small intestine gorged with tapeworms. One woodcock taken on October 1, 1955, had a total of 509 parasites, including all three major types; another woodcock had 472 tapeworms alone. These data did not preclude the possibility that parasites were detrimental to some individuals or in local situations. Because of the bird's habits it was likely that sick or dead birds were overlooked. One sick and heavily parasitized woodcock was caught by a bird dog in 1954. This woodcock was apparently a victim of

parasitization.

Accidents.

Only 13 woodcock were reported or found to be killed by factors other than hunting. Nine of these birds were picked up from dirt or gravel roads and most of them had been hit by cars. At least two were injured critically when they flew into electric wires along roads. Another woodcock was found beneath an electric wire in woods near the Pigeon River Research Station. Two woodcock were killed in traps, one in a clover-leaf trap and another in a decoy trap. The other bird was a chick caught and injured by a dog. These observations were made incidental to other studies; consequently, other types of accidents probably occurred and went unnoticed.

Many accidents have been attributed to the low-flying habits of woodcock, and such habits probably account for most of the accident mortalities. Mendall and Aldous (1943) mentioned that accidents appeared to constitute one of the most serious decimating factors other than hunting.

MANAGEMENT

Practical methods for managing the woodcock population seem to be limited. Weather conditions are uncontrollable, predation is not a limiting factor except in localized situations, diseases and parasites normally do not prove detrimental, and it is unlikely that accidents

resulting from cars and obstructions will decrease. Therefore, the only two management techniques remaining which seem to be practical are vegetation control and hunting regulations.

Vegetation Control

Control of vegetational cover is necessary on singing grounds and in feeding areas. Many singing grounds are becoming unusable as breeding sites while some feeding areas are being used less frequently. The major cause of decreased use seems to be the density and height of vegetation rather than a decrease in bird population.

No actual control of vegetation on singing grounds was attempted, but it is likely that by keeping the cover, especially the woody plants, sparse and scattered the area would be more attractive to breeding males. This method of retaining present "grounds" is more feasible than making new openings for singing grounds since the occupied openings require less time and effort to remove encroaching brush than to remove a solid stand of woods. The practice of opening areas in an attempt to attract singing males to an area was tried by Mendall and Aldous (1943) with success. At least most of the artificial clearings were used whether or not the actual population increased. Such clearing operations would be more expensive as explained previously; however, in some instances it may be desirable to make small clearings in forested areas. These openings should not be made indiscriminately, but in carefully selected potential woodcock habitat.

In many places normal land-use practices such as timber operations and the laying aside of agricultural land provide many new clearings for breeding birds. With these practices and the maintenance of openings already available, clearing operations in wooded lands are not necessary in most areas.

One area of dense pole-sized quaking aspen was spot-sprayed from an airplane with a brush killer (Dichlorophenoxyacetic acid - a low volatile ester form of 2, 4-D) in August, 1955. The area was treated to improve the area for breeding birds in the spring and migrants in the fall. A few clearings were available but woody vegetation was increasing. At one time the area was used extensively as a woodcock loafing and feeding ground, but the increasing density of aspen caused a drop in the use by woodcock and hunters. Final results of the spraying have not been determined. Much vegetation covered by the chemical died, but the trees have not fallen.

The present practice should be to try to restore former or potential breeding areas by chemicals, fires, or cuttings where such methods seem practical and where breeding grounds are critically few. The major management technique regarding singing grounds should be to control the vegetation on those "grounds" which are being used regularly or intermittently.

It was determined that the use of chemicals could improve and bring back habitat for feeding purposes. Three areas which were once ideal feeding sites, but gradually became useless or, at the best, fair feeding spots because of a heavy ground cover (Plate 21), were improved by Dalapon, a chemical spray (2,2-dichloropropionic acid).

PLATE 21

A. A stand of speckled alder along McMaster Creek, Cheboygan County, showing the density of ground cover, primarily grasses.

B. A dense stand of grass and sedge which has taken over a woodcock feeding area.

These areas were primarily alder stands located in the flood plains of the Pigeon River, Black River, and McMaster Creek.

Plots were sprayed in those feeding areas with evident success. The plots were one-hundredth acre in size; ten such quadrats were located in each area. Dalapon was used on the plots at a dosage of 35 - 55 pounds per 50 gallons of water per acre. The spray was applied with a hand-pump garden sprayer during the middle of July, 1955.

First effects of the spray were noticed on the following day, but the results became more evident as the summer progressed. By fall most of the herbaceous stems and leaves were dead and many root systems were dead or dying. The subsequent decrease in density of ground cover probably caused the differential use exhibited by woodcock in the three areas (Table 39). Usually, splashings observed on the control plots were on the more open spots such as deer trails.

Table 39. Use of sprayed areas by woodcock as indicated by splashings.

	McMaster Creek		Black River		Pigeon River	
	Splashings plot		Splashings plot		Splashings plot	
Date	Sprayed	Control	Sprayed	Control	Sprayed	Control
Sept. 2	2.5	0	5.7	0	1.1	0
27			6.1	.6		
29					.5	0
Oct. 8	1.3	0	1.3	0		
9					0	0
11	2.5	.8				
13			.5	0	1.5	0
18	1.9	.5				
20					.8	0
21			2.1	.5		
24	0	0			0	0
25			.5	0		
31					0	0
Nov. 1	.3	.1	7.4	.7		
"t" values for differences	7.993**		2.941*		10.712**	

The above "t" values indicate there was a real difference between the sprayed and control areas in regards to use by woodcock.

By the end of the fall migration it seemed that the use of chemical sprays to control ground cover was a success for improving woodcock habitat. But when the sprayed areas were examined in July, 1956 (one year from the time of spraying) the method appeared to be more of a success. The sprayed spots were practically barren of grasses and sedges while surrounding areas approached a maximum density. Several of the open sites were being used by woodcock as indicated by splashings and probings.

Some concern had been expressed that the chemicals might harm soil animal life and thus reduce the benefit of the spraying. However, an examination of the sprayed areas in July, 1956, revealed that animal life was still present. In fact, more earthworms were found in all three areas than on previous occasions (Table 40). Earthworms were not found on some plots in the Tin Bridge area, but those sites held standing water which could have caused the absence of worms.

Table 40. Results of an examination to determine the presence of earthworms on areas sprayed with Dalapon for the control of ground cover.

Area	Number of samples*	Total number of earthworms	Number of earthworms per sample*
Tin Bridge	12	93	7.75
Tin Shanty Bridge	12	770	64.17
McMaster Creek	16	115	7.19

* Square-foot samples.

Many of the feeding or potential feeding areas which now have a dense ground cover of grasses and sedges should be sprayed in order to control such cover.

In combination with chemicals used for control of narrow-leaved plants, some chemicals should be included to open the dense alder stands which frequently occur along with the dense ground cover. It has been suggested by other workers (Mendall and Aldous, 1943, and Liscinsky, 1952) that over-mature stands become poor woodcock habitat. The conditions which result and prevail with such stands probably are the cause of decreased populations and not the age of the vegetation alone. In many cases the older alder stands become too thick and a corresponding dense ground cover occurs. Or the overstory becomes so dense that the ground cover is removed, soil conditions are changed, and food disappears. Control of such areas should restore them to productive woodcock coverts again.

Often woodcock coverts which are not used or seldom used may be discerned by casual observations of such sites. If such observations are insufficient, a brief examination of the vegetational composition and density, food supply, and relative use by woodcock should suffice in determining controls needed to restore or maintain the coverts.

Hunting Regulations

A second management technique is the control of hunting pressure by regulations based on sound biological principles. To be considered

under such regulations are bag limits, time of season, and length of season. At the present time the various regulations in Michigan seem to be appropriate for the woodcock population and the hunter whether or not they were based on biological reasonings. A few changes could be made.

Bag limits of four woodcock per day per hunter with a possession limit of eight have been the same for the entire state. These limits were established by federal order. Michigan game laws describe three zones, roughly equivalent to the three administrative regions (page 7 and plate 2). Game seasons differ in the three zones. In Zone 1 (the Upper Peninsula) the woodcock season was October 1 to November 1. In Zone 2 (the northern Lower Peninsula) it was October 1 to November 9, and for Zone 3 (southern Michigan) a shorter period, October 20 to November 9, prevailed. Each of these seasons has been set primarily to coincide with hunting seasons for other game species. In Zones 1 and 2 the woodcock season coincided with the ruffed grouse season. In Zone 3 the opening of the woodcock season was set for October 20, the general small game opening. The woodcock season could not extend beyond November 9, since by Federal order the birds may be hunted only for a period of 40 days.

As indicated in previous sections where natural mortality, survival, and hunting kill were discussed, the woodcock population is relatively stable. If the population remains at the present level, more woodcock could be harvested. To harvest the additional numbers one of two methods should be employed. More hunters could be encouraged by conservation education methods to hunt woodcock. Also,

hunters could be instructed where to look for birds. However, most hunters prefer to hunt for bigger game for the quantity of meat involved and it would be difficult to change their attitudes.

In order to harvest additional birds an adjustment of the season might be more practical than trying to increase the number of hunters. Recent data indicate, that for Regions I and II, some woodcock may be migrating south in September, most migrants have gone through by October 20, and only a few woodcock are present in November. If this type of migration does happen then perhaps the woodcock season should be started sometime in September. Two objections normally are raised to such a recommendation. First, the point is made that an early season on one species results in illegal kills of other species. Actually, it is probable that no really serious increase in violations occurs, but there is often a belief on the part of the public that violations are rampant. In such cases the objection may be valid regardless of the biological facts. Second, heavy foliage during an earlier season would be a serious handicap to the shooter. Conversely, in many years the early disappearance of woodcock and bad weather conditions bring objections to the present seasons. From the hunter's point of view it would seem that shooting through leaves at woodcock would be more enjoyable than walking through a snowstorm flushing chickadees.

If it is desired to harvest more woodcock in Region III the season could be opened as early as October 1. A relatively heavy resident population is present in the region up to October 20, and although band returns indicate that many residents remain through most of the

season it is probable that many others leave even before the season opens. Observation and hunting records show that concentrations of woodcock, evidently migrants, have occurred in many places by October 20.

Even though some data are available upon which such recommendations may be made, additional information should be gathered. More information concerning times of migration especially is needed. If it is discovered that changes are needed in the present woodcock hunting regulations, then serious consideration should be given to the biological aspects as well as the law enforcement and public relation angles.

Recommendations For Further Studies

On the basis of research findings several recommendations may be presented regarding further studies and experiments. Even though the proposed control of vegetation mentioned above seems feasible, an area should be established for a detailed, long-term project on the effects and benefits of various tools, including herbicides, fires, and brush-removing equipment, for improving feeding and singing grounds. This area should include potential habitat as well as habitat being used either occasionally or frequently. Fluctuations in the woodcock population on the area should be determined often in order to evaluate the project.

The detailed analysis of vegetation in woodcock habitat should be discontinued because of the time and expense involved and the small amount of data received. It might be more advantageous to concentrate efforts on: (1) specific factors, such as the age of alder stands in relation to woodcock abundance, and (2) broader aspects, as the relationship between relative density and general composition of ground cover and overstory as they affect woodcock populations.

In addition, a study of waterfowl flooding projects should be made to determine the beneficial or detrimental aspects involved. Small impoundments for the specific purpose of improving woodcock habitat by maintaining a suitable soil moisture in certain critical locations could be tried.

A reconnaissance and stratification should be made of woodcock habitat in each Game Division district. Such knowledge of woodcock habitat would provide the district game supervisors and research personnel with information necessary for management and research practices.

Records should be maintained on the changes in cover on several singing grounds in one or more study areas to determine the relationships between habitat changes and the breeding population.

A continued increase in the number of singing ground routes is needed; this increase should be made by departmental personnel. Although the present non-departmental cooperators should be maintained, no intensive effort should be made to increase the number of routes by enlisting the aid of other such people. For the time and expense involved and the results obtained, department personnel are more

reliable.

In connection with singing-ground counts, an experiment should be conducted on a method of stratifying routes. It should be possible to set up a series of randomized counts or routes in a county in Region II based on a stratification of the woodcock habitat. In the same area the total number of singing males should be determined on several randomly located quadrats. A comparison of the two sets of data might reveal a better population index method and possibly a census technique.

A special attempt should be made to gather more information regarding nesting success, brood sizes at various ages, and juvenile mortality so that population production may be determined each year.

Banding operations should be intensified at strategic locations. Although the major problem is locating concentration areas and local flight routes, efforts also should be made to improve present methods of capturing woodcock.

A search for practical methods of determining seasonal occurrence of woodcock should be continued. One such method could be to capture woodcock in their spring and summer habitat and dye them various colors. Their movements could be followed in order to discover when they leave that area. This technique could give a clue as to the length of time a bird remains in the fall, the relation between resident and migrant woodcock, and the migration routes followed.

The sex and age techniques described previously should be used on specimens taken in subsequent hunting seasons to determine the reliability of such methods. If the leg coloration proved to be a

distinguishing age criterion, a color chart should be devised for a more accurate comparison. The criterion of aging juveniles prior to fall (Duvall, 1956) should be used on woodcock captured in summer operations to define more closely the period when juvenile mortality is greatest.

SUMMARY

Investigations of the American woodcock in Michigan were made for the purpose of developing and improving management techniques involving the bird. Phases especially investigated were (1) migratory habits, annual production, and population levels, (2) extent of present utilization of the resource, and (3) factors influencing the distribution, abundance, and activities of the bird.

Woodcock arrived in Michigan the last week of February, 1953 and 1954, and the first week of March, 1955. By the time migration was ended in the last half of April, birds were distributed in every county. Only local movements occurred after that until late summer when evidence of fall migration was observed. By October 1, especially in the more northern regions of the state, some woodcock had moved southward, and by October 20 the largest portion of the migrants moved through Regions I and II. Many migrants entered Region III before October 20, while some resident birds of the region probably had departed by that time. All residents did not leave early because banding records showed that some of the last woodcock to be observed in Regions II and III were local birds.

The major part of the breeding season occurred between April 15 and May 15 in the Lower Peninsula and between April 25 and May 25 in the Upper Peninsula. During this breeding activity singing-ground counts were made on special study areas and on routes scattered through Michigan. Data obtained on these counts were used to determine

factors affecting woodcock activity, factors affecting observations, population trends, number of times a route should be run, and number of routes to be run in the state.

Several factors affected woodcock activity on singing grounds. Time of day and amount of light determined when the courtship display started; evening activity began earlier when a heavy cloud cover existed than when skies were clear. Weather conditions such as rain and temperatures below 35 degrees F. caused a decrease in the number of active birds and length of display, while wind caused an erratic display. Animals, particularly man, disturbed woodcock by various operations near singing grounds.

Those factors which were most important in affecting observations were wind and noise interference. Winds of velocities exceeding 10 miles per hour reduced the distance and affected the direction in which an observer could hear active birds. Noises, caused by man-influenced activities, frogs, dogs, and certain birds, were instrumental in reducing the distance which woodcock could be heard.

Singing-ground counts, used to determine population trends, have varied from .80 woodcock heard per stop per route in 1953 to 1.04 in 1954 and .92 in 1955. The reliability of these counts has been questioned because of the methods used to gather data. Originally, routes were supposed to be run two or three times each. However, a statistical analysis of data from one route indicated that the route would need to be run 27 times to obtain confidence limits 25 per cent of the observed mean. Other data showed that several routes scattered through an area of woodcock habitat would give more accurate information

regarding populations than one route run several times. In addition, an analysis of costs involved in establishing routes revealed that economically a route should be run twice the first year it is used and once in each year thereafter.

Although the 56 routes run in 1955 represented a sample with confidence limits 13 per cent of the mean (.92 birds heard per stop), a better coverage of woodcock habitat would be desired.

Woodcock specimens were examined for criteria by which birds could be sexed and aged. Three possible combinations of bill and primary measurements were devised for sexing woodcock externally. These included a comparison of bill length and total width of the outer three primaries, bill length and total length of the same primaries, and the width and length of the three primaries. The first two comparisons were most accurate. Leg color was used tentatively as a criterion of age. Birds with dusky-grey legs were considered juveniles while those with flesh-colored legs were adults.

Sex and age data in conjunction with nesting success, brood sizes, and kill figures were used to determine survival and mortality and to analyze the extent of harvest. Data indicated that woodcock are not being overharvested in Michigan and that more birds could probably be harvested. An extra surplus would be present if the large juvenile mortality of approximately 60 per cent during the first five months of life was reduced.

Major factors affecting the distribution, abundance, and activities of woodcock were vegetation, food, and weather. Minor factors included competition, predation, diseases and parasites, and accidents.

Vegetation was important in restricting distribution as well as serving as an indicator of the general habitat. Breeding areas were in relatively open sites of low ground vegetation and sparsely-scattered shrubs. Nests were usually near edges of openings or in relatively open second-growth woods, while broods were found in the latter type of cover almost entirely.

Summer and fall feeding areas were characterized by certain plants which occurred more abundantly and frequently than other plants. The major species was speckled alder, which indicates that feeding areas were in lowlands. These feeding sites were used often as diurnal loafing sites; however, other more distinct and purely loafing areas occurred in adjacent uplands of aspen and mixed conifer.

Vegetational density and composition in these areas were determined by two methods, one of which was based on a random sampling. The resulting data were analyzed for distinguishing plants and the most economical sample sizes to use hereafter. The analysis showed that financially about 10 samples should be taken in one area instead of 25. This decrease would allow more areas to be studied.

Soil types varied considerably. Singing grounds and nests were on several different types while broods were found on the heavier soils. Feeding areas were on the moderately- to poorly-drained soils and loafing areas were on well-drained sites.

Food consisted primarily of animal life with earthworms composing the greatest bulk. Woodcock often were found concentrated in low sites where earthworms were most abundant.

Weather, including temperature, wind, and precipitation, influenced local activity and migration. Temperature was of primary importance in late summer and early fall when sudden changes caused southward movements. High winds caused a decrease in evening flights, while migratory movements seemed to be favored by light northerly winds or none at all. Precipitation restricted both local activity and migrations.

Competition was not very evident except where man was concerned. Some operations as agriculture and forestry often eliminated woodcock habitat while similar activities produced suitable habitat elsewhere. Predation was inconsequential as were diseases and parasites. However, most woodcock were parasitized by one or more species of cestodes, nematodes, or trematodes. Accidents resulted usually from birds flying into electrical power lines or vehicles.

For managing the woodcock population two methods seemed promising. First, improvement of habitat by vegetation controls should be used on singing grounds and feeding areas. Experimental plots on which the ground cover was reduced by chemical sprays were used more than control plots. Second, a change in hunting season dates to correspond more closely to migratory movements might be helpful for increasing the harvest of woodcock if such an increase is desired.

Future studies should emphasize the relationship between woodcock populations and habitat changes, practical methods for determining seasonal occurrence of birds, increased vegetation control by various means, and better techniques for determining population trends. In the meantime, banding operations and singing-ground counts should be continued and increased when possible.

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APPENDIX

Instructions for the Censusing of Woodcock

I. Introduction

Woodcock can be censused most easily by counting the number of males heard calling along a given length of road running through territory which woodcock inhabit during the breeding season.

The purpose of this type of census is to obtain an index of population abundance in the region sampled, not to determine the total population in any area. The principle involved is to make the observations as standardized as possible both as to time and space, so that they will be comparable with results obtained in different regions and in different years. To accomplish this, trips are made over a given route. Stops are always made at the same place and of definite duration. The number of birds heard calling per stop per route is taken as the index of abundance for that particular area. With these objectives in view and considering all that has been learned to date of woodcock behavior and the problems of recording their calls, the following standard method has been decided upon for trial.

II. Locating the Census Area

Careful consideration should be given to the locating of the census area. Since the count can be made most effectively by using an automobile, a driveable route will necessarily need to be selected. A stretch of road bordered by numerous alder runs, open young mixed growths, or young hardwood stands (especially where numerous small openings, fields or pastures occur) probably will yield counts representative of the best type of woodcock cover. A few scattered houses along the road will not detract from the suitability of the census route. However, care should be taken to avoid areas where excessive noises will occur, such as small settlements, heavily traveled highways, and series of small ponds or drainage ditches which are likely to contribute noisy choruses of frogs.

III. Length of the Census Route

The length of your route should be based on the distance that can be covered during the minimum time woodcock have been observed calling in your area. If there is any doubt on this point use the arbitrary time of thirty minutes. The length of the route will vary with woodcock population densities. With discontinuous habitat and a low population it may be possible to cover more than 4 miles, whereas in areas of high concentration even 3 miles may be all that can be covered. If a route longer than can be covered during the singing period in one evening is available it may be divided into two or more individual routes and covered in separate evenings.

IV. Taking the Census

1. Note to beginners.--To those who are wholly unfamiliar with the courtship behavior of the woodcock and the census technique, it is suggested that they spend some time (in the field particularly) with one experienced person before starting out on their own.

2. Time of year to start the census.--The time of the year the census should be started will vary with the locality and region. Woodcock being migratory will visit states south of New England, and equivalent areas to the west, much earlier than Maine or northern Minnesota, for example. The census work should be carried out after migration has ceased in a given locality and before the peak of the hatching period. For example, in Pennsylvania starting between the first and tenth of April and stopping around May 1 is about right. States south of Pennsylvania or equivalent areas would need to start earlier, and the most northerly areas of the United States and adjoining sections of southern Canada would start no earlier than the latter part of April.

3. Time of day to start the census.--The census data are collected during the evening period. The average male woodcock begins to "sing" at about ten to thirty minutes after sunset, depending on weather conditions. The period during which woodcock perform on their singing grounds varies from about twenty minutes to about forty-five minutes, averaging about thirty-five minutes in length. It would be most desirable for the first stop (or starting point) to be at a point where a woodcock is likely to be heard so that the starting time for any given evening's count may be accurately determined.

4. How to choose a starting point and interval stops.--Besides starting at a point where a woodcock is known to sing regularly, the starting point should be as distinct a land feature as possible, such as a railroad crossing, a culvert, a bridge, a crossroad, etc. Subsequent listening points should be no closer than four-tenths of a mile apart. Intervals between stops may be increased to the extent necessary to avoid nonwoodcock habitats or exceptional disturbances.

5. Number of times to make the counts.--Preliminary statistical studies of this census method indicate that it is preferable to run more routes once than fewer routes more than once. If, however, there is reason to believe that conditions were not normal on the night the route was run, it would be advisable to repeat the coverage another night as a check.

6. Making the count.--The "peent" call given by woodcock on the ground should be used for counting entirely, if possible, as being more reliable for separating different individuals. The flight song should only be resorted to if it can be definitely distinguished as a separate bird, or if disturbing noises such as frogs make it is impossible to hear woodcock ground calls. Once the approximate starting

time has been confirmed the census taker waits at the first stop until a woodcock is definitely heard calling on a known "singing ground." Check the time and wait there 2 minutes counting all different birds heard. However, since the first stop may not have a performing bird each evening, a certain amount of discretion must be used. The experienced census taker will know approximately what time his birds will start performing on a given evening. The suggested procedure, in case no bird is singing at the first stop, would be to wait 5 minutes after the latest expected commencement of song, then drive on to the second stop. Because of this, as well as other unpredictable points, it is almost essential that a census taker receive instruction from someone experienced with woodcock ground calls and flight songs before starting out "on his own." At the end of 2 minutes proceed as rapidly as possible to the next stop and listen there for 2 minutes, again counting all birds heard. Repeat this procedure over the entire route. If timing is correct (except on very short routes) the evening calling period should be practically over after the last 2 minutes of listening is completed.

7. Things to avoid.--Counts should not be made during the period of 2 days before a full moon and one day afterwards (4 days in all), as it has been found the birds are very inconsistent in performing then. They should not be made in heavy rain or snow or when the temperature is below approximately 25 degrees or when a strong wind is blowing. A wind velocity of "Beaufort 3" (8-10 miles per hour, causing leaves and twigs to be in constant motion and light flags to be extended) is too strong. The best results will be obtained on warm, clear, quiet evenings.

V. Recording the Census Data

A standard form is provided for recording the pertinent data concerning your specific route and counts. For your convenience the attached sample data sheet (filled in) may help clarify the technique. Records should include: Date, weather (points circled on the form) including sky conditions and precipitation if any, temperature, wind, moon's phase, length of route, intervals between each stop, birds heard at each stop - combining both sides of the road (record 0 if no birds are heard), time of starting, and time of finishing. Space is supplied for recording data on the same route three different nights if it should be necessary to repeat the coverage for any reason. All data should be recorded on the forms furnished you. Please describe each area by definite local geographical boundaries, (example: Black Hill Road, running 2.4 miles south from the road leading to Brown's gravel pit). This exact description is needed in case of change in observers in subsequent years. It is recommended that a rough sketch made of your census route be drawn on the back of the data sheet unless the boundaries have obvious geographical markers shown on easily available maps. In case stop No. 1 (the start of the route) does not have a convenient geographical marker it may then be described as being a given number of tenths of a mile and a definite

compass direction from a known marker. Indicate whether the route is exactly the same as that covered last year to aid the compiler.

VI. Reporting the Census Data

At the conclusion of census studies please return your forms directly to your local coordinator. Please make a special effort to meet his deadline date, otherwise the over-all compilation will be held up and the usefulness of your efforts impaired.

Remember this method of obtaining an index of abundance of woodcock is still in the experimental stage and your comments and suggestions will be welcome.

Table 41. Woodcock breeding ground counts in Michigan, 1953 - 1955

Location of Route	1953			1954			1955		
	No. of occupied singing grounds	Total no. of stops	Avg. no. birds per stop	No. of occupied singing grounds	Total no. of stops	Avg. no. birds per stop	No. of occupied singing grounds	Total no. of stops	Avg. no. birds per stop
Alger County, Stutts Creek	17	30	.567	29	33	.879	29	32	.902
Allegan Co., # 1 Ely L. Rd.	1	16	.063	6	27	.222			
Allegan Co., # 2 Gables Corner	2	15	.133	6	18	.333			
Allegan Co., # 3 Manlius				7	24	.292	1	24	.042
Baraga Co., L'Anse							23	16	1.438
Baraga Co., Clear Creek							7	9	.778
Barry Co., Yankee Springs				33	30	1.100	19	30	.633
Cheboygan Co., Tin Bridge							19	18	1.056
Chippewa Co., Johnswood	43	30	1.433	51	30	1.700	30	22	1.364
Chippewa Co., Sault Point				20	38	.526	9	14	.643
Chippewa Co., Dunbar				8	16	.500	8	16	.500
Chippewa Co., Tilson Road							7	14	.500
Chippewa Co., Beavertail							16	18	.889
Clinton Co., Chandler Marsh				31	21	1.476	16	20	.800
Clinton-Shiawassee cos., Rose Lake Exp. Sta.	17	30	.567	34	24	1.417	30	24	1.250

Delta-Marquette cos. Cornell				27	36	.750			
Dickinson Co., Channing	28	33	.848						
Dickinson Co., Sagola	29	21	1.381	29	18	1.611			
Gladwin Co., Cedar River	25	33	.758	43	33	1.303	21	22	.955
Gratiot Co., # 1 Gratiot-Saginaw	32	30	1.067	52	30	1.733	55	30	1.833
Gratiot-Saginaw cos. #2							9	9	1.000
Houghton Co., Sidnaw	23	21	1.095	24	21	1.143	12	14	.857
Huron Co., # 1 Colfax				41	27	1.519	20	9	2.222
Huron Co., # 2 Colfax							10	7	1.429
Huron Co., # 3 Colfax							5	5	.833
Ingham Co., # 1 Dansville	2	18	.111						
Ingham Co., # 2 Dansville	4	18	.222						
Ingham Co., #1-2 Dansville				4	21	.190	4	8	.500
Ingham Co., # 3 Dansville	7	30	.233	13	29	.448	10	20	.500
Ingham Co., # 3a Dansville							6	10	.600
Iron Co., Channing	44	33	1.333	27	30	.900	30	30	1.000
Isabella Co., # 1 Mt. Pleasant	45	32	1.406						
Isabella Co., # 2 Mt. Pleasant	22	27	.815						
Isabella Co., # 3 Mt. Pleasant	22	26	.846						

Isabella Co., # 4 Mt. Pleasant	22	42	.524						
Isabella Co., # 5 Mt. Pleasant				59	39	1.513			
Isabella Co., I Mt. Pleasant							22	15	1.467
Isabella Co., II Mt. Pleasant							1	9	.111
Isabella Co., # 1 Chippewa							14	9	1.556
Isabella Co., # 2 Chippewa							5	9	.556
Isabella Co., # 3 Chippewa							12	11	1.091
Isabella Co., # 4 Chippewa							7	10	.700
Isabella Co., # 5 Chippewa							5	9	.556
Kalamazoo Co., Howlandsburg	9	11	.818	19	39	.487	8	9	.889
Kalamazoo Co., Kalamazoo	32	36	.889	32	28	1.143	28	45	.622
Kalamazoo Co., Alamo	28	33	.848	27	30	.900	21	36	.583
Kalamazoo Co., Augusta							27	30	.900
Lake Co., Baldwin				45	24	1.875	10	8	1.250
Livingston Co., Pinckney				15	36	.417			
Luce Co., McPhee's Landing	9	11	.818	14	16	.875	16	16	1.000
Mackinac Co., # 1 Carp River							18	22	.818
Mason Co., Big Sable River				8	18	.444	24	32	.750
Midland Co., # 1 Dow Corning				39	21	1.857	11	7	1.571

Midland Co., # 2 Midland				9	36	.250			
Midland Co., # 3 Coleman							7	9	.778
Montmorency Co., Hunt Creek							8	8	1.000
Newaygo Co., # 1 Fremont				59	27	2.185			
Newaygo Co., # 2 Bridgeton				44	18	2.444	6	6	1.000
Newaygo Co., # 3 Jackson Corners							8	10	.800
Oakland Co., # 1 Lake Orion							33	17	1.941
Oakland Co., # 2 Highland Area							5	10	.500
Ogemaw Co., Greenwood Road				40	27	1.481	21	18	1.167
Ontonagon Co., # 1 N. Cemetery Road				14	18	.778	6	6	1.000
Ontonagon Co., # 2 Matchwood Twp.				12	9	1.333	21	12	1.750
Otsego Co., # 1 Ford (Au Sable)	5	24	.208	18	21	.857	4	14	.286
Otsego Co., # 2 Ford Lake Rd. (Pigeon River)							5	7	.714
Presque Isle Co., Rogers City				13	21	.619			
Roscommon Co., # 1 Loxley	41	36	1.139	27	24	1.125	12	12	1.000
Roscommon Co., # 2 Michelson	16	10	1.600	24	19	1.263	8	11	.727
Roscommon Co., # 3 Houghton Lake	21	27	.778						

Schoolcraft Co., Driggs River (Seney Refuge)				5	9	.556	16	27	.593
St. Joseph Co., Fabius	12	24	.500				5	24	.208
Van Buren Co., Almena	42	33	1.273	29	28	1.036	42	45	.933

Table 42. Records of woodcock banded in Michigan, 1953-1955.

Band Number	Age	Sex	Date of Banding	Place of Banding
513-96901*	L	-	5/10/53	5 mi. N. of Alba, Antrim County
513-96902	L	-	"	" "
513-96903	L	-	"	" "
513-96913	A	M	5/ 3/54	Rose Lake Exp. Sta., Orange, Shiawassee
513-96914	A	M	5/ 6/54	" " " "
513-96915	A	M	5/11/54	" " White, Clinton Co.
513-96916	A	M	5/15/54	Gratiot-Saginaw Game Area, Gratiot Co.
513-96917	A	M	5/16/54	Rose Lake Exp. Sta., Orange, Shiawassee
513-96918	A	M	5/18/54	" " "
513-96919	A	M	5/21/54	" Brown, Shiawassee
513-96920	L	-	5/28/54	" " "
513-96921	L	-	5/28/54	" " "
513-96922	A	F	5/28/54	" " "
513-96923	A	M	5/30/54	" " "
513-96924	A	F	5/30/54	" " "
513-96925	-	M	8/24/54	Tin Bridge, Cheboygan County
523-33501	-	F	9/21/54	" "
523-33502	-	F	9/25/54	" "
523-33503	-	M	9/27/54	" "
513-96904	A	M	4/ 6/55	Rose Lake Exp. Sta., Clinton County
553-38001	A	M	4/27/55	Pigeon River Exp. Sta., Otsego County
553-38002*	A	M	4/28/55	" " "
513-96905	A	F	5/ 2/55	Rose Lake Exp. Sta., White, Clinton Co.
513-96906	A	M	5/ 2/55	" " "
553-38003	L	-	5/ 5/55	" Brown, Shiawassee
553-38004	L	-	5/ 5/55	" " "
553-38005	L	-	5/ 5/55	" " "
513-96907	A	M	5/14/55	" White, Clinton Co.
513-96908	A	M	5/14/55	" Brown, Shiawassee
553-38006	A	M	5/17/55	" Orange, Clinton Co.
513-96909	L	-	5/14/55	" Brown, Shiawassee
513-96910*	A	M	5/20/55	" " "
553-38007	A	M	6/ 3/55	" Orange, Shiawassee
523-33505	J	M	7/ 5/55	Tin Bridge, Cheboygan County
523-33507*	-	M	7/ 7/55	" "
523-33508	-	F	7/11/55	" "
523-33509	-	F	7/11/55	" "
523-33510	-	F	7/15/55	" "
523-33511	-	M	7/19/55	" "
523-33512	-	M	7/19/55	" "
523-33513	-	M	7/25/55	" "
523-33514	-	M	7/25/55	" "
523-33515*	-	M	7/29/55	Old Grant School, Cheboygan County
523-33516	-	M	8/ 2/55	W. McMaster Creek, " "
523-33517	-	F	8/ 2/55	" "
523-33518	-	M	8/ 3/55	" "

Band Number	Age	Sex	Date of Banding	Place of Banding
523-33519*	-	M	8/ 4/55	W. McMaster Creek, Cheboygan County
523-33520	-	F	8/11/55	" "
523-33521	-	M	8/11/55	" "
523-33522	-	M	8/12/55	" "
523-33523	-	M	8/13/55	" "
523-33524	-	F	8/16/55	" "
523-33525	-	M	8/18/55	Elk Hill, Pigeon River, Otsego County
523-33526	-	M	8/18/55	" " "
523-33539	-	M	8/20/55	W. McMaster Creek, Cheboygan County
523-33540	-	F	8/20/55	Elk Hill, Pigeon River, Otsego County
523-33541	-	M	8/21/55	W. McMaster Creek, Cheboygan County
523-33542	-	M	8/21/55	Elk Hill, Pigeon River, Otsego County
523-33543	-	M	8/25/55	Tin Bridge, Pigeon River, Cheboygan Co.
523-33544	-	-	8/25/55	" " "
523-33545	-	M	8/26/55	W. McMaster Creek, Cheboygan County
523-33546	-	M	9/ 1/55	Elk Hill, Pigeon River, Otsego County
523-33547*	-	F	9/ 5/55	" " "
523-33548	-	M	9/11/55	" " "
523-33549*	-	M	9/28/55	" " "

* See Table 4 for recovery data.

Table 43. Records of woodcock banded as juveniles and eventually recovered.

Band Number	Banding State	Banding Date	Recovery State	Recovery Date	Longevity*
343 39973	Maine	6/ 1/38	Mass.	10/25/40	29
373 20451	"	5/21/37	Maine	10/28/37	5
373 20452	"	5/21/37	"	10/27/37	5
373 20478	"	5/26/37	New Jersey	11/ 6/37	5
373 20840	"	5/10/41	Penn.	10/24/41	5
383 17285	"	5/25/38	Maine	10/20/38	5
393 16053	"	5/21/39	Virginia	11/23/39	6
393 16084	"	5/27/39	Maine	10/18/39	5
403 23573	"	6/ 1/40	"	10/21/40	5
403 23604	"	6/ 4/40	Mass.	10/31/42	29
403 23655	"	5/29/41	New Hamp.	10/20/42	17
403 23676	"	5/ 7/42	Maine	10/21/43	17
423 05008	"	5/21/46	"	10/13/48	29
06 51858	Mass.	5/13/30	Mass.	10/20/30	5
06 51859	"	5/13/30	"	10/20/30	5
563 33003	"	8/ 8/55	"	11/ 9/55	6
493 09702	Mich.	5/30/51	Mich.	10/ 6/51	4
513 96901	"	5/10/53	Georgia	2/19/55	21
02 44598	Minn.	5/ 8/32	Miss.	1/ 7/33	8
373 20725	New Bruns.	3/28/39	New Jersey	11/15/39	8
373 20763	"	6/ 9/40	New. Bruns.	10/ 7/41	16
423 02139	"	6/ 6/43	"	10/29/43	5
423 02143	"	6/ 6/43	"	10/27/46	41
473 05407	"	5/21/50	Maine	10/15/50	5
473 08479	"	5/10/51	"	10/ /51	5
503 14202	"	5/19/50	New Jersey	11/13/50	6
503 14207	"	5/19/50	Florida	12/15/52	19
503 14224	"	5/20/50	New Bruns.	10/10/50	5
503 14241	"	5/22/50	"	10/19/50	5
503 14905	"	5/15/52	Delaware	11/25/52	6
503 14936	"	5/17/52	New Bruns.	10/ 3/52	5
503 14938	"	5/18/52	"	10/ 9/52	5
503 14939	"	5/18/52	"	10/ /52	5
503 14959	"	5/14/52	"	10/10/53	17
424 01002	New Jersey	4/29/45	New Jersey	11/ 6/45	6
06 48502	New York	4/28/29	New York	10/25/29	6
483 59929	"	5/13/52	"	10/28/53	18
394 25017	Penn.	5/ 8/39	Miss.	12/27/40	20
513 83341	"	4/29/53	S. Carolina	2/11/54	9
553 39043	"	4/27/55	Penn.	10/15/55	6
553 39062	"	4/30/55	"	10/15/55	6

Table 44

SCIENTIFIC AND COMMON NAMES OF PLANT SPECIES

Scientific names are based on M. L. Fernald, 1950, Gray's Manual of Botany, Eighth Edition, American Book Co. Common names are from Fernald and the following additional sources:

Billington, Cecil. 1943. Shrubs of Michigan. The Cranbrook Institute of Science.

Fassett, Norman C. 1940. A Manual of Aquatic Plants, 1st Edition, McGraw-Hill Book Company, Inc.

Rydberg, Per Axel. 1932. Flora of the Prairies and Plains of Central North America. The New York Botanical Garden.

"Woody plants"

Abies balsamea, Balsam-fir
Acer sp., Maple
Acer rubrum, Red maple
Acer saccharum, Sugar-maple
Alnus rugosa, Speckled alder
Amelanchier spp., Juneberry
Amelanchier canadensis, Canadian Juneberry

Betula lutea, Yellow birch
Betula papyrifera, Paper or white birch
Betula pumila, Swamp-birch

Carya ovata, Shagbark-hickory
Castanea dentata, Chestnut
Clematis virginiana, Virgin's-bower
Comptonia peregrina, Sweet-fern
Cornus alternifolia, Green osier
Cornus obliqua, Silky dogwood
Cornus racemosa, Grey dogwood
Cornus stolonifera, Red osier
Corylus cornuta, Beaked hazel
Crataegus spp., Hawthorn

Diervilla Lonicera, Bush-honeysuckle

Fagus grandifolia, Beech
Fraxinus americana, White ash
Fraxinus nigra, Black ash

Ilex verticillata, Black alder

Juniperus communis, Common juniper

Larix laricina, Tamarack
Lespedeza sp., Bush clover
Lonicera spp., Honeysuckle
Lonicera canadensis, Fly-honeysuckle
Lonicera dioica, Wild honeysuckle
Lonicera hirsuta, Hairy honeysuckle
Lonicera oblongifolia, Swamp-fly-honeysuckle

Picea glauca, White spruce
Picea mariana, Black spruce
Physocarpus opulifolius, Ninebark
Pinus Banksiana, Jack-pine
Pinus resinosa, Red pine
Pinus Strobus, White pine
Pinus sylvestris, Scotch pine
Populus x gileadensis, Balm-of-Gilead
Populus grandidentata, Large-toothed aspen
Populus tremuloides, Quaking aspen
Prunus pensylvanica, Pin-cherry
Prunus serotina, Black-cherry
Prunus virginiana, Choke-cherry
Pyrus Malus, Apple

Quercus spp., Oak
Quercus rubra, Red oak
Quercus velutina, Yellow-barked oak

Rhamnus alnifolia, Buckthorn
Rhus radicans, Poison ivy
Rhus typhina, Staghorn-sumac
Rhus Vernix, Poison sumac
Ribes spp., Currant and Gooseberry
Rosa spp., Rose
Rubus spp., Blackberry and Raspberry
Rubus pubescens, Dwarf raspberry

Salix spp., Willow
Sambucus canadensis, Common elder
Spiraea spp., Spiraea
Spiraea alba, Meadow-sweet

Thuja occidentalis, White cedar

Ulmus americana, American elm

Vaccinium vacillans, Low blueberry
Vaccinium angustifolium, Low sweet blueberry
Viburnum spp., Viburnum

Viburnum cassinoides, Wild-raisin
Viburnum Lentago, Nannyberry
Viburnum trilobum, Highbush-cranberry

"Herbaceous plants"

Achillea Millefolium, Common yarrow
Actaea rubra, Red baneberry
Anaphalis margaritacea, Pearly everlasting
Anemone spp., Anemone
Anemone canadensis, Broad-leaf anemone
Anemone cylindrica, Thimbleweed
Anemone virginiana, Thimbleweed
Anemonella thalictroides, Rue-anemone
Antennaria spp., Pussy's-toes
Anthemis spp., Chamomile
Apocynum spp., Dogbane
Aquilegia canadensis, Wild columbine
Aralia nudicaulis, Wild sarsaparilla
Artemisia caudata, Wormwood
Asclepias spp., Milkweed
Aster spp., including: A. azureus, A. cordifolius, A. laevis, A. macrophyllus, A. prenanthoides -- Asters
Athyrium Filix-femina, Lady fern
Athyrium thelypterioides, Silvery spleenwork

Bidens cernua, Stick-tight
Botrychium dissectum, Grape-fern
Botrychium multifidum, Leathery Grape-fern

Caltha palustris, Marsh-marigold
Campanula uliginosa, Marsh-bellflower
Carex spp., Sedge
Castilleja spp., Painted-cup
Cerastium vulgatum, Common mouse-ear chickweed
Chelone glabra, Turtlehead
Chrysosplenium americanum, Water-mat
Cirsium spp., Common thistle
Cirsium Hillii,
Clintonia borealis, Corn-lily
Comandra umbellata, Bastard-toadflax
Coptis groenlandica, Goldthread
Corallorhiza odontorhiza, Late coral-root
Cornus canadensis, Bunchberry
Cynoglossum officinale, Common Hound's tongue
Cystopteris fragilis, Fragile fern

Dryopteris cristata, Crested wood-fern

Eleocharis spp., Spike-rush
Epigaea repens, Trailing arbutus
Equisetum spp., Horsetail
Equisetum litorale,
Equisetum sylvaticum, Wood-horsetail
Erigeron spp., Fleabane
Erigeron strigosus, Daisy-fleabane
Eupatorium maculatum, Joe-pye-weed
Eupatorium rugosum, White snakeroot

Fragaria spp., Strawberry

Galium spp., including: G. palustre, G. trifidum, G. triflorum--
Bedstraws
Gaultheria procumbens, Teaberry (aromatic wintergreen)
Geum aleppicum, v. strictum, Avens

Habenaria hyperborea, Northern green orchis
Habenaria obtusata, Blunt-leaf orchis
Hieracium aurantiacum, Orange hawkweed
Hieracium Gronovii,
Hieracium venosum, Poor Robin's plantain

Impatiens capensis, Spotted touch-me-not
Iris versicolor, Blue flag

Juncus effusus, Soft rush

Krigia spp., Dwarf dandelion

Lactuca spp., Lettuce
Lemna minor, Lesser duckweed
Leontodon sp., Hawkbit
Liatris spp., including: L. spicata and L. Nieuwlandii --
Blazing-star
Linaria sp., Toadflax
Linnaea borealis, Twinflower
Lobelia Cardinalis, Cardinal-flower
Lycopodium tristachyum, Ground-pine
Lycopus spp., Water-horehound
Lycopus americanus,
Lycopus rubellus,
Lycopus uniflorus, Bugle weed
Lysimachia sp., Loosestrife
Lysimachia ciliata, Fringed loosestrife
Lythrum sp., Loosestrife

Maianthemum canadense, False Lily-of-the-valley
Melampyrum lineare, Cow-wheat
Melilotus alba, White sweet clover
Mentha sp., Mint
Mentha arvensis, Field mint

Mimulus spp., Monkey-flower
Mimulus alatus, Wing-stem monkey-flower
Mimulus ringens, Square-stem monkey-flower
Mitchella repens, Partridge-berry
Mitella diphylla, Coolwort
Mitella nuda, Bishop's-cap
Monarda fistulosa, Wild bergamot
Monotropa Hypopithys, False beech-drops

Nasturtium officinale, Watercress

Onoclea sensibilis, Sensitive fern

Panicum spp., Panic-grass
Pedicularis canadensis, Wood-betony
Physalis sp., Ground-cherry
Plantago sp., Plantain
Poa pratensis, Junegrass
Polygala paucifolia, Fringed polygala
Potentilla spp., Cinquefoil
Potentilla simplex, Old-field-cinquefoil
Prenanthes alba, White lettuce
Prunella vulgaris, Selfheal
Pteridium aquilinum, Bracken
Pyrola spp., including: P. elliptica, P. minor, P. rotundifolia, and P. secunda -- Shinleaf

Ranunculus spp., Crowfoot
Rorippa islandica, v. hispida, Yellow cress
Rumex acetosella, Common sorrel

Sagittaria spp., Arrowhead
Scirpus cyperinus, Bulrush
Scutellaria epilobiifolia, Common skullcap
Scutellaria lateriflora, Mad-dog skullcap
Senecio sp., Groundsel
Smilacina sp., False Solomon's-seal
Solanum sp., Nightshade
Solidago spp., including: S. altissima, S. canadensis, S. rugosa, S. uliginosa -- Goldenrods
Sonchus spp., Sow-thistle
Sorghastrum nutans, Indian grass

Taraxacum sp., Dandelion
Thalictrum dasycarpum, Purple Meadow-rue
Tiarella cordifolia, Foamflower
Trientalis borealis, Star-flower
Trifolium hybridum, Alsike clover
Trillium grandiflorum, Trillium

Urtica dioica, Stinging nettle

Viola spp., Violet

Figure 17. Precipitation and average temperatures recorded at Pigeon River Trout Research Station - 1954.

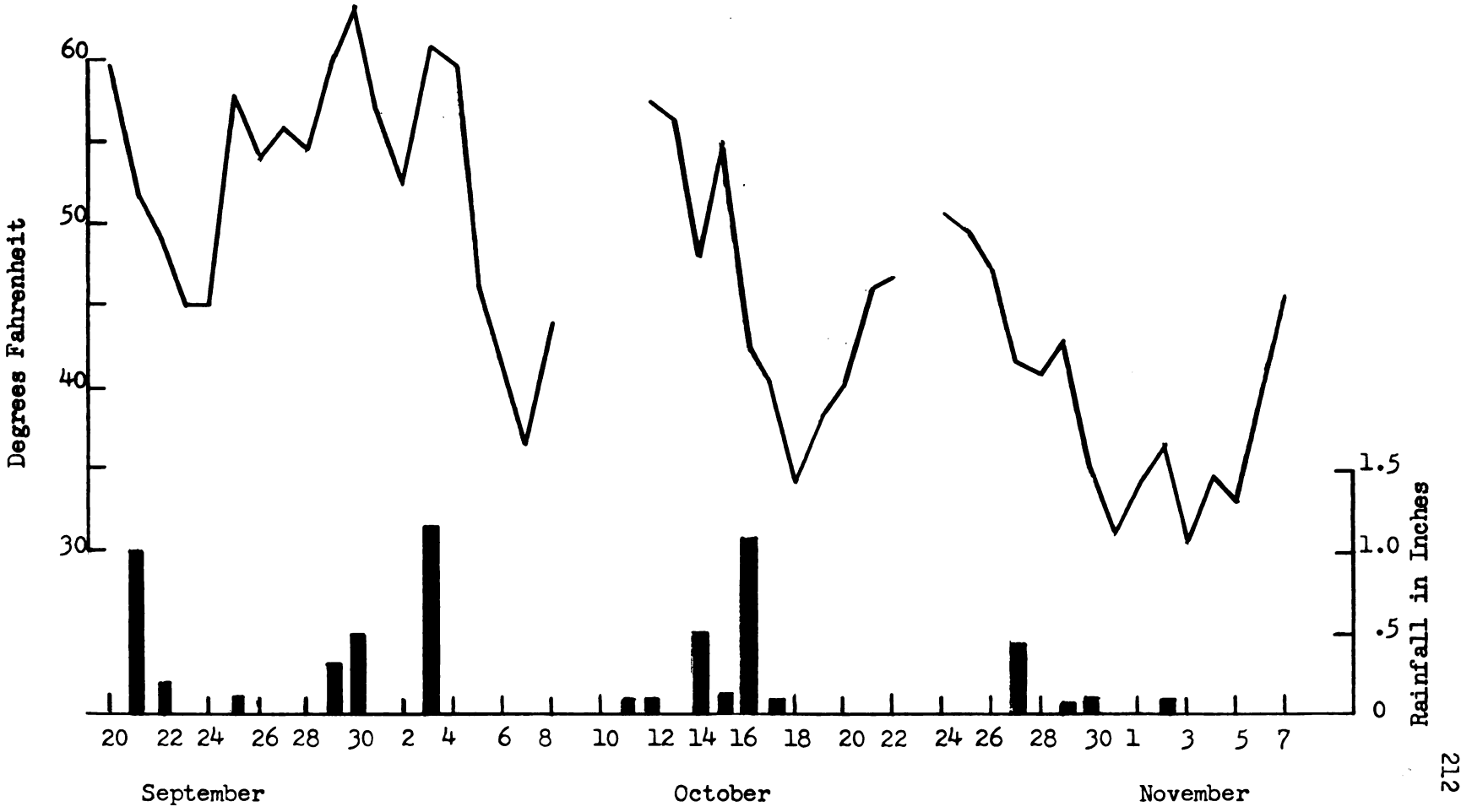

Figure 18. Precipitation and average temperatures recorded at Pigeon River Trout Research Station - 1955.

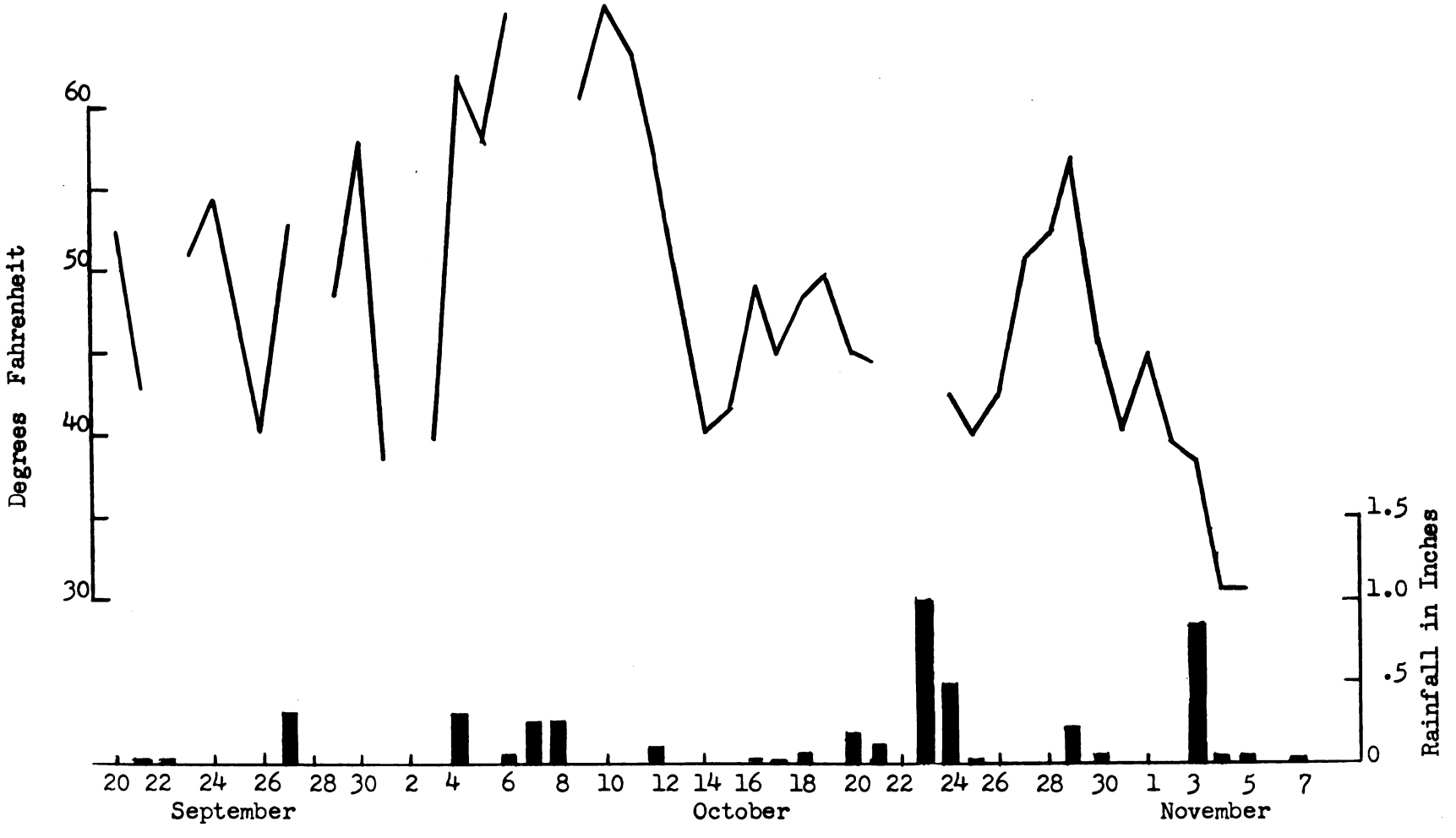

Figure 19. Precipitation and average temperatures recorded at Sault Ste. Marie - 1954.

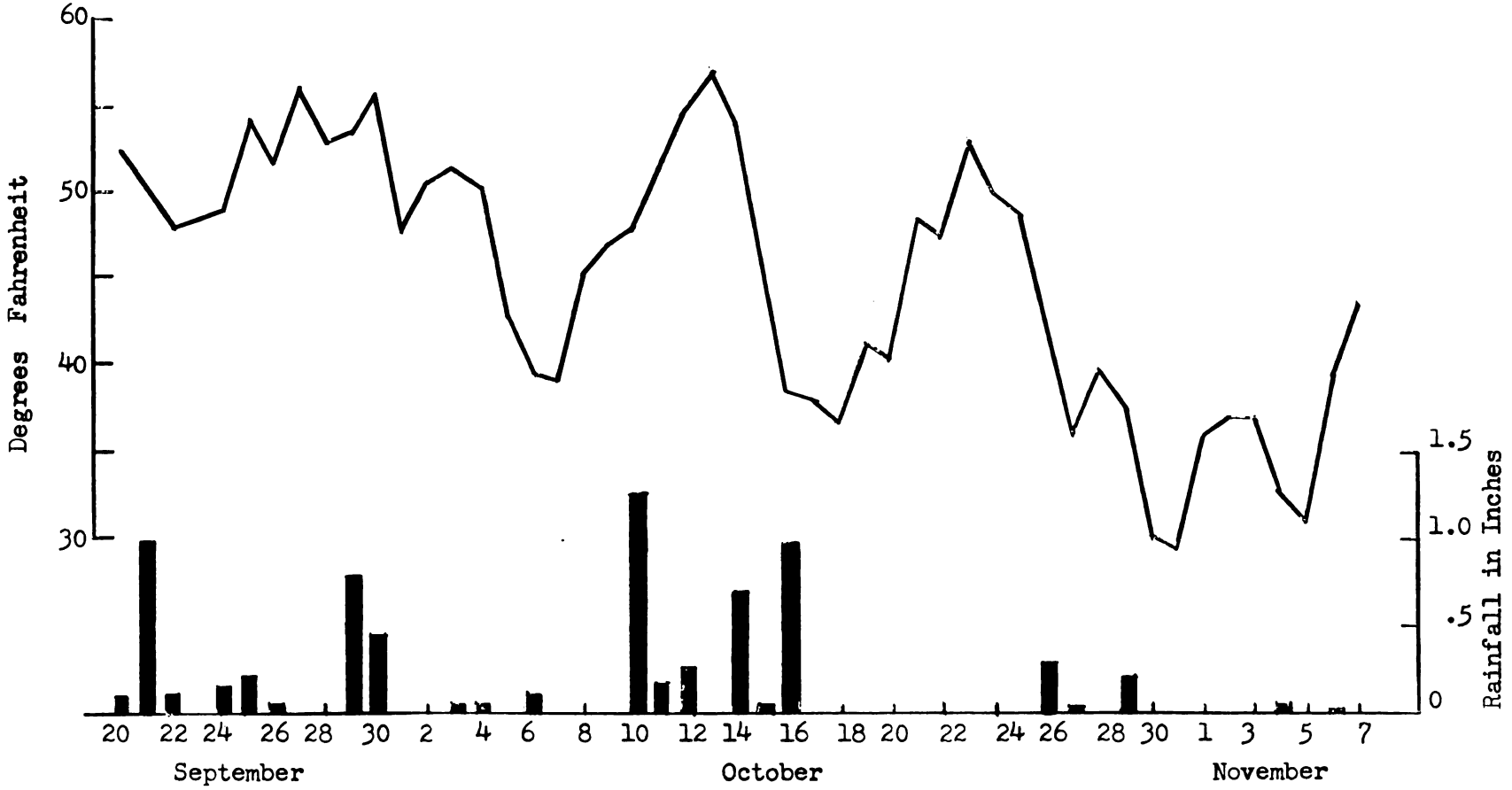

Figure 20. Precipitation and average temperatures recorded at Sault Ste. Marie - 1955.

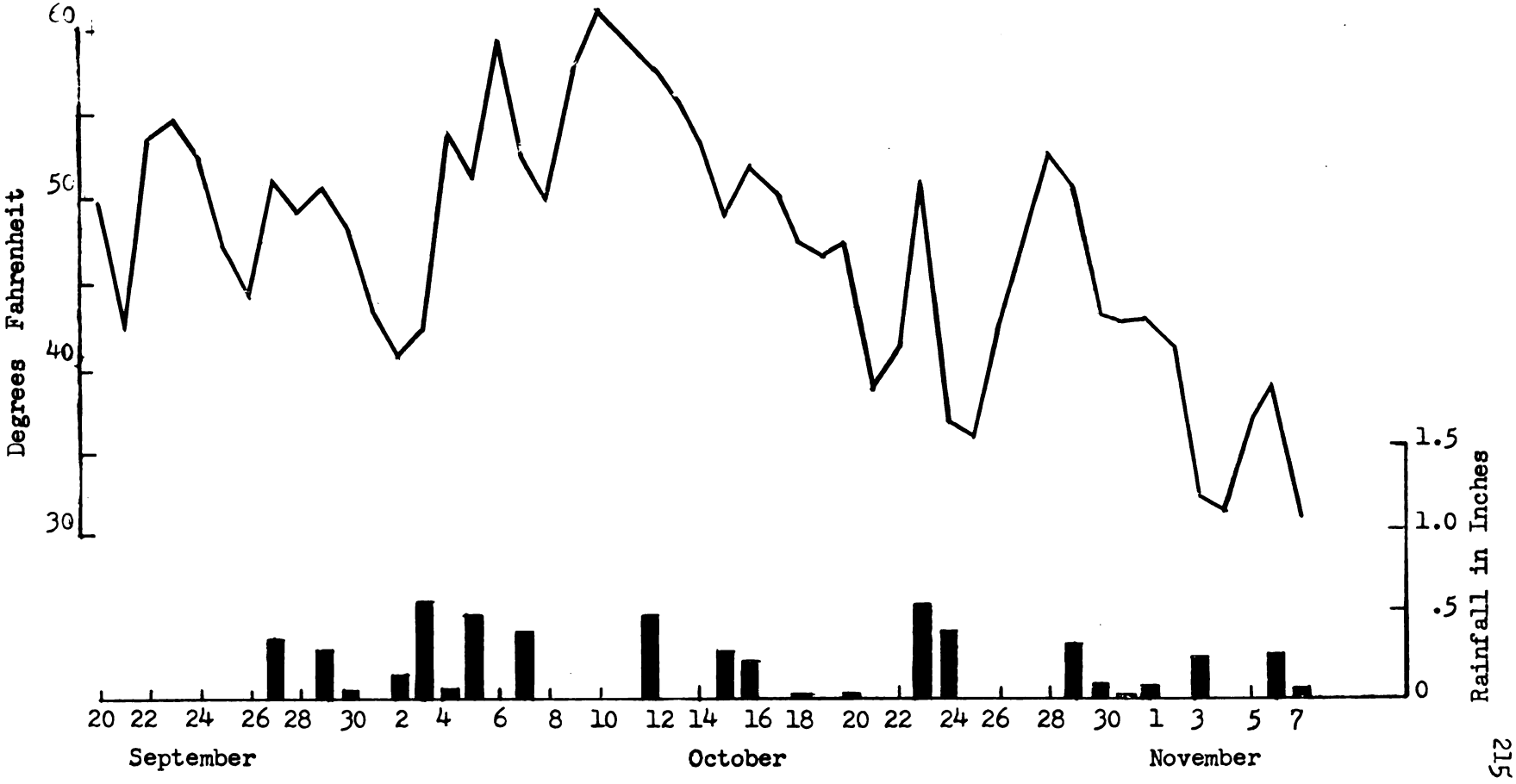

Figure 21. Precipitation and average temperatures recorded at Mackinaw City - 1954.

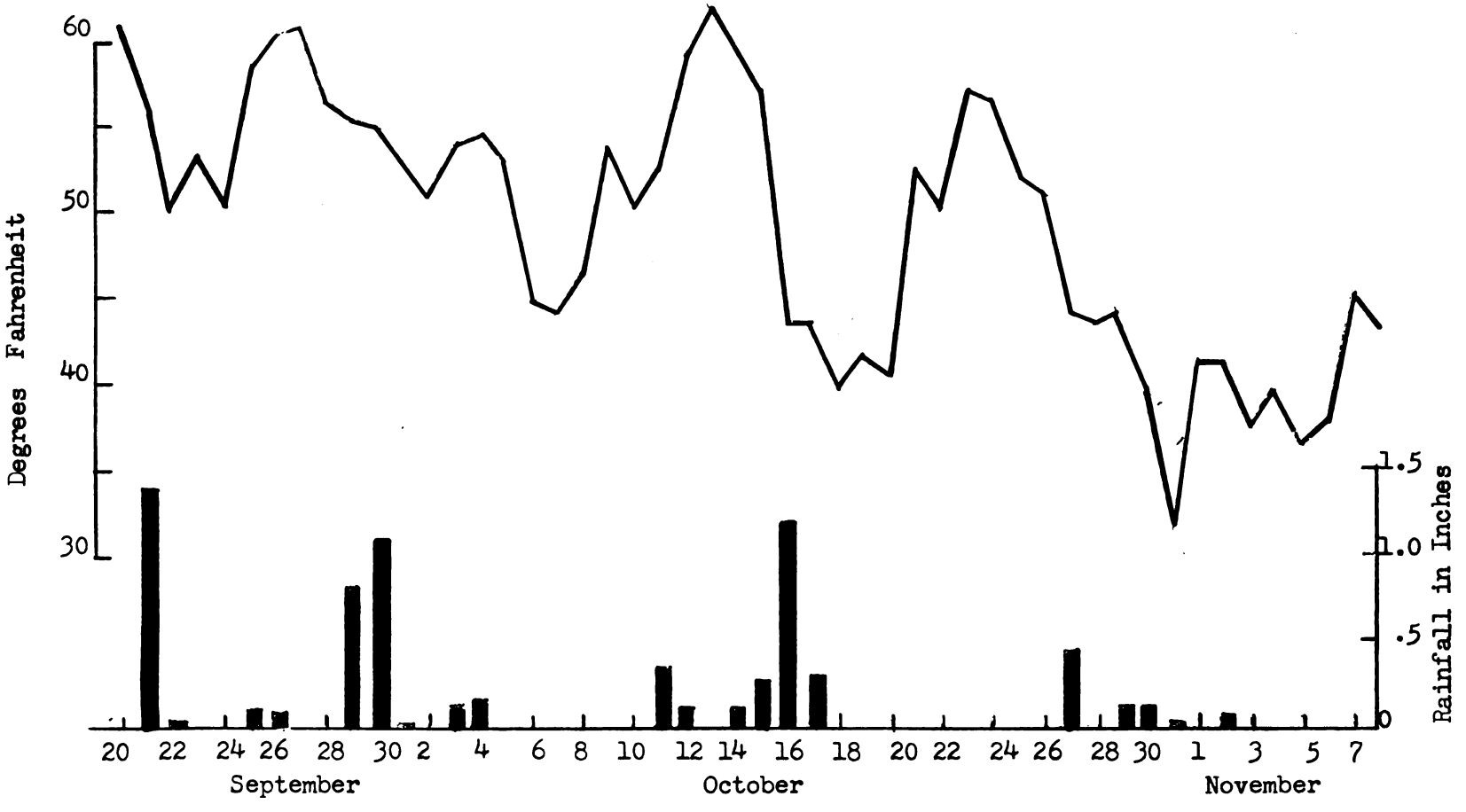

Figure 22. Precipitation and average temperatures recorded at Mackinaw City - 1955.