STUDY OF THE RELIABILITY OF CENSUSES OF SINGING MALE WOODCOCK

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY

Gary Earl Duke

1964

ABSTRACT

STUDY OF THE RELIABILITY OF CENSUSES OF SINGING MALE WOODCOCK

by Gary E. Duke

The annual Woodcock Singing Ground Survey of the U. S. Bureau of Sport Fisheries and Wildlife is widely used as an index to woodcock abundance. Observers drive along pre-selected roads and stop at intervals to record the number of male woodcock heard performing their courtship calls and flight songs. This study was undertaken to determine the nature of factors which may affect this type of survey.

Counts of "peents" and "flight songs" during many woodcock courtship performances were made by two minute intervals. They were made alternately on areas of different densities for two seasons. Simultaneously cooperators made the standard Singing Ground Survey each evening through the area in which study observation-points were located.

Recorded variations in courtship performances showed the time during the season with the most stable courtship activity. Climatic factors, unless extreme, had little effect on courtship. The performance was not significantly affected by moonstage though it appeared to be initiated by light intensity. The average starting times in relation to cloud-cover and official sunset were determined. The pre-dawn performance was found to be unsuitable for singing-ground surveys. The hearing ability of the person making surveys can significantly alter

survey results. The inclusion of flight songs in the survey tally was not detrimental to the daily totals obtained by the survey. The stage of the brood cycle may affect the male performance.

As the density of performing males increased, the level of activity per bird significantly decreased. Probabilities of hearing each individual male became lower with increasing density.

STUDY OF THE RELIABILITY OF CENSUSES OF SINGING MALE WOODCOCK

By

Gary Earl Duke

A THESIS

Submitted to
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for the degree of

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1964

Approved
George A Petrides

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This study of the reliability of woodcock censuses was a cooperative project of the Department of Fisheries and Wildlife at Michigan State University, the United States Bureau of Sport Fisheries and Wildlife, and the Game Division of the Michigan Department of Conservation.

I wish to express my appreciation to Dr. George A. Petrides, Professor, Department of Fisheries and Wildlife, for his advice in planning and methods, constructive criticism of the project, and for his editing of the manuscript. Dr. Leslie W. Gysel, also of that Department, provided advice and assistance in making field measurements of physical factors. Drs. Gysel and George J. Wallace of the Department of Zoology, both critically read the manuscript.

Dr. G. A. Ammann of the Michigan Conservation Department gave considerable assistance in the field. His advice, encouragement, and interest throughout the project are gratefully acknowledged. Other members of the Conservation Department made woodcock brood searches and made their results available to me.

Messrs. John Arnsman, Charles Eakle, John Fletcher, John Foster, Joe Johnson, Robert Kart, Michael Peterson, Carl Polomski, Roger Priest, and Nick Steen, Michigan State University students, served as cooperators in making Singing Ground Survey counts. They each devoted several evenings during the season to this work and also participated in hearing tests. Their help is greatly appreciated.

Dr. Fant W. Martin of Patuxent Wildlife Research Center of the U. S. Fish and Wildlife Service offered valuable advice and supervision throughout the research and during the writing of the dissertation.

My wife, Maryann, deserves much credit for her typing skills, her help in the field, and for constant encouragement.

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INTRODUCTION

Each spring throughout the eastern United States and southeastern Canada, several hundred people are involved in singing ground surveys to determine the annual relative abundance of the American woodcock (Philohela minor). The survey findings are utilized in regulating woodcock hunting. The woodcock, a migratory game bird of the shorebird family, Scolopacidae, inhabits uplands. Its courtship performance and calls are given during two periods each day throughout the mating season and make the survey possible.

Survey observations (U. S. Fish and Wildlife Service, 1963) are made in preselected woodcock habitat. A point where woodcock are known to perform is selected as the start of the survey and the census begins when the first male is heard. The observer travels by car over a planned route for 35 minutes at dusk. Stops are made at no less than 0.4 mile intervals, since it is believed that woodcock may be heard for 0.2 miles, but may be made at greater intervals to avoid unsuitable conditions such as busy road intersections. At each stop the number of male woodcock heard performing during a two-minute period is recorded. The count is carried out under standardized procedures and is intended to yield an index to population size. Summarized counts serve to determine population trends; no estimate of the total woodcock population is expected.

This study was conducted to determine what factors may influence the male mating performance and thus affect the population index as determined by the survey.

The bird's courtship performance occurs just prior to dawn and just after sunset. It takes place on a relatively open area called the singing ground. Most of each performance is on the ground where a buzzing "peent" call is given at regular brief intervals. "Flight songs" also occur during aerial displays which involve a rapid ascent to a height of two or three hundred feet, several circling maneuvers, and a descent in zig-zag swoops to the singing ground again. Characteristically two sounds are emitted during the courtship flight: a mechanical twittering made by the rapid beating of the wings and a vocal chirping given usually during the descent (Mendall and Aldous, 1943).

Mendall and Aldous (1943) studied the ecology of the woodcock and initiated the survey. Sheldon (1953) analyzed the singing ground survey, made observations of single birds, and appraised trapping data in efforts to improve the survey. Goudy (1960) studied the effects of various factors on the survey results and attempted again to refine the methods used.

In order to appraise further the sources of error in the survey method, my study was undertaken to determine (1) the most desirable daily and seasonal time for useful surveys; (2) the most desirable climatic conditions for useful surveys; (3) the effects of climatic and physical factors and population density on the courtship performance; and (4) the effects of observers' hearing ability and the inclusion of flight songs on the survey results.

THE STUDY AREAS

The study was conducted at Rose Lake Wildlife Experiment Station of the Michigan Department of Conservation, located about 12 miles northeast of Lansing, in Clinton and Shiawassee Counties.

Listening points in 1963 were established in four predominately grassy fields (Figure 1). Two fields possessed scattered brush and two were fairly clear of woody vegetation. In both 1963 and 1964, a single male used field number one, fields two and four had two singing males each, and in field three, three birds could be heard from one listening point. Field number two was not used in 1964. The number of performing males that I could hear from one listening point was accepted as the "density" of males there. The presence of a male was ordinarily established when I heard at least a part of its courtship performance.

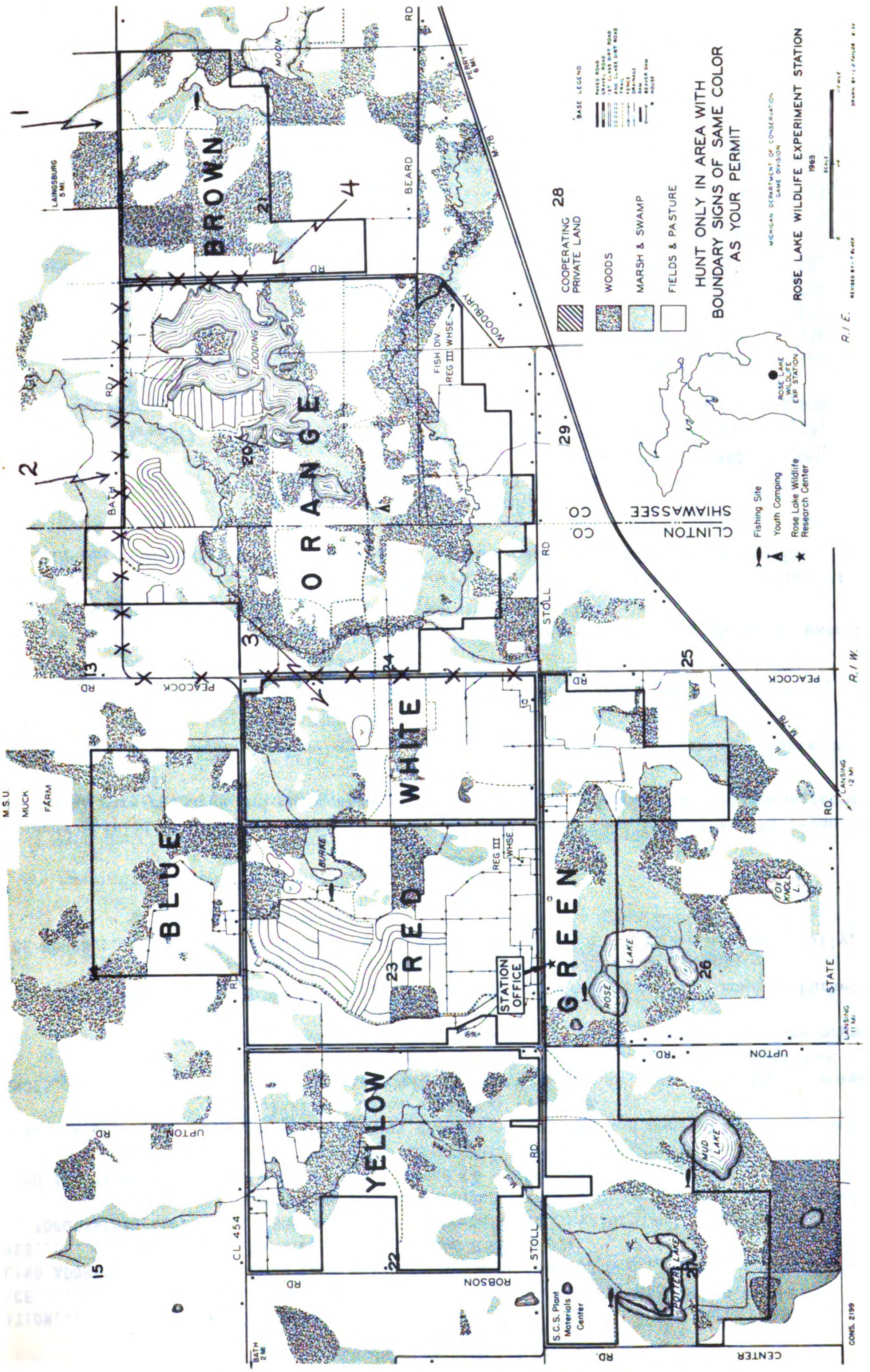
Field number one was the smallest, about 2.5 acres. It was in an early stage of old field succession with grasses predominant and scattered aspen seedlings and dogwood (*Cornus spp.*) shrubs. It was bordered by cultivated land. Fields two and four were about the same size, approximately 7.5 acres each. Field two was currently pastured and was also bordered by cultivated land. Field four was edged by water and woodland and was in a moderately advanced stage of old field succession where low vegetation was predominately grasses and woody vegetation was predominately aspen from seedlings to pole sizes. Field number three, a pasture, was the largest of the study areas, about 75 acres.

All fields were flat in general and moderately well drained. Rose Lake soils are from medium to poor fertility.

Figure 1. The woodcock listening posts. Rose Lake Wildlife Experiment Station, East Lansing, Michigan. March-June, 1963 and 1964.

= Position of listening posts

= Singing Ground Survey route


ROSE LAKE WILDLIFE EXPERIMENT STATION
MICHIGAN DEPARTMENT OF CONSERVATION
GAME DIVISION
1963
HUNT ONLY IN AREA WITH
BOUNDARY SIGNS OF SAME COLOR
AS YOUR PERMIT
COOPERATING PRIVATE LAND
WOODS
MARSH & SWAMP
FIELDS & PASTURE
Fishing Site
Youth Camping
Rose Lake Wildlife Research Center
BASE LEGEND
BROWN
ORANGE
WHITE
BLUE
RED
GREEN
YELLOW
STATION OFFICE
REG III WHSE.
FISH DIV. REG III WHSE.
FLOODING
ROSE LAKE
MUD LAKE
POTTER LAKE
FOX KNOLL L.
BURKE L.
MOON L.
M.S.U. MUCK FARM
S.C.S. Plant Materials Center
ROSE LAKE WILDLIFE EXP STATION
LAINGSBURG 5 MI.
PERRY 6 MI.
LANSING 12 MI.
LANSING 11 MI.
BATH 2 MI.
BATH RD
BEARD RD
WOODBURY RD
PEACOCK RD
STOLL RD
UPTON RD.
ROBSON RD.
CENTER RD.
STATE RD.
CL 454
M-78
SHIAWASSEE CO.
CLINTON CO.
R.1 W.
R.1 E.
1
2
3
4
13
15
20
21
22
23
24
25
26
27
28
29
CONS. 2199

GENERAL INFORMATION

LOCATION....................12 miles northeast of Lansing, just north of highway M-78.
OFFICE......................In Rose Lake Wildlife Research Center, 8562 Stoll Road.
MAILING ADDRESS.............Rose Lake Wildlife Research Center, Rt. 1, East Lansing, Michigan.
PHONES......................Lansing FE 9-8638; Bath MI 1-6921.
SIZE, TOPOGRAPHY, COVER.....3,300 acres of moderately rolling farmland, abandoned fields, oak and swamp woods, and marsh; includes 700-acre partially retired farm.
HUNTING AND TRAPPING........Daily permits issued to small game and deer hunters; seasonal permits available for trappers and raccoon hunters.
SPECIAL FEATURES............Game management demonstrations; soil conservation farm practices; multiflora rose; waterfowl flooding.
FINANCES....................Paid for entirely by hunting license fees and federal excise tax (Pittman-Robertson Act) on sporting firearms and ammunition.
TOURS.......................Arranged on request for schools, sportsmen's clubs, farm organizations, and similar groups.
PUBLIC RECREATION...........Pan fish in Rose, Mud, Potter and Moon Lakes; trout in Burke Lake; camp site for supervised groups such as Boy Scouts.
OFFICE HOURS................Week days only, 8:00 a.m.-5:00 p.m.; hunting seasons, daily, dawn to dark.

OBJECTIVES

To provide a solidly-blocked extensive area of publicly-owned land in southern Michigan, where experimental game research and management might be conducted and accurate continuous records of the results secured.

To develop practical, economical methods for increasing game and fur-bearing animals on farms and state game areas.

To determine the effect of farming practices on game and fur-bearers and vice versa.

To set up wildlife management demonstrations.

To develop methods of censusing game populations and evaluating Southern Michigan game range conditions to aid in game surveys and setting hunting regulations.

To permit the Department to appreciate and understand more fully the farmer's point of view, especially regarding hunters, and practicality of game management programs on the farm.

SUMMARY OF HUNTING 1958-1962

	1958	1959	1960	1961	1962
Size of Hunting Area (Acres)........................	3,120	3,181	3,181	3,181	3,204
Daily Hunting Permits........................	4,043	3,501	4,080	3,908	3,986
Total Farm Game Kill:					
Pheasants........................	211	145	177	161	201
* Rabbits........................	407	404	456	438	405
Fox Squirrels........................	265	179	141	137	119
TOTAL........................	*883*	*728*	*774*	*736*	*725*
Ducks Bagged........................	216	201	466	182	160
Farm Game Kill per 100 Acres (Size of an Average Farm):					
Pheasants........................	7	5	6	5	6
Rabbits........................	13	13	14	14	13
Fox Squirrels........................	9	6	4	4	4
TOTAL........................	*29*	*24*	*24*	*23*	*23*

* *Rabbit hunting season includes January and February of following year*

OTHER CONSERVATION AGENCIES AT THE STATION

GAME DIVISION LABORATORY..........In east wing of office building.
GAME DISTRICT 14 OFFICE............In south wing of office building.
REGION III GAME WAREHOUSE..........Half mile east of office.
FISH DIVISION WAREHOUSE............Lake and Stream Improvement Warehouse, two miles east of offi..

A QUANTITATIVE DESCRIPTION OF THE COURTSHIP PERFORMANCE

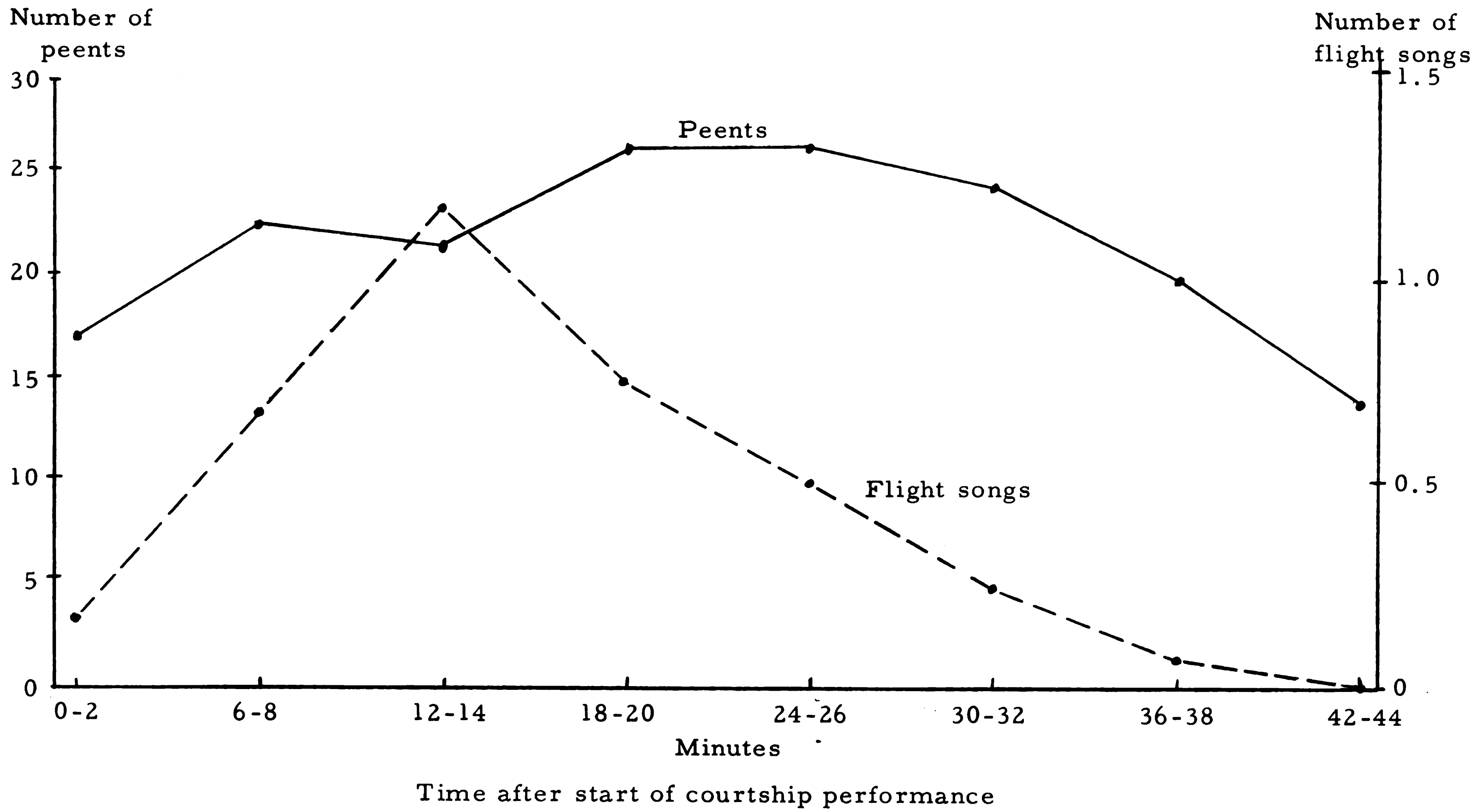
An examination of 50 birds shot while peenting (Fant W. Martin, personal conversation, July 1963) revealed that all were males. Apparently, only males make this call.

Peents and flight songs were counted during two-minute intervals during each performance in 1963 and for both one and two-minute intervals in 1964. Three types of counts were made during each performance: type one, collective counts of all peents and flight songs of all birds present; type two, counts of peents and flight songs of a single bird of those present; type three, counts of peents and flight songs of one particular second bird, if more than one was present. These counts allowed a quantitative description of the performance. Also, these counts and a Singing Ground Survey taken simultaneously each evening by student cooperators made four measures of woodcock courtship activity available. These were: the number of peents and flights per bird per two-minute period, the length of each daily performance, the daily Singing Ground Survey totals, and the consistency of activity throughout the performance.

A special set of observations, made as time permitted during the counts described above, showed there was an average peenting frequency of 21 peents per minute per bird (40 one-minute counts). Peenting frequency was greatest during the middle of the performance (Figure 2). Fifty flights were timed and their average duration was 56 seconds. Courtship flights and flight songs occurred predominately during the first half of the performance (Figure 2). During the time when the most flights occurred, there was an average of about 28 peents between flights (35 counts).

These averages were determined at the dusk performance when one bird was present. The same pattern of peenting and flighting activity prevailed when more than one bird was present within my hearing range, but the activity did not increase proportionately with density (see beyond).

Figure 2. Woodcock peenting and flight song activity per two-minute period during the performance. Rose Lake Wildlife Experiment Station, East Lansing, Michigan. March-June, 1963 and 1964.



Number of peents
30
25
20
15
10
5
0
Number of flight songs
1.5
1.0
0.5
0
Peents
Flight songs
0-2
6-8
12-14
18-20
24-26
30-32
36-38
42-44
Minutes
Time after start of courtship performance

SOURCES OF VARIATION IN THE WOODCOCK PERFORMANCE

Seasonal Variations in Activity and the Stable Period

Repeated visits to the study area were necessary in early spring, and even after the first male was heard, several evenings were required to select listening points where there were different densities of singing males. In 1963, the first male was heard on March 18 and observations were recorded from March 25 to June 7. In 1964, the first bird was heard on March 14 but recorded observations were delayed until April 3 by snowfall and very cold weather. Observations then were made through June 3.

Early in the 1964 season, courtship activity was limited somewhat by adverse weather conditions, but I observed fairly normal activity even during a snowfall. Early-season activity on the singing ground normally is characterized by daily variations in the number of singing males present, apparently due to the presence of transients (Figure 5 and 7), and by frequent performances evidently to demarcate territories. The territorial performance involves a very low flight by a territory-holder over an intruder. It is accompanied by a "cackling" or growling call given above the intruder's head. On one occasion, five of these flights were made in one evening by a bird dislodging an intruder. The disputes usually ended with both birds flying together out of my sight, the territory-holder cackling at frequent intervals all the way. On one occasion, an apparently pugnacious or confused male dived and cackled at me. This aggressive behavior did not last beyond the first week of April in either season of the study.

With the passing of migrants, courtship activity seemed to become fairly regular until mid-May when activity waned. This pattern of activity allows the determination of a period which has stability and a high level of courting activity. This I have called the stable period and unless otherwise stated all results which follow are based on observations recorded only during this time (Figures 3, 4, 5, 6, 7). The stable period extended from April 15 to May 16 in 1963 and from April 12 to May 14 in 1964. Confidence limits based on daily performance length and daily singing ground survey totals were used to determine the extent of this period in 1963. A similar but less involved technique was used with the 1964 data. Counts of "peents" and "flight songs" as measures of activity could not be used in establishing the stable period since, as will be shown later, peenting and flight song activity varies with the density of performing males.

The description of this stable period and its chronological position in the season showed general agreement with the findings of both Sheldon (1953) and Goudy (1960). Sheldon observed that in the period prior to April 15 there was much variability probably due to passing migrants; and that the period after May 10 probably was variable because of diminution of courtship activity. Goudy recommended a "central period" of April 20 to May 10 for making surveys.

Effect of Density of Performing Males on Singing Activity

Tests showed that during the stable period both peenting and flighting activity per bird became less per two-minute period as the density of performing males increased (Table 1). Peenting was highly significantly greater for all lone birds than for others in 1963. There were significant differences in two of three of the 1964 comparisons. The exception was that there was no significant difference in peenting activity

Figure 3. Woodcock pre-dawn length of performance. March-June, 1963. Rose Lake Wildlife Experiment Station, East Lansing, Michigan.

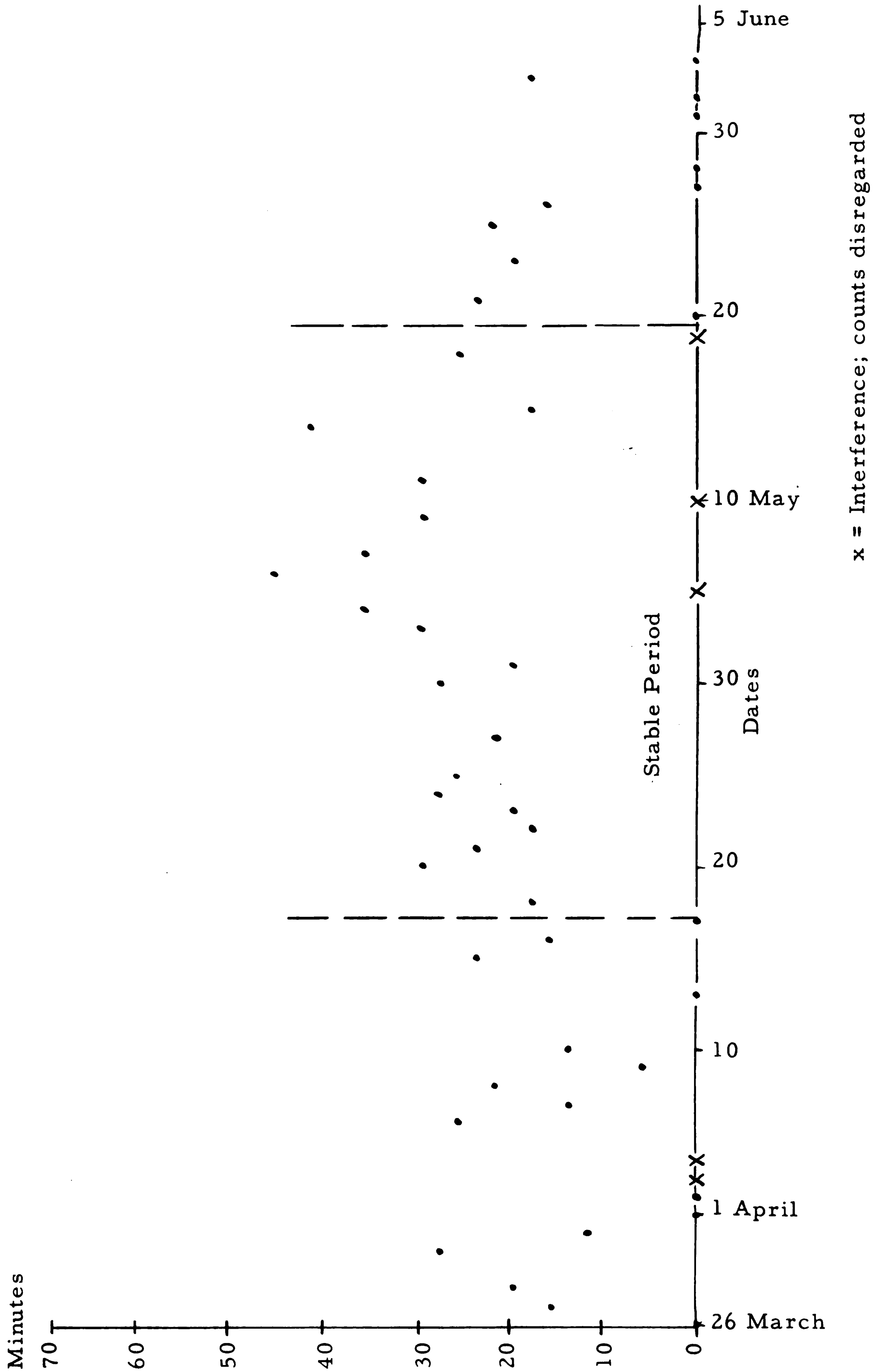

Minutes
70
60
50
40
30
20
10
0
26 March
1 April
10
20
30
10 May
20
30
5 June
Dates
Stable Period
x = Interference; counts disregarded

Figure 4. Woodcock length of performance at dusk. March-June, 1963. Rose Lake Wildlife Experiment Station, East Lansing, Michigan.

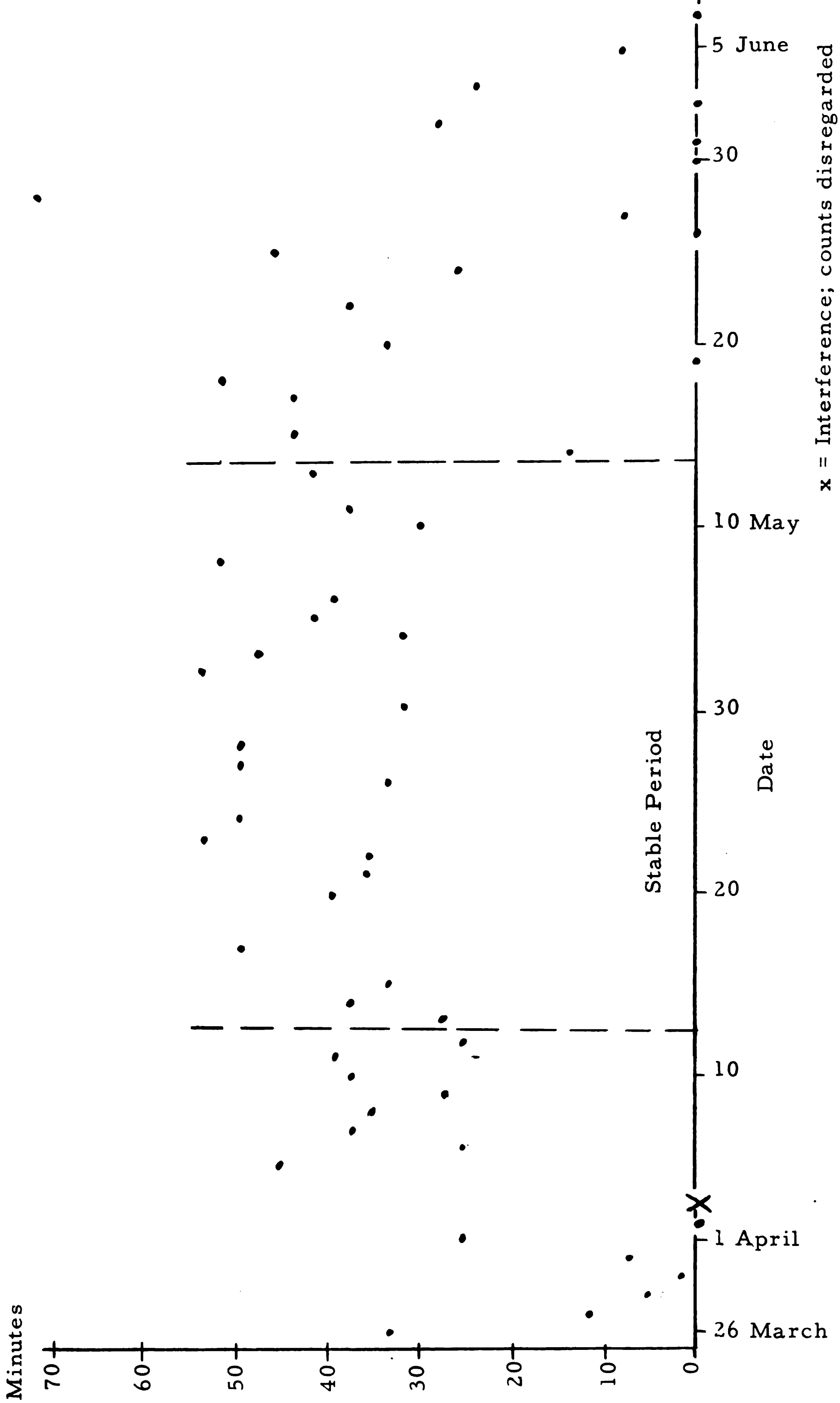

Minutes
70
60
50
40
30
20
10
0
26 March
1 April
10
20
30
10 May
20
30
5 June
Stable Period
Date
x = Interference; counts disregarded

Figure 5. Daily woodcock Singing Ground Survey totals. March-June, 1963. Rose Lake Wildlife Experiment Station, East Lansing, Michigan.

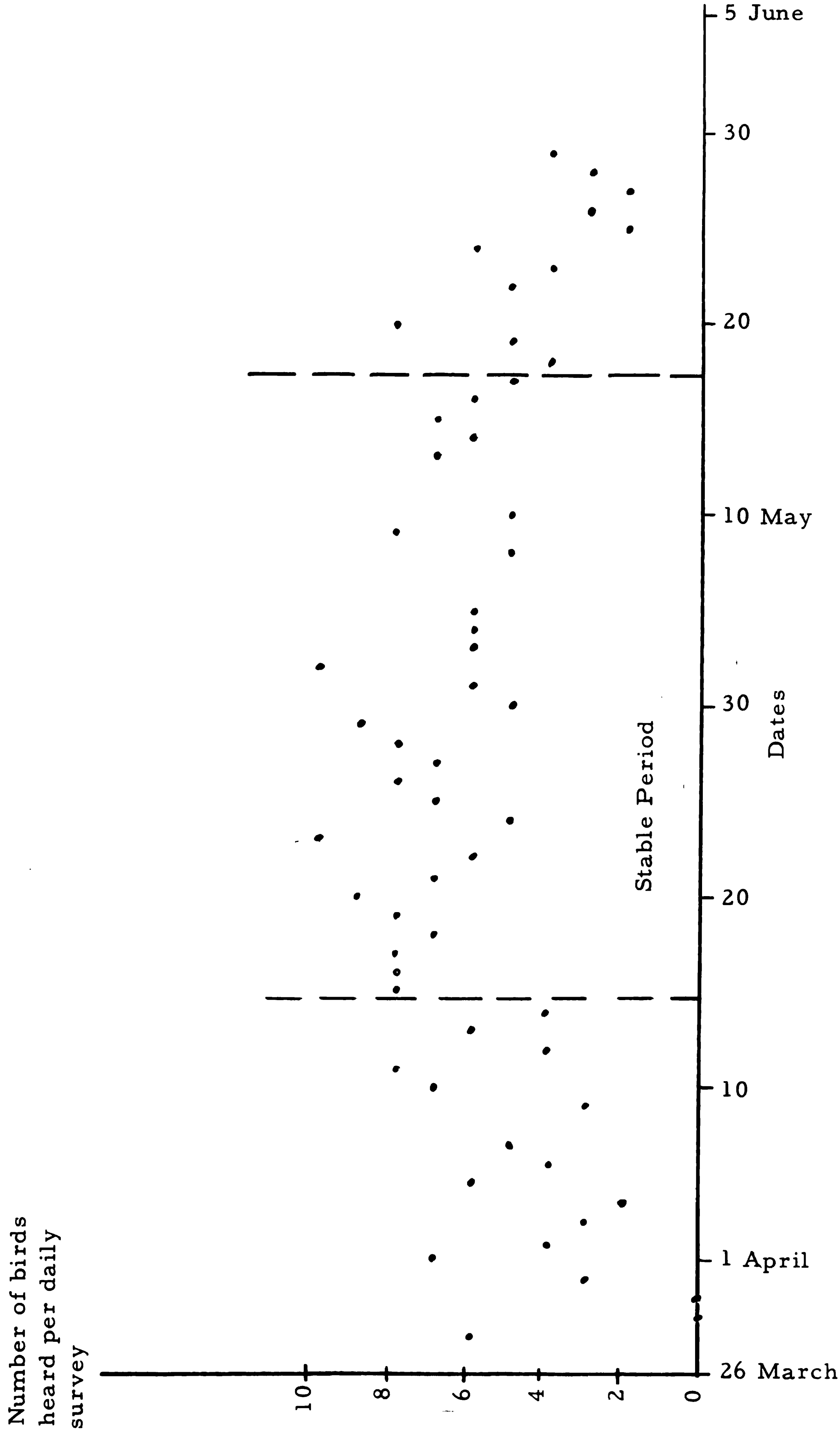

Number of birds heard per daily survey
0
2
4
6
8
10
26 March
1 April
10
20
30
10 May
20
30
5 June
Dates
Stable Period

Figure 6. Woodcock length of performance at dusk. March-June, 1964. Rose Lake Wildlife Experiment Station, East Lansing, Michigan.

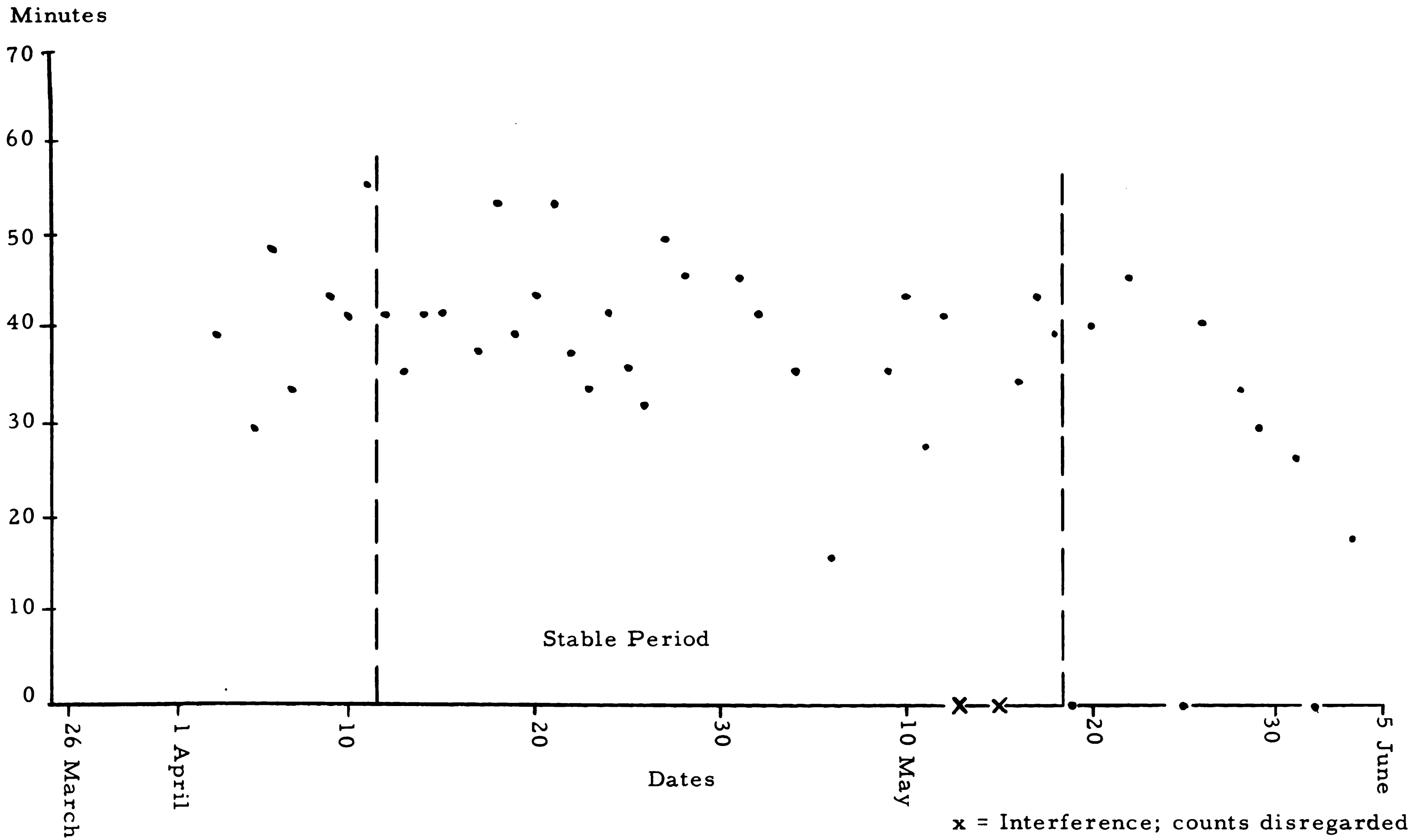

Minutes
70
60
50
40
30
20
10
0
Stable Period
26 March
1 April
10
20
30
10 May
20
30
5 June
Dates
x = Interference; counts disregarded

Figure 7. Daily woodcock Singing Ground Survey totals. March-June, 1964. Rose Lake Wildlife Experiment Station, East Lansing, Michigan.

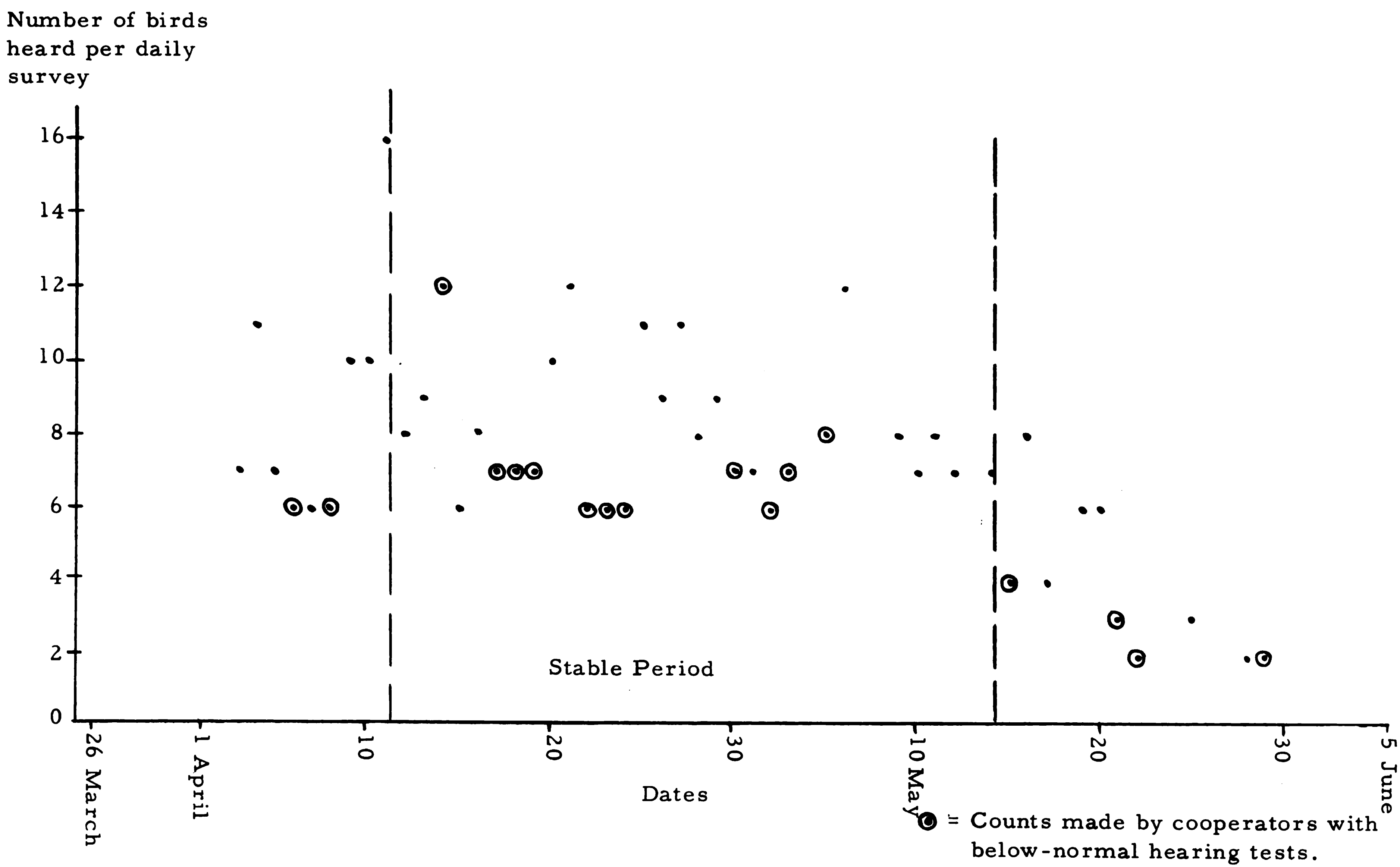

Number of birds
heard per daily
survey
16
14
12
10
8
6
4
2
0
Stable Period
26 March
1 April
10
20
30
10 May
20
30
5 June
Dates
= Counts made by cooperators with
below-normal hearing tests.

Table 1. A comparison of activities of male woodcock on singing grounds occupied by different densities of birds. Rose Lake Wildlife Experiment Station, East Lansing, Michigan. March-June, 1963 and 1964.

Activities	Comparison of one-density to two-density	Comparison of one-density to three-density	Comparison of two-density to three-density
Peenting			
1963, Dusk	t=5.6232, 12d.f.*	t=9.3158, 10d.f.*	t=2.8961, 12d.f.*
Dawn	t=3.2349, 12d.f.*	t=3.8450, 10d.f.*	t=3.349 , 10d.f.*
1964, Dusk	t=0.0001, 17d.f.	t=1.529, 10d.f.#	t=2.368 , 13d.f.ƀ
Flight Calls			
1963, Dusk	t=1.6771, 12d.f.#	t=1.6158, 10d.f.#	t=0.1890, 12d.f.
Dawn	t=0.9015, 12d.f.	t=1.3994, 10d.f.#	t=0.9434, 10d.f.
1964, Dusk	t=0.623, 17d.f.	t=0.4039, 10d.f.	t=2.197 , 13d.f.ƀ

*= Highly significant difference, at the one percent level
ƀ= Significant difference, at the five percent level
#= Significantly greater, at the ten percent level
d.f. = Degrees of freedom

when one and two birds were present. The density difference could have been in part due to my inability to hear every "peent" of all birds at the higher density. This would not account for all the difference, however, since there was a decrease in the frequency of flight songs with increased density as well, and flight songs can be counted with certainty.

This density response also supports the idea that it is not simply hearing ability which lowers probabilities of counting birds at higher population densities (see beyond). Similarily, some of the difference between the two years may be due to my increased experience. However, the birds at the two-density listening post (i.e., two birds present) were separated by a line of brush and were further apart in 1964 than in 1963, so that there may have actually been a decreased effective density. Although activity decreased as density increased there should be little effect on the probabilities of hearing each bird (see beyond) since one "peent" in two minutes is enough to determine the presence of a bird. However, since fewer "peents" were uttered, the periods of silence are longer with consequent lowering of the likelihood of hearing each bird in every two-minute period.

Since singing activity per bird decreased as density increased, it was thought that this might be due to the dominance of one or more individuals on a field occupied by several performing males. Field records were studied to determine what differences in peenting activity occurred when more than one bird was present. Eight cases of dominance seemed apparent (Table 2), if the following is an acceptable criterium. Dominant birds were assumed to be those which displayed during the stable period at least two peents more per two minute period than other birds in the group, without marked reduction in flight performances.

Only four of the eight cases tested showed significant differences in peenting activity (Table 2). Thus, of 68 acceptable performances

Table 2. Results of significance tests to determine whether differences in peenting activity indicate dominance among male woodcock who share a singing ground. Rose Lake Wildlife Experiment Station, East Lansing, Michigan. March-June, 1963 and 1964.

Number of birds present	Test Results from average peenting frequencies
2	sample sizes 7,7; means 16.1, 18.7 t = 0.489
2 #	sample sizes 9,9; means 18.8, 15.7 t = 0.7908
2	sample sizes 6,6; means 23.1, 14.7 t = 2.3416 *
3 #	sample sizes 6,6; means 12.7, 22.8 t = 3.485 *
3	sample sizes 8,5; means 22.8, 18.0 t = 1.563
2	sample sizes 6,6; means 23.7, 19.5 t = 0.7183
2	sample sizes 7,7; means 24.6, 14.6 t = 1.4708 *
2 #	sample sizes 8,6; means 20.3, 31.3 t = 1.5674 *

* = Significantly more peents uttered by one bird
\# = Combat flights observed

observed during both seasons, both dawn and dusk in 1963, and during the stable period, only 5.8 percent actually displayed dominance. In two of the four cases showing this dominance effect, combat flights occurred. They also occurred in one case where there was no dominance. If a dominant individual were present, one would not expect combat to occur; whereas it would be expected from those individuals attempting to establish dominance.

Perhaps the dominant individual is the one which does not share a singing ground. Lone males do more singing than males which share a singing field but this may be merely a result of efforts to attract females in the absence of close neighbors which help to bring them in.

Dominance, if it exists, is not considered to be important in affecting the woodcock Singing Ground Survey. Sheldon (1954) mentions "a surprising amount of intraspecific tolerance" and varying degrees of territorialism among birds. I observed that even when birds were widely spaced on the ground, their flight paths frequently overlapped.

Effects of Physical Factors

According to Sheldon (1953) "analyses suggested no correlation between weather conditions and count unless the former was extreme or there was bright moonlight." With the exception that I found no significant relationship between activity and moon stage, this quotation aptly summarizes my findings too.

Physical factors were determined for each performance. Temperature, relative humidity, wind velocity, and cloud cover were measured every half hour throughout each performance. Other factors were recorded daily or measured prior to the start of the performance.

Temperature and relative humidity were measured with a sling psychrometer. Wind velocity was determined using both a Dwyer Wind Meter and the Beaufort wind scale. Percentage cloud cover was estimated visually. Vegetation moisture was determined by the weight differences of blotters in 1963 and of air-dry plaster of paris slabs in 1964. These blotters and slabs were weighed before and after two minutes of contact with the grass at preselected random points on a field used as a singing ground. The blotters were held down by weighted plywood covered with $\frac{1}{4}$ inch wire mesh. The slabs required no weights. Barometric pressures, moonstage, and times of sunrise and sunset were obtained from local U. S. Weather Bureau reports. Light intensity measurements were made with an Olden light meter.

Phenological calendars which I maintained throughout both seasons were similar but not identical for the two years. The appearance of first buds and blossoms of common native plants was about eight days later in 1964 than in 1963 at the beginning of the season. By mid-April this difference in blooming dates for certain species for the two years was reduced to about two days. The early season differences were undoubtedly due to cold weather in 1964.

Correlation coefficient tests were made between some of the physical factors measured and three measures of courtship activity, (1) peenting frequency, (2) daily Singing Ground Survey totals, and (3) performance lengths at dusk. Due to the density effect, only the activity of the one-density bird for 1963 and only that of one and two bird density groups combined for 1964 could be used for these correlation tests. The results of these tests, with two exceptions, showed no significant correlations between climatic factors and those measures of activity compared (Table 3).

The two exceptions were a negative correlation between wind velocity and peenting activity and a positive correlation between survey totals and temperature. As will be shown later, hearing efficiency is affected by wind velocity. Therefore, the significant negative correlation between peenting activity and wind velocity may be due to hearing

Table 3. Correlation coefficients between physical factors and three measures of woodcock courtship activity. Rose Lake Wildlife Experiment Station, East Lansing, Michigan. March-June, 1963 and 1964.

Physical Factors	Measures of activity 1963			Measures of activity 1964		
	Daily survey totals	Peents per two minutes	Performance length	Daily survey totals	Peents per two minutes	Performance length
Temperature	+.1534	-.0775	+.0207	*+.5231	-.2083	-.3373
Relative humidity	-.1541	+.2924	+.1793	+.2214	-.0516	+.3019
Wind velocity	-.2113	*-.9563	-.2383	+.3073	-.3676	+.3348
Cloud cover	+.1234	-.6059	-.2408	+.0323	-.1925	+.1585
Vegetative moisture	-.2529	+.3414	-.1825	+.4708	-.0539	+.1549
Barometric pressure	+.1411	+.5903	+.0486	-.1421	-.2536	-.0355

* = a correlation coefficient that is significantly different from zero at the five percent level.

difficulty rather than to a significant change in male courtship activity. Also, observations of peenting activity would be more severely affected by increases in wind velocity than determining performance length or obtaining an accurate singing ground survey tally.

The positive correlation between daily survey totals and temperature may also be due to human sensitivity. Colder temperatures probably lower the efficiency of the counter. Also, warmer temperatures occur later in the season and the student cooperators had gained experience, thus probably raising their efficiency. Lastly, temperatures probably do have a slight effect on the birds, with warmer temperatures stimulating activity. This is indicated by the probability data too (see beyond).

As mentioned above, no significant effects on activity were found to be due to the stage of the moon. Instructions for the 1963 woodcock Singing Ground Survey directed that "counts should not be made during the period of two days before a full moon and one day afterward."

In 1963, data were not sufficient to allow conclusive analysis of the effect of moon stage. However, in 1964, a special set of observations was made to determine the effects of the full moon. One particular bird was observed for three days before, and three days during the full moon. This test allowed comparison of performance length, daily survey totals, peenting and flighting activities, and probability of hearing each bird for performances during and before the full moon period. No significant differences were found between any of these activities for the two periods. The probability of hearing each individual bird during the full moon was lower than that for the period preceding the full moon, however, due to earlier cessation of the performance. The probability of hearing each individual bird in the period preceding the full moon was 0.933. During the full moon period this probability was 0.867. (The computation of these probabilities is explained beyond). Three of the performances during this special test were slightly less than 36 minutes long, but this is not characteristic of the full moon period (see Figures 4 and 6). The results of comparisons between activities observed in this test before and during the full moon period are:

performance lengths	peenting activity per 2 minutes	flighting activity per 2 minutes	daily survey totals
t = .5331	t = 1.224	t = .9937	t = .6795

Since moonlight did not seem to affect the performance (see also, Table 6), it was desirable to know to what extent the performance was influenced by light intensity. Light intensity was measured at the beginning and ending of each performance. The performance was determined to have started with the first "peent" or "flight song" given on the singing ground (not in diurnal covert). The light measurement was made in a standard way each day and readings were taken in an open area where light conditions would have been similar to those on a singing ground. Average light intensity at starting time was zero foot candles at the predawn performance. This average was 2.1 foot candles at dusk with a standard deviation of 2.4 foot candles. Light readings at the end of all performances were zero. No attempt was made to determine the part of the spectrum influencing the starting time. Low variability in starting-time light readings indicated that light intensity initiates the dusk performance. Minor variation may have been due to the position of the bird and the amount of light reaching it.

Further evidence of a phototropic response is found in the relationship of starting time under varying amounts of cloud cover to official sunset time (Table 4). As cloud cover increases, starting times become earlier in the evening. This is as would be expected if a particular light intensity is necessary to initiate the male performance. However, as cloud cover increased, so did the variability of the starting time.

Table 4. Mean and standard deviation in minutes from sunset to start of the dusk woodcock courtship performance. Rose Lake Wildlife Experiment Station, East Lansing, Michigan. March-June, 1963 and 1964.

Cloud cover	Mean for season	Standard deviation	Sample size	Mean for stable period	Standard deviation	Sample size
1963						
0-25%	18.000	3.835	18	16.125	3.682	8
26-50%	17.889	4.649	9	17.000	3.873	5
51-75%	11.750	7.111	7	16.333	7.637	3
76-100%	9.412	9.636	17	10.000	12.501	8
90-100%	9.333	9.582	15	10.000	12.501	8
1964						
0-25%	15.235	5.506	17	16.714	3.684	7
26-50%	------*	-----	0	14.500	4.679	6
51-75%	15.300	5.857	5	15.500	9.192	2
76-100%	6.000	6.640	12	6.750	7.747	8
90-100%	7.200	6.300	10	7.167	9.497	6

* = Conditions of 26-50% cloud cover occurred only during the stable period in 1964.

Data on pre-dawn starting times are interesting but inconsistent and do not show a clear-cut relationship to light intensity (Table 5). Normally there is complete darkness at the start of this performance. Pre-dawn starting times are related to sunrise but not to cloud cover.

The greatest inconsistancy in pre-dawn starting times was shown by an abrupt change occurring about May 1, 1963. The time range from start of the performance to sunrise before this date was 42-58 minutes. After this date this range became 56-85 minutes. The averages of the minutes before sunrise under different amounts of cloud cover for these two periods are:

Cloud Cover	Mean before May 1	Mean after May 1
0-25%	50.27	73.50
26-50%	46.50	66.00
51-75%	58.00	75.50
76-100%	50.25	69.57
90-100%	50.00	70.60

This difference cannot be explained. The first week in May of 1963 was approximately the center of the stable period and appears to be a significant time in the seasonal cycle for that year (see next section).

Table 5. Mean and standard deviation in minutes before sunrise to start of the pre-dawn woodcock courtship performance. Rose Lake Wildlife Experiment Station, East Lansing, Michigan. March-June, 1963.

Cloud Cover	Mean for Season	Standard Deviation	Sample Size
0-25%	58.47	12.684	17
26-50%	58.20	13.516	5
51-75%	69.67	12.583	3
76-100%	59.27	11.126	15
90-100%	59.36	11.944	11

Previous results have shown sizeable differences in activity between morning and evening performances. This led me to a statistical comparison of aspects of the performance for these two times of the day.

These comparisons showed that: (1) there are significantly fewer birds heard at dawn than at dusk (at the six percent level, $Z = 1.643$); (2) the dawn performance is significantly shorter than the dusk performance (at the one percent level, $Z = 3.670$); (3) there are significantly more "peents" per bird per two minute period at dusk (at the five percent level, $t = 2.1296$, 11 degrees of freedom); and (4) there are significantly more flights per bird per two minute period at dusk (at the ten percent level, $t = 1.543$, 11 degrees of freedom).

The first two tests were made using data for the entire season, the second two were made with data from the stable period when there was evidence that only one bird was present.

Evening performance length averaged 43 minutes in 1963 and 41 minutes in 1964. The average length of the morning performance during the peak period was 27.1 minutes. This, coupled with the results presented above shows the performance at dawn is less desirable as a time for singing ground surveys. Another factor also contributes to this conclusion: interference due to wind and/or rain is more noticeable in the morning performance because birds start in the dark and are more difficult to locate by sight as well as by sound. Pre-dawn observations were not made during 1964 because of the above findings.

The Relationship of Brood Activity to Male Courtship Activity

Brood searches were conducted each year by Michigan Conservation Department personnel in the areas of my study. In 1963 nine broods were located and the following approximations of the hatching dates were made (Dr. G. A. Ammann, conversation, 1963):

April 21 or earlier	April 24
April 22	April 24
April 23 or 24	May 2
April 23	May 15
April 23	

Three-fourths of these hatchings occurred just before the first week of May, the week which represented the approximate peak in male activity in 1963 (Figures 3, 4, and 5). The last hatching date probably represents a re-nesting effort.

These results agree well with those of Sheldon (1953) who found, with the exception of the first week in April, that the first week in May yielded the highest roadside counts and the best results in trapping; and that this week occurred "just after the height of the hatch in Massachusetts coverts." However, Blankenship (1957) found that the major nesting season in southern Michigan occurred during the last two weeks of April and the first two weeks of May.

Hatching in my study areas in 1964 agreed more with Blankenship's findings in that the dates of hatchings were spread out during the last of April and the first of May. These dates are as follows (Dr. G. A. Ammann, conversation, 1964):

April 14	April 30
April 19	May 2
April 21	May 10
April 25	May 12
April 27	May 12
April 28	May 22
April 29	

This spread may have been due to late March snowfall and cold weather in early April. The significant point however, is that no real peak in male courtship activity appeared in the 1964 season (Figures 6 and 7). Thus, there is indication that male activity may increase with the coincident appearance of many broods.

SOURCES OF VARIATION IN THE SINGING GROUND SURVEY

Hearing Tests

The woodcock peent is well within the range of normal human hearing. "The energy of the peent is concentrated between 4.7 and 6.0 Kc. and almost all energy occurs between 2.6 and 6.7 Kc." (Stein, 1963). "The audiogram of man shows maximum sensitivity in the range from 800 to 2500 c.p.s. with the upper limit around 16,000 c.p.s." (Prosser and Brown, 1961).

Two hearing tests were made in the field during each season of this study. Weather, habitat, and aural interference conditions were different for each of the tests in one season. Conditions in the second season were similar to those of corresponding tests in the previous season. I conducted the field tests using the student singing ground survey cooperators. Each test was made by approaching the test bird (which I knew to be singing) from a distance of 500 yards. The approach was made by 50 yard advances along a route tangent to the bird's singing ground. The persons being tested were given a record sheet and instructed to note at each stop either a zero or the number of birds heard. Also, they were to record whether each bird was heard by peenting or by flight song, and they were not to reveal their findings to the other testees. A listening period of 30 seconds was used at each stop. Since the position of the bird was known in relation to each stop, hearing distances were computed by triangulation.

The first test each season required that the bird be heard through a beech-maple forest for the first half of the test. Aural interference was at a minimum for this test with wind velocity averaging from 3-4 m.p.h. and there was no frog or automobile interference. Temperatures were similar in both years, ranging from 55°-59° F.

In 1963, the test bird was first heard by one man at 257 yards, three other people heard it at 209 yards, and one person heard it at 118 yards. In this test in 1964, five men first heard the bird at 102 yards, and the other two men heard it at 82 yards. Thirty seconds of silence by the test bird probably caused the lower results in 1964.

Field test number two involved a singing ground on which there were two birds in 1963 and three in 1964. The area was a grassy field with scattered shrubs which did not hamper hearing. There was some interference from both frogs and automobiles and the average wind velocities each year were six and nine m.p.h. Temperatures ranged from 50°-60° F. for these tests. The maximum hearing distance for the two years at which the men being tested could hear each bird were:

	First Bird		Second Bird		Third Bird	
	Hearing distance	No. of testees	Hearing distance	No. of testees	Hearing distance	No. of testees
1963	162 yds.	1	82 yds	5*	-------	------
	116 yds.	4*				
1964	71 yds.	5*	170 yds.	1	117 yds.	4*
	50 yds.	1	129 yds.	4*	78 yds.	1
			not heard	1	not heard	1

* Hearing distances which applied to me.

The results of the second tests, particularly for the 1963 test, showed the adverse effect of aural interference. The rather short hearing distances for the second bird of the 1963 test and for the first bird of the 1964 test were due to interference from frog calls.

None of the hearing distances recorded were over 0.15 miles (257 yards). This is less than the .2 miles distance observed in the standard FWS Singing Ground Survey. The FWS recommends that survey stops be no less than 0.4 miles apart to avoid errors due to counting the same bird at two consecutive stops. A 0.4 mile interval is probably better than a 0.3 mile interval to allow a margin of safety from this error.

A hearing examination given to the cooperators by the Michigan State University Speech and Hearing Clinic strongly validated the results of the field hearing tests. Those individuals with low scores in the field tests in 1964 had below-normal hearing in the frequency range of the woodcock "peent." Individuals with the higher scores on the field tests had normal hearing. Two individuals who had below-normal hearing test results had averaged daily singing ground survey totals which were significantly lower at the one percent level ($t = 2.71$) than the averages of those individuals with normal hearing (see also Figure 7). Because of this difference the surveys made by the two men with lower hearing ability were not used in the analysis of data.

On the basis of my findings it would seem worth-while to provide a hearing test for prospective participants in Singing Ground Surveys. The field tests described above are simple and can be conveniently accomplished. A recording of the woodcock "peent" would probably work as well as a performing male and would allow the test to be made at any suitable time or place. Hearing distances determined for cooperators with normal hearing may be used in establishing adequate hearing ability under various conditions. Distances of 102-257 yards were obtained for testees with normal hearing under conditions of low interference. Distances of 71-170 yards were obtained for testees with normal hearing under conditions of moderate wind, auto, and frog interference.

The elimination of participants with below-normal hearing would reduce the chances of a low woodcock population estimate due to this error.

Effect of Including the Flight Song in the Singing Ground Survey

Since Sheldon (1953) advised that "only peenting birds should be counted," an investigation was made to determine in what manner and to what extent the inclusion of flight songs affects the survey.

Singing Ground Survey cooperators recorded the number of birds heard by peenting, the number heard by flight song, and the total number of birds heard at each stop during both seasons for a total of 104 Singing Ground Surveys. A comparison of daily survey totals when the flight song was included with totals when it was not, showed no significant difference between the totals from either method for the first season ($t = .96164$). A similar comparison for the data of the second season showed that the counts were significantly higher due to the inclusion of the flight song but only at the ten percent level ($t = 1.3387$). Since the inclusion of flight songs tends to increase the quantity of survey data it probably should be included. The flight song is helpful too, in locating birds. But since less than ten percent of the birds are located by flight song alone, flights cannot be depended upon to the exclusion of peenting.

PROBABILITY THAT THE SURVEY WILL TALLY ALL PERFORMING MALES PRESENT

Sufficient data were collected to account for all birds present during a performance and during any two-minute period. Thus it was possible, using type one counts (see above), to calculate the probability of hearing each individual male woodcock present at any one listening post as follows:

$$\frac{\text{Total number of birds heard in all two-minute periods}}{\text{Number of birds present} \times \text{Number of periods}}$$

In other words, the number of birds heard calling is divided by the number expected to call, yielding the proportion of the expected birds which call. The expected number is my density rating for the performance, as described earlier. I determined the density for each performance at the time of observation. Although it was ordinarily constant at each listening point during the stable period, changes in the birds heard calling did occur for a single performance, more often due to birds leaving my hearing range than to the occurrence of additional birds in an area.

My hearing ability was shown by all tests to be average and the probability of hearing each individual male within my hearing range during any part of the season or performance regardless of external conditions was calculated to be:

	Dawn (1963)	Dusk (1963, 1964)
When 3 birds were present	0.756	0.742
When 2 birds were present	0.802	0.863
When 1 bird was present	0.976	0.977

These probabilities were based on 152 two-minute periods at dawn and 570 two-minute periods at dusk.

Obviously all birds will not start or cease their performance at precisely the same time. Therefore, the probability of hearing all birds in the area is greater if time is allowed at the start of the performance for all males to begin and if counting is stopped early enough to avoid the irregularities of stopping times.

As shown earlier, evening performance lengths during the stable period averaged about 42 minutes. When six minutes at either end of the performance are allowed for irregular starting and stopping times (of the birds), 30 minutes remain in which a survey may be made. A survey system is which the counter waits six minutes after hearing the first bird and then counts for 30 minutes would provide a higher probability of hearing each individual male.

Probabilities were found to be highest under this system when computed from my evening observations. However, since the pre-dawn performance averaged only 27 minutes in length, probabilities of hearing each individual bird are lower with this system. These lower probabilities contributed to the earlier conclusion that the pre-dawn performance is unsuitable for making surveys.

The probabilities of hearing each individual male are higher also, if only data from the stable period are used in their computation. Employing the stable period, the six minute wait, and the subsequent 30 minute counting period as standard conditions, the probabilities of hearing each individual bird at various densities were:

	Dawn (1963)	Dusk (1963, 1964)
When 3 birds were present	0.680	0.867
When 2 birds were present	0.700	0.911
When 1 bird was present	0.657	0.943

These probabilities were based on 90 two-minute periods at dawn and 225 two-minute periods at dusk.

The probabilities of hearing each individual bird under standard conditions and for various physical conditions were computed for the several bird densities encountered (Table 6). These probabilities allow the selection in some cases of optimum conditions for hearing each individual bird.

Considering sample size as well as the probability of hearing each bird, temperatures 40°-60° F., relative humidities 51-75%, and wind velocity 0-4 m.p.h., represent optima when probabilities were conclusive as to optimum conditions. Lowered probabilities of hearing each bird when temperature was over 60°F. probably were associated more with waning activity during the later part of the season (when higher temperatures occur) than with temperature alone. Similarly, the lower probabilities at temperatures under 40°F. may be in part due to irregular early season activity.

Probabilities of hearing each individual bird during one-minute and three-minute periods were also computed. Under standard conditions these probabilities (without regard to weather conditions) are:

	One-minute period	Three-minute period
When 3 birds were present	0.933	1.000
When 2 birds were present	0.985	1.000
When 1 bird was present	0.943	1.000

This set of probabilities is from the 1964 data only since the field recording sheet was not arranged to gather data on a one-minute basis in 1963.

These probabilities are deceptively good. In comparing the one-minute period to the two-minute period, the sample size was doubled but the number of periods in which birds were not accounted for was not

Table 6. The probability of hearing each individual bird under various contitions, during the stable period after waiting six minutes then counting for thirty minutes (dusk). Rose Lake Wildlife Experiment Station, East Lansing, Michigan. March-June, 1963 and 1964.

	3 Birds Present		2 Birds Present		1 Bird Present	
	Number of 2-minute samples	Probability	Number of 2-minute samples	Probability	Number of 2-minute samples	Probability
Temperature						
20-40°	15	0.800	20	0.550	5	1.000
41-50°	--	-----	70	0.900	30	1.000*
51-60°	105	0.895*	90	0.933*	20	1.000
60 or more	45	0.822	10	1.000	15	0.733
Relative hum.						
0-25%	--	-----	--	-----	--	-----
26-50%	--	-----	40	0.925	20	0.800
51-75%	75	0.891*	120	0.925*	45	1.000*
76-100%	90	0.833	30	0.700	5	1.000
Wind velocity						
0-4 mph	90	0.878*	110	0.945*	35	1.000*
5-8 mph	45	0.844	50	0.900	20	1.000
9 or more	30	0.867	30	0.667	15	0.733
Moon stage						
0-8 days	15	0.867	80	0.888	25	1.000
9-11 days	30	0.900	10	1.000	15	1.000
12-15 days	45	0.889	20	1.000	5	1.000
16-20 days	15	1.000	30	0.800	5	1.000
21-29 days	60	0.800	50	0.880	20	0.800
Vegetative moisture						
0 gm.	60	0.800	80	0.875	40	0.900
more	60	0.917	50	0.820	15	1.000
Cloud cover						
0-25%	60	0.883	70	0.957	20	1.000
26-50%	30	1.000	50	0.840	20	1.000
51-75%	15	0.733	--	-----	5	1.000
76-100%	60	0.817	70	0.857	25	0.840
90-100%	45	0.844	60	0.833	15	1.000
Barometric Pressure						
29.50-29.80	60	0.867	20	0.700	15	1.000
29.81-30.00	30	0.867	40	0.925	15	0.733
30.01-30.20	45	0.844	70	0.843	15	1.000
30.21 more	15	0.933	40	0.975	10	1.000

* = Optimum conditions.

doubled. However, there were more periods when birds weren't accounted for on a one-minute basis than on a two-minute basis. Thus, for small samples, probabilities would be lower. Also, there probably would have been a greater number of one-minute periods when birds were not accounted for in my records had I not been present throughout the performance and been aware of the number of birds present. In other words, one minute is not enough time to locate and account for individual birds when one is not already familiar with the number of birds actually present.

Using a three-minute period appears to provide the perfect solution to hearing each individual bird that is present. However, the three-minute period is undesirable because less area can be covered on a survey, particularly where roads are rough and where the 30 minute survey period is used.

In 1963 and especially in 1964, efforts were made to determine what caused probabilities to be less than one. Since probability of hearing each bird was best at a one-bird density, the most apparent reason seemed to be that the birds were active but had moved from my hearing range at the two and three bird densities. Previous studies (Mendall and Aldous, 1943, and Sheldon, 1953) have shown that males may change their singing grounds throughout the season or even during a performance.

It should be made clear that I was closer to the bird when one male was present than to any of the birds when two or three birds were present. This was due to the spacing of the birds caused by their territorialism. At the single bird area, minor movements in singing position were observed (by the bird walking or running as well as by changes after a flight) but they usually didn't take the bird out of my hearing range. These same minor movements on areas of greater density could have moved the bird out of my range and they would have been difficult to distinguish from periods of silence. When movement occurred by flight or if the bird peented as it moved away I could account for periods of silence.

Field records from 1963 indicated that in one-third of the cases where birds were not accounted for they were not heard after a flight song. These were cases where birds were not accounted for during one or more two-minute periods (of the 30 minute counting period) when they should have been heard. In 20.0 percent of these cases, some birds were not heard in all two-minute periods because they started later than other birds at the listening points. The birds were not heard 2.5 percent of the time simply because they were silent. In 44.2 percent of the cases I could not be certain why birds were not heard.

In 1964, birds were not heard in all periods 42.8 percent of the time because they moved out of my hearing range. Another 42.8 percent of the time birds were not heard because they ceased performing before the end of the 30-minute counting period. In 14.4 percent of the cases birds weren't heard because they started their performance later than six minutes after the first bird had begun. Thus, approximately 40 percent of the cause of lowered probabilities is due to movement of the birds.

During the stable periods of both seasons only ten cases of males moving into my hearing range occurred in over 600 acceptable two-minute periods. So, movement into my hearing range did not balance with the movement away from it. However, habitat limitations could have accounted for this. My one and two-bird areas were probably capable of supporting only the number of males I found there with room left for minor movements but no room for additional males. My three-bird area was so large that performing males were widely spread and minor movements would not be enough to move them into my hearing range. Movements into my range were accounted for by flight song in nine of the above ten cases; in other words, these were "overflights."

It is unfortunate that movement is not the only cause of lowered hearing probability. Movement towards a survey route is probably as likely as movement away from it and birds who move and still peent would not affect the reliability of widespread censuses. However, it is still possible to compute a correction factor on the probabilities for use in Singing Ground Surveys to consider those periods when males are not accounted for due to things other than movement. First, it must be assumed that the proportion of movement is the same for all birds. That is, 40 percent of the cause of not hearing any bird is because minor movements had taken it from the observers hearing range. Also, it must be assumed that the direction of movement is random. I did not find the first assumption to be true on my one-density area, but I sat closer to the bird in that case and movement didn't contribute to my not hearing the bird in all periods. If these assumptions are true, then movement alone should not prevent a bird from being included in a Singing Ground Survey tally. Thus, the loss to the probability due to movement, now may be regained.

No cases were observed where two of the three birds present were not accounted for simultaneously during the 30 minute counting period. Thus, it should be possible to correct Singing Ground Survey tallies of zero for the possibility of one male being present, tallies of one for the possibility that two were present, and tallies of two for the possibility that three were present.

First, the probabilities of hearing each individual bird can be corrected to include 40 percent absence from the hearing range due to movement, thus:

$$P + (1-P)(.4) = P \text{ corrected for movement.}$$

Additionally, the counters tally for birds present but not heard can be corrected as:

$$X \text{ corrected} = X + (1 - P \text{ corrected})$$

X = the counters estimate of density at any one listening point.

P = the probability of hearing each individual bird for X + 1 bird density. (See the probabilities of hearing each individual bird under standard conditions).

Putting the two formulas together:

$$X \text{ corrected} = X + \left\{1 - [P + (1 - P)(.4)]\right\}$$

For example, if a counters tally is one:

$$X \text{ corrected} = 1 + \left\{1 - [.911 + (1 - .911)(.4)]\right\} = 1.0534$$

Usually no more than two birds are heard at a single listening point. Therefore a corrected tally for zero birds would be 0.0342 birds, and a corrected tally for two birds would be 2.0798 birds. Although the correction factor is small for any one survey count, the corrected value may be important where many surveys are considered collectively.

The probability results indicate most clearly that the stable period is a better surveying time than other portions of the season and show in some cases which physical conditions produce the best survey results. Probability findings agree with the findings of Goudy (1960) who recommended that surveys not be made when the roadside air temperature is less than 40° F. and wind velocity is over 15 m.p.h. Thus, when observing standard and optimum conditions (see above) the survey is a truer representation of the number of males present on the survey route.

CONCLUSIONS AND RECOMMENDATIONS

With the exception of light intensity, male woodcock are little affected by physical conditions except in extremes. They are most affected by the time of season and density of performing males on an area. Thus, Singing Ground Surveys can yield a truer appraisal of population levels if the following recommendations are adopted:

1. Test cooperating observers, selecting only those whose ability to hear woodcock (see text), or sounds between 4.7 and 6.0 K.C. is normal.

2. Confine the surveys to any time during the period of greatest uniformity in courtship activity which in central Southern Michigan is April 15 to May 15.

3. Make surveys on calm evenings with temperatures 40-60^{o} and the relative humidity 51-75 percent.

4. Restrict the surveys to the dusk performance, avoiding predawn.

5. If a male is not heard at the starting point of the survey route, starting time should be 22 minutes after official sunset when 0-75 percent cloud cover exists, and 15 minutes after sunset with 76-100 percent cloud cover.

6. If a male is present at the starting point, wait six minutes after hearing the first call, then make the survey during the next 30 minutes, utilizing two-minute listening periods.

7. Use both peents and flight songs in counting the number of birds heard at a listening point on the survey route.

SUMMARY

The annual woodcock Singing Ground Survey of the U. S. Bureau of Sport Fisheries and Wildlife is widely used as an index to woodcock abundance. Observers drive a preselected route and stop at intervals to record the number of male woodcock heard performing their courtship calls and flight songs. This study was undertaken to determine the nature of factors which may affect this type of survey.

The male courtship performance occurs before dawn and again at dusk on a relatively open field called the singing ground. Most of the performance occurs on the ground where the peent call is given. Interspersed throughout the performance are flights which involve ascent to 200 to 300 feet, circling and descending to the ground. A rapid mechanical twittering made by the wings and a vocal chirping are given during the flight.

I made counts for two seasons of peents and flight songs by two-minute intervals on areas occupied by several different densities of performing males. Physical conditions were measured and recorded for each performance. Cooperators made the standard Singing Ground Surveys each evening through the areas in which my observation points were located.

Woodcock surveys evidently can be most affected by the time during the season when counts are made and by the hearing ability of the counter. Climatic conditions were not found to be important in influencing the survey except for extremes. However, the probability of hearing each individual bird is best when wind velocity is below four m.p.h., air temperature during the count is between 40 and 60° F. and relative

humidity is 51 to 75 percent. The survey results are not lowered by counting flight songs as well as peents, nor are they altered significantly during the occurrence of the full moon. Woodcock courtship activity is affected by the density of performing males on an area and by the stage of the brood cycle, but surveys are not seriously affected by either factor. The pre-dawn performance is much less desirable as a survey period than the dusk performance.

LITERATURE CITED

Blankenship, Lytle H. 1957. Investigations of the American woodcock in Michigan. Michigan Conservation Department, Game Division, Final report number 2123, 217 pp.

Goudy, William H. 1960. Factors affecting woodcock spring population indexes in southern Michigan. Michigan Conservation Department, Game Division, report 2281, 44 pp.

Mendall, Howard L. and Clarence M. Aldous. 1943. The ecology and management of the American woodcock. Maine Coop. Wildl. Research Unit, Orono, Maine. 201 pp.

Prosser, C. Ladd and Frank A. Brown Jr. 1961. Comparative animal physiology. W. B. Saunders Co. Philadelphia. 688 pp.

Sheldon, William G. 1953. Woodcock studies in Massachusetts. Trans. No. Am. Wildl. Conf. 18:369-377.

Stein, Robert C. 1963. Personal communication to Cornell Laboratory of Ornithology from the author. Dated August 14, 1963.

U. S. Fish and Wildlife Service. 1963. Instructions for the Singing Ground Survey, 1963. Mimeographed, 4 pp.