ECOLOGY OF THE AMERICAN WOODCOCK IN CENTRAL WISCONSIN

by

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PREFACE

The format of this thesis deviates from the norm because it is in the form of three papers written for publication in the Journal of Wildlife Management. Each paper deals with a different aspect of research on the American woodcock (*Philohela minor*) in central Wisconsin. The research was conducted in the spring and summer of 1975 and 1976 with some additional work in the spring of 1977. The primary objectives of the study were to: (1) determine habitat preferences (2) study breeding biology including nesting success and growth of chicks (3) study characteristics of a heavily hunted population and (4) investigate the potential for initiating a banding program in the area. Material not intended for publication is found in the Appendix.

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PART I: HABITAT USE
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ABSTRACT

Habitat preferences of woodcock (Philohela minor) were investigated from 15 April to 15 September in 1975 and 1976. Cover type use was similar for nesting and brood-rearing woodcock, with both avoiding alder. Chi-square analysis indicated spring cover type use was significantly different ($p<0.01$) from summer cover type use. Both conifer and hardwood use increased during the summer. Nest locations were closer to openings and to overhead cover than random plots and had significantly more ($p<0.001$) vertical cover. Flightless broods preferred greater shrub density ($p<0.001$) and lower tree density ($p<0.01$) than that found on random plots. Broods of flying age showed no habitat preference compared to random sites, but were generally found in stands surrounding natal areas. Compared to random plots, spring adult habitat was characterized by close proximity to openings, low tree density and basal area, and high sapling and shrub density ($p<0.05$). Preferred summer habitat had sparse ground cover, close overhead cover ($p<0.01$) and was closer to openings than expected ($p<0.001$). With the exception of flightless broods, woodcock generally avoided dense graminoid cover. Shrubs were more evenly distributed ($p<0.001$) around flush sites than around random locations. The results suggest that woodcock select coverts primarily on the basis of understory structure and the amount of ground cover.

INTRODUCTION

Recently interest in the American woodcock as a recreational resource has increased (Clark 1971a), yet our knowledge of this species is incomplete. Of critical importance to better management of the woodcock is an understanding of its habitat needs (Owen 1977).

Most previous studies of woodcock habitat have explored cover type selection or floristic composition. Weeden (1955) and Blankenship (1957) studied diurnal cover preference during the breeding season. Mendall and Aldous (1943) and Reardon (1950) studied woodcock habitat use in Maine. Studies of cover preferences of radio-equipped immature and adult woodcock in summer have been conducted by Dunford and Owen (1973) and Owen and Morgan (1975). Liscinsky (1972) and Caldwell and Lindzey (1974) investigated woodcock cover requirements in Pennsylvania. Nesting habitat has been quantitatively analyzed in Alabama (Causey et al. 1974) and in northern Wisconsin (Gregg 1974).

A number of studies indicate that physical characteristics of the vegetation are of primary importance in determining woodcock habitat choice (Krohn 1969; Wenstrom 1973; Britt 1971). Although cover type is considered, this study focuses on the physical structure of woodcock habitat. The objectives were to investigate cover type preferences of woodcock and to analyze vegetation and other components of nest, brood and diurnal habitat. The study was conducted from 15 April to 15 September, 1975 and 1976.

For their help with this project, I thank R.K. Anderson and D.O. Trainer, of the University of Wisconsin, Stevens Point. I especially thank my advisor, L.E. Nauman, of the University of Wisconsin, Stevens Point, for his concern, for the use of his dog and for reviewing the manuscript. I am indebted to L.E. Gregg, Wisconsin Department of Natural Resources woodcock biologist, who shared his knowledge of woodcock with me. Finally, my thanks to all the woodcock enthusiasts who helped with field work, especially P. Haasch, my secretary, editor, wife and friend.

STUDY AREA

The study was conducted in Dewey Marsh, a 3100 ha wetland in Dewey Township, Portage County, Wisconsin (Fig. 1). This wetland lies in the northern part of the Central Wisconsin River Basin in a gently sloping plain consisting of outwash and glacial lake deposits underlain by outwash. The wetlands are a result of a flat topography, high water table and impermeable layers of silt or clay within the lake deposits. The area is drained by Hay Meadow Creek.

Major hardwood species are quaking aspen (Populus tremuloides), white birch (Betula papyrifera), red maple

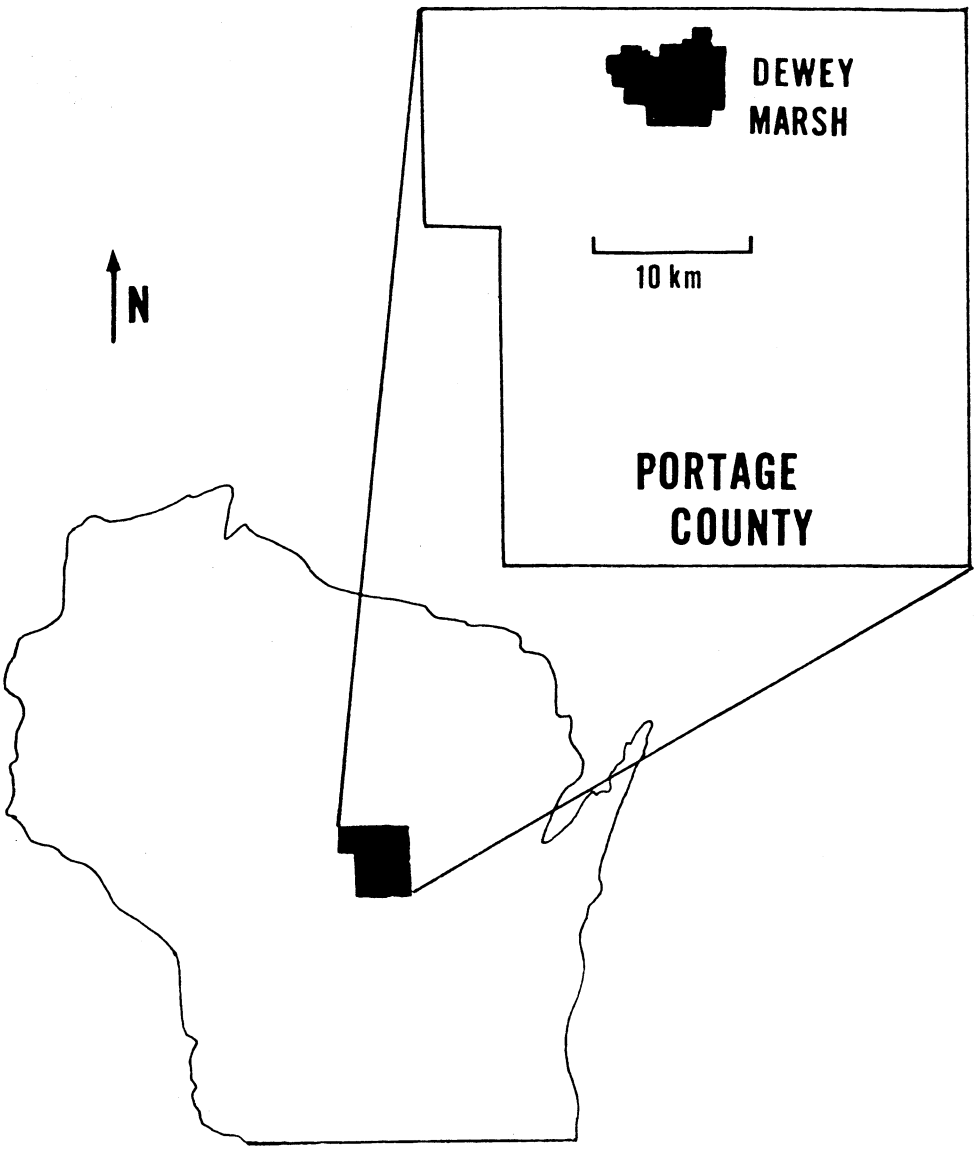

Fig. 1. Location of woodcock study area - Dewey Marsh, Portage County, Wisconsin.

(*Acer rubrum*) and red and white oak (*Quercus* spp.). Conifers include black spruce (*Picea mariana*), tamarack (*Larix laricina*), red pine (*Pinus resinosa*), white pine (*Pinus strobus*) and jack pine (*Pinus banksiana*). Shrub species are speckled alder (*Alnus rugosa*), willow (*Salix* spp.), hazelnut (*Corylus* spp.) and gray dogwood (*Cornus stolonifera*).

Within Dewey Marsh, 2 study areas were used. The Maple Road Study Area is 79.5 ha of the following cover types: 36.8 ha hardwood, 12.0 ha shrub, 7.2 ha alder, 15.4 ha conifer, 7.0 ha opening and 1.1 ha hardwood-conifer. The area slopes from a large oak-dominated forest to pine plantations, stands of aspen, birch and red maple to alder thickets. The openings are small and scattered, resulting in much edge.

The Pine Road Study Area is 47.0 ha which includes 17.5 ha hardwood, 5.2 ha alder, 5.1 ha conifer, 3.0 ha marsh and 16.2 ha opening. The openings are few and large and there is little interspersion of cover types.

METHODS

Habitat was classified into 5 types: upland shrub (shrubs other than alder where overstory was 30 percent or less), hardwood (81 percent or more hardwood), conifer (81 percent or more conifer), hardwood-conifer (20-80 percent each of hardwood and conifer) and alder (50 percent or more alder).

Locations of woodcock use (spring and summer flushes, nests, broods) were made by systematically searching diurnal cover using a Brittany spaniel. Cover preference was measured by recording flushes per dog-hour of search in each cover type. A dog-hour is 1 dog used for 1 hour. Spring searches were conducted from 1 April to 14 June and summer searches from 15 June to 15 September in 1975 and 1976.

Vegetation at each site was analyzed according to Ohmann and Ream (1971). Data collected includes tree and sapling density and basal area, distance to an opening, percent graminoid and forb cover, percent "open soil", distance to overhead cover, shrub density and distribution and "adjacent cover type". "Open soil" is not synonymous with bare soil which was rare on the study area. Rather it is soil covered with leaf litter but devoid of ground level vegetation, rock, dead falls, etc. Shrub distribution was assigned a number on a scale of 0-4 where a score of "0" implies that shrubs are clumped and "4" implies an even distribution. "Adjacent cover type" refers to the nearest general cover type different from that at the location analyzed (Clark 1971b).

The amount of vertical cover at nest sites was measured as follows: the total diameter at breast height (dbh) in cm's of trees and saplings within 0.9 m of the nest was determined. Then the number of shrubs in the milacre plot was added to the total dbh. This results in an index of the extent to which the nest is laterally enclosed. For comparison, the same measurements were made at plots located 12 m in each cardinal direction from the nest.

As a control, plots obtained by stratified random sampling were analyzed for the same parameters as those at woodcock locations. These plots were established at intervals of 60 paces along randomly located transects. However, random plots were analyzed for ground cover only in summer and were compared to summer flush sites only. Comparison with spring locations would be invalid because of the increased size and density of ground cover in the summer. For each parameter, means of nest, brood, and spring and summer flush sites were statistically compared to one another and to random plots with student's "t" test. The Chi-square test was used to compare cover type distributions.

RESULTS

Locations Analyzed

Fifteen nests and 37 broods were found in 125.7 dog-hours for an average of 0.11 nests and 0.29 broods per dog-hour. In the same amount of time, 93 adult woodcock were flushed for a mean of 0.74 flushes per dog-hour. In 120.9 dog-hours of searching in summer, 131 woodcock were flushed for a mean flush rate of 1.1 flushes per dog-hour.

Cover Type

Cover types used by woodcock in Dewey Marsh are presented in Table 1. There were no differences in cover type use between nesting and brood-rearing woodcock ($p > 0.05$, χ^2). However, alder was little used by either. Only 1 nest and 1 brood were found in the alder cover type. Nests found in conifer were in plantations with less than 1/3 canopy cover or at the edge of thicker stands. Broods largely avoided pure conifer.

Cover types from which woodcock were flushed in the spring differed significantly from summer flush sites ($p < 0.01$, χ^2). In spring, the highest use occurred in alder and hardwood-conifer, while conifer was little used. There was high use of hardwood-conifer in summer although this cover type was scarce on the study areas and little time was spent in it. Woodcock showed no cover type preference in summer. Use of conifer increased 10-fold from spring to summer, but woodcock were flushed only in plantations where trees were moderately dense with scattered openings and where there was some herbaceous ground cover. Woodcock did not use dense plantations

Table 1. Cover type use by woodcock in Dewey Marsh, 1975-1976. Differences in cover type use between nesting and brood-rearing woodcock were not significant ($p>0.05$, χ^2) while differences between cover types from which woodcock were flushed in spring and summer were significant ($p<0.01$, χ^2).

Cover Type	Nest			Brood			Spring Flushes			Summer Flushes		
	D-Hr[a]	No.	No./D-Hr	D-Hr	No.	No./D-Hr	D-Hr	No.	No./D-Hr	D-Hr	No.	No./D-Hr
Hardwood	62.1	8	0.1	62.1	25	0.4	62.1	38	0.6	64.6	77	1.2
Shrub	18.1	2	0.1	18.1	8	0.4	18.1	12	0.6	9.9	9	0.9
Conifer	8.9	3	0.3	8.9	1	0.1	8.9	1	0.1	8.8	10	1.3
Hard/Con	6.5	1	0.2	6.5	2	0.3	6.5	6	0.9	2.4	4	1.6
Alder	30.1	1	0.0	30.1	1	0.0	30.1	36	1.2	36.0	31	0.9
Total	125.7	15		125.7	37		125.7	93		120.9	131	
Average			0.1			0.3			0.7			1.1

[a]Dog-Hour = 1 bird dog used 1 hour

with an unbroken carpet of pine needles.

Habitat Analysis

Locations of 18 nests, 32 broods, 54 spring flushes and 135 summer flushes were analyzed for habitat characteristics (Table 2). In addition, 296 stratified random summer sites were analyzed for comparison.

Nest habitat was variable but 3 parameters were statistically significant at nest locations. The mean distance to overhead cover was less for nests than for random ($p<0.01$), spring ($p<0.05$) and summer ($p<0.05$) flush sites. The amount of vertical cover was greater ($p<0.001$) for nests than for random locations. Nests were farther from a change in cover type than were random sites ($p<0.05$).

In general, flightless broods were found in nest habitat while flying broods used stands adjacent to nesting cover. This association with nests was due, in part, to greater searching effort in likely nest habitat. However, I searched all stands regularly to reduce biased sampling.

Habitat preferred by flightless broods had lower tree density ($p<0.01$) and was closer to an opening ($p<0.05$) than random plots. Shrub density was greater in flightless brood habitat than at random ($p<0.001$), flying brood ($p<0.05$), spring ($p<0.05$) and summer ($p<0.001$) locations. Graminoid cover used by flightless chicks was more dense ($p<0.01$)

Table 2. Means (± S.E.) of habitat parameters at woodcock locations and and random plots, Dewey Marsh, 1975 and 1976.

Parameter	Random (N=296)	Nest (N=18)	Flightless brood (N=19)	Flying brood (N=13)	Spring (N=54)	Summer (N=135)
Distance to opening (m)	14.7 ± 1.3abcd[a]	6.1 ± 1.7	4.9 ± 1.7a	7.9 ± 2.2b	7.2 ± 1.2c	7.8 ± 0.6d
Distance to adjacent cover type	22.5 ± 0.7a	28.1 ± 0.8a	—	—	25.6 ± 1.4	24.8 ± 0.8
Tree density (stems/ha)	782.2 ± 26.5ab	718.0 ± 463.5	601.0 ± 14.7a	861.3 ± 13.6c	492.8 ± 61.6bcd	908.5 ± 113.8d
Tree basal area (m^2/ha)	24.7 ± 1.8a	33.2 ± 20.8	27.9 ± 13.8	29.6 ± 5.4b	15.2 ± 2.5abc	25.1 ± 2.5c
Sapling density (stems/ha)	1894.5 ± 114.6a	1786.8 ± 1083.0	1288.8 ± 384.4	2230.1 ± 579.7	2715.3 ± 425.4a	2205.1 ± 233.5
Sapling basal area (m^2/ha)	6.3 ± 0.5	4.0 ± 2.0	4.1 ± 1.0	6.5 ± 2.0	7.7 ± 1.2	9.1 ± 2.6
Shrub density (stems/m^2)	3.5 ± 0.3a	4.9 ± 1.4	10.1 ± 2.6abcd	2.9 ± 0.9b	5.2 ± 0.8ac	4.5 ± 0.4d
Shrub distribution index	2.2 ± 0.1a[b]	—	—	—	3.2 ± 0.3a[c]	
Distance to overhead cover (m)	2.6 ± 0.2ab	0.7 ± 0.1abc	—	—	2.0 ± 0.3b	1.8 ± 0.2a
Vertical cover index	15.1 ± 2.2a[d]	28.6 ± 5.9a	—	—	—	—
Graminoid cover (%)	27.2 ± 1.9a[e]	—	34.4 ± 9.5	10.4 ± 5.5	11.1 ± 3.0c	10.6 ± 2.1ad
Forb cover (%)	28.9 ± 1.7[e]	—	19.4 ± 7.3	22.1 ± 5.3	17.4 ± 3.1	24.9 ± 2.1
Open soil (%)	49.6 ± 2.0a[e]	—	63.9 ± 9.7	89.3 ± 4.7	85.2 ± 3.8c	76.5 ± 3.0ad

[a]Means of a particular parameter followed by the same letter are different at $p<0.05$.

[b]N=160

[c]Spring and summer samples were combined to increase sample size (N=69).

[d]N=72

[e]Random plots for graminoid, forb and open soil were analyzed in summer and were compared to summer flush sites only.

than that used by adults in spring. Open soil was found less often ($p<0.001$) at flightless brood sites than at flush sites of spring adults.

Flying broods preferred sites closer to an opening ($p<0.05$) than random sites. Ground cover selection by these broods was similar to that of adults in spring. All other parameters were similar to those at random plots.

Spring adult habitat was characterized by close proximity to openings ($p<0.05$), low tree density ($p<0.001$) and basal area ($p<0.05$), and high sapling and shrub density ($p<0.05$).

Preferred summer habitat had sparse ground cover and was close to openings ($p<0.001$) and to overhead cover ($p<0.01$). The mean of graminoid cover at summer flush sites and at random sites was 10.6 and 27.2 percent, respectively ($p<0.001$). Open soil was 76.5 percent at flush sites and 49.6 percent at random plots ($p<0.001$), whereas forb cover was similar.

To increase sample size, spring and summer data were combined to assess the importance of shrub distribution. Shrubs were more evenly distributed around flush sites than random sites ($p<0.001$).

DISCUSSION

Cover Type

The woodcock in Dewey Marsh demonstrated a seasonal change in cover type selection. The most striking change was the increased use of upland conifers in summer, possibly as loafing sites (Sheldon 1967). In Maine, radio-equipped woodcock in summer rarely used conifers; second-growth hardwoods and alder were the preferred cover types (Owen and Morgan 1975). Radio-eqquipped woodcock in Pennsylvania preferred tamarack (Tsuga canadensis) plantations over pine plantations or mixed hardwoods (Caldwell and Lindsey 1974). Reardon (1950) found that woodcock favored hardwoods in spring and alder in summer. Weeden (1955) found no seasonal habitat preference.

In my study, alder use was high in the spring, although relatively little of this was pure alder. Wishart and Bider (1976) note that woodcock used seepage areas in alder in early spring but alder use decreased after snowmelt. They also found a substantial increase in the use of hardwoods during the summer. In this study, hardwood use also increased during the summer while alder use was similar to that in spring.

Habitat Analysis

The close proximity of most nests to openings is similar to the findings of others (Gregg 1974; Bourgeois 1976). However, there are notable exceptions and in this study 1 nest was located over 30 m from an opening while another nest was in an open field. Evidently, some factor in nest selection is most available at edges but can be met in other situations.

Although, on the average, overhead cover was closer to nests than expected in comparison with data from random sites, overhead concealment ranged from 0 to 100 percent. The wide range of habitat at nest locations indicates that concealment of some nests (e.g. those under conifer boughs) is probably incidental to some other factor such as nearness to vertical cover.

In this study, close vertical cover was important in nest site selection. Bourgeois (1976) noted that all nests on his study area were situated at the base of or within 0.3 m of a small tree or other type of vertical cover. Seven nests analyzed in Alabama had vertical cover including saplings, shrubs and slumps of grass within 1 m of the nest (Causey et al. 1974).

My results indicate that broods preferred to be near openings. However, Wenstrom (1973) found that radio-fitted chicks showed no affinity for edges. Bourgeois (1976) reported that broods averaged 18 m from an edge although he did not compare this to available habitat.

Brood habitat on my study area was essentially the same as nest habitat except that flightless broods prefer denser shrub cover. Bourgeois (1976) found that brood and nest habitat in Michigan were distinctly different from one another. Wenstrom (1973) found that stands selected for nesting may or may not be used for brood rearing, depending on the nesting habitat type.

A high stem density of saplings and shrubs appears to be more important to woodcock in spring than in summer. It is likely that a high stem count in the understory is important to create needed cover in the spring when leaf cover is sparse. In the summer, additional cover is provided by ferns (Filicinae), other herbaceous growth and the foliage of woody plants.

Treating shrub densities separately according to study area illustrates the difficulty of generalizing about the importance of 1 parameter. On Maple Road the mean shrub density used by summer woodcock was significantly greater than at random plots. On Pine Road, however, shrubs were used as they were available. Other factors, such as soil type or moisture probably enter into selection of coverts. Dyer and Hamilton (1977) found that woodcock select habitat according to light intensity, selecting denser coverts on brighter days.

Clark (1971b) and Britt (1971) found that understory cover was an important component of woodcock habitat. Wishart and Bider (1976) found that understory cover was not significantly different between good and poor habitat. Rabe (1977) found that the understory was the most important structural feature of woodcock habitat in northern Michigan.

Rabe (1977) and Britt (1971) also felt that horizontal cover was important. My results support this contention. Close overhead cover, which created a canopy-like effect, was important to woodcock in the summer.

In this study, woodcock preferred sparse ground cover. Wishart and Bider (1976) found that percent ground cover and percent open soil were the only factors which were significantly different between heavily and lightly used woodcock coverts. Poor coverts had ground cover at both extremes, i.e. too much or too little. My findings agree closely with Liscinsky's (1972) contention that 25 percent ground cover is optimum for woodcock.

In general, my study shows the importance of vertical and horizontal cover in the understory in the woodcock's selection of habitat. The requirements may be met by high stem densities, especially in the spring. In the summer, sapling and shrub foliage probably contribute to cover density so that a high stem count is not a necessary feature of summer habitat. At this time of the year, moisture is more limiting than in spring and dense coverts may maintain the moisture level needed for production of earthworms, the woodcock's staple diet. In all seasons, understory cover probably limits ground cover and provides protection from predators. Very likely, the woodcock's association with the "edge" is a reflection of its need for a well developed understory.

Habitat management should be geared to maximizing "edge". The aim should be to create a patchwork of scattered clearings and small shrubby stands as opposed to large blocks of openings and woodland. The habitat should be distributed over a slope so that the right moisture level is present within the woodcock's home range at any season. Conifers should be available for nesting and for summer loafing sites.

A number of research needs were suggested by this study. The effect of size, age and distribution of alder coverts on woodcock density should be studied. Further study is also needed on the role of conifers, in particular the extent to which they enhance the value of hardwood stands as woodcock habitat. The optimum ratio of woodland to opening should be determined. This is particularly important where diurnal cover is the limiting factor. Finally, research should explore cost effective ways to create and maintain good woodcock habitat.

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PART II: BREEDING BIOLOGY OF THE AMERICAN WOODCOCK IN CENTRAL WISCONSIN

ABSTRACT

The breeding biology of the American woodcock (*Philohela minor*) was studied in central Wisconsin between 1975 and 1977. A singing ground survey in 1975 averaged 1.7 birds per stop (SD=0.9; R=0.3-4.0). Of 16 singing grounds located in 1976, 15 were used in 1977. Numbers of singing males per 100 ha on 4 study areas were 13, 11, 8 and 4. Mean distance between singing grounds was 258 m (SD=114.9; R=87-500). Eighteen nests and 37 broods were located. The mean distance from nests to the nearest singing ground was 121 m (SD=39.5; R=53-173). The mean distance between nests was 227 m (SD=140.8; R=53-114). Nesting success was 72.7 percent and hatching success was 75.9 percent. The minimum mean clutch size was 3.5 (SD=1.2; R=2-4) and brood size averaged 3.2 chicks (SD=1.1; R=1-5). Weight gain of chicks was linear for at least the 1st 14 days and averaged 6.4 g daily.

INTRODUCTION

Increased use of the American woodcock as a gamebird and unexplained reductions in woodcock populations in some areas (Clark 1971) has led to a greater effort to understand the woodcock's life history, including its breeding biology.

Mendall and Aldous (1943) did an intensive study of breeding woodcock in Maine. More recent research includes that of Whitcomb (1974) in Michigan and Causey et al. (1974) in Alabama. Woodcock breeding biology studies are currently being conducted in northern Wisconsin (Gregg 1971).

The purposes of this study were to conduct censuses of breeding male woodcock, study nesting and brood rearing and to record growth of woodcock chicks. The study was conducted from 1 April to 15 June in 1975, 1976 and 1977.

For their help with this project, I thank L.E. Nauman, R.K. Anderson and D.O. Trainer, of the University of Wisconsin, Stevens Point, L.E. Gregg of the Wisconsin Department of Natural Resources, and all the students and woodcock enthusiasts who helped with the field work.

STUDY AREA

The study was conducted in Dewey Marsh, a 3100 ha wetland in Dewey Township, Portage County, Wisconsin

(Fig. 1). This wetland lies in the northern part of the Central Wisconsin River Basin in a gently sloping plain consisting of outwash and glacial lake deposits underlain by outwash. The wetlands are a result of a flat topography, high water table and impermeable layers of silt or clay within the lake deposits. The area is drained by Hay Meadow Creek.

Major hardwood species are quaking aspen (Populus tremuloides), white birch (Betula papyrifera), red maple (Acer rubrum) and red and white oak (Quercus spp.). Conifers include black spruce (Picea mariana), tamarack (Larix laricina), red pine (Pinus resinosa), white pine (Pinus strobus) and jack pine (Pinus banksiana). Shrub species are speckled alder (Alnus rugosa), willow (Salix spp.), hazelnut (Corylus spp.) and gray dogwood (Cornus stolonifera).

Within Dewey Marsh, 4 study areas were used. Two of these, Maple Road and Pine Road, were used for singing ground counts and to locate nests and broods. The other 2, Hay Meadow Road and Reserve Road, were used for singing ground counts.

The Maple Road Study Area is 79.5 ha of the following cover types: 36.8 ha hardwood, 12.0 ha shrub, 7.2 ha alder, 15.4 ha conifer, 7.0 ha opening and 1.1 ha hardwood-conifer. The area slopes from a large

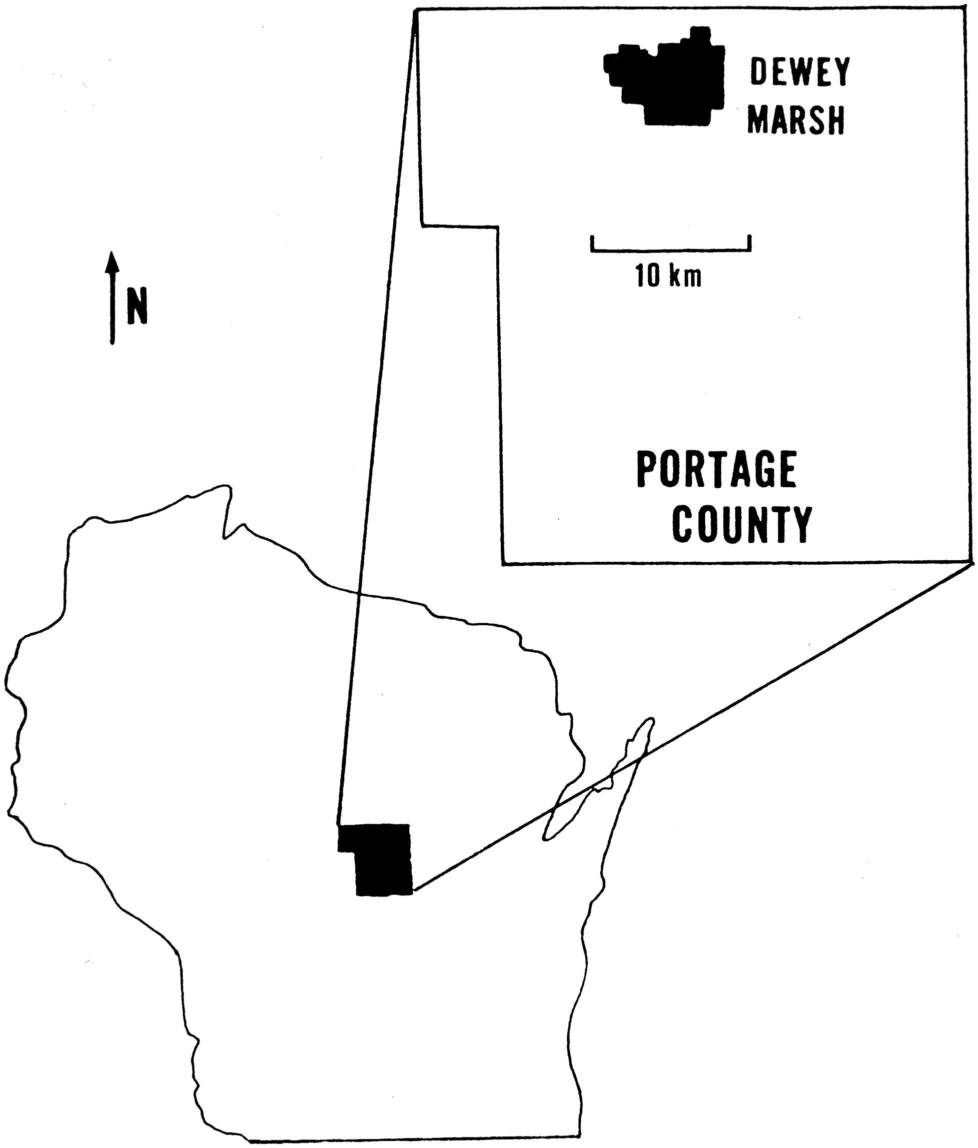

Fig. 1. Location of woodcock study area - Dewey Marsh, Portage County, Wisconsin.

oak-dominated forest to pine plantations, stands of aspen, birch and red maple to alder thickets. The openings are small and scattered, resulting in much edge.

The Pine Road Study Area is 47.0 ha which includes 17.5 ha hardwood, 5.2 ha alder, 5.1 ha conifer, 3.0 ha marsh and 16.2 ha opening. The openings are few and large and there is little interspersion of cover types.

METHODS

In 1975 and 1976, singing ground counts were conducted by driving or walking as suggested by Duke (1966). When routes were walked, the distance between stops was estimated by calculating the amount of time it took to walk 0.4 miles (the standard distance between stops) on a paved surface and increasing this time according to the terrain. In 1976 and 1977, exact locations of singing grounds were plotted on the 4 study areas. Singing grounds were located by using a 125 cc trail bike and by walking.

Nests and broods were located using a Brittany spaniel in conjunction with a study of woodcock habitat preferences. Since woodcock nests and broods are generally found near openings, most searching effort was conducted within 50 meters of an opening. However, all portions of the study area were searched frequently to find nests or broods not close to openings.

When a nest was found, I noted its location and left the immediate vicinity to minimize the chance of nest abandonment. Nests were checked every few days to capture newly-hatched chicks. Any nest found with eggshells opened along its longitudinal axis was considered successful (Sheldon 1967).

Non-flying broods were captured and aged using techniques described by Ammann (1970). Flying broods were all assumed to be a minimum of 21 days old since woodcock chicks attain flight capability at this time (Liscinsky 1972). Chicks were banded with No. 3 leg bands provided by the U.S. Fish and Wildlife Service and were weighed to the nearest gram with a 100-gram spring balance scale.

RESULTS AND DISCUSSION

Singing Grounds

In 1975, the 1st singing male was observed on 7 April while there was still 15 cm of snow on the ground. In 1976, birds were heard in the area in mid-March when snow cover was virtually gone. Six of 7 known singing grounds were occupied on 24 May, 1976 and in both years singing had effectively ceased by the 2nd week in June.

Twenty-five singing ground surveys were conducted in 1975 between 17 April and 23 May. Counts averaged 1.73 birds per stop. Only those counts obtained from trails or paved roads are included in the average. Counts conducted off trails were unreliable because of the difficulty of accurately determining the distance between stops. The highest count along random routes conducted in Wisconsin from 1968 to 1970 was 1.2 per stop (Gregg 1971). Random routes surveyed in the states west of the Applachians (i.e. the Central Region) over a 10 year period averaged 0.32 birds per stop (Artmann 1975). In Dewey Marsh, 3 routes established in 1975 were repeated between 16 April and 8 May, 1976. These routes averaged 1.9 birds per stop in 1975 and 0.85 birds per stop in 1976, a 55.3 percent reduction.

Accessing the reliability of this finding is difficult since frog calls often interferred with hearing singing woodcock and because other variables influence the intensity of singing activity. Assuming that inaccuracies would be equal in both years, there was a population decline from 1975 to 1976. Studholme and Norris (1942) noted a 40 percent decline in singing males from 1939 to 1940.

Sixteen singing grounds in 4 study areas were located in 1976. Fifteen singing grounds were on the study areas in 1977 and all but 1 were located on the same fields as in 1976.

The data on known singing grounds indicate that if the population did decline between 1975 and 1976, it had stabilized by 1977. The data also illustrate the woodcock's fidelity to the same singing ground. Whitcomb (1974) noted that the same locations were used as singing grounds from 1968 to 1972 on his study area in Michigan. Sheldon (1967) states that a particular singing ground may be used indefinitely by keeping the site in an early stage of succession.

Of 16 singing grounds, 9 were in overgrown fields, 5 in pine plantations and 2 were along wetland edges. Short woody vegetation, characteristic of singing grounds studied elsewhere (Sheldon 1967), was present on all but 1 of these sites. On 3 occasions I saw woodcock on singing grounds not normally used. On 1 occasion I watched a woodcock "peenting" on the blackened remains of a willow (Salix sp.) thicket that had burned the previous year.

Numbers of singing males per 100 ha were 13, 11 8 and 4 on the 4 study areas. Sheldon (1967) reports that woodcock researchers in a number of states found densities of 10, 8, 19 and 24 singing males per 100 ha of woodcock habitat.

The mean distance between singing grounds was 258 m (SD=114.9; R=87-500). Weeden (1955) reported a mean distance of 59.5 m in central Maine. Wishart (1973) found singing grounds to be an average of 172.5 m apart in Quebec.

Nests

From 1 April to 15 June in 1975 and 1976, 125.7 dog-hours were spent searching for nests and broods as part of a woodcock habitat study. A dog-hour is defined as 1 hour of searching effort using 1 bird dog. Fifteen nests were found for an average of 8.4 hours per nest. An additional 3 nests were found accidentally, including 2 outside of Dewey Marsh. In Michigan, Bourgeois (1976) spent an average of 5.8 dog-hours per nest, while Simon et al. (1971) reported an average of 35.9 dog-hours per nest in Pennsylvania.

The earliest hatching date was 19 April and the latest was 17 June. The calculated hatching chronology (Fig. 2) may be later than normal because for purposes of back dating, flying broods were assumed to be 21 days old. In fact, some may have older and their calculated hatching dates would therefore be later than the actual dates.

The mean distance from nests to the nearest singing grounds was 121 m (SD=39.5; R=53-173). In Maine, Mendall

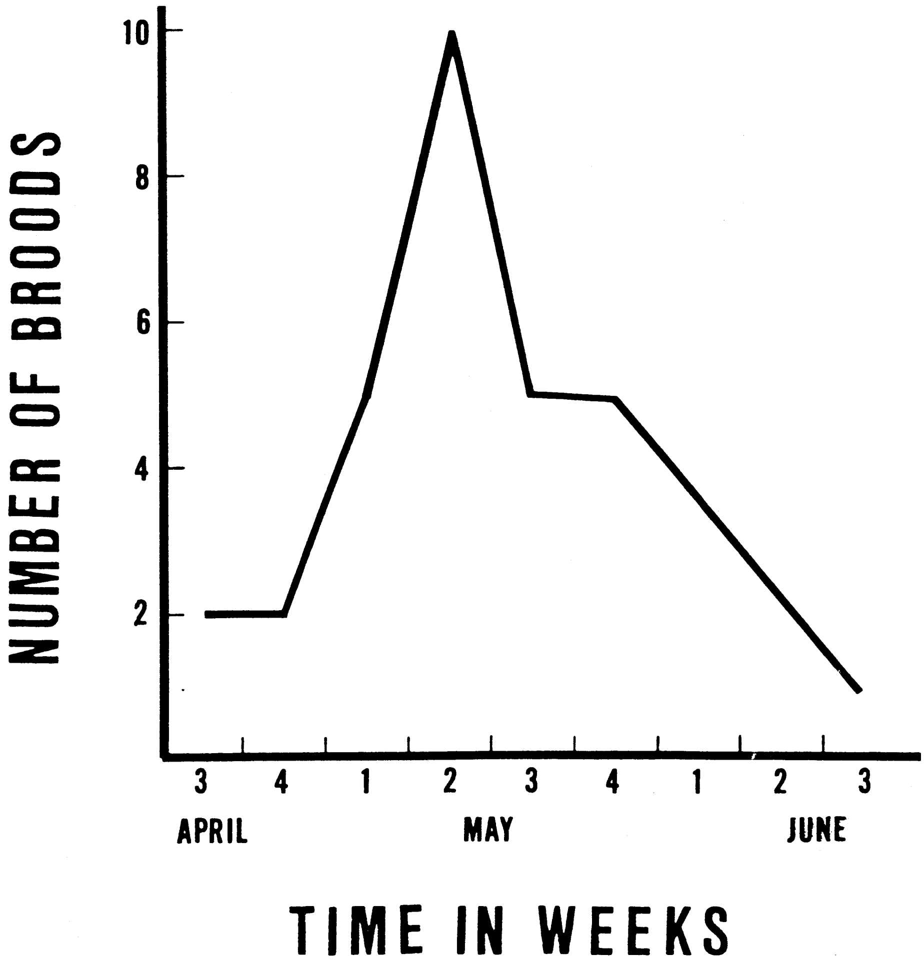

Fig. 2. Hatching chronology of 30 woodcock broods, Dewey Marsh, 1975-1976.

and Aldous (1943) and Weeden (1955) report nest-to-singing ground distances of 104 and 67.5 meters, respectively. Blankenship (1957) reported an average of 96 m between nests and singing grounds in Michigan.

The mean distance between nests was 227 m (SD=140.8; R=53-514). In 1976, on the Maple Road Study Area, 5 nests were found in or near a 5.8 ha 8 year-old pine plantation which had been the site of a singing ground. One of these nests was located 15 m from a previous year's nest.

Finding concentration areas could be a result of uneven searching effort. However, I specifically spent considerable time searching around a number of known singing grounds and was unsuccessful in locating any nests. Two of these, 1 on the Pine Road Study Area and 1 at Hay Meadow, were pine plantations which were used as singing grounds. I found 1 nest just outside the pine plantation at Pine Road and 0 at Hay Meadow.

Of the 18 nests found, 6 were destroyed by predators, 2 were abandoned and 1 had an unknown fate. Based on this data, nesting success was 50 percent. However, nest abandonment and predation of 4 nests may have been caused by my research activities. These 4 nests were destroyed within 2 days after I located them. By eliminating these nests from the calculations, nesting success was 72.7 percent. Mendall and Aldous (1943) felt nesting success was at least 75 percent. Liscinsky (1972) reported 56 percent nesting success while Whitcomb (1974) reported 88.9 percent.

Of the 6 nests lost to predation, 1 was probably destroyed by a raccoon (Procyon lotor) and 4 by unidentified mammals. The eggs in the 6th may have been taken by a snake. Fox snakes (Elaphe vulpina) were seen nearby on 2 occasions.

Hatching success was 75.9 percent and the infertility rate was 10.3 percent (Table 1). Mendall and Aldous (1943), Liscinsky (1972) and Whitcomb (1974) report a hatching success of 67, 50 and 85 percent, respectively.

The minimal average clutch size was 3.5 (SD=1.2; R=2-4). Clutch size before and after 14 May was 3.9 and 3.2, although the difference was not significant. Late nests usually contain fewer eggs than early nests (Mendall and Aldous 1943). Blankenship (1957) found an average clutch size of 3.9 for 31 nests in Michigan. Whitcomb (1974) found 18 nests with a mean of 3.4 eggs per clutch. Ten nests in Alabama contained an average of 3.7 eggs (Causey et al. 1974).

Broods

Thirty-seven broods were flushed in 125.7 dog-hours for a mean of 3.4 dog-hours per brood. Fifty-four chicks

Table 1: Clutch size and hatching success of woodcock nests in central Wisconsin, 1974-1976.

Year	Nest No.	No. Eggs	No. Successfully Hatched	Nest Fate
1974	1	3	3	
1975	1	0	0	abandoned
	2	4	0	predation
	3	4	4	
	4	4	0	predation
	5	3	0	predation
1976	1	4	4	
	2	4	4	
	3	?	?	empty with "successful eggshell" nearby
	4	4	2	2 eggs infertile
	5	4	0	predation
	6	2	0	predation
	7	?	?	empty when found
	8	2	1	1 egg pipped but chick died before emerging
	9	4	2	1 egg pipped; 1 egg - dead chick inside
	10	2	0	abandoned
	11	4	2	1 infertile egg; 1 dead chick on the nest
	12	4	0	predation

Total eggs 52 22 Total eggs in successful nests=29

Average clutch size=3.5 Hatching success= 22/29 = 75.9%

were banded. Simon et al. (1971) spent 19.9 dog-hours per brood while Bourgeois (1976) searched 4.8 dog-hours per brood.

The average brood size in Dewey Marsh was 3.2 (SD=1.1; R=1-5). The brood with 5 chicks had 1 chick which was adopted by the hen. This chick, a few days older than its adopted siblings, had been banded 58 m away on the previous day. This behavior, though apparently uncommon, has been reported elsewhere (Ammann 1976a).

Non-flying broods averaged 3.2 and flying broods averaged 3.1 chicks. Ammann (1976b) reported an average of 3.36 chicks per non-flying brood and 3.12 per flying brood. Blankenship (1957) and Whitcomb (1974) found 3.6 and 3.5 chicks per brood, respectively.

The average size of day-old broods was 3.5 (N=4) and of flying broods 3.1 (N=7). This indicates a mortality rate of 11.4% during the first 3 weeks of life.

Woodcock chicks grow rapidly. Sixteen day-old chicks averaged 13.5 g (SD=2.3; R=11-19) and 2-13 day-old chicks averaged 91.5 g, a 7-fold increase. Flight feathers develop rapidly and birds are flying at 2 weeks of age.

A regression plotting age and weight indicates young woodcock grow at a constant rate (Fig. 3). Chicks gained an average of 6.4 g per day. Whitcomb (1974) found weight gain to be linear for at least the 1st 19 days of life.

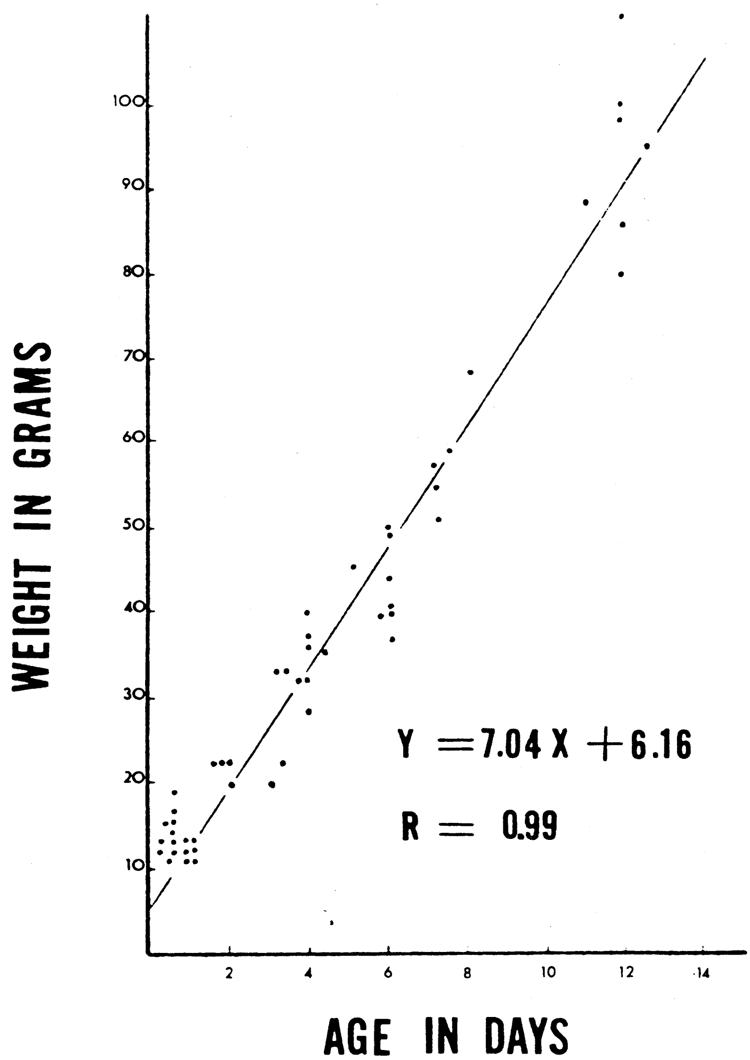

Fig. 3. Weights of woodcock chicks 0 to 14 days old, Dewey Marsh, 1975-1976.

CONCLUSION

There is a substantial woodcock population in Dewey Marsh. While there may have been a decline in singing males between 1975 and 1976, the population of singing males was virtually unchanged between 1976 and 1977.

In general, other studies show that woodcock have higher nesting and hatching success than most gamebirds. My results agree with this. The results also demonstrate the woodcock chick's rapid and consistent weight gain during the 1st 2 weeks of life.

In a study of a local breeding population, I would urge researchers to actually locate singing males rather than use census routes. A substantial number of singing males can be located relatively easily. A motorcycle designed for trail use greatly facilitated finding fields but searching on foot was satisfactory. Even though fewer singing males are counted than on a census route, the results are more accurate because problems associated with hearing singing woodcock are eliminated. Furthermore, changes in field use are more readily apparent.

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PART III: HARVEST RATE, POPULATION CHARACTERISTICS AND NOCTURNAL FIELD USE OF THE AMERICAN WOODCOCK

ABSTRACT

The harvest rate, population characteristics and nocturnal field use of the woodcock (Philohela minor) were studied. The harvest rate was 55.0 percent for immature males and 40.0 percent for immature females. Harvest rates of adults were not determined. The results indicate that the population cannot sustain itself without immigration into the area.

Field use was low or birds were widely scattered, indicating that large scale trapping of woodcock was not feasible. One site, a muddy hunting trail, attracted woodcock during crepuscular flights. Mist-netting success was 45 captures per 100 net nights and a ratio of 207 immature males: 100 immature females was obtained (N=51). A fall wing survey had a ratio of 144 immature males: 100 immature females and 73 adult males: 100 adult females (N=89). Productivity was 1.7 immatures: adult female.

INTRODUCTION

The effect of hunting on woodcock populations is largely unknown. However, Liscinsky (1972) states that "hunting is an important factor limiting local breeding woodcock populations." Goudy et al. (1970) found that hunting caused a substantial reduction of local birds on his study area. Whitcomb (1974) reported yearly declines of woodcock due to high rates of exploitation.

Sheldon (1961) discovered that woodcock fly out to openings at dusk, enabling researchers to study woodcock populations to an extent never before possible. Researchers in Maine, Louisiana, New York and other states have used mist-netting and night-lighting of these "nocturnal fields" to band thousands of woodcock (Krohn et al. 1974; Glasgow 1958; Chambers 1971). However, the density of woodcock on nocturnal fields varies greatly. In Maine few fields contained more than 4 woodcock (Krohn 1971a). On the other hand, clearcut aspen areas in northern Wisconsin attract large numbers of woodcock (Hale and Gregg 1976).

Objectives of this study were to determine the harvest rate and characteristics of a woodcock population in central Wisconsin and to study the use of nocturnal fields to assess the feasibility of large scale banding in the area.

I wish to thank L. Nauman, D. Trainer and R. Anderson of the University of Wisconsin-Stevens Point. I am grateful to L. Gregg of the Wisconsin Department of Natural Resources for giving me the opportunity to learn woodcock trapping techniques. I am also indebted to D. Dedecker and P. Klein for their help with the fall wing survey.

STUDY AREA

The study was conducted in Dewey Marsh, a 3100 ha wetland in Dewey Township, Portage County, Wisconsin (Fig. 1). The marsh lies in the northern part of the Central Wisconsin River Basin in a gently sloping plain consisting of outwash and glacial lake deposits underlain by outwash. The area has extensive wetlands which result from a flat topography, high water table and impermeable layers of silt or clay within the lake deposits. The area is drained by Hay Meadow Creek.

Major hardwood species are quaking aspen (Populus tremuloides), white birch (Betula papyrifera) and red maple (Acer rubrum). Conifers include black spruce (Picea mariana), tamarack (Larix laricina), red pine (Pinus resinosa), white pine (Pinus strobus), and jack pine (Pinus banksiana). Major shrub species are speckled alder (Alnus rugosa), willow (Salix spp.), hazelnut (Corylus spp.) and gray dogwood (Cornus stolonifera).

Woodcock were mist-netted primarily on the 79.5 ha

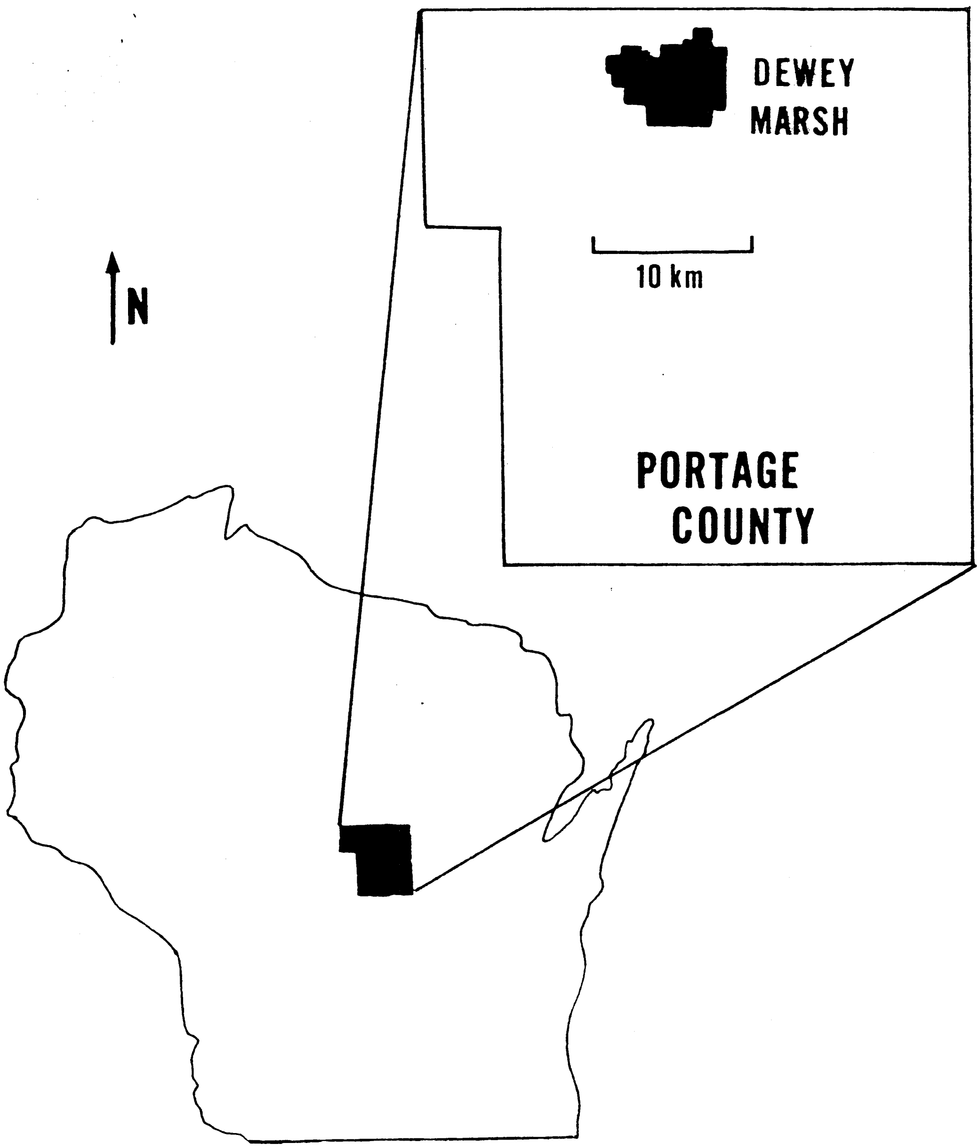

Fig. 1. Location of woodcock study area - Dewey Marsh, Portage County, Wisconsin.

Maple Road Study Area which contained the following cover types: 36.8 ha hardwood, 12.0 ha shrub, 7.2 ha alder, 15.4 ha conifer, 7.0 ha opening and 1.1 ha hardwood-conifer. The area slopes from a large oak-dominated woodlot to pine plantations, stands of aspen, birch and red maple to alder thickets. The openings are small and scattered, resulting in much edge.

METHODS

Woodcock were mist-netted on summer evenings during 1975 and 1976. Birds were sexed and aged using wing feather characteristics (Martin 1964) and were banded with No.3 Fish and Wildlife Service leg bands. Wings and bands collected from cooperating hunters provided information on sex and age composition, productivity, local movements, homing and hunting.

Nocturnal field use by woodcock was investigated by locating woodcock sign (probe holes, splashings, footprints), by watching for flying woodcock at dusk and by searching likely locations after dark with an aircraft landing light powered by a 6-volt motorcycle battery.

RESULTS AND DISCUSSION

Woodcock were mist-netted on 37 nights between 7 July and 12 September, 1975 and 1976. Fifty-one birds were trapped in 113 net-nights for 45 captures per

100 net-nights. Captures per 100 net-nights by other researchers were 16, 9, 27 and 73 (Gregg 1972; Sanford 1971; Whitcomb 1974; Hale and Gregg 1976). Four birds were recaptured from 53 chicks banded on the study area in the spring and 3 birds were mist-netted twice.

In the fall of 1975, 89 wings were received from cooperating hunters. All but a few of these wings were from 2 hunters. Due to extreme drought conditions in the area, Dewey Marsh was closed to hunting in 1976 and no wings were obtained that year.

Direct recovery rates were based on birds banded in July and August of 1975 and shot in the fall of 1975. Direct recovery rates were 55.0 percent for immature males and 40.0 percent for immature females. Thus, immature males appear to be more vulnerable to hunting than are immature females. Too few adult woodcock were banded to calculate recovery rates for this age class.

Goudy et al. (1970) found that immature males were the most vulnerable to hunting of all sex and age classes with harvest rates of 44.0 percent for immature males, 36.0 percent for immature females and 34.0 percent for adults. Whitcomb (1974) found harvest rates of 32.8 percent for immature males, 44.0 percent for immature females and 38.0 percent for adults. Williams (1969) found that sex and age classes did not differ in vulnerability to hunting.

A spring to fall survival rate based on direct recovery rates was derived in the following manner. The direct recovery rate (hunting season) was 0.19 for woodcock chicks banded from 15 April-14 June. The direct recovery rate for immatures banded 14 August-15 September was 0.56. Using the procedure of Whitcomb (1974), I divided the 1st recovery rate (0.19) by the 2nd (0.56) and obtained a survival rate of 33.9 percent. This figure seems low. A survival rate based on the change in the immature to female ratio from spring to fall is 70.8 percent. Whitcomb (1974) found a survival rate of 72.5 percent for immatures on High Island, in Michigan. Sheldon (1967) estimated spring to fall survival of immatures at 50 percent in Massachusetts.

A spring to fall mortality rate of 29.2 percent for immature woodcock (100-70.8=29.2) and a harvest of 50.0 percent (immature and females combined) results in an annual mortality of 79.2 percent in the 1st year of life. This figure is minimal since it does not include winter and crippling loss.

In a study of woodcock breeding biology done in conjunction with this study, I found that 72.7 percent of woodcock hens nested successfully, each producing 3.5 chicks. I assumed an annual mortality rate of 79.2 percent for immature females from my study and 50.0

percent annual mortality for adult females based on averaging mortality rates determined by Martin and Britt (1971) and Krohn et al. (1974). With this data, I calculate that at least 25.0 percent of the female segment of the spring population would have to be immigrants to the area in order for the population to maintain itself. Goudy et al. (1970) estimated that the woodcock population (with an annual mortality of 72.0 percent) on his study area maintained itself with an immigration rate of at least 50.0 percent.

The wing survey indicated an immature ratio of 144 males: 100 females (N=44). The greater proportion of males is probably a result of differential vulnerability to hunting because the ratio of immature males to females (1.44:1.00) is similar to the ratio of the harvest rate of immature males to the harvest rate of immature females (55:40 = 1.37:1.00). There were 73 adult males:100 adult females (N=45). Other reported adult sex ratios in hunting samples are 63, 56 and 45 (Sheldon 1967; Chambers 1971; Whitcomb 1974).

There were 1.7 immatures:adult female. Productivity figures from other studies are 1.8,1.8,1.9 and 2.4 (Goudy et al. 1970; Chreighton 1972; Artmann 1973; Whitcomb 1974).

A ratio of 207 immature males:100 immature females was obtained by mist-netting (N=47). This is typical of the unbalanced sex ratio (with males predominant) of immature woodcock captured on nocturnal fields. Sex ratios (males per 100 females) of woodcock captured on nocturnal fields in other studies are 169, 214, 128 and 137 (Sheldon 1967; Chambers 1971; Martin and Britt 1971; Whitcomb 1974). Too few woodcock (N=4) were mist-netted in this study to report sex ratios of adults using this method.

Some local woodcock remained in the area relatively late in the fall. Three banded woodcock were shot on or near the study area after flights of migrating woodcock occurred. One bird was taken on 10 November. Sheldon (1967) found local birds remaining on his study area in Massachusetts after flights went through in late October and November.

Of 22 banded birds harvested in 1975, 17 were taken on the Maple Road Study Area. Of these, 5 were banded there as chicks and 12 were mist-netted on the area during the summer. In contrast, 1 bird was shot a distance of 2.1 km from where it was banded as a chick. A hatching year male mist-netted on 12 July 1975 was shot 5.0 km northwest of the banding site on 11 October 1975. In West Virginia, Kletzly and Rieffenberger (1969) found that between April and September 67 percent of their recaptures occurred less than 0.8 km from the point of original capture. Gregg (pers. com.) felt that woodcock in northern Wisconsin remain in a relatively restricted area throughout the summer, with few movements of over 1.6 km. Owen and Morgan (1975) found that even with disturbance caused by handling, radio-equipped woodcock in central Maine remained in the same general locality.

Limited data illustrated the woodcock's ability to return to its natal area. One bird, banded as a immature female in 1975, was recaptured the following spring less than 100 m from its original capture site. It was shot on the study area in September of 1977. Another woodcock banded as a chick in the spring of 1975 was taken on the study area in September of 1977. An immature male banded in July of 1976 was shot in the vicinity in October of 1977. Whitcomb (1974) felt that the return rate to his study area in Michigan was at least 31 percent. Other studies have demonstrated the woodcock's homing ability (Sheldon 1967; Clark 1971; Schemnitz 1969).

Night-lighting for woodcock indicated that summer field use was limited or that birds were scattered throughout the area. Thus large scale trapping was not feasible. In 11.8 hours of searching on 14 nights between 3 July and 8 August 1975, 2 woodcock were flushed, 1 in an abanonded field and 1 in a pine plantation. Openings investigated included cultivated and abandoned fields, hunting trails, shrubby fields, pastures and pine plantations. Densities of woodcock on Pennsylvania fields were quite low. Simon et al. (1971) flushed woodcock at a rate of 4 man-hours per flush. In contrast, in 1 evening 95 woodcock were flushed in a 7.3 ha aspen clearcut in northern Wisconsin (Hale and Gregg 1976).

The low densities of woodcock on nocturnal fields in Dewey Marsh is probably due to lack of suitable openings rather than low woodcock densitites. A survey of singing males in Dewey indicated that the marsh supports a large population of birds. Generally ground cover on abandoned fields appeared to be too dense for woodcock. Krohn (1971b) found that roosting woodcock preferred areas with sparse or medium vegetative cover surrounded by more dense and taller vegetation.

Only 1 nocturnal site, a hunting trail on the Maple Road Study Area, attracted appreciable numbers of woodcock. The bulk of the mist-netting occurred there. Woodcock used a 200 m portion of the trail which held standing water at various times throughout the summer and was bordered on both sides by an open red pine (*Pinus resinosa*) plantation.

Woodcock were mist-netted on nights which were thought to be most conducive to attracting birds. The best times were calm nights when puddles were present on the road. Dry conditions restricted the use of the trail. Drought conditions were especially prevalent the 2nd summer and few woodcock were captured.

Others have found a decrease in the woodcock capture rate during dry conditions (Clark 1971; Sheldon 1967; Gregg 1972). Hale and Gregg (1976) found that woodcock preferred the muddier portions of trails. The reason for this attraction to muddy trails is unknown. While some probing occurs, woodcock apparently do little feeding on nocturnal sites (Krohn 1970). However, puddles my be important for bathing. Morgenweck (1974) noted bathing by 71.5 percent of woodcock observed in crepuscular activites.

The "peent" call, uttered by males on their breeding territories, was heard on 4 occasions in late summer, the latest on 11 September. A partial flight "song" consisted of the twittering sound produced by the primary feathers. The "warbling" song was not heard. Sheldon (1967), Whitcomb (1974) and others have noted woodcocks exhibiting breeding-like behavior during the summer.

The activity level (number of woodcock heard and/or seen during the flight period) was recorded each evening of mist-netting. There was no correlation between the activity level and the number of woodcock captured.

Woodcock were seen landing in the red pine plantation which bordered the mist-netted trail. On 2 occasions birds were flushed from this plantation just prior to the evening flight time. On 2 separate evenings a bird landed in the same opening in the plantation and "peented" numerous times. I could not determine whether this was the same bird each time.

CONCLUSION

The results of this study support the evidence that woodcock are overharvested in some local areas. The ultimate effect of intensive hunting pressure depends to some extent on replacement by immigrants, as may be occurring in Dewey Marsh. However, if woodcock hunting increases as habitat losses continue, there may be no surplus birds to bolster declining populations. This points up the need for better information on harvest and population dynamics throughout the woodcock's range.

Currently, Dewey Marsh is unsuited for large scale trapping of woodcock. Evidently the large number of openings provides easy access to suitable nocturnal sites. As a result roosting woodcock are scattered with few birds per field.

Nevertheless, as in northern Wisconsin, woodcock in Dewey Marsh are attracted to muddy openings at twilight and will use them when available. Creation of such "crepuscular landing sites" is practical and relatively inexpensive (Hale and Gregg 1976). The strategic placement of these sites within the marsh may be a practical method to effect large scale banding.

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PART IV: APPENDIX

Appendix A. Species composition of habitat used by woodcock in Dewey Marsh, 1975-1976.

Species composition of trees and saplings was analyzed for 297 random sites, 135 summer flush sites, 47 spring flush locations and 30 brood and 18 nest locations. Shrub species were determined for 100 random sites, 130 summer sites, 16 broods and 5 nests. Frequency of occurance of tree, sapling and shrub species is given in Appendices B, C and D.

Species composition of trees and saplings did not differ significantly ($p>0.05$, χ^2) between nest and random locations. Due to small sample size, species composition of shrubs was not analyzed statistically for nests, broods or spring adults.

There was no significant difference ($p>0.05$, χ^2) in overstory composition between brood and random locations. However, white oak (*Quercus* sp.) was present in the overstory at 30.7 percent of the brood sites compared to 14.2 percent of the random sites. Speckled alder (*Alnus rugosa*) was found in the understory less than at random plots ($p<0.05$, χ^2).

Bourgeois (1976) found a higher occurance of aspen in the understory at nest sites than at brood sites. He found red maple (*Acer rubrum*) used more frequently by nesting hens than by broods, with musclewood (*Carpinus caroliniana*) little used by either. Oak was found almost 3 times more frequently at brood than at nest sites but the percentage was low compared to other species. In northern Wisconsin quaking aspen (*Populus tremuloides*) was the most frequently encountered tree and sapling species at nest sites (Gregg 1974).

Broods (especially those old enough to fly) were often found in stands surrounding fields used for nesting. These stands had much white oak and musclewood in the interior, while the edges, where nests were located, were dominated by quaking aspen. The difference between nest and flying brood sites may have been related to choice of location rather than preference for particular species. Broods may also have frequented wetter sites than where nests were established. In Michigan, Bourgeois (1976) found broods on damp sites near water while nests were on dry, well-drained sites.

In the tree strata, quaking aspen was significantly more frequent ($p<0.05$, χ^2) at spring adult flush sites than at random locations. White oak and red pine (*Pinus resinosa*) were used less than expected ($p<0.05$, χ^2). Sapling species were frequented as they were available ($p>0.05$, χ^2). Overstory species significantly preferred by woodcock in summer were alder, aspen and red oak while white oak and red pine were avoided ($p<0.001$, χ^2). In the understory preferred saplings were alder and white birch, while hop hornbeam (*Ostrya virginiana*), white oak and dead stems were avoided ($p<0.001$, χ^2). Shrub species used more than expected are

Appendix A. Continued

alder, gray dogwood (*Cornus racemosa*), cherry (*Prunus* spp.) and aspen ($p<0.05$, X^2).

In both spring and summer woodcock show a preference for aspen in the overstory. Red pine and white pine (*Pinus strobus*) in the overstory increases in the summer, but is still less frequent than expected on the basis of chance. In the understory, red pine is found more frequently in the summer, while white pine occurs at the same rate equally as often in both seasons. Alder is found somewhat more frequently in summer in both the overstory and understory. Red maple and white birch are also more frequent in summer than in spring. In general, changes in tree and sapling composition between the two seasons indicates a shift to wetter sites. This is consistent with the woodcock's habit of moving to lowland areas as uplands dry out (Blankenship 1957; Liscinsky 1972).

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Appendix B. Percent frequency of occurance of tree species at woodcock locations and random sites, Dewey Marsh, 1975-1976.

Tree species	Random (N=297)	Summer (N=135)	Spring (N=47)	Brood (N=30)	Nest (N=18)
Populus tremuloides	41.9	57.0	59.6	30.1	38.9
Betula papyrifera	37.2	40.0	29.8	24.2	27.8
Acer rubrum	26.7	29.6	27.7	26.1	16.7
Alnus rugosa	6.8	14.8	10.6	3.3	11.1
Pinus strobus	7.1	11.1	6.4	17.6	11.1
Quercus sp. (red)	6.1	11.1	4.3	11.8	11.1
Prunus sp.	7.4	8.8	12.8	5.2	0.0
Quercus sp. (white)	14.2	7.4	8.5	30.7	16.7
Pinus resinosa	10.8	5.2	2.1	9.2	11.1
Ulmus sp.	4.1	5.2	14.9	9.2	5.6
Pinus banksiana	0.0	2.2	0.0	0.0	0.0
Fraxinus sp.	0.3	2.2	2.1	0.7	0.0
Tilia americana	0.0	1.5	0.0	1.3	0.0
Populus grandidentata	1.0	1.5	0.0	0.0	0.0
Larix laricina	0.3	1.5	4.3	0.0	0.0
Ostrya virginiana	2.0	0.0	2.1	1.9	5.6
Carpinus caroliniana	0.7	0.0	2.1	1.3	0.0
Salix sp.	0.0	0.7	2.1	0.7	0.0
Hamamelis virginiana	0.0	0.0	0.0	0.7	0.0
Crataegus sp.	0.0	0.7	0.0	0.7	0.0
Dead	0.3	0.0	2.1	2.6	0.0

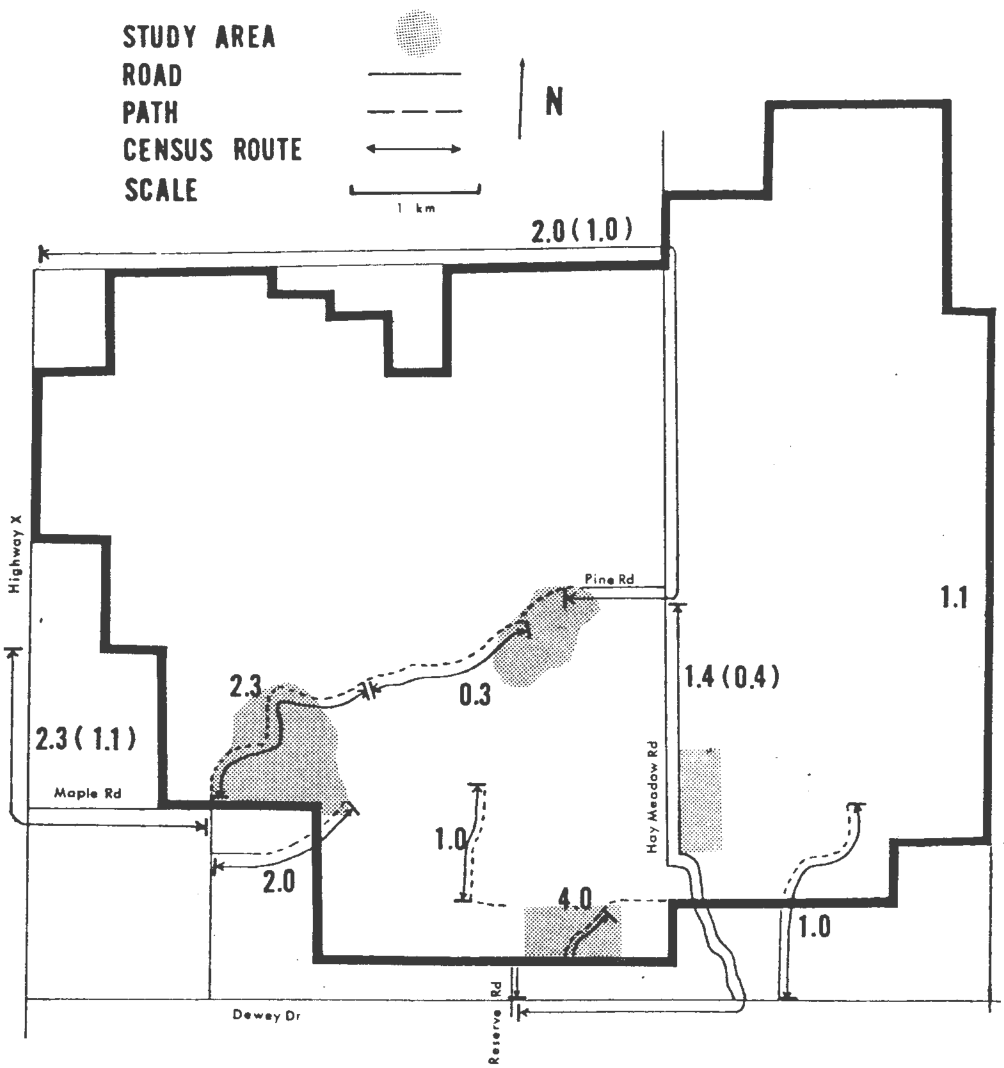
Appendix C. Percent frequency of occurance of sapling species at woodcock locations and random sites, Dewey Marsh, 1975-1976.

Sapling species	Random (N=297)	Summer (N=135)	Spring (N=47)	Brood (N=30)	Nest (N=18)
Alnus rugosa	34.3	45.2	38.3	5.9	16.7
Populus tremuloides	34.0	38.5	42.6	32.7	50.0
Betula papyrifera	19.9	26.7	19.1	24.2	16.7
Acer rubrum	20.9	23.7	14.9	33.9	16.7
Prunus sp.	17.8	18.5	19.1	10.5	11.1
Carpinus caroliniana	10.4	11.1	2.1	20.3	5.6
Pinus resinosa	10.1	5.2	2.1	8.5	11.1
Pinus strobus	8.8	8.1	12.8	4.6	11.1
Ostrya virginiana	7.7	0.7	10.6	3.9	0.0
Quercus sp. (white)	6.4	0.7	4.3	13.7	5.6
Quercus sp. (red)	6.1	6.7	8.5	16.3	11.1
Hamamelis virginiana	6.1	2.9	2.1	3.3	0.0
Salix sp.	5.1	4.4	6.4	1.9	0.0
Dead	5.1	0.7	6.4	2.6	0.0
Ulmus sp.	2.7	2.2	4.3	11.8	5.6
Fraxinus sp.	1.0	0.7	0.0	0.7	0.0
Crataegus sp.	0.7	0.7	2.1	1.3	0.0
Amelanchier sp.	0.3	1.5	0.0	2.6	0.0
Rhus typhina	0.3	1.5	0.0	0.0	0.0
Larix laricina	0.3	0.0	0.0	0.0	0.0
Populus grandidentata	0.3	1.5	0.0	0.7	0.0
Tilia americana	0.3	0.7	0.0	0.0	0.0

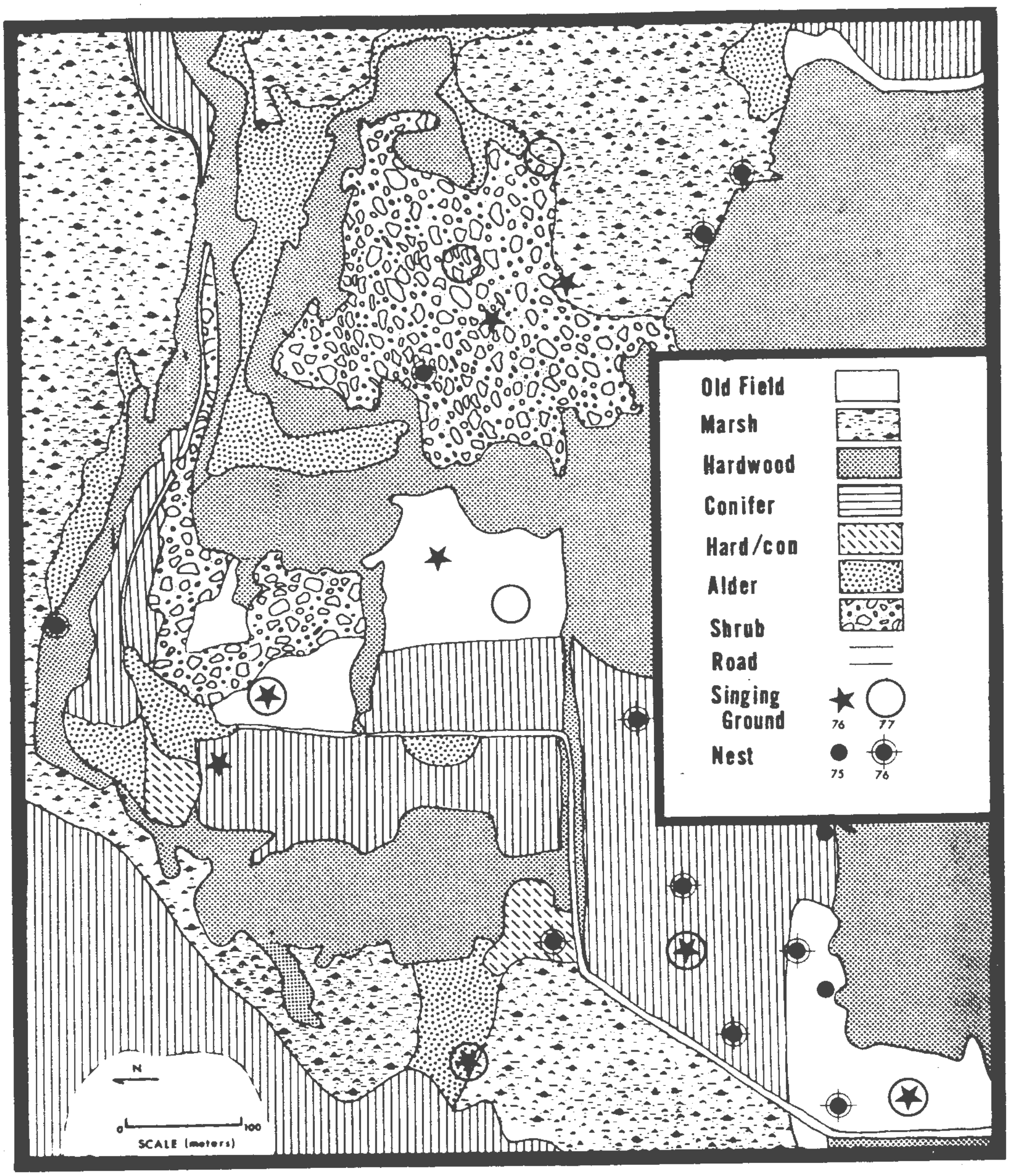
Appendix D. Percent frequency of occurance of shrub species at woodcock locations and random sites, Dewey Marsh, 1975.

Shrub species	Random N=100	Summer N=130	Brood N=16	Nest N=5
Dead	35.0	33.7	0.0	0.0
Alnus rugosa	21.0	34.8	6.8	8.0
Cornus racemosa	16.0	25.0	17.8	24.0
Corylus cornuta	15.0	17.4	23.3	28.0
Rubus sp.	13.0	13.0	1.4	0.0
Spirea tomentosa	9.0	2.2	1.4	0.0
Corylus americana	7.0	7.6	21.9	0.0
Salix sp.	7.0	7.6	21.9	0.0
Carpinus caroliniana	7.0	6.6	17.8	4.0
Hamamelis virginiana	7.0	3.3	16.4	8.0
Aronis melanocarpa	7.0	10.9	1.4	4.0
Populus tremulvides	6.0	13.0	8.2	8.0
Quercus sp. (red)	4.0	4.4	2.8	0.0
Prunus sp.	4.0	9.9	2.8	0.0
Ilex verticillata	4.0	6.6	4.1	4.0
Betula papyrifera	3.0	3.3	8.2	6.0
Quercus sp. (white)	3.0	0.0	4.1	16.0
Fraxinus sp.	2.0	1.1	0.0	0.0
Spirea alba	2.0	3.3	0.0	0.0
Amelanchier sp.	1.0	3.3	5.5	4.0
Viburnum leutago	1.0	3.3	2.8	4.0
Rhus sp.	1.0	1.1	0.0	0.0
Pinus strobus	1.0	0.0	1.4	0.0
Viburnum acerifolium	1.0	0.0	2.8	0.0
Ribes sp.	1.0	0.0	1.4	0.0
Rosa sp.	1.0	0.0	0.0	0.0
Zanthoxylum americanum	0.0	1.1	1.4	0.0
Crataegus sp.	0.0	1.1	1.4	0.0
Populus grandidentata	0.0	1.1	0.0	0.0

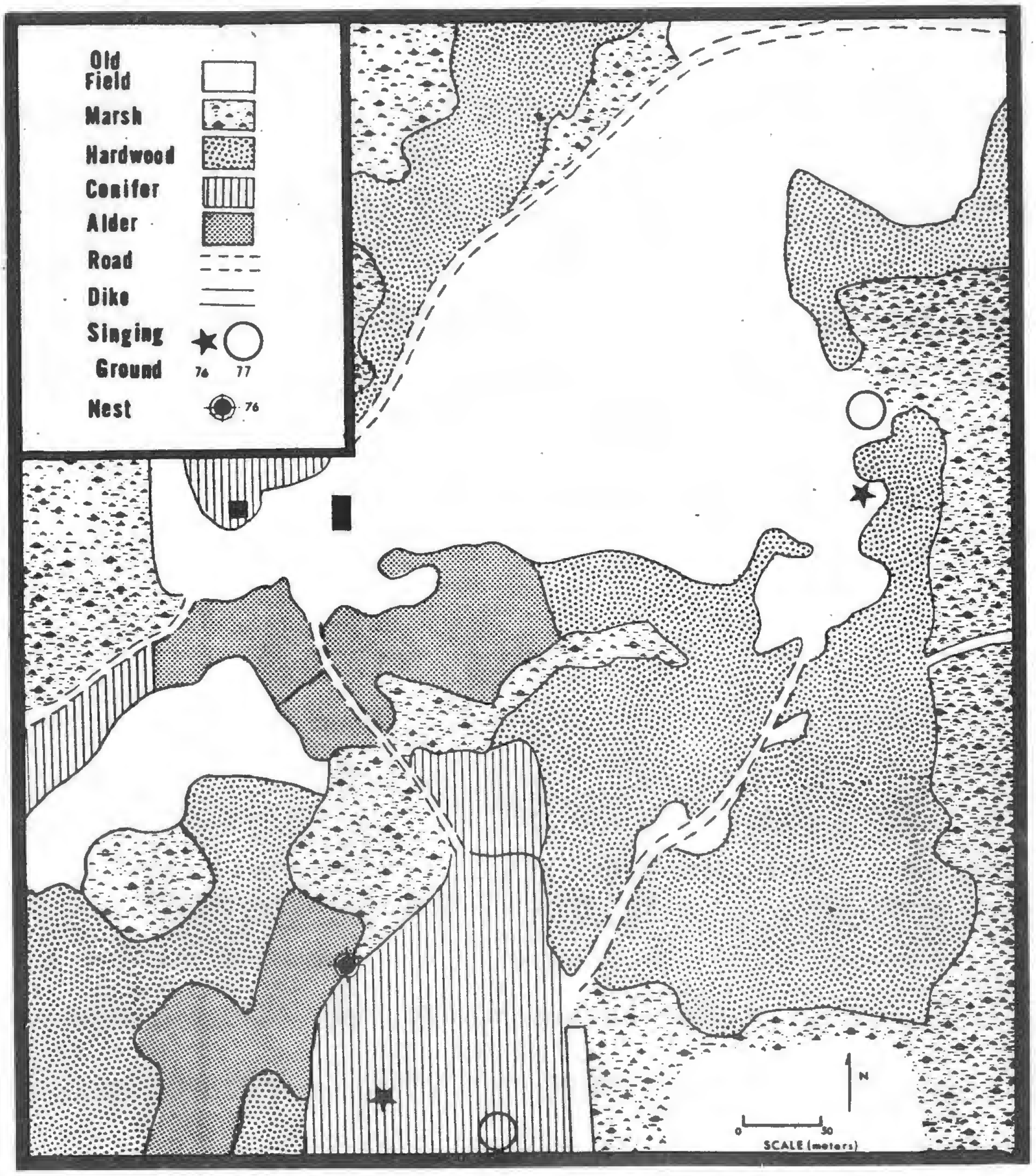
Appendix E. Dewey Marsh, showing location of study areas and woodcock census routes. Numbers are mean singing males heard per stop in 1975. Numbers in parentheses are 1976 figures.



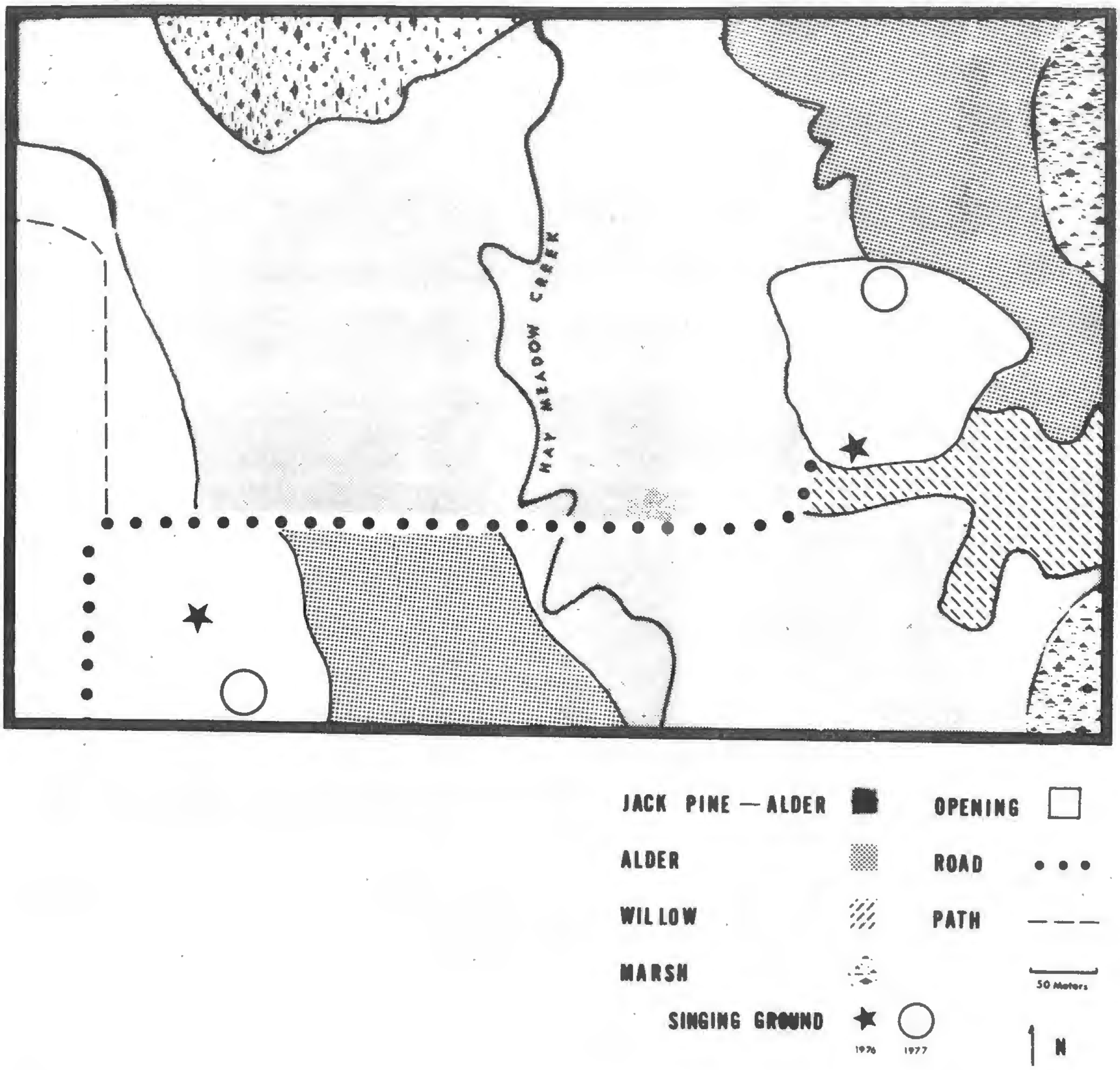
Appendix F. Maple Road study area showing location of singing grounds and nests, 1975-1977.



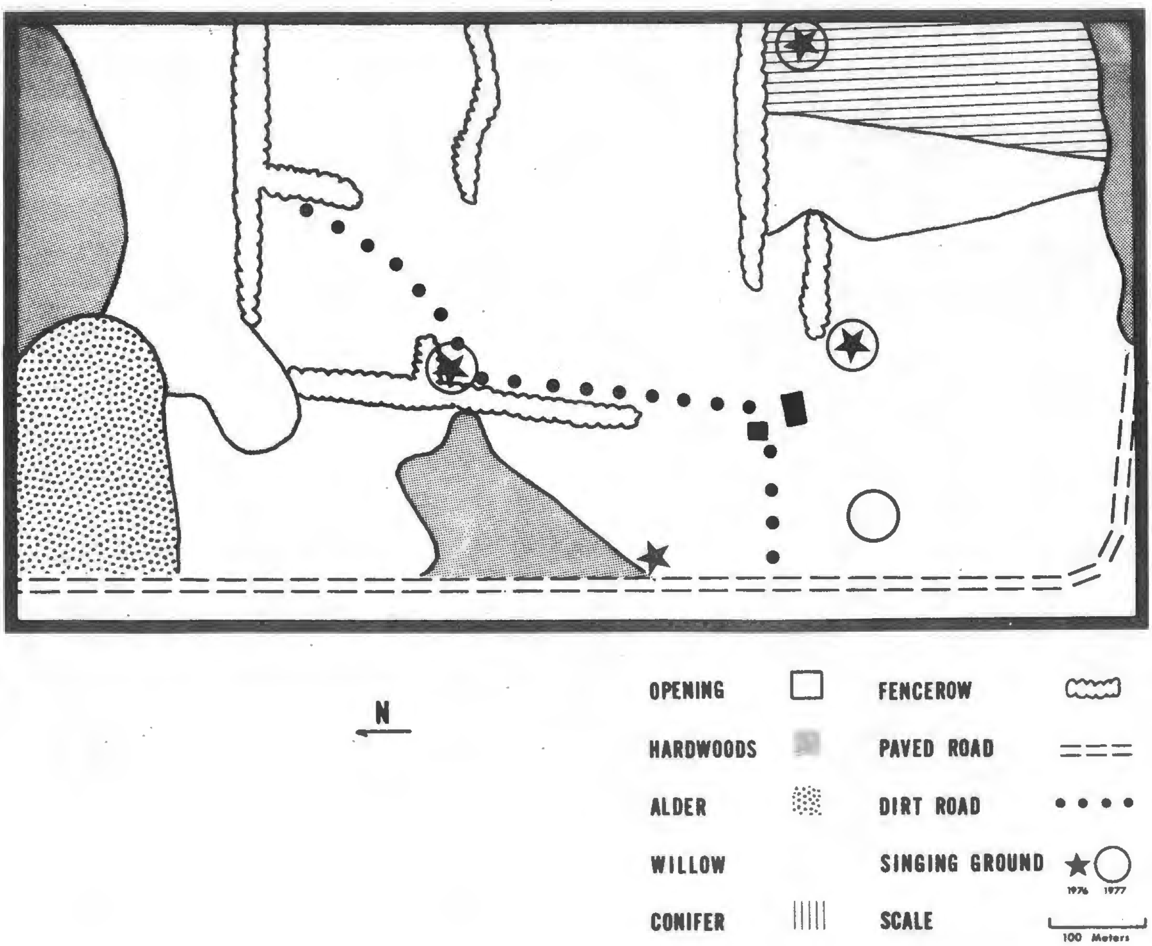
Appendix G. Pine Road study area showing location of singing grounds and nests, 1976-1977.



Appendix H. Reserve Road study area showing location of singing grounds, 1976-1977.



Appendix I. Hay Meadow Road study area showing location of singing grounds, 1976-1977.



Appendix J. Approximate nesting and hatching dates of woodcock broods in Dewey Marsh, 1975 and 1976.

Year	Onset of nesting	Hatching
1975	4-12 (F)*	5-3
	4-18	5-9
	4-18	5-9
	4-19	5-10
	4-21	5-12
	4-21	5-12
	4-23	5-14
	4-30 (F)	5-21
	4-30 (F)	5-21
	5-1	5-21
	5-6	5-27
1976	3-30	4-19
	3-31 (F)	4-20
	4-2 (F)	4-23
	4-5	4-26
	4-13	5-4
	4-14	5-5
	4-15 (F)	5-6
	4-16 (F)	5-7
	4-17	5-8
	4-17	5-8
	4-22	5-13
	4-22	5-13
	4-26 (F)	5-17
	4-26	5-17
	4-30	5-21
	5-1	5-22
	5-3 (F)	5-24
	5-4	5-25
	5-28	6-17

*F= flying brood-- assumed to be 21 days old, the minimum age of full flight capability.

Appendix K. Above: Typical nest location along the edge of aspen - birch stand. Nest is at the base of a small sapling (arrow). Below: Nest site in open pine plantation. Nest is between pine tree and shrub (arrow). This field was also used as a singing ground.

Appendix L. Above: Woodcock hen on nest (arrow). Below: Woodcock nest (arrow points to piece of flagging tape in nest). In both pictures, note vertical cover provided by woody stems.

Appendix M. Above: Four woodcock chicks less than 1 day old. Note the nickel for size comparison. Below: Two-week old woodcock chick, capable of flying short distances.

Appendix N. Woodcock population densities in Dewey Marsh, 1975-1976.

Due to small sample size, point-estimates of the woodcock population had wide confidence limits (Appendix B). Estimates based on banding chicks and mist-netting summer fields are likely to be high because some mortality has occurred from the time of initial capture to mist-netting. Population figures derived from data where both captures and recaptures are mist-netted birds are also likely to be inflated because there is some evidence that woodcock often change nocturnal sites after capture and handling (Owen and Morgan 1975), although they remain in the vicinity.

The most reliable estimate is probably the one based on mist-netting and hunting. I assumed that woodcock flew to nocturnal fields from an area with a maximum radius of 1.6 km, since this is the maximum distance most woodcock move, barring migratory flights, of course (Kletzly and Riffenberger 1969; Clark 1971). Given this assumption, the density of woodcock (based on mist-netting and hunting during 1975) is 13 birds per 100 ha. This is probably a minimal figure since there is evidence that woodcock fly relatively short distances to nocturnal fields. In Maine, the average length of movements by immature woodcock between diurnal coverts and nocturnal sites was 332±78 m (Dunford and Owen 1973). In Alabama, 4 adults and 1 immature moved an average of 217 m to nocturnal fields (Horton and Causey 1974). If this is typical of woodcock in Dewey Marsh, the density figure would increase considerably.

There is little basis for comparison in the literature. Whitcomb (1974) found a density of 26 woodcock per 100 ha while Goudy et al. (1970) found 12-14 woodcock per 100 ha.

The estimate based on birds that were mist-netted and recaptures visually refers to birds that were fitted with back-tags. The tags were made of colored vinyl (Safety Flag Company, Pawtucket, Rhode Island) and were attached with surgical tubing (Godfrey 1970).

An unusual incident provided information regarding the visibility of these tags under field conditions. A woodcock flushed at a right angle to my line of sight, passing over the head of a cooperator, who caught the bird in his hand. As it turned out the bird was wearing a back-tag, which I had not seen as the bird flew. Thereafter, only flushes where the back of a bird was clearly visible were counted as part of the capture-recapture experiment. However, the number of tagged birds was small (N=13) and no others with a tag were seen. The bird that was caught was within 200 m of where it was mist-netted 2 weeks prior to the incident. It appeared to be in excellent health.

Appendix N. Continued

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Appendix O. Estimates of woodcock population densities in Dewey Marsh, 1975-1976.

Year	Method of Computation	Trapping Technique		Time Period (Mid-point)	Population Estimate	Density (Birds/100 ha)
		Capture	Recapture			
1975	Lincoln Index[a]	chicks	mist-net	26 May	774 (110-29936)[b]	48
1975	Schnabel Index[a]	mist-net	mist-net	11 Aug	543 (174-1392)	33
1975	Lincoln Index	mist-net	hunting	11 Aug	210 (110-362)	13
1976	Lincoln Index	chicks	mist-net	20 May	214 (48-792)	13
1976	Schnabel Index	mist-net	mist-net	2 Aug	301 (66-1109)	19
1976	Lincoln Index	mist-net	visual	2 Aug	71 (10-2808)	4

[a]formula from Overton (1969)*   [b]population estimate ± 95% confidence limits

Lincoln $N = \frac{Mn}{X}$

Schnabel $N = \frac{\Sigma Mn}{\Sigma X}$

Where:
N = population estimate
M = number of marked members in the population
n = number of members of the population sampled
X = number of marked individuals in the sample

*Overton, W.S. 1969. Estimating the numbers of animals in wildlife populations, pp. 433-441. in R.H.Giles, Jr. (editor). Wildlife investigational techniques. 3rd ed. The Wildlife Society, Washinton, D.C. 633 pp.

Appendix P. Activity level (number of woodcock heard and/or seen during the flight period) and number of woodcock captured per net-night.

Date	No. heard/seen	No. captured
7-10-75	9.0	1.0
7-12-75	2.5	5.0
7-15-75	6.0	2.0
7-16-75	8.0	0.5
7-19-75	1.0	0.0
7-20-75	0.0	0.0
7-23-75	3.0	0.5
7-24-75	1.0	0.0
7-28-75	0.0	0.3
7-30-75	1.0	0.0
8-26-75	3.0	1.0
8-27-75	13.0	0.7
9-2-75	10.0	0.3
9-8-75	6.0	0.3
9-11-75	11.0	0.5
9-12-75	15.0	0.8