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Thomas H. Roberts

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I am submitting herewith a thesis written by Thomas H. Roberts entitled "Migration, distribution and breeding of American woodcock." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Ralph W. Dimmick, Major Professor

We have read this thesis and recommend its acceptance:

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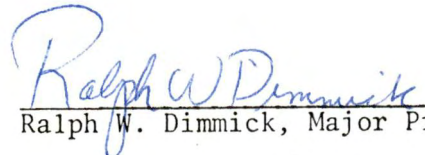
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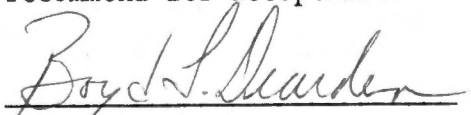
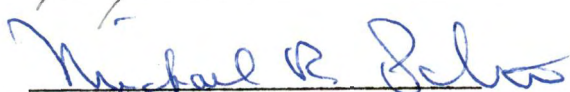
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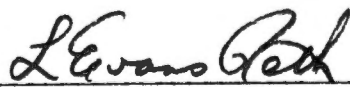
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Ralph W. Dimmick, Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:


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Graduate Studies and Research

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Thesis

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MIGRATION, DISTRIBUTION AND BREEDING OF AMERICAN WOODCOCK

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Thomas H. Roberts

December 1978

1373084

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ABSTRACT

Woodcock are widely distributed over Tennessee, but are most common during fall and spring in the Great Valley, Central Basin, and throughout western Tennessee. Harvest records indicate that peak fall migration occurs in mid-November. In 1977 and 1978, spring migration began during mid-February, and ended during mid-March. Peak migration occurred in late February or early March, but this chronology may not be representative of normal years. Testes lengths averaged 9.2 mm, indicating that male woodcock are in breeding condition by mid-February. Follicle development suggested that 44 percent of the females collected in February 1977 and 52 percent of the females collected in February 1978 were rapidly approaching nesting. The breeding season began during mid-February and lasted until late May. Peak nesting occurs from early to mid-March. Temperatures near 0°C curtailed breeding activity. Courtship activity began an average of 12.6 minutes after sunset; mean light intensity was 3.2 foot candles. Stands of second growth hardwoods found in poorly drained areas were favored diurnal coverts. Singing grounds were frequently early succession old fields, although pastures and other open areas were also used. Most nests were in young hardwood stands and were less than 50 m from a singing ground. Four of 5 broods were in honeysuckle thickets and were less than 50 m from streams.

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CHAPTER I

INTRODUCTION

The American woodcock (Philohela minor Gmelin) has advanced from specialty game bird status, highly regarded by a few hunters, to a broader based recreational resource actively pursued by many sportsmen. The estimated continental woodcock harvest exceeded 1.5 million birds during the 1973-74 hunting seasons (Artmann, 1975). Owen (1977) estimated that woodcock annually provide between 2.5 and 3.0 million man-days of hunting recreation.

Traditionally a game bird of only minor importance in Tennessee, woodcock are most often taken incidentally to bobwhite quail (Colinus virginianus), rabbit (Sylvilagus floridanus), and ruffed grouse (Bonasa umbellus). In spite of low hunter interest, Gore (1974) estimated the annual statewide harvest to be as high as 10,000 birds and this figure has likely increased because of more public awareness of woodcock and increased hunter opportunity. Woodcock also provide excellent recreational opportunity for the nonhunting public. The unique courtship display of the male provides numerous hours of enjoyment for the increasing numbers of bird watchers and other nature oriented groups.

In spite of the increased popularity of woodcock among various groups of Tennesseans, much information essential to sound management of the species is unknown. Of particular significance is the general lack of knowledge about the extent and chronology of breeding that occurs in the state and the chronology of spring and fall migration. Glasgow

(1958) stated that he observed males in courtship flight in early December in Louisiana. Causey et al. (1974) documented concentrations of breeding woodcock in Alabama and demonstrated that nesting in February is fairly common. Kletzly (1976) stated that males usually begin courtship flights from mid to late February in West Virginia. In Kentucky, male woodcock have been observed performing courtship flights as early as 3 February (Russell, 1958). Taylor (1976) stated that singing males were already numerous on 19 February in Virginia, the first date that Virginia census routes were run in 1975. Stamps and Doerr (1977) provided evidence that testicular recrudescence in males occurs as early as December in North Carolina. They also noted that a large percentage of females collected during February were in advanced stages of reproductive maturation. Tennessee's woodcock hunting season has recently been split into 2 parts, the late season running from 1-28 February. In light of the evidence that woodcock breeding activity begins at such an early date in several bordering states, it was desirable to determine the reproductive status of woodcock in Tennessee during winter.

Tennessee's woodcock season has traditionally been set to correspond with the opening date for bobwhite quail and other small game. Clark (1970) noted that most woodcock have departed from the northern states by early November and many arrive on the wintering grounds between October and mid-December. Consequently, intermediate states, by opening their season in mid-November or later, may be missing a substantial portion of the migrant woodcock available for hunting.

Gore (1974) summarized much of the available information pertaining to fall migration and concluded that Tennessee sportsmen would benefit from an earlier fall season. Hunting during the month of February provides sportsmen additional opportunity to harvest woodcock since migration through Tennessee is often substantial during that month. This late season has to be viewed, however, in light of the evidence of early nesting in the Southeast.

Woodcock occur in Tennessee as spring and fall migrants and as breeding residents. In mild winters, some birds may also remain as winter residents. However, the distribution of woodcock across the state and the size of the population during various seasons of the year is not well documented. Primary objectives of this study were to: (1) delineate the seasonal and geographic distribution of woodcock in Tennessee, (2) define the chronology and extent of breeding that occurs in the state with particular emphasis on the extent of breeding occurring in February. Other aspects of the ecology of woodcock in Tennessee were also noted.

CHAPTER II

DESCRIPTION OF STUDY AREA

The description of the physiography of Tennessee is adapted from Fenneman (1938), Miller (1966), and Miller (1974). Climatic information is from Miller (1966) and Dickson (1974).

I. PHYSIOGRAPHY

Tennessee lies between the coordinates of approximately 35° to 36° 30' north and 81° 40' to 90° 31' west. The state is divided into 9 physiographic regions.

The Unaka Mountains are a 12.9 km wide series of irregular ridges which lie along the state's eastern border. They are the southern extension of the Appalachian Mountains and are called the Blue Ridge elsewhere. The mountains are characterized by rugged terrain, heavily forested slopes, and numerous streams. Several peaks exceed 1830 m. Maximum elevation is 2025 m.

The Great Valley is the part of the Great Appalachian Valley which traverses Tennessee. It is about 89 km wide and extends from the Unakas to the escarpment of the Cumberland Plateau. The region consists of numerous parallel ridges and valleys oriented in a northeast-southwest direction. The valley was formed by erosion on sandstones, shales, and limestones. Ridges vary in height from 456 m in the southwest to 944 m in the northeast. Valleys range from 230 m to 300 m in elevation.

The Cumberland Plateau is the southern portion of the Appalachian Plateau. It is a region of generally flat terrain with some rolling topography and mountains in the northeast. The eastern border is a steep escarpment, Waldens Ridge, while the western edge is more irregular. The plateau has an average elevation of about 550 m and ranges up to 1066 m in the mountainous areas. Prominent features include numerous deep gorges and 2 large linear valleys, the Sequatchie in the south and the Elk in the north.

The Eastern Highland Rim region is about 40 km wide and forms the eastern portion of the plateau encircling the Central Basin. The terrain is nearly level and averages approximately 300 m in elevation. Unusual features include extensive areas of Karst terrain and the Barrens, a nearly flat area in the south central part of the Rim. Caves and sink-holes are common throughout the region.

The Central Basin is an area of gently rolling to hilly terrain enclosed by the Highland Rim. The basin is elliptical in shape and extends across the state from northeast to southwest with an extreme width of about 97 km. The hilly outer areas of the basin average about 230 m in elevation. The inner basin is less hilly with an average elevation of about 180 m.

The Western Highland Rim extends from the Central Basin westward to the Coastal Plain. The Western Rim is characterized by dissected rolling terrain with numerous streams. Extensive areas in the southwest portion of the region exceed 300 m in elevation.

The Western Valley of the Tennessee River is often included in current descriptions of the state as a separate physiographic region. The valley is as much as 32 km wide in the southern portion of the state but narrows somewhat in the north. The flood plain ranges from 5.6 km to 2.4 km in width. Extensive alluvial bottomlands and high rocky bluffs are found throughout much of the valley's length.

The Coastal Plain lies between the Tennessee and Mississippi River valleys. It is an area of relatively low elevation and relief with sediments having the same characteristics as the coastal regions of other southeastern states. The easternmost part is hilly with elevations of up to 213 m, but less hilly to nearly flat terrain is characteristic of most of the region. Loess, windblown deposits of fertile soils, covers much of the region.

The Mississippi Flood Plain is an area of extensive alluvial bottomlands. The region is characterized by low gradient meandering streams, oxbow lakes and cutoffs. The region is essentially flat with little topography throughout its length.

II. CLIMATE

Except for areas of high elevation in the Unakas, Tennessee is entirely within the "humid mesothermal" region typified by 4 relatively distinct seasons of approximately equal length. Winters are warmer than those to the north and are characterized by high humidity and precipitation. Springs are generally mild with lower precipitation due to fewer general rains and more showers. Summers are warm and humid with

most precipitation coming from thunderstorms. Falls are characterized by mild temperatures, low humidities, and light to moderate rainfall.

The average annual temperature ranges from 16°C in the extreme southwest to about 7°C at high elevations in the Unakas. The decrease in temperature with increasing elevation, about 1.6°C per 305 m, accounts for most of the temperature variation in the state. Mean summer temperature for the Unaka Mountains is 17°C, 22°C on the Cumberland Plateau, 24°C in the Great Valley and Highland Rim regions, 25°C in the Central Basin and 26°C in the Coastal Plain. The mean winter temperature for the state is approximately 3°C. The frost-free period for most of Tennessee is from 180 to 220 days.

Average annual precipitation is about 1270 mm. Most of the state receives 1140 to 1400 mm annually, except for the mountainous areas where the total may exceed 2000 mm. Most precipitation occurs during winter and early spring, the least during fall. Although all parts of Tennessee generally receive adequate precipitation, there are, on the average, one or more prolonged dry periods each year during summer and fall.

Average annual snowfall varies from 100 mm to 150 mm in the southern and western parts of the state and in most of the Great Valley, to more than 250 mm over the northern Cumberland Plateau and in the Unakas. Snow cover rarely persists for more than a few days.

CHAPTER III

METHODS AND MATERIALS

I. BACKGROUND

Records in the files of the Tennessee Wildlife Resources Agency (TWRA), and all issues of the Tennessee Ornithological Society (TOS) journal, The Migrant, were examined to summarize the present state of knowledge of woodcock in Tennessee. The locations of singing grounds, observations of nests or broods, harvest records, observations of migratory flights, and other pertinent information were recorded to supplement the data collected during this study.

II. MIGRATION AND DISTRIBUTION

Letters describing the study were sent to each of the local chapter presidents of the TOS, asking for the names and addresses of members who occasionally observed woodcock, as well as others who might be interested in cooperating with the study. The persons whose names were submitted were mailed a survey form or were contacted by telephone and asked to locate singing grounds within their home county. TWRA biologists and all county wildlife officers were asked to furnish information concerning woodcock migration or breeding activity in their county or region. Several major Tennessee newspapers—the Knoxville News Sentinel, The Commercial Appeal (Memphis), the Nashville Banner, the Nashville Tennessean, The Chattanooga Times, and the Jackson Sun—carried articles

describing the study and asking for information concerning woodcock. In addition, several smaller newspapers carried similar requests in weekly columns written by the county wildlife officers. A description of the study was also carried in the quarterly TOS journal, The Migrant.

Field work was conducted in all parts of the state from late fall through spring both years in order to locate areas containing suitable woodcock habitat. Singing grounds were located by listening for courting males in openings near coverts where woodcock had been flushed or in areas that appeared to contain good diurnal cover.

Harvest records were used to determine the geographic distribution of woodcock in Tennessee, as well as patterns and chronology of fall migration through the state. Clark (1972) and Artmann (1975) compiled results of the U.S. Fish and Wildlife Service wing surveys for Tennessee. Gore (1974) and Marcum (1977) summarized early wing collection data and results of studies conducted in Tennessee from 1974 to 1976. Records from other states were also used to determine fall migration patterns.

Since male woodcock occupy territories during migration (Pitelka, 1943), then the numbers of singing males in an area should be a good indicator of the chronology of spring migration and the distribution of the woodcock population in Tennessee during late winter. It was assumed that peak numbers of singing males indicated peak migration and that migration had ended when the numbers of singing males stabilized. Woodcock that were collected during the study or that were contributed by sportsmen during the February 1977 and 1978 hunting seasons were also used to determine the chronology of migration and distribution of the species in Tennessee during late winter.

III. BREEDING ACTIVITY

Beginning in early January of both years, areas known to be used as singing grounds were regularly checked to determine the onset of courtship. Persons who had demonstrated an interest in the study were asked to check singing grounds in their areas for the presence of singing males during January and February, in order to increase the sample size and the geographic distribution of singing grounds visited. Selected areas utilized by several courting males were monitored throughout late winter and spring to define the peak and duration of breeding activity in Tennessee.

Singing grounds were checked with a few exceptions only during the evening. Observations generally began about dusk and lasted until all courtship activity had ceased. The number of singing males that could be heard was recorded. The presence of other woodcock on the singing ground was also noted. In areas where only a few males were present, performances were often observed in their entirety. In areas of extensive good habitat, the standard census technique of driving a selected route and stopping every 0.6 km to count the numbers of peenting males was used.

A Gossen light meter was used throughout the 1978 breeding season to measure the light intensity at which courtship was initiated. The illumination at the time of the first peent call and at the beginning of the first courtship flight was recorded to the nearest 0.1 footcandle. Temperature, cloud cover, time of the first peent, and relation of the

first flight to sunset were recorded throughout the breeding season. Duration of courtship was measured from the first peent (on the singing ground or in diurnal covert) until all activity ceased.

IV. GONAD DEVELOPMENT

Gonads from woodcock collected by hunting with pointing dogs during 1977 and 1978 were examined to determine the extent of sexual maturation. County wildlife officers were asked to collect carcasses from woodcock hunters or from quail or grouse hunters who occasionally killed woodcock. Hunters were requested to furnish the date and location for each bird killed. The birds were wrapped and frozen as quickly as possible and were transported to the TWRA regional offices. The length and width of the testes and the diameter of ovarian follicles were measured to the nearest 0.1 mm with small dial calipers. All birds were sexed and aged according to characteristics of the primaries and secondaries. Birds received intact were weighed to the nearest gram.

V. NESTS AND BROODS

Pointing dogs were used to locate nests and broods. Two days were spent searching coverts located near occupied singing grounds in March 1977 in Cumberland, Anderson, and Knox Counties. More intensive searches were conducted during March and April 1978 in Knox, Bradley, Cumberland, Henderson, Fayette, and Shelby Counties. Flightless chicks were captured by hand, aged according to bill length (Ammann, 1967), banded, and released near the point of capture. No attempts were made to capture

hens found with the broods. One clutch was aged according to the flotation method described by Ammann (1967). The approximate hatching date for some broods found by cooperators was determined by estimating the age of chicks from the description given by the observer.

VI. HABITAT PREFERENCES

Land use patterns, proximity to diurnal coverts, successional stage, and dominant cover types of fields or openings utilized by male as singing grounds were determined to help define breeding habitat in Tennessee. Singing grounds were measured to determine if woodcock exhibited preferences toward openings of a particular size. The successional stage and cover types of singing grounds were determined by visual inspection. The size of singing grounds was estimated by pacing straight line distances around the perimeter of the opening. Whenever several males were observed singing in large fields which had no apparent divisions, the entire area was measured.

The physical and vegetative makeup of diurnal coverts was noted throughout the study. Dominant species of both overstory and understory were determined by visual inspection. Characteristics of nest and brood cover were determined by inspection. Proximity to singing grounds and other general site characteristics were also measured.

CHAPTER IV

RESULTS AND DISCUSSION

I. DISTRIBUTION OF WOODCOCK IN TENNESSEE

Tennessee's woodcock population consists of spring and fall migrants and birds that are probably residents except for periods during especially severe winters. Woodcock numbers in Tennessee fluctuate greatly throughout the year. Immigration and emigration, additions through natality, losses due to hunting, natural mortality, and many other factors all contribute to the dynamics of the population. While TOS and TWRA records show that woodcock are found in all areas of the state, the seasonal and geographic distribution is not well documented. Owen (1977), in the most recent compendium of woodcock knowledge, included all of Tennessee in the known breeding range and a section of western Tennessee in the wintering range.

Singing grounds were located in 39 counties representing all 8 physiographic regions of the state (Figure 1). Some of these singing grounds were occupied only briefly by birds believed to be transients, but many were occupied for several weeks, probably by males on established breeding territories. The failure to detect singing grounds in the remaining counties probably reflects insufficient field work in those areas. The most significant interpretation is that woodcock singing grounds are widely distributed across Tennessee during late winter and spring.

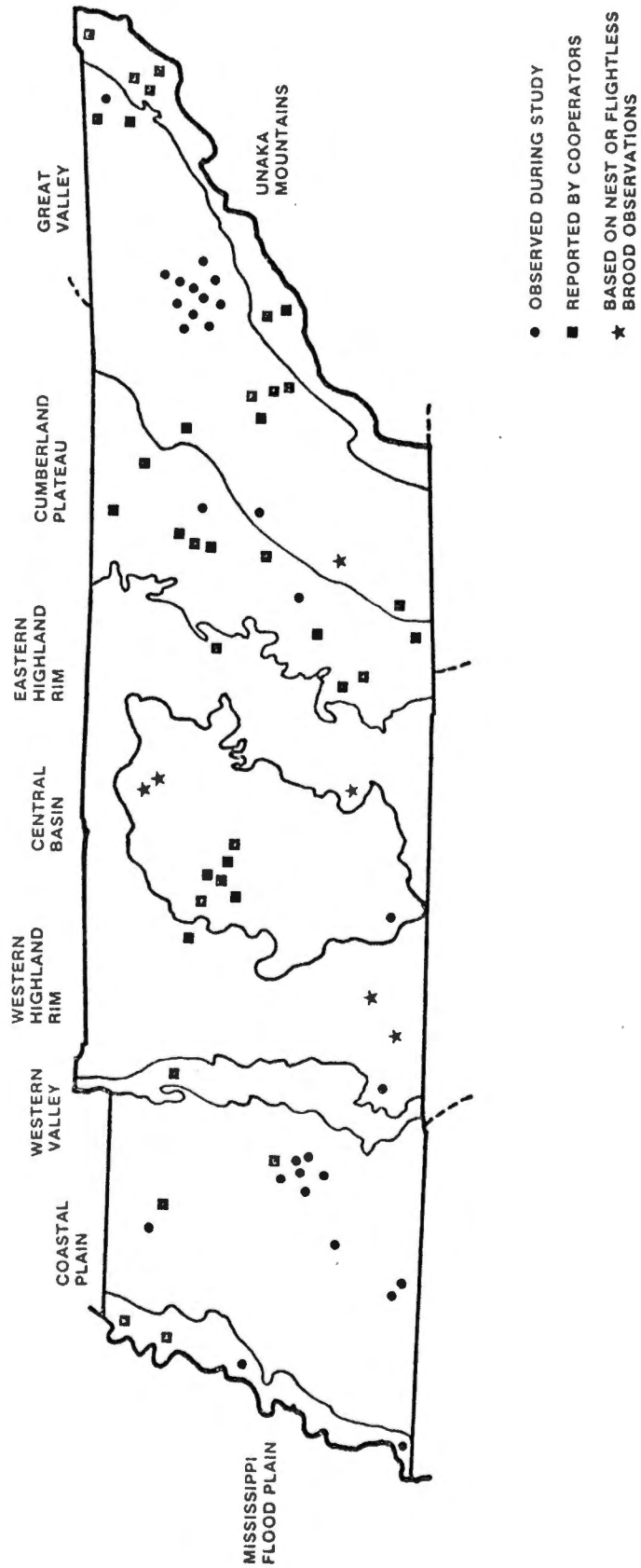


Figure 1. Distribution of woodcock singing grounds in Tennessee (1977 and 1978).

Harvest records for Tennessee summarized by Marcum (1977) also showed that woodcock are widely distributed over the state during fall and early spring. The Great Valley, especially the southern half, and the Central Basin generally report high kills, while those from the Eastern Highland Rim and the Unaka Mountains are consistently low. Due to biases caused by small sample sizes and different methods used to calculate the annual harvests, these data may not accurately depict regional woodcock populations in Tennessee. The reported woodcock harvest in Tennessee is often so small ($n < 100$) that a group of interested hunters or even an individual hunter can significantly affect the reported harvest figures for a particular region.

The proportion of the reported harvest from the western regions is surprisingly low since the Coastal Plain and Mississippi Flood Plain contain most of Tennessee's wetlands. The low figures probably result from a lack of hunting effort, since woodcock were observed to be abundant in these areas during the study.

Harvest figures for 1974 are especially significant in illustrating the widespread distribution of woodcock in Tennessee during the fall (Figure 2). During 1974, Tennessee's woodcock season ran from 12 October to 15 December. Persons who planned to hunt woodcock before 28 November (opening of quail season) were required to obtain a free permit. These persons were mailed a post-season questionnaire regarding their woodcock hunting activities. Hunters reported killing 1066 woodcock during the season, making this the largest single sample of harvest data available for the state.

A total of 156 woodcock collected by us or contributed by hunters for this study were used to estimate the proportion harvested in western (Western Valley, Coastal Plain, and Mississippi Flood Plain), central (Eastern and Western Highland Rim, Central Basin, and Cumberland Plateau), or eastern (Great Valley and Unaka Mountains) Tennessee. Ninety-two (92) percent of the birds were taken during the February 1977 and 1978 hunting seasons. No effort was made to collect woodcock during the fall hunting seasons. The percentage harvest from western Tennessee during both years (37 and 35 percent) was considerably higher than that calculated by Marcum (1977) for previous years. This distribution of harvest more closely reflected the expected distribution based on the proportion of wetland habitat in each of the 3 divisions. The very low February harvest for eastern Tennessee in 1977 (7 percent) was probably due to low hunting effort. Woodcock were frequently observed near Knoxville during the last 2 weeks in February, indicating that the low harvest did not necessarily reflect a scarcity of birds.

Observations of male woodcock on the singing grounds and harvest data show that woodcock are widely distributed across Tennessee during fall and spring. Both sets of data suggest that woodcock are most common in the Great Valley, portions of the Cumberland Plateau, the Central Basin, and throughout western Tennessee. Few woodcock were reported from the northern Cumberland Plateau, the Eastern and Western Highland Rim, and the Unaka Mountains, and it is likely that these areas have the lowest woodcock densities in the state.

Since woodcock are difficult to observe except during the breeding season, and harvest records are not available year round, the distribution

of the woodcock population in Tennessee from the end of the breeding season until the fall hunting season is not well documented. Although Ammann (1978) mentioned instances of extensive juvenile wanderings, there is little information in the literature to suggest that woodcock move appreciably during summer. Woodcock observations recorded in The Migrant show that woodcock are present in Tennessee during this period, but the small number of observations preclude delineating either the distribution or the abundance of the species. Although field studies were not conducted to document the status of woodcock in Tennessee during late spring through early fall, observations indicated that woodcock are locally abundant. During both summers of the study, large numbers of woodcock were observed near Knoxville, roosting in summer fields. These birds were likely permanent residents that had all stayed in the vicinity of their breeding or natal grounds. Since breeding activity was documented to be widespread over the state, Tennessee's summer woodcock population should be widely distributed as in other seasons. Except for losses through natural mortality, the size of the summer population probably changes little from the post-breeding period in the spring.

II. FALL MIGRATION

There is a paucity of information concerning fall migration patterns through many of the mid-latitude states, including Tennessee. The chronology of the fall woodcock migration has been well documented for much of the northern part of the range, and in Louisiana, where large

concentrations of birds winter. Although no field investigations were conducted during this study to determine the chronology of fall migration, several sources of information were used to determine the migratory patterns through Tennessee. The annual wing survey conducted by the USFWS, results of a woodcock hunter survey conducted by the TWRA in 1974, and extrapolation of migration data from other states all helped to delineate the fall migration in Tennessee.

Mendall and Aldous (1943) stated that even in the northern limits of the range little definite migration begins until September, and most of the migrants pass through the northeastern region during October. Sheldon (1967) cited several papers which indicated that the heaviest New England flights occurred during October. Liscinsky (1972) stated that in recent years peak migration in Pennsylvania occurred during the last week in October or the first week in November. Gore (1974) examined harvest records for several northern states and concluded that woodcock begin large scale migration from Minnesota, Wisconsin and Michigan during the last week in October. Migration peaked in Indiana and Ohio during late October and the first week of November. Russell (1958) stated that peak fall flights occurred during November in Kentucky. Taylor (1976) reported that good concentrations of woodcock were present in Virginia by late October 1973, although peak harvest occurred in November. Stamps and Doerr (1977) stated that in western North Carolina woodcock are numerous during October and early November. Kletzly (1976) stated that most woodcock migrate through West Virginia during the last week in October and the first 2 weeks in November.

Concentrations of woodcock were observed in northeastern Georgia during the last week in November, but were most common during the first week in December (Pursglove, 1974). Glasgow (1958) found that migratory woodcock begin to arrive in Louisiana in October and gradually increase in numbers until about 20 November, after which there is a noticeable acceleration in the number arriving.

The fall woodcock migration is highly dependent on annual weather conditions (Mendall and Aldous, 1943; Sheldon, 1967), but evidence shows that peak fall migration from New England, upper Michigan, and other northern parts of the range, occurs during October. Most migrants are observed in Pennsylvania, Ohio, Indiana, West Virginia, and Virginia during late October and early November. Thus, based on average migration dates of states to the north, peak migration through Tennessee should begin after the first week in November, with the largest numbers of woodcock present during the second and third week of the month. These dates are supported by the late November and early December arrivals reported in Georgia and Louisiana.

Tennessee's woodcock harvest based on the annual wing survey conducted by the USFWS (Table 1) indicated that woodcock are most numerous in Tennessee during the last 20 days of November, but these figures may partially reflect different season opening dates. For example, during 4 of the 5 years when the season did not open until mid November or later, a large percentage of the harvest was taken during that opening period. This suggests that large numbers of migrants were already present. However, even during years when the season was opened

Table 1. Distribution of woodcock harvest in Tennessee by 10-day periods, 1968-69 through 1973-74 seasons, based on U.S. Fish and Wildlife Service wing surveys.

| Year | N | October | | November | | December | | January | | February | | |
|----------------------|----|---------|-------|----------|-------|----------|------|---------|-------|----------|-------|-------|
| | | 12-21 | 22-31 | 1-10 | 11-20 | 21-30 | 1-10 | 11-20 | 21-31 | 1-10 | 11-20 | 21-28 |
| 1968-69 | 37 | - | - | - | 45.9 | 48.7 | 2.7 | 0 | 0 | 2.7 | - | - |
| 1969-70 | 46 | - | - | - | 39.1 | 47.9 | 2.2 | 6.5 | 0 | 4.3 | - | - |
| 1970-71 | 21 | - | - | - | - | 71.4 | 14.2 | 4.8 | 4.8 | 4.8 | 0 | - |
| 1971-72 | 51 | - | - | 19.6 | 35.3 | 31.4 | 3.9 | 7.8 | 2.0 | 0 | - | - |
| 1972-73 | 14 | - | - | - | 28.6 | 35.8 | 7.1 | 0 | 21.4 | 7.1 | 0 | - |
| 1973-74 | 24 | - | - | - | - | 25.0 | 20.8 | 33.3 | 20.8 | 0 | 0 | - |
| 1974-75 | 4 | 0 | 0 | 25.0 | 0 | 25.0 | 0 | 50.0 | - | - | - | - |
| 1975-76 ¹ | 85 | 0 | 5.9 | 22.5 | 30.6 | 30.6 | - | - | - | - | - | - |
| 1976-77 | 86 | - | 14.0 | 14.0 | 11.6 | 24.4 | - | - | - | - | 0 | 3.5 |
| 1977-78 | 53 | - | 15.1 | 22.7 | 30.2 | 11.3 | - | - | - | - | 0 | 9.4 |

¹10.6 percent from 9-17 through 10-11.

prior to November, the highest harvest interval still occurred from 11 through 30 November. In most years, the harvest declined sharply during December, suggesting that most migrants had passed through the state by this time.

Although the 1974 harvest survey is the largest single sample of harvest information available for Tennessee, the data may not be representative of a typical year since migration probably began at least 2 to 3 weeks earlier than normal. The harvest results (Table 2) indicated that woodcock were abundant in Tennessee at least as early as mid-October.

Table 2. Distribution of 1974 woodcock harvest in Tennessee by 10-day periods, based on TWRA hunter questionnaire.

| | 10-Day Periods | | | | | | | |
|----------------------|----------------------|----------------------|---------------------|----------------------|----------------------|---------------------|----------------------|-------|
| | 10-12 to 10-21 | 10-22 to 10-31 | 11-1 to 11-10 | 11-11 to 11-20 | 11-21 to 11-30 | 12-1 to 12-10 | 12-11 to 12-15 | 12-16 |
| N = 755 ¹ | | | | | | | | |
| Percent Harvest | 22.2 | 12.6 | 15.2 | 17.5 | 13.4 | 7.5 | 3.3 | 8.2 |

¹The total harvest was 1066, but 311 were not dated.

From 30 September to 6 October the average temperature for most of the area east of the Mississippi River ranged from 10° to 15° below normal. Record low temperatures occurred from New York to Florida (U.S. Department of Commerce, 1974). Since fall woodcock migration is influenced by freezing temperatures (Sheldon, 1967), it is likely that many woodcock departed from the northern states during late September and early

October. This early migration, coupled with Tennessee's early woodcock season and favorable hunting conditions, likely accounted for the good harvest reported during October. These data showed that, in spite of the early migration, woodcock remained common throughout November.

Both average migration dates for other states and harvest data from Tennessee indicate that woodcock migrate into Tennessee during late October or early November and continue throughout the month. Peak migration probably occurs about mid-November, varying somewhat from year to year. In most years, the numbers decline sharply after 1 December although some migrants are still present. In years that the season opened early, the harvest in October and early November showed that woodcock hunters do benefit from the early opening dates.

III. SPRING MIGRATION

Since harvest records are not generally available for February and no hunting occurs in March, little information exists concerning the spring woodcock migration through Tennessee. Tennessee did have a late woodcock season, 1-28 February, during 1977 and 1978, and harvest records are available for these 2 years. In addition, hunter reports, field studies conducted during winter and spring 1977 and 1978, observations of male woodcock on the singing grounds, and comparison of dates from other states were all used to document the chronology of the spring migration period.

1977. Courting males were first observed near Knoxville on 19 February. Courtship flights were also first reported in western

Tennessee on 19 February. Near Nashville, woodcock were first heard singing on 24 February.

No field studies were conducted near Knoxville during the last 10 days of February, but it is likely that peak migration occurred in late February or early March. Counts of singing males near Knoxville showed that most migrants had passed through that area by mid-March. For example, the number of singing males on 2 areas declined from 5 and 3, respectively, to 1 over the second week in March. Cooperators in western Tennessee observed a similar peak in the number of singing males but noted that most migrants had departed by 10 March.

Wildlife officers and hunters reported that few woodcock were harvested before mid-February. Some small concentrations of woodcock were observed in the western sections of Tennessee during January and early February. Woodcock were consistently flushed throughout the winter by hunters near Memphis, but apparently few woodcock wintered elsewhere in Tennessee. The distribution of the harvest likewise showed that woodcock were most numerous in February during the last week of the month, with 91.4 percent ($n = 58$) of the birds harvested for this study taken during that period.

1978. Woodcock were reported regularly from several areas of the state throughout December 1977 and early January 1978. Sub-freezing temperatures prevailed from about 10 January until the second week in February, apparently causing mass migration of woodcock. Intensive searches of coverts which harbored birds the previous winter suggested that few, if any, woodcock were in Tennessee during this period.

Hunters first reported seeing woodcock in the second week in February and by 20 February woodcock were reported from many areas of the state. Of 88 woodcock collected in February, 68.2 percent were killed in the last 7 days of the month.

The appearance of birds on singing grounds indicated that spring migration through eastern Tennessee began during the third week in February. Courting males were first observed near Knoxville on 17 February, and peak numbers occurred from the end of February through the second week in March (Figure 3). Cold temperatures in early March may have delayed some migrants from moving up through the state during this period. In eastern Tennessee, most migrants had departed by 20 March. Observers in western Tennessee reported that migration began 4-5 days later, but that otherwise the chronology was much the same.

One point of interest concerning the 1978 February harvest is the preponderance of males in the sample (72.7 percent). Glasgow (1958) found that male woodcock begin migration from Louisiana earlier than females, while Kletzly (1976) and Owen (1977) found that males are first to arrive on the breeding grounds. Since migration through Tennessee in 1978 did not begin until mid-February, the harvest would include the earliest migrants. Thus the disparity in the sex ratio further documents early migration by males.

The federal wing survey from both February seasons was small ($n = 31$, 1977, and 11, 1978), but the chronology of harvest was similar to that of the birds collected for this study. In 1977, 90 percent of the harvest was taken during the last week of the month. The earliest

harvest date was 12 February. In 1978, the earliest harvest date was 16 February, with the rest of the kill spread evenly throughout the remainder of the month.

Sheldon (1967) noted that the severity of weather in January and February governs, to a large extent, the time when woodcock begin their spring migration. Both years of this study were characterized by abnormally severe weather during January and February; thus, the chronology of migration observed in 1977 and 1978 may not be representative of normal years. Records in The Migrant show that during some years woodcock are present in Tennessee throughout December, January, and February. For example, woodcock were frequently observed in Hardin County throughout December and January 1967. Whether these wintering birds are locals, migrants which have stopped short of traditional wintering grounds, early spring migrants, or some combination has not been determined.

It is speculated that some portion of the woodcock present in Tennessee after mid-January may be early spring migrants. Glasgow (1958) stated that in mild winters most woodcock had departed from Louisiana by 1 February, in normal winters by 12 February, and in cold winters by 28 February. Harvest figures indicated that woodcock leave northeast Georgia by late January (Pursglove, 1974). Kletzly (1976) stated that during most years male woodcock reach southern West Virginia by early February. Hunter surveys in North Carolina suggested spring migration begins about mid-January in western North Carolina (Stamps and Doerr, 1976). Thus, in some years, spring migration through Tennessee

may begin 3 to 4 weeks earlier than was observed during this study, although it is likely that peak flights do occur in late February or early March.

IV. MIGRATION ROUTES

Several of the main woodcock migration routes postulated by various researchers pass through Tennessee. Glasgow (1958) stated that one main route from the extreme northeast portion of the range passes through East-central Tennessee, while another route used by birds from both the Central and Atlantic subpopulations passes through the western part of the state. Sheldon (1967) suggested that woodcock move through Tennessee along 2 main routes, through the Great Valley and through the West-central portion of the state. Combining band returns and parasitologic "tags," Pursglove (1973) showed one route passing through the central part of the state. Though few banded woodcock have been recovered in Tennessee ($n = 9$), recoveries from Louisiana (Martin et al., 1969), Pennsylvania (Liscinsky, 1972), Michigan (Whitcomb, 1976), and West Virginia (Kletzly, 1976) all show straight line migration patterns crossing Tennessee.

Although harvest surveys, breeding records, and observations of singing males show that woodcock are widely distributed over the state during both the spring and fall migratory periods, the Great Valley, portions of the Cumberland Plateau, the Central Basin, and western Tennessee consistently harvest the largest numbers of woodcock. This indicates that more woodcock move through these regions than through other areas of the state.

During the study, flights of woodcock were observed or were reported from several regions. In the Great Valley, the writer observed large numbers of migrants both years of the study. Large flights were reported in Knox, Monroe, Loudon, and Bradley Counties. No observations of migrant woodcock were made in the Central Basin, but reports from TWRA biologists and harvest figures confirm that large numbers of woodcock commonly move through this area. In the western part of the state, large flights were observed in Hardin and Henderson Counties, and were reported by wildlife officers from Benton and Shelby Counties. Hunters reported seeing large numbers of woodcock in Fayette and Perry Counties.

Thus, harvest records, hunter reports, and observations during this study support several of the generalized routes crossing Tennessee. It appears that woodcock move through the eastern and central parts of the state by way of the Great Valley and the Central Basin. These areas contain much of the moist, fertile soils in the eastern and central portions of the state, so it is not surprising that they are utilized by large numbers of migrant woodcock. Additionally, harvest and breeding records and TWRA biologists report large numbers of woodcock from Cumberland County on the Cumberland Plateau. Although the area does not appear to contain extensive woodcock habitat, woodcock consistently pass through this region during migration. Migration through western Tennessee appears to be rather widespread since woodcock are commonly reported throughout the region. It was postulated that the majority of woodcock move through the western area of the state by way of the Mississippi and Tennessee River Valleys. Although large numbers

of migrants have been reported from these areas, it could not be documented that these valleys are the major travel routes.

Additional banding effort coupled with harvest surveys are necessary to better delineate major woodcock passageways through Tennessee.

V. REPRODUCTION

Measurements of gonads were obtained from 113 woodcock. Length of the left testis was measured for 66 males. The diameter of the single largest ovarian follicle was measured for 27 females in 1977 and measurements of several of the largest ovarian follicles were taken for 20 females collected during 1978. Several of the birds were too badly shot or were so decomposed that no information concerning gonad development could be salvaged.

Males

All males collected during February or March contained enlarged testes and were assumed to be sexually mature. Since only a few woodcock were collected before mid-February either year, it could not be determined when testes enlargement began. Testes lengths of February-shot males were similar both years, averaging 9.2 mm ($n = 20$, $SE = 1.1$, 1977, and $n = 46$, $SE = 0.91$, 1978).

Marshall (1959) stated that in many species of birds testicular recrudescence is accompanied by territory selection, song, and increasingly intensive sexual activity. In Tennessee, male woodcock were observed performing courtship flights as early as 14 December 1977 and

early January 1978 near Chattanooga and Knoxville. The severe weather during January halted courtship and apparently forced most woodcock to emigrate from Tennessee. Courtship displays were not observed throughout this period until spring migration began during mid-February.

Courtship flights in December and January are not uncommon in Tennessee, suggesting that at least during some winters gonadal enlargement in male woodcock begins as early as December. Since all males that were examined had enlarged testes, reproductive maturation apparently is completed no later than mid-February. Courtship performances observed in February 1977 and 1978, when woodcock first returned to Tennessee, did not differ noticeably in duration or intensity from those observed later during peak breeding activity.

Marshall (1961) noted that gonad development is influenced by a number of factors, temperature being one of the more important. Most of the early courtship flights reported by various researchers have been observed during periods of unseasonably mild weather, suggesting that temperatures may be a factor affecting testicular recrudescence in woodcock. Additional work during more moderate winters is needed to determine the effect that yearly weather variation has on the chronology of reproductive maturation of male woodcock in Tennessee.

Females

Measurements of the ovarian follicles showed that the degree of sexual maturation varied widely among females (Table 3). The diameter of the single largest ovarian follicle ranged from 1.5 mm to one of 23.3 mm in a female with a shelled egg in the lower oviduct.

Table 3. Diameter of largest ovarian follicles from woodcock collected during February 1977 and 1978.

| Diameter class (mm) | 1977 | | 1978 | |
|------------------------|-----------|------|-----------|------|
| | No. | (%) | No. | (%) |
| 1.5-2.0 | 55 | (19) | 11 | (5) |
| 2.1-3.0 | 44 | (15) | 22 | (10) |
| 3.1-4.0 | 66 | (22) | 77 | (33) |
| 4.1-5.0 | 33 | (11) | 88 | (38) |
| > 5.0 | <u>99</u> | (33) | <u>33</u> | (14) |
| Total | <u>27</u> | -- | <u>21</u> | -- |

Since eggs are produced in succession, the ova differ in relative maturity and range in size. During the final phase of growth, layers of yolk are deposited rapidly and after the oocyte reaches a threshold point the rate of growth accelerates rapidly. In chickens, the diameter of the yolk increases from 6 mm to 35 mm in just 6 days (Romanoff and Romanoff, 1949).

Since woodcock were not collected in January or early February, it could not be determined when ovarian maturation began. Stamps and Doerr (1977) arranged follicles in order of decreasing size as described by Romanoff and Romanoff (1949) to determine the growth intervals between successive follicles. Their data suggested that follicles greater than 4 mm in diameter were in the final rapid growth phase of ovarian maturation, and that females with follicles of that size were rapidly approaching nesting.

Assuming that a follicle diameter of 4 mm defines the point at which follicular growth accelerates, then 44 percent of the females

collected during February 1977 and 52 percent of the females collected during February 1978 would have begun nesting in a short time. An examination of 5 gravid females suggested that follicles of 4 mm may not be indicative of a readiness to nest (Figure 4), but more work is needed to determine precisely at what point final rapid growth does begin.

The chronology of nesting observed in 1978 further suggested that laying and incubation may not begin for some time after follicles reach the 4-5 mm stage. One female collected on 17 February, 3 females collected on 18 February, and several females shot during the last week in February all contained enlarged follicles, yet the earliest clutch that was located was estimated to have been started on 7 March.

Marshall (1961) stated that the gonads of migratory birds are active when they leave their wintering grounds, but suggested that although the birds are physiologically prepared for reproduction, certain stimuli such as behavioral interactions, territory, traditional breeding grounds, and a suitable nesting site, among others, might be necessary before reproduction and nesting actually takes place. It seems likely that this is the case with woodcock, but the factors that initiate nesting behavior are as yet incompletely understood.

Chronology of Nesting

Seven nests and 11 broods were located during March and April of 1977 and 1978 (Table 4). Clutches or broods were located in all physiographic regions except the Unaka Mountains and the Eastern

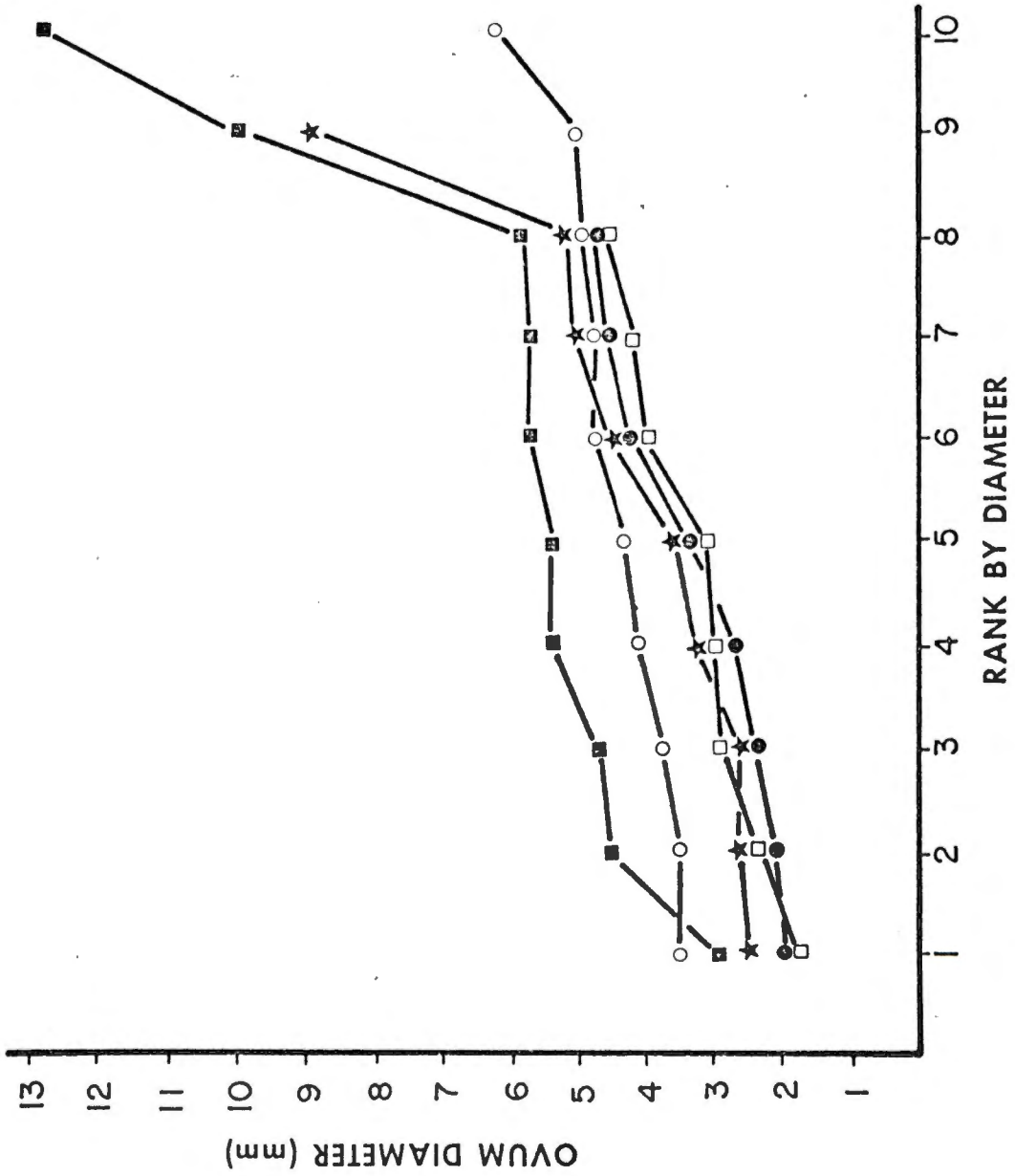


Figure 4. Diameters of largest ovum (mm) in 5 woodcock shot during February 1978.

Highland Rim suggesting that woodcock breeding is widespread over Tennessee. The earliest estimated clutch initiation date during 1978 was 7 March, but most clutches were initiated during the second and third week in March. Sample size was much too small to estimate chronology of nesting in 1977. Nine chicks were banded near Knoxville during 1978.

Table 4. Woodcock clutch and brood observations in Tennessee during 1977 and 1978.

| <u>Date Found</u> | <u>County</u> | <u>Number of Eggs or Chicks</u> | <u>Estimated Date Clutch Initiated</u> |
|-------------------|---------------|-------------------------------------|--|
| | | <u>Clutches</u> | |
| 3-17-78 | Shelby | 4 | 3- 9-78 |
| 3-23-78 | Cumberland | 4 | - |
| 3-25-78 | Henderson | 4 | 3-15-78 |
| 3-25-78 | Henderson | 4 | 3-12-78 |
| 3-26-77 | Knox | 4 | 3- 1-77 |
| 3-28-77 | Davidson | 4 | 3- 3-77 |
| 4-??-78 | Wayne | 4 | - |
| | | <u>Broods</u> | |
| 4- 5-78 | McMinn | 2 | 3-9 or 3-10-78 |
| 4- 7-77 | Knox | 3 | 3- 4-77 |
| 4- 8-78 | Cumberland | 4-5 | 3-11-78 |
| 4-13-78 | Anderson | 4 | - |
| 4-14-78 | Knox | 4 | 3- 7-78 |
| 4-15-78 | Knox | 4 | 3-17-78 |
| 4-16-78 | Anderson | 2 | - |
| 4-19-78 | Knox | 4 | 3-13-78 |
| 4-21-78 | Knox | 2 | 3-17-78 |
| 4-23-78 | Weakley | 3 | 3-15-78 |
| 4-24-77 | Wilson | 2 | 3-21-77 |

The date that nesting began could not be determined for some of the clutches or broods reported by cooperators. Approximately 8-10 additional broods were located 22 April 1978 in Wilson County by TWRA biologists. All the chicks were flightless (less than 14 days old).

In Tennessee, clutches have been reported as early as the last of February and as late as 27 April, but records in The Migrant suggest that peak nesting occurs from early to mid-March. Data collected during this study support these dates, but there are few nesting records for Tennessee and since intensive searches were not conducted prior to this study, it is not known whether these records accurately portray nesting chronology.

Although no clutches were found in February of either year, ovarian maturation was evident in a large proportion of the females; eggs were found in females that were shot near the end of February. Woodcock have been observed nesting during January or February in Arkansas (Pettingill, 1936), Alabama (Causey et al., 1974), and North Carolina (Stamps and Doerr, 1977), and it is speculated that in mild winters some nesting may occur as early as mid-February in Tennessee.

Breeding Season

During both years of this study, male woodcock began courtship activity immediately upon arrival in Tennessee in mid-February. Although some males were observed performing during December 1977 and January 1978, this activity was believed to represent the pre-season courtship described by Marshall (1961). Several singing grounds were monitored throughout both years of the study to determine the length of the singing period. In 1977, some males continued singing activity until late May. One male was heard peenting on 1 June, although no flight was observed. Late dates that courtship activity was last observed on

other singing grounds include 6 May, 8 May, and 25 May. The exact dates that courtship activity ceased are not known, but singing grounds were checked at least once per week. Activity on some singing grounds ceased as early as mid-March, but it is not known whether this resulted from a decline in breeding activity, northward movement of migrants, or abandonment of the singing grounds for more favorable sites.

In 1978, courtship was last observed on 24 May. As in 1977, singing activity ceased on some areas during March and April. This late activity is surprising since investigators in the north have reported courtship ending by early June (Mendall and Aldous, 1943; Liscinsky, 1972; Whitcomb, 1974).

The length of the woodcock breeding season in Tennessee is not well documented in the literature. There are several records in The Migrant of males performing courtship flights in November, December, and January, but it is unlikely that these early flights result in copulation and nesting. Pettingill (1936) summarized early woodcock nesting records and found the earliest nesting date in the Southeast was 4 January, reported from South Carolina. Most southern states report earliest nesting dates during February. The earliest record for Tennessee is 1 March, although evidence indicates that in some years nesting may begin during February. Although courtship extended into late May, it is not known whether this late activity results in appreciable breeding since the latest clutch observed in Tennessee was 27 April. Additional field studies during April and May are needed to better define the length of the breeding season and to determine the importance of late

courtship activity. Sheldon (1967) and Modafferi (1967) both felt that late breeding activity probably was necessary for renesting efforts, although there is no evidence to support this in Tennessee.

VI. COURTSHIP

Woodcock breeding activity is influenced by a variety of environmental conditions. Temperature, light intensity, wind, and precipitation have all been shown to affect male courtship. In order to document the effects of some of these environmental parameters on male woodcock in Tennessee, temperature, cloud cover, and light intensity at the time of courtship initiation were recorded for evening performances during 1978. The duration of performances was measured periodically throughout the breeding season.

The unique courtship of the male woodcock has been adequately described by Pettingill (1936), Mendall and Aldous (1943), Pitelka (1943), Sheldon (1967), and numerous others. The performances observed in Tennessee during this study were similar to those described from other parts of the range.

Temperature

Male woodcock were observed performing courtship flights in temperatures ranging from 3°C to 23°C. Woodcock were heard peenting when the temperature was 1°C, but no flight song was observed. On several occasions when the temperature was 0°C or lower, courtship activity was not observed on areas where males had previously performed on warmer evenings.

Duke (1966) stated that temperatures from 4°C to 15°C were most favorable for male courtship. Mendall and Aldous (1943) and Pitelka (1943) noted instances of cold temperatures inhibiting courtship. Sheldon (1967) stated that temperatures below freezing curtailed breeding activity. Blankenship (1957) found singing decreased when the temperature dropped below 2°C. Thus, it is well documented that low temperatures suppress courtship activity. The writer's observations corroborated that low temperature inhibited courtship during periods of the 1978 breeding season in Tennessee. Although Dubke (personal communication, 1977) reported that he had observed male woodcock performances in Tennessee when the temperature was -3°C, activity at temperatures of 0°C or lower is not common.

While temperatures lower than 0°C did interrupt breeding activity, higher temperatures did not have any noticeable effect. Males courted actively throughout both springs when temperatures ranged above 20°C. Unseasonably high temperatures might adversely suppress activity although it was not observed to do so during the study period.

Light Intensity

Excluding 2 extremely high values (33.0 and 20.0 foot candles) recorded on consecutive days at the end of the courtship period, the light intensity when peenting began ranged from 0.4 foot candles to 10.0 foot candles (mean = 3.2, SE = 2.62). The light intensity at the time of the first courtship flight began ranged from 0.3 to 2.8 foot candles (mean = 0.86, SE = 0.62). The initiation of courtship activity was also measured in relation to sunset and cloud cover (Table 5).

Table 5. Initiation of courtship in relation to official sunset for evening performances observed in Tennessee during 1978.

| | Clear to 3/4 Overcast | Overcast | All Cloud Conditions |
|----------------------------------|--------------------------|---------------------|-------------------------|
| | Mean \pm SE (No.) | Mean \pm SE (No.) | Mean \pm SE (No.) |
| Minutes after official sunset | 15.5 \pm 6.6 (11) | 10.5 \pm 6.6 (10) | 12.6 \pm 6.5 (35) |

Pettingill (1936) and Mendall and Aldous (1943) reported that evening courtship performances usually began when light intensity was about 2.0 foot candles. Pitelka (1943) stated that calling began when light intensity reached 0.5 to 1.0 foot candles. Leopold and Eynon (1961) found that woodcock gave their first evening peent between 0.2 and 5.0 foot candles (mean = 0.71). Duke (1966) stated that light intensity of 2.1 foot candles initiated evening courtship.

The variation in mean light intensity found by different researchers to initiate male courtship is probably due in part to differences in the time that the measurements were taken. Duke (1966) and Pitelka (1943) measured the light intensity at the time the first courtship flight began, not when males began peenting.

Woodcock frequently begin peenting from diurnal cover before flying onto the singing ground. Many of the singing grounds utilized by woodcock during this study were adjacent to diurnal coverts and males often peented for several minutes and frequently began their first flight song directly from these coverts prior to flying onto the singing ground. Even discounting differences due to study approach, there is considerable

variation in the time at which individual birds will begin courtship activity (Mendall and Aldous, 1943). All studies have indicated, however, that a low level of light intensity is necessary to initiate courtship.

Courtship Duration

During 1978, 20 evening courtship performances were observed in their entirety. Mean courtship length was 26.5 minutes, SE = 8.0. This agrees with Stamps and Doerr (1977), who found that courtship (measured from the first peent after arrival on the singing ground) in North Carolina averaged 23 minutes. Mendall and Aldous (1943) stated that the courtship period in Maine generally lasts 40 to 50 minutes. Pitelka (1943) found the average singing period (from first to last flight) in Illinois to be 24.8 minutes, but regarded this to be shorter than normal. Duke (1966) found evening performances averaged 43 and 41 minutes in length, respectively, during a 2-year study in Michigan. Sheldon (1967) found average April performances in Massachusetts lasted 24.4 minutes (from the first flight to the last peent), while May performances averaged 38 minutes. Sheldon (1967) also stated that performances are longer in the more northern parts of the breeding range.

Woodcock have been observed performing throughout the night during periods of bright moonlight (Sheldon, 1967). This was not observed in Tennessee, although on some evenings woodcock did peent sporadically long after dark when the only illumination was moonlight. The peent call was generally given only infrequently and this activity was not

considered to be a part of the evening courtship. Performances did not differ noticeably in length throughout the breeding period.

VII. HABITAT

Woodcock habitat requirements have been determined for most of the northern part of the range. Mendall and Aldous (1943), Sheldon (1967), Liscinsky (1972), and Wishart and Bider (1976) all provided excellent descriptions of woodcock habitat on the northern breeding grounds. In spite of this knowledge of the northern range, there is a dearth of information concerning specific habitat preferences of woodcock in the Southeast (Pursglove and Doster, 1970).

Owen (1977) listed 3 major habitat requirements of woodcock. They are (1) forest openings for singing grounds and nocturnal roost sites, (2) fertile, generally poorly drained soils with abundant concentrations of earthworms for feeding areas, and (3) the proper life form of vegetation to give adequate cover on both diurnal and nocturnal sites.

Diurnal Habitat

In Tennessee, diurnal coverts generally consist of young stands of second growth hardwoods characterized by sweet gum (Liquidambar styraciflua), sycamore (Platanus occidentalis), hackberry (Celtis occidentalis), red maple (Acer rubrum), and boxelder (Acer negundo). Dense stands of black willow (Salix nigra) and alder (Alnus serrulata) are also attractive to woodcock. Understory species commonly found in woodcock coverts include blackberry (Rubus spp.), honeysuckle (Lonicera japonica), greenbriar (Smilax spp.), privet (Forestiera acuminata),

and switch cane (Arundinaria tecta), as well as various other shrubs, vines, and small hardwood saplings.

Woodcock were generally found in areas with poorly drained, fertile soils. Suitable habitat is spotty in Tennessee, but moist woodlands, brushy streamlands, young hardwoods stands adjacent to ponds, marshes or other swampy areas, the brushy borders around croplands and pastures all provide cover favorable for woodcock. Woodcock were also commonly found around small woodland seepages and other similar moist site areas.

Sheldon (1967) stated that during migration woodcock may be found almost anywhere and noted that during the fall woodcock may be found on well-drained hillsides. Observations during this study indicated that this departure from typical cover occurs frequently in Tennessee. Woodcock were commonly flushed during both fall and spring migration from upland areas characterized by various species of dry site hardwoods and pine (Pinus spp.). Quail hunters in Hardin County reported flushing large numbers of woodcock during migration on dry ridges that had been clearcut and planted to loblolly pine (Pinus taeda). Wildlife officers in Benton and Rhea Counties also reported flushing woodcock from upland areas that were being converted to pine plantations. In Henderson County, 15 woodcock were flushed during midday from a 2 ha broomsedge (Andropogon virginicus) and lespedeza (Lespedeza spp.) field located on a dry hillside.

Nocturnal Cover

At dusk, woodcock fly from diurnal coverts into fields and small forest openings (Glasgow, 1958; Sheldon, 1968; and Krohn, 1970).

Although these openings were first thought to be feeding sites, recent evidence (Krohn, 1970; Whitcomb, 1974) suggests that feeding may not be their primary utilization. These crepuscular flights to open areas were first documented in Tennessee during a preliminary woodcock investigation conducted by the TWRA in the fall of 1974. During both years of this study, woodcock first began these nocturnal flights during mid-May while male courtship was still occurring.

Two fields used as roosting sites were located in Knox County. Both had served as courtship sites in the spring. One area which was used in 1977 was a 2.8 ha field that had been cleared and burned during the previous winter. The field was covered with a dense stand of weeds, mainly ragweed (Ambrosia spp.), goldenrod (Solidago spp.), and johnsongrass (Sorghum halepense). Woodcock were generally flushed from relatively open areas, where movement on the ground would have been unhampered. On one evening, 3 woodcock were flushed from a wet portion of the field where the ground cover was predominantly clumps of rushes (Juncus spp.). Although males courted on this field in 1978, no woodcock were observed using it as a roosting site during the following summer.

The second area used by woodcock as a night roosting site was a 0.2 ha field planted to corn (Zea mays). The field had been planted only recently before woodcock began using it and the only vegetative cover was 20 cm tall corn. Woodcock abandoned this field completely after about 2 weeks, likely because the increasing height and density of the corn made the field unattractive. This same period was extremely dry and it is possible that decreased soil moisture also may have made the field less useful.

Few data are available on the types of openings used at night in the Southeast, although nocturnal use of fields continues during migration and throughout the winter (Owen, 1977). Glasgow (1958) stated that fields containing protective overhead cover interspersed with small patches of short, sparse vegetation were utilized by woodcock in Louisiana. Extensive use was made of pastures, fallow fields, and cropland devoted to the production of cotton (Gossypium hirsutum), corn, or sugar cane (Saccharum officinarum).

Singing Grounds

Woodcock in Tennessee utilized areas for singing grounds that are similar to those described from other parts of the range. Old fields in early succession, but with some woody cover, seemed to be preferred although males were observed performing from such diverse sites as cultivated fields, closely cropped pastures, dirt roads, pine plantations, and highway and power line rights-of-way.

Size. Sizes of 34 singing grounds measured during the study ranged from fields smaller than 0.1 ha to large clearcuts of several hundred hectares (Table 6).

Several researchers (Mendall and Aldous, 1943; Sheldon, 1967; Liscinsky, 1972; and Whitcomb, 1974) found the range of sizes and shapes of singing grounds is virtually unlimited. Given the wide range in sizes of singing grounds that male woodcock utilized during this study, the same seems to be true in Tennessee. There was no apparent preference for singing grounds of a particular size as both very small (<0.1 ha)

and very large (>4.0 ha) areas were used throughout both breeding seasons. Woodcock that used large open pastures as singing grounds frequently landed near field edges or clumps of permanent cover.

Table 6. Size of singing grounds located in Tennessee during 1977 and 1978.

| Size (ha) | No. | Percent |
|-----------|----------|-------------|
| <0.1 | 3 | 8.8 |
| 0.1-0.4 | 10 | 29.4 |
| 0.5-1.0 | 4 | 11.8 |
| 1.0-4.0 | 11 | 32.4 |
| >4.0 | <u>6</u> | <u>17.6</u> |
| Total | 34 | -- |

Distance to diurnal cover. Most singing grounds were less than 50 m from diurnal cover (Table 7). Results are similar to those of Mendall and Aldous (1943), who reported that 25 of 29 singing grounds in Maine were located less than 91.4 m from diurnal cover, and Sheldon (1967), who found that 89 percent of 55 singing grounds in Massachusetts were less than 182.8 m from diurnal territories.

Table 7. Distance from diurnal cover to singing grounds located in Tennessee during 1977 and 1978.

| Distance (m) | No. | Percent |
|--------------|----------|-------------|
| 0-50 | 23 | 50.0 |
| 50-100 | 10 | 21.7 |
| 100-200 | 8 | 17.4 |
| 200-400 | <u>5</u> | <u>10.9</u> |
| Total | 46 | -- |

Vegetation. Broomsedge (Andropogon virginicus), various grasses, honeysuckle, blackberry, eastern red cedar (Juniperous virginiana), ragweed, goldenrod, and various young pines and hardwoods were common on many of the singing grounds located during this study. Early succession old fields with their associated vegetation seemed to be preferred by male woodcock. Cedars invade many old fields and these areas were frequently used as singing grounds. Young pine plantations, when near diurnal cover, were also readily utilized by courting woodcock.

Evidence indicated that the species composition of vegetation on a singing ground may not be a significant factor in influencing its use by male woodcock. Wishart and Bider (1976) compared plant checklists of singing grounds in southwestern Quebec with those from other areas (Studholme and Norris, 1942; Sheldon, 1967) and concluded that taxonomic composition of a field is not critical to its use. Blankenship (1957) stated that the most important vegetational characteristics on a singing ground seemed to be that plant succession on the openings was in the early woody or low shrubby stage. The kinds of woody plants and herbs, except those that might indicate soil type or moisture content, seemed to be of little importance.

No quantitative analysis of the vegetative characteristics of singing grounds was conducted during this study, but observations suggested that the same holds true in Tennessee. The structure of cover present in the opening may be more important than the vegetation itself. Fields with scattered shrubs or brush were utilized when available, but woodcock frequently utilized pastures and cultivated fields without any

woody cover. Maxfield (1961, in Wishart and Bider, 1976) and Liscinsky (1972) likewise found that clearings without woody cover commonly were used as singing grounds. However, Mendall and Aldous (1943) and Sheldon (1967) stated that fields with shrubs were preferred, while Wishart and Bider (1976) noted that woody vegetation was a requirement for utilization by male woodcock.

Nest and Brood Habitat

Seven nests and 11 broods were located during 1977 and 1978. Of this total, one nest and 6 broods were found by cooperators; site characteristics for these were not available. All broods observed were less than 2 weeks old.

Nest cover. Five of the 6 nests that were observed were in young stands of second growth hardwoods, while one was located in the center of an old field overgrown with ragweed, broomsedge, and goldenrod. All nests were less than 50 m from openings that were used as singing fields by male woodcock. Five nests were at the base of a small tree; one was next to a large clump of broomsedge.

The nests were similar to those described in Sheldon (1967). Ground cover in the immediate vicinity varied from nest to nest although leaf litter, hardwood sprouts, and honeysuckle vines were present on most sites.

Many researchers have described woodcock nesting cover in the northern parts of the range (Mendall and Aldous, 1943; Sheldon, 1967; and Gregg, 1974, among others). Young to middle age second growth

hardwoods are generally preferred, although nests have been found in a variety of sites. Causey et al. (1974) found 7 nests in Alabama, all located in relatively open woods near a forest opening or field and near a small stream.

Brood cover. Three of the 5 broods located during 1978 were in young mixed stands of second growth hardwoods and conifers. One of these broods was in moderately open woods with little understory or ground cover, while 2 were in dense honeysuckle thickets.

The other 2 broods were in more open areas. One was located in an old overgrown fencerow that separated 2 idle fields, while the other was in a recently cleared field with slash scattered on the ground.

Distance to the nearest singing ground ranged from 70 m to 180 m. All 5 broods were less than 150 m from streams; 4 were closer than 50 m.

Mendall and Aldous (1943) stated that brood cover does not differ materially from that used in nesting. Observations during this study suggested that this may not be the case in Tennessee, as several of the broods were in cover that was much denser than where most nests were located.

Although certain parameters were observed to be similar to those in other parts of the range, the small number of nests and broods observed during this study precluded making definite assumptions about nesting and brood cover in Tennessee.

CHAPTER V

SUMMARY

Objectives of this study were to: (1) delineate the seasonal and geographic distribution of the woodcock population in Tennessee, (2) define the chronology and extent of breeding that occurs in the state with particular emphasis on the extent of breeding occurring in February, and (3) gain additional information about the biology and status of woodcock populations in Tennessee.

TOS and TWRA records, a special woodcock hunter survey conducted in 1974, and harvest data from this study, were all used to determine the seasonal and geographic distribution of woodcock in Tennessee. These data indicated that woodcock are widely distributed over the state, but are most common during fall and spring in the Great Valley, portions of the Cumberland Plateau, the Central Basin, and throughout western Tennessee. Woodcock remain in Tennessee throughout some winters, but during both years of this study subfreezing temperatures during January and early February forced most woodcock to emigrate from the state. Although no field studies were conducted to determine the status of woodcock in Tennessee from early summer through early fall, observations indicate that the population is distributed as in other seasons and changes little from post-breeding levels in the spring. Thus, the Tennessee woodcock population consists of spring and fall migrants and birds that are permanent residents, except for periods during especially severe winters.

Fall migration dates for Tennessee were determined from results of the annual USFWS wing survey, the 1974 woodcock hunter survey, and extrapolation of migration data from other states. During most years, woodcock depart the northern states in October or early November, but since fall migration is influenced by freezing temperatures, the average dates vary from year to year. USFWS harvest records indicate that woodcock are most numerous in Tennessee the last 20 days of November. The 1974 harvest based on a woodcock hunter survey showed that woodcock were abundant in Tennessee from mid-October through November, but weather records suggested that migration may have occurred several weeks earlier than normal. Arrival records from Georgia and Louisiana further support a mid- to late-November peak migration through Tennessee.

Harvest data collected during the 1977 and 1978 February hunting seasons, hunter reports, observations of male woodcock on the singing grounds, and migration records from other states were used to document the chronology of spring migration through Tennessee. Hunter reports, harvest data, and observations of singing male woodcock all showed that spring migration through Tennessee during both 1977 and 1978 began during mid-February. Ninety-one percent of the harvest occurred during the last week of February in 1977; 68 percent during the same period in 1978. The federal wing survey indicated a similar chronology. Using the number of singing males as an indicator of abundance, peak migration during both years occurred about the first week in March, with numbers declining sharply after mid-March.

Since both years of the study were characterized by abnormally severe weather during January and February, and dates for other southern states indicate a somewhat earlier migration, the chronology observed during the 2 years of this study may not be representative of normal years.

Several of the main migration routes postulated by various researchers pass through Tennessee. Harvest data, hunter reports, and observations of singing males suggest that most woodcock move through the eastern and central parts of Tennessee by way of the Great Valley and the Central Basin, while the movement through western Tennessee is rather widespread.

A total of 160 woodcock was examined during the study to determine their state of reproductive development. Testis measurements of the February-shot males averages 9.2 mm, indicating that males come into breeding condition at least by mid-February. Since no birds were collected during January or early February, it was not determined when reproductive maturation began.

Measurements of ovarian follicles showed that the degree of sexual maturation varied widely among females. Assuming that follicular development accelerates once a diameter of 4 mm is reached, then 44 percent of the females collected during February 1977 and 52 percent of the females collected during February 1978 would have begun nesting in a short time.

A perusal of the literature suggested that peak nesting in Tennessee occurs from early to mid-March. During this study most clutches were

initiated during the second and third weeks in March. The presence of eggs in February-shot females and nesting records from other states suggest that during mild winters nesting in Tennessee may begin as early as mid-February.

The length of the breeding season in Tennessee is not well documented in the literature. Males have been observed performing courtship flights in November, December, and January, but it is unlikely that these early courtship flights result in copulation and nesting. During both years of this study, spring courtship activity began immediately upon arrival from the wintering grounds (mid-February) and lasted until late May. It is not known whether this late activity results in appreciable breeding since the latest clutch observed in Tennessee was 27 April.

Woodcock breeding activity is influenced by a variety of environmental factors. Male woodcock were observed performing courtship flights in temperatures ranging from 3°C to 23°C. As frequently reported in the literature, temperatures of about 0°C adversely affected courtship activity. High temperatures did not noticeably suppress breeding activity.

During the 1978 breeding season, male woodcock began evening courtship when the mean light intensity dropped to 3.2 foot candles. Courtship activity began an average of 12.6 minutes after official sunset. The mean light intensity at the time of the first courtship flight was 0.86 foot candles. Courtship performances averaged 26.5 minutes in length.

Diurnal coverts in Tennessee were generally found in areas with poorly drained, fertile soils. Vegetation consisted of young stands of second growth hardwoods characterized by hackberry, boxelder, red maple, sweet gum, sycamore, willow, alder, and others. Common understory species included blackberry, honeysuckle, greenbriar, privet, and switch cane. During migration woodcock commonly used dry upland sites as well as more typical coverts.

Woodcock were observed making crepuscular flights from diurnal coverts to open fields used as roosting sites. Only 2 summer fields were located. One was an old field overgrown with weeds; the other was a freshly planted corn field.

Male woodcock utilized areas for singing grounds in Tennessee that are similar to those in other parts of the range. Old fields in an early successional stage seemed to be preferred but a variety of sites were used. Singing grounds ranged in size from 0.1 ha to several hundred ha. Fifty percent of the singing grounds located were less than 50 m from diurnal cover. Vegetation on singing grounds varied considerably, but broomsedge, various other grasses, honeysuckle, blackberry, eastern red cedar, ragweed, goldenrod, and various young pines and hardwoods were common on many sites. Although fields with woody vegetation seemed to be preferred, male woodcock frequently courted from pastures, cultivated fields, and other areas with little woody cover.

Most nests were located in young stands of second growth hardwoods. All nests were less than 50 m from singing grounds. Nest construction was similar to that described from other parts of the range. Vegetational

characteristics of brood cover varied somewhat, but 4 of 5 broods were located in dense stands of honeysuckle. Distance to the nearest singing ground ranged from 70 m to 180 m. Four broods were less than 50 m from streams.

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APPENDIX

TENNESSEE WOODCOCK INVESTIGATION

Singing Ground Survey

Cooperator's name:
address:

Instructions

- (1) Fill out one (1) sheet for each singing ground that you know is currently being used by courting woodcock, or has been used in recent years (since 1974).
- (2) Return the completed form(s) via the enclosed envelope.
- (3) All comments will be gratefully received. Use back of form.

Location of singing ground

County: _____ Nearest town or community: _____

Name of area or farmstead (if known): _____

Owner: _____

Distance and directions from nearest point of reference
(Example: 200 yards North of Grassy Creek Ridge, West of Highway 49): _____

Habitat description (check as appropriate)

Type

- Agricultural crop land
 Hay field or pasture
 Fallow
 Old field
 Forest opening
 Other (please specify) _____

Ground cover

- None
 Grassy
 Brushy
 Other (please specify) _____

Number of additional survey forms needed _____.

Number of additional envelopes needed _____.

Thanks for Your Contribution

Table 8. Regional distribution of woodcock collected during the 1976-77 and 1977-78 hunting seasons.

| | No. | Percent Harvest | | |
|---------|-----------|-------------------|-------------------|-------------------|
| | | Western Tennessee | Central Tennessee | Eastern Tennessee |
| 1976-77 | 60 | 36.7 | 56.7 | 6.6 |
| 1977-78 | <u>96</u> | <u>35.4</u> | <u>34.4</u> | <u>30.2</u> |
| Total | 156 | -- | -- | -- |

Table 9. Light intensity at the initiation of 34 evening courtship (first peent) performances during the 1978 breeding season in Tennessee.

| Date | Light Intensity (Foot Candles) | Date | Light Intensity (Foot Candles) |
|------|-----------------------------------|------|-----------------------------------|
| 3-3 | 4.0 | 4-11 | 1.8 |
| 3-4 | 0.5 | 4-13 | 8.0 |
| 3-5 | 0.6 | 4-13 | 2.4 |
| 3-6 | 3.8 | 4-14 | 0.9 |
| 3-7 | 5.0 | 4-15 | 5.0 |
| 3-11 | 1.0 | 4-15 | 1.8 |
| 3-12 | 2.0 | 4-17 | 8.0 |
| 3-13 | 4.2 | 4-19 | 3.7 |
| 3-15 | 3.6 | 4-20 | 2.0 |
| 3-19 | 1.8 | 4-20 | 7.9 |
| 3-21 | 10.0 | 4-21 | 3.2 |
| 3-23 | 0.4 | 4-22 | 0.8 |
| 3-25 | 1.0 | 4-24 | 2.5 |
| 3-27 | 2.0 | 4-25 | 1.8 |
| 4-3 | 1.8 | 5-1 | 9.7 |
| 4-9 | 1.8 | 5-1 | 6.0 |
| 4-10 | 0.8 | 5-5 | 2.3 |

Mean \pm SE

3.2 \pm 2.62

Table 10. Light intensity at the time of first courtship flight for 23 performances during the 1978 breeding season in Tennessee.

| Date | Light Intensity (Foot Candles) | Date | Light Intensity (Foot Candles) |
|------|-----------------------------------|------|-----------------------------------|
| 2-19 | 0.8 | 4-19 | 0.7 |
| 3-3 | 1.5 | 4-20 | 0.5 |
| 3-6 | 0.4 | 4-21 | 1.2 |
| 3-7 | 0.6 | 4-22 | 0.4 |
| 3-19 | 0.6 | 4-24 | 0.3 |
| 3027 | 1.0 | 4-25 | 0.6 |
| 4-3 | 0.6 | 5-1 | 0.7 |
| 4-10 | 0.3 | 5-5 | 2.0 |
| 4-11 | 0.7 | 5-10 | 1.8 |
| 4-13 | 0.4 | 5-11 | 2.8 |
| 4-15 | 0.6 | 5-13 | 0.4 |
| 4-17 | 0.8 | | |

Mean \pm SE

0.86 \pm 0.62

Table 11. Duration of 20 courtship performances of male woodcock in Tennessee during 1978.

| Date | Starting Time | Completion Time | Duration (minutes) |
|------|---------------|-----------------|--------------------|
| 3-6 | 6:47 | 7:15 | 28 |
| 3-10 | 6:53 | 7:17 | 24 |
| 3-11 | 6:59 | 7:16 | 17 |
| 3-21 | 6:54 | 7:26 | 32 |
| 3-23 | 7:15 | 7:30 | 15 |
| 3-27 | 7:03 | 7:27 | 24 |
| 4-3 | 7:11 | 7:40 | 29 |
| 4-9 | 7:20 | 7:49 | 29 |
| 4-10 | 7:21 | 7:41 | 20 |
| 4-11 | 7:20 | 7:45 | 25 |
| 4-13 | 7:22 | 7:53 | 31 |
| 4-14 | 7:31 | 7:51 | 20 |
| 4-17 | 7:13 | 7:52 | 39 |
| 4-19 | 7:14 | 8:00 | 46 |
| 4-20 | 7:29 | 7:58 | 29 |
| 4-22 | 7:36 | 7:47 | 11 |
| 4-24 | 7:19 | 7:44 | 25 |
| 4-25 | 7:22 | 7:47 | 25 |
| 5-1 | 8:30 (DST)* | 9:01 | 31 |
| 5-5 | 8:43 | 9:16 | 33 |

*DST = Daylight Savings Time

Mean \pm SE

26.5 \pm 8.0

Table 12. Woodcock nest observations in Tennessee (1920 to 1975).¹

| Date Found | County | Clutch Size | Comments |
|--------------------|------------|-------------|----------------------------------|
| 3-10-37 | | 4 | Still nesting on 3-21-37 |
| 3-10-75 | McMinn | 2 | |
| 3-12-22 | Davidson | 4 | Just started incubating |
| 3-15-22 | Davidson | 4 | Incubated about 2 days |
| 3-15-31 | Davidson | 4 | Fresh |
| 3-18-37 | | 4 | |
| 3-22-71 | Coffee | 4 | |
| 3-29-33 | Hardin | 3 | Hatching date |
| 3-29-71 | Sullivan | 3 | |
| 3-31-38 | Rutherford | | |
| 4- 2-65 | Hardin | 4 | |
| 4- 3-40 | Rutherford | 3 | |
| 4-11 or 4-15-20 | | 2 | Nesting began on 3-21 or 3-25 |
| 4-15-30 | Davidson | 4 | Heavily incubated |
| 4-27-31 | Knox | 4 | |

¹Data taken from The Migrant, Pettingill (1936), and personal records of H. C. Monk, M. Williams, and W. Coffey.

Table 13. Woodcock brood observations in Tennessee (1917 to 1975).¹

| Date Found | County | Number of Chicks | Comments |
|------------|------------|------------------|---------------------|
| 3-25-75 | Roane | 4 | |
| 3-27-65 | | 3 | Downy chicks |
| 3-28-71 | Davidson | 3 | Half-grown |
| 3-30-30 | Davidson | 1 | About 1 week old |
| 4- ?-75 | | 4 | |
| 4- ? 64 | Hardin | 4 | |
| 4- 6-70 | Knox | 4 | Downy chicks |
| 4-15-67 | Knox | 1 | Downy chick |
| 4-16-20 | Davidson | 2 | |
| 4-18-70 | Campbell | 1 | Very young chick |
| 4-18-64 | Johnson | 3 | Non-flying young |
| 4-21-17 | Davidson | 1 | |
| 4-22-50 | Knox | 1 | |
| 4-25-20 | Davidson | 2 | |
| 4-25-21 | Knox | 1 | Several weeks old |
| 4-29-68 | Sullivan | 3 | |
| 5- 7-70 | Sullivan | 2 | |
| 5-10-75 | Roane | 3 | |
| 5-26-73 | | 2 | |
| 6- 4-34 | Washington | 2 | Three-fourths grown |

¹Data taken from The Migrant, Pettingill (1936), and personal records of H. C. Monk, M. Williams, and W. Coffey.

Table 14. Sex and age characteristics of 151 woodcock harvested in Tennessee (1976-1978).

| Hunting Season | N | Males | | Females | |
|----------------|-----------|-------------------|----------------------|-------------------|----------------------|
| | | Adults No. (%) | Juveniles No. (%) | Adults No. (%) | Juveniles No. (%) |
| 1976-77 | 53 | 8 (15.1) | 20 (37.7) | 9 (17.0) | 16 (30.2) |
| 1977-78 | <u>98</u> | <u>35 (35.7)</u> | <u>32 (32.7)</u> | <u>20 (20.4)</u> | <u>11 (11.2)</u> |
| Total | 151 | 43 (28.5) | 52 (34.4) | 29 (19.2) | 27 (17.9) |

Table 15. Sex and age characteristics of woodcock harvested in Tennessee (1965-1978).¹

| Hunting Season | N | Males | | | | Females | | | |
|----------------|-----------|----------|---------------|-----------|---------------|----------|---------------|-----------|---------------|
| | | Adults | | Juveniles | | Adults | | Juveniles | |
| | | No. | (%) | No. | (%) | No. | (%) | No. | (%) |
| 1965-66 | 5 | 1 | (20.0) | 2 | (40.0) | 1 | (20.0) | 1 | (20.0) |
| 1966-67 | 2 | 2 | (100.0) | 0 | | 0 | | 0 | |
| 1967-68 | 2 | 1 | (50.0) | 0 | | 0 | | 1 | (50.0) |
| 1968-69 | 35 | 12 | (34.3) | 10 | (28.6) | 9 | (25.7) | 4 | (11.4) |
| 1969-70 | 49 | 14 | (28.6) | 9 | (18.3) | 17 | (34.7) | 9 | (18.4) |
| 1970-71 | 22 | 4 | (18.2) | 9 | (40.9) | 5 | (22.7) | 4 | (18.2) |
| 1971-72 | 55 | 9 | (16.4) | 19 | (34.5) | 17 | (30.9) | 10 | (18.2) |
| 1972-73 | 14 | 3 | (21.4) | 5 | (35.7) | 2 | (14.3) | 4 | (28.6) |
| 1973-74 | 25 | 13 | (52.0) | 5 | (20.0) | 6 | (24.0) | 1 | (4.0) |
| 1974-75 | 4 | 1 | (25.0) | 0 | | 3 | (75.0) | 0 | |
| 1975-76 | 86 | 22 | (25.6) | 22 | (25.6) | 22 | (25.6) | 20 | (23.2) |
| 1976-77 | 85 | 18 | (21.2) | 31 | (36.4) | 23 | (27.1) | 13 | (15.3) |
| 1977-78 | <u>50</u> | <u>9</u> | <u>(18.0)</u> | <u>20</u> | <u>(40.0)</u> | <u>9</u> | <u>(18.0)</u> | <u>12</u> | <u>(24.0)</u> |
| Total | 434 | 109 | (25.1) | 132 | (20.3) | 114 | (26.3) | 79 | (18.2) |

¹Data from U.S. Fish and Wildlife Service Wing Surveys. Birds of unknown age or sex were omitted.

Table 16. Average body weights by sex and age class of 117 woodcock harvested in Tennessee (1976-78).

| Year | Males | | | | Females | | | |
|---------|--------|--------------|-----------|--------------|---------|--------------|-----------|--------------|
| | Adults | | Juveniles | | Adults | | Juveniles | |
| | No. | Weight(g) | No. | Weight(g) | No. | Weight(g) | No. | Weight(g) |
| 1976-77 | 7 | 145.5 | 19 | 146.2 | 9 | 204.3 | 16 | 189.8 |
| 1977-78 | 26 | <u>140.4</u> | 19 | <u>140.7</u> | 13 | <u>192.0</u> | 8 | <u>190.5</u> |
| Mean | | 141.5 | | 143.5 | | 197.0 | | 190.0 |

Table 17. Body weight and percentage body fat of 10 woodcock collected in Tennessee (1977-78).

| Date Collected | Sex | Age | Body Weight (g) | Percent Fat |
|----------------|--------|----------|-----------------|-------------|
| 2-23-78 | Male | Adult | 141 | 17.9 |
| 2-24-78 | Female | Adult | 175 | 17.4 |
| 2-25-78 | Female | Adult | 194 | 20.9 |
| 2-26-78 | Female | Juvenile | 179 | 17.8 |
| 2-26-78 | Male | Adult | 143 | 13.9 |
| 2-27-78 | Male | Juvenile | 149 | 23.6 |
| 2-28-78 | Male | Juvenile | 133 | 16.8 |
| 3-13-78 | Female | Juvenile | 204 | 27.7 |
| 3-13-78 | Female | Adult | 198 | 26.7 |
| 3-13-78 | Male | Juvenile | 136 | 25.4 |

VITA

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