# ABSTRACT

BLACKMAN, EMILY BATEY. American Woodcock Winter Habitat Use in an Agricultural Landscape. (Under the direction of Christopher S. DePerno and M. Nils Peterson).

Since the 1960s, American Woodcock (*Scolopax minor*) have undergone population declines, largely due to the loss of early-successional habitat. Research from the 1970s-80s documented wintering woodcock use of conventionally-tilled soybean fields at night. The ridge and furrow topography in the fields provided critical cover as birds foraged on earthworms. However, the use of no-till technology has increased and many fields now lack ridge and furrow topography. We assessed woodcock winter nocturnal foraging habitat use given recent changes in agricultural technology, and investigated how crop type, earthworm abundance, and environmental variables affect the selection of nocturnal foraging sites. We counted woodcock in five crop types twice in each of 67 fields during December-March 2008-09 and 72 fields during December-March 2009-10. During both seasons, we collected earthworm and soil samples from a subset of fields of each crop type. We recorded higher woodcock densities in no-till soybean fields planted after corn and in undisked corn fields with mowed stalks than in other crop types. No-till soybean planted after corn and undisked corn fields contained ridge and furrow topography, while other crops did not, and no-till soybean fields had a higher abundance of earthworms than other crop types. Ridges and furrows in no-till soybean fields planted after corn and undisked corn fields may provide wintering woodcock with thermal protection and concealment from predators. Farmers can provide nocturnal winter foraging sites for woodcock by delaying field disking and leaving ridge and furrow topography in crop fields.

Past woodcock research in North Carolina reported woodcock foraging in soybean fields, but did not address the frequency of field use. We returned to the same study area to determine the frequency of woodcock crop field use, and used radio-telemetry to compare woodcock use of crop fields and bottomland forests. We recorded 93% of nocturnal locations in forest (*n* = 180), 7% of nocturnal locations in crop fields (*n* = 14), and 100% of diurnal locations in forest (*n* = 215 relocations). Although woodcock occasionally foraged in crop fields, birds primarily used bottomland forests diurnally and nocturnally. Forest patches are important foraging and roosting sites for wintering woodcock and should be conserved in agricultural landscapes.

The primary food source of woodcock on their wintering grounds is earthworms, but few studies have identified the earthworm species available. Previous wintering woodcock research in North Carolina reported that 99% of earthworms consumed by woodcock were *Apporectodea* or *Diplocardia* spp. Today, most farmers have switched to no-till agriculture, which may have affected the diversity of earthworms available to woodcock. During February 2009 and February-March 2010, we collected 2102 earthworms and identified 13 species, 81.3% of which were *Apporectodea* or *Diplocardia* spp. The species richness of earthworms in our sample compared to prior research suggests the conversion from conventional-tillage to no-till agricultural practices may have increased earthworm species richness on woodcock foraging grounds.

The potential for migratory bird species to transfer pathogenic strains of avian influenza to the Americas has created international concern over monitoring efforts. Avian influenza has been isolated in multiple migratory shorebird species, and those that spend time in agricultural areas are more likely to share the virus with poultry. Thirty nine woodcock

were tested during February 2009 and December-March 2009-10 for Type A avian influenza virus; all tests were negative. To our knowledge, this is the first study to evaluate woodcock for avian influenza.

# American Woodcock Winter Habitat Use in an Agricultural Landscape

by
Emily Batey Blackman

A thesis submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements for the degree of
Master of Science

Fisheries, Wildlife, and Conservation Biology

Raleigh, North Carolina

2011

APPROVED BY:

Christopher S. DePerno
Committee Co-Chair

M. Nils Peterson
Committee Co-Chair

Christopher E. Moorman

Ron W. Heiniger

# DEDICATION

I owe any writing ability I possess to my mother, Sue Anne Batey Blackman. She was an editor, writer and researcher by profession, and read every paper I wrote from grade school through college. She encouraged me in everything, including the pursuit of a career in wildlife conservation. I dedicate this work to her; she passed away in 2007.

# BIOGRAPHY

Emily Batey Blackman is a native of Princeton, NJ, where she was born on November 11, 1984. She grew up with a love of wildlife and being outdoors that led her to study animal behavior as an undergraduate at Bucknell University in Lewisburg, PA. During her undergraduate work she gained experience working with squirrel monkeys, spotted swordtails, manatees and little brown bats. An internship with the U.S. Fish and Wildlife Service introduced her professionally to birds and led her into the American Woodcock project at NC State University. She plans to pursue a career in wildlife conservation and is especially interested in habitat preservation. When not working on something wildlife-related, she enjoys running, hiking, singing and traveling. Her recent adventures have taken her to Ireland, Israel, Belize, India, Nepal, Laos and Thailand.

# ACKNOWLEDGMENTS

My family and friends have supported me and kept me sane- I especially want to thank my father Martin Blackman, my cousin Ellen Gertel and my aunt Cindy Batey. Thank you to my fellow graduate students for endless discussions about class work and writing, for helping with field work and for all those discussions that had nothing to do with our graduate projects. Many people contributed directly to the successful completion of this project. Thank you to my field technicians: Jessica Stocking, Corey Shake and Corinne Diggins, for chasing woodcock, jumping ditches, wading through mud and digging up earthworms. Thank you to the many NC State students and professors who came out to help catch woodcock. Thank you to John Connors, Phil Doerr and Clyde Sorenson for sharing woodcock catching memories and advice. Thank you to David Krementz, Dan McAuley, Mike Olinde and David Anderson for sharing woodcock field advice. Thank you to Ted Simons, Josh Heitman, Dick Lancia, Mac Gibbs, David Ley, Becky Desjardins, and John Gerwin for equipment and advice. Thank you to John Reynolds for earthworm identification and manuscript review. Thank you to Matthew Krachey for statistical assistance. My study site was completely on private property- I greatly appreciate the hospitality of all the landowners near Lake Mattamuskeet in Hyde County, NC, who graciously allowed people with headlamps and fishing nets on their land in the middle of the night. I especially want to thank Kelly Davis and family for their assistance and kindness. A big thank you to Cindy Burke and Sarah Slover: no one would make it to graduation without your patience and administrative assistance. Finally, thank you to my committee: Chris DePerno, Chris

Moorman, Nils Peterson and Ron Heiniger, for endless meetings, editing, and advice throughout my 2+ years at NC State.  This research was made possible by funding from the U.S. Fish and Wildlife Service Webless Migratory Game Bird Research Program and the Fisheries, Wildlife, and Conservation Biology Program at North Carolina State University.

# TABLE OF CONTENTS

LIST OF TABLES……………………………………………………………….......viii

LIST OF FIGURES …………………………………………………….....................x

EFFECTS OF CROP FIELD CHARACTERISTICS ON NOCTURNAL WINTER USE BY AMERICAN WOODCOCK ……………………………………...1

Abstract ……………………………………………………………………...1
Introduction………………………………………………………………….2
Study Area……………………………………………………………….....4
Methods………………………………………………………………………5
*Woodcock Surveys*…………………………………………………………5
*Environmental Variables*……………………………………………..…6
*Statistical Analyses*..…………………………………………..…......7
Results…...…………………………………………………………………...7
*Woodcock Surveys*…………………………………………………………7
*Environmental Variables*………………………………………....…..8
Discussion……………………………………………………………….......8
Management Implications ……………………………………………………10
Literature Cited ……………………………………………………………11

USE OF CROP FIELDS AND FOREST BY WINTERING AMERICAN WOODCOCK…………………………………………………………………………22

Abstract………………………………………………………………………..22
Introduction……………………………………………………………………22
Study Area……………………………………………………………………..23
Methods………………………………………………………………………..24
*Woodcock Captures, Banding, and Radio-transmitter Attachment*……..24
*Telemetry*……………………………………………………………………24
Results…………………………………………………………………………25
Discussion……………………………………………………………………..26
Literature Cited………………………………………………………………..28

EARTHWORM SPECIES AVAILABLE TO AMERICAN WOODCOCK ON THE WINTERING GROUNDS IN EASTERN NORTH CAROLINA ……………34

Abstract………………………………………………………………………..34
Introduction……………………………………………………………………34
Study Area……………………………………………………………………..36
Methods………..………………………………………………………………36
Results and Discussion………………………………………………………...37

Literature Cited……………………………………………………………..………39

AVIAN INFLUENZA TESTING OF AMERICAN WOODCOCK IN AN AGRICULTURAL LANDSCAPE……………………………………………………45
Abstract……………………………………………………………………..45
Introduction…………………………………………………………………45
Study Area and Methods……………………………………………………47
Results and Discussion……………………………………………………...48
Literature Cited……………………………………………………………..50

# LIST OF TABLES

EFFECTS OF CROP FIELD CHARACTERISTICS ON NOCTURNAL WINTER USE BY AMERICAN WOODCOCK

Table 1. Bayesian complete likelihood density model comparison of constant detection probability ({$p_{\text{single}}$}) versus variable detection probability based on crop type ({$p_{\text{variable}}$}) from American Woodcock surveys in Hyde County, North Carolina, USA, 2008-2010 ……………………………………………19

Table 2. American Woodcock per ha by crop type from Bayesian complete likelihood density model, Hyde County, North Carolina, USA, 2008-2010. Standard deviation (SD), 2.5% (Q.025) and 97.5% (Q.975) quartiles are shown. Crop types with different letters had different woodcock densities based on quartile separation. …………………………………………………….............20

Table 3. Mean soil pH, percent organic matter (OM), nitrate content ($NO_3$) (kg/ha), percent moisture (M), and temperature (T) (°C) per 0.5-$m^2$ sample plot, and row width (RW) (cm) and ridge height (RH) (cm) with standard errors (SE) by crop type, Hyde County, North Carolina, USA, 2008-2010. Different letters within columns indicate differences ($P < 0.05$) among crop types ………………………………………………………...21

USE OF CROP FIELDS AND FOREST BY WINTERING AMERICAN WOODCOCK

Table 1. Number of diurnal and nocturnal relocations per woodcock in crop fields and bottomland forest, Hyde County, North Carolina, December 2009-March 2010. No diurnal relocations were in fields……………………………...33

# LIST OF FIGURES

EFFECTS OF CROP FIELD CHARACTERISTICS ON NOCTURNAL WINTER USE BY AMERICAN WOODCOCK

Figure 1. Study area near Lake Mattamuskeet National Wildlife Refuge and New Holland in Hyde County, North Carolina, USA, 2008-2010 ……………17

Figure 2. Average number of earthworms collected per 0.5-$m^2$ plot by crop type (+SE) in Hyde County, North Carolina, USA, 2009-2010. Crop types with different letters had different numbers of earthworms …………………………….18

USE OF CROP FIELDS AND FOREST BY WINTERING AMERICAN WOODCOCK

Figure 1. Study area in Hyde County, North Carolina (35° 26’ 36.61’’ N, 76° 10’ 10.46’’ W), December 2009-March 2010. We caught woodcock in crop fields south of and adjacent to US-264. We relocated woodcock in bottomland forests south of Lake Mattamuskeet National Wildlife Refuge and in the crop fields……………………………………………………………...31

Figure 2. Relocations for an individual woodcock in Hyde County, North Carolina, December 2009-March 2010………………..…………………………...32

EARTHWORM SPECIES AVAILABLE TO AMERICAN WOODCOCK ON THE WINTERING GROUNDS IN EASTERN NORTH CAROLINA

Figure 1. Study site near New Holland in eastern North Carolina, 2009-2010. Woodcock nocturnal foraging habitat included crop fields south of Lake Mattamuskeet National Wildlife Refuge and US-264.…………………...44

## Effects of Crop Field Characteristics on Nocturnal Winter Use by American Woodcock

### Abstract

Since the late 1960s, American Woodcock (*Scolopax minor*) have undergone population declines due to habitat loss. Previous research suggested ridge and furrow topography in conventionally-tilled soybean fields provided critical cover as birds foraged on earthworms. However, the use of no-till technology has increased and many fields now lack ridge and furrow topography. We assessed woodcock winter nocturnal foraging habitat use given recent changes in agricultural technology, and investigated how crop type, earthworm abundance, and environmental variables affect the selection of nocturnal foraging sites. We counted woodcock along transects in five crop types twice in each of 67 fields during December-March 2008-09 and 72 fields during December-March 2009-10. During both seasons, we collected earthworm and soil samples from a subset of fields of each crop type. We recorded higher woodcock densities in no-till soybean fields planted after corn and in undisked corn fields with mowed stalks than in other crop types. No-till soybean planted after corn and undisked corn fields contained ridge and furrow topography, while other crops did not, and no-till soybean fields had a higher abundance of earthworms than other crop types. Ridges and furrows in no-till soybean fields planted after corn and undisked corn fields may provide wintering woodcock with thermal protection and concealment from predators. No-till soybean fields planted after corn offered the additional benefit of relatively high food availability. The presence of ridge and furrow topography can be used to predict woodcock field use on the wintering grounds in agricultural areas. Farmers can provide

nocturnal winter foraging sites for woodcock by delaying field disking and leaving ridge and furrow topography in crop fields.

## Introduction

American Woodcock (*Scolopax minor*) (hereafter referred to as woodcock) are a species of conservation concern because of range-wide population declines, associated with a decrease in early-successional forest habitat (Dessecker and McAuley 2001, Cooper and Parker 2010). The loss of early-successional habitat has been documented in northeastern North America, where most woodcock breeding occurs, and in the Southeast where woodcock migrate for the winter (Thompson and DeGraaf 2001, Trani et al. 2001). Hence, woodcock are listed as a Species of High Concern by the U.S. Shorebird Conservation Plan (U.S. Shorebird Conservation Plan 2004), and a Game Bird Below Desired Condition by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 2004).

Woodcock habitat use changes seasonally and from night to day, and varies depending on geographic region. Across their range, woodcock use different nocturnal habitat types for roosting and foraging, including lightly grazed pastures (Glasgow 1958), bottomland hardwoods, young pine plantations, seed-tree harvests and fallow-old fields (Krementz et al. 1995, Berdeen and Krementz 1998), forest openings (Horton and Causey 1979), and fallow soybean and abandoned grass fields (Krementz et al. 1995). Most research has not evaluated woodcock use of crop fields because none were present in the study areas. However, during the 1970s and early 1980s, researchers in eastern North Carolina documented woodcock use of crop fields at night (Stamps and Doerr 1976, Connors and Doerr 1982, Stribling and Doerr 1985).

Results of the North Carolina studies indicated woodcock used conventionally-tilled soybean fields with ridge and furrow topography more than disked corn or winter wheat fields. Soybean fields were richer in organic matter and nitrogen than other field types and provided higher quality habitat for earthworms, the primary food item for woodcock across their range (Stribling and Doerr 1985). Soil between rows in soybean fields was warmer and easier to probe for earthworms than in other field types. Additionally, woodcock likely used the crop furrows for protection from winter weather and predators (Connors and Doerr 1982, Stribling and Doerr 1985). However, recent changes in agricultural practices associated with the adoption of no-till technology, including lack of bedding and narrower row spacing, may have altered nocturnal foraging habitat structure and changed woodcock behavior (Heiniger et al. 2000).

No-till, or conservation tillage, has become a popular alternative to conventional tillage because no-till technology reduces soil erosion, surface water runoff, and wind erosion, and increases carbon sequestration (Uri et al. 1999). Additionally, multiple studies have reported benefits to wildlife from no-till agriculture, especially increased crop residue on the soil surface that provides quality cover and food resources (Flickinger and Pendleton 1994, Lokemoen and Beiser 1997). Warburton and Klimstra (1984) recorded higher bird abundance and invertebrate diversity and abundance in no-till corn fields compared to conventionally-tilled corn fields. Small mammals were more abundant in no-till compared to tilled fields, due to quality cover from predators and increased food supply (Warburton and Klimstra 1984). Also, there is evidence that no-till agriculture provides better avian nesting habitat than conventional tillage because of reduced soil disturbance and chemical use

(Lokemoen and Beiser 1997, Martin and Forsyth 2003). Stribling and Doerr (1985) hypothesized that woodcock would use no-till soybean fields if they provided abundant earthworm prey and protection from winter weather.

We hypothesized that no-till fields would have higher earthworm abundance than tilled fields due to reduced soil disturbance (Smith et al. 2008). In addition to tillage, other soil factors (e.g., crop history, soil type, percent organic matter, temperature, moisture, and pH) can affect earthworm communities (Owen and Galbraith 1989, Kladivko et al. 1997). Reynolds et al. (1977) reported soil moisture and temperature as two of the most critical factors, and Owen and Galbraith (1989) reported soil pH as the best predictor of earthworm biomass.

Our objective was to determine winter nocturnal foraging habitat use by woodcock given recent changes in agricultural technology. Additionally, we investigated how crop type, earthworm abundance, and environmental variables (i.e., field structure, soil moisture and temperature, nitrate content, pH, and percent organic matter) affect the selection of nocturnal foraging sites.

## Study Area

We studied wintering woodcock from 2008-2010 in the same area woodcock were studied during the late 1970s and early 1980s (Stamps and Doerr 1976, Connors and Doerr 1982, Stribling and Doerr 1985). All fields were south of and bordering US-264 near New Holland and Lake Mattamuskeet National Wildlife Refuge in Hyde County, North Carolina (Fig. 1). Field size varied from 0.6 ha to 90.5 ha, with an average of 9.6 ha. In 2008-2009, crop types included no-till soybean planted after corn (*n* = 19), no-till soybean planted after wheat (*n* = 19), winter wheat (*n* = 14), disked corn (*n* = 9), and undisked corn with mowed stalks (*n* = 6). In 2009-2010, crop types included no-till soybean planted after wheat (*n* = 23), disked corn (*n* = 21), undisked corn with mowed stalks (*n* = 13), no-till soybean planted after corn (*n* = 8), and winter wheat (*n* = 7). Farmers rotated crops between years, and alternated between soybeans and corn, or among soybeans, corn, and winter wheat. Also, corn stalks were mowed after harvest and wheat was planted into corn fields that were disked flat in the fall. No-till soybean fields planted after corn had ridges and furrows from the previous corn crop, while no-till soybean fields planted after wheat lacked ridge and furrow topography due to disking when wheat was planted. Some farmers tilled ridges and furrows into fields to improve crop drainage and soil warming (Lilly 1981); the beds were then used for multiple seasons and fields were considered no-till after the first season. The local soil type was mainly a combination of Scuppernong muck, Hydeland silt loam, Gullrock muck, Engelhard loamy very fine sand, Fortesque silt loam, and Belhaven muck, and all soils were poorly drained (Soil Survey Staff, Natural Resources Conservation Service 2009).

## Methods

### *Woodcock Surveys*

We surveyed 67 fields twice from December-March 2008-09 and 72 fields twice from December-March 2009-10 by looking for woodcock eye shine using halogen bulb headlamps (Stribling and Doerr 1985). We conducted all surveys between dusk and midnight to coincide with peak nocturnal woodcock activity (Glasgow 1958, Stribling and Doerr 1985). Two observers each walked 400-m transects in every field to control for varying field size, and recorded the total number of woodcock seen and the distance from observer to bird

(Anderson et al. 1979). We used distance sampling to account for detection probability and surveyed in multiple crop types each night to control for variation in weather and moon phase (Glasgow 1958, Royle and Dorazio 2008).

### *Environmental Variables*

During February-March 2009 and January-March 2010, we collected soil and earthworm samples from all crop types: no-till soybean fields planted after corn (*n* = 11 fields for soil; *n* = 10 fields for worms), no-till soybean planted after wheat (*n* = 28; *n* = 30), disked corn (*n* = 8; *n* = 27), undisked corn with mowed stalks (*n* = 18; *n* = 19), and winter wheat (*n* = 8; *n* = 12). We collected earthworms and soil with hand-held shovels from six 0.5-$m^2$ plots in each field (Duriez et al. 2006). We spaced sample plots 15 m apart and oriented on a diagonal to assure that sampling was conducted across rows. We collected samples between rows when present, because woodcock were observed roosting and feeding between rows. We sampled to a depth of 7.5 cm, the depth that earthworms are available to probing woodcock (Stribling and Doerr 1985), and collected samples from dusk until midnight to mimic woodcock feeding hours (Glasgow 1958). We preserved earthworms in 70% ethanol and identified them to species (Blackman et al. 2010).

Because soil characteristics are a good indicator of quality earthworm habitat and quality woodcock foraging grounds, we gathered data on soil moisture content and temperature using a moisture probe and a soil thermometer, respectively (Owen and Galbraith 1989). The probe reported soil water content as a percentage by volume. Soil samples were tested for pH level, percent organic matter, and nitrate content (Waters

Agricultural Laboratory, Camilla, Georgia). During both seasons, we collected six row width and ridge height (when present) measurements per field.

### *Statistical Analyses*

We used JAGS statistical software to run a Bayesian complete data likelihood density model with data augmentation to account for non-detected, but present individuals in our woodcock surveys and compare woodcock density among crop types (Tanner and Wong 1987, Royle and Dorazio 2008, Plummer 2010). The complete data likelihood model used a half-normal distance function and the distribution of the observed data to create the augmented data, and quartiles were used for mean comparison (Tanner and Wong 1987). We used two models: one allowed each crop type to have a unique distance function, and the other assumed a single distance function across crop types. We used the Deviance Information Criterion (DIC) to select the best detection probability model (Spiegelhalter et al. 2002). We used analysis of variance with Tukey's post-hoc analysis ($P < 0.05$) to test for differences in earthworm abundance and environmental variables among crop types.

## **Results**

### *Woodcock Surveys*

The relationship between woodcock detections and crop type was similar between the two years ($F = 0.61$, df = 1, $P = 0.44$), so we combined all data across years. The density model with constant detection probability was favored by DIC over the model with detection probability varying by crop type (Table 1). We detected higher mean densities of woodcock in no-till soybean fields planted after corn and in undisked corn fields with mowed stalks than in other crop types (Table 2).

### *Environmental Variables*

Earthworm abundance differed among crop types ($F = 8.52$, df = 4, $P < 0.001$), with more earthworms in no-till soybean planted after corn and no-till soybean planted after wheat than in other crop types (Fig. 2). Ridge height ($F = 107.82$, df = 3, $P < 0.001$), row width ($F = 569.11$, df = 3, $P < 0.001$), soil nitrate content ($F = 15.73$, df = 4, $P < 0.001$), soil moisture ($F = 18.93$, df = 4, $P < 0.001$), and soil temperature ($F = 12.67$, df = 4, $P < 0.001$) all varied among crop types (Table 3). No-till soybean after corn and undisked corn with mowed stalks had greater ridge height (range 7.62-14.00 cm and 2.00-19.05 cm, respectively) and row width (range 91.40-104.10 cm and 76.20-99.06 cm, respectively) than other crop types. No-till soybean and undisked corn fields had lower soil temperature and higher soil moisture than disked corn and winter wheat fields. Disked corn and winter wheat fields had the highest nitrate content. Soil organic matter content ($F = 0.21$, df = 4, $P = 0.93$) and pH ($F = 2.26$, df = 4, $P = 0.06$) were similar among crop types (Table 3).

## **Discussion**

The presence of ridge and furrow topography appeared to have the greatest influence on woodcock use of crop fields. At the same study area, Stribling and Doerr (1985) reported woodcock foraging in conventionally-tilled soybean fields. In both studies, woodcock used crop types with ridge and furrow topography. Ridges and furrows likely offer woodcock thermal advantages over other field types by acting as a wind break and lowering wind chill and velocity (Stribling and Doerr 1985). Also, the ridges and furrows likely provide concealment from predators (Connors and Doerr 1982). Woodcock use of no-till soybean fields planted after corn rather than those planted after wheat demonstrates the importance of ridges and furrows because the two types of no-till fields only differed in their topography. Similarly, Krementz et al. (1995) reported that woodcock likely did not use crop fields in Virginia because residual crop materials were removed and fields were tilled flat. Gutzwiller et al. (1983) suggested habitat structural variables (e.g., tree density and edge height) were useful to identify important woodcock habitat on the breeding grounds. Similarly, the presence of ridge and furrow topography in crop fields could help predict woodcock habitat use on the wintering grounds in agricultural areas.

The adoption of no-till technology likely has increased earthworm availability for woodcock because tillage negatively impacts earthworm communities by exposing individuals to predation, and altering soil moisture and organic matter content (Edwards et al. 1995). Also, others have documented higher earthworm abundance in no-till fields compared to conventional tillage, primarily due to no-till technology's minimal soil disturbance (Edwards and Lofty 1982, Kladivko et al. 1997, Smith et al. 2008). Stribling and Doerr (1985) reported no difference in earthworm abundance among conventionally-tilled soybean, disked corn, and winter wheat fields. However, earthworms collected from conventionally-tilled fields had higher protein levels than worms from disked corn and winter wheat fields because duff accumulation in furrows increased food availability for earthworms (Stribling and Doerr 1985). Therefore, no-till fields with ridges and furrows offer woodcock an abundant earthworm supply that may provide greater nutritional benefits than no-till fields that lack topography.

Although we recorded differences in soil moisture, temperature, and nitrate content among crop types, soil disturbance (i.e., tillage) was the main factor that impacted earthworm communities, and woodcock foraging success. Crop types that were most recently tilled (i.e., disked corn and winter wheat) had lower soil moisture, higher soil temperature, and lower earthworm abundance than other crop types. Higher soil moisture values in no-till fields likely improved habitat quality for earthworms (Reynolds et al. 1977). Soil temperature and pH likely did not impact earthworm abundance because temperatures were relatively low in all crop types due to cold winter weather, below the 10-18°C ideal range for earthworms, and pH measurements were close to neutral, which supports most earthworm populations (Edwards and Lofty 1972, Reynolds et al. 1977). Soil organic matter and nitrogen content are important factors regulating earthworm distribution (Reynolds et al. 1977). However, we did not record higher earthworm abundance in crop types with high soil organic matter or nitrate content because organic matter and nitrate were not limiting factors in the soil types at our study area. The soils were rich in organic matter, regardless of crop type, because historic water saturation caused anaerobic slowing of organic matter decomposition (Lilly 1981). Similarly, Clapperton et al. (1997) reported that high earthworm abundance in no-till fields compared to conventional-tillage was due to a lack of soil disturbance, and not differences in soil organic carbon, moisture, or temperature.

## Management Implications

Woodcock conservation efforts in agricultural areas should focus on educating farmers about agricultural practices that benefit woodcock. To create nocturnal habitat for woodcock following conventional corn production, farmers can leave ridges and furrows intact. If field disking is necessary, it should be delayed until spring. By not disking, farmers save time and fuel and labor costs (Sahota 2008). Farmers can mow corn stalks for the winter instead of disking. Mowed stalks may benefit woodcock because dense cover in unmowed corn fields can impede woodcock flight (Glasgow 1958). In the next planting season, soybeans can be drilled into the existing corn ridge and furrow system, and the topography will be retained into the next winter. In fields not in corn production, farmers can till in the spring to create ridges and furrows to improve crop drainage and soil warming. The beds can be used for multiple seasons and crops can be rotated with no further tillage required until the beds need to be re-created. Crop row width and ridge height are important considerations for woodcock management. Rows must be wide enough to allow woodcock movement and foraging, and ridges tall enough to provide protection from predators and winter weather. Because woodcock use of crops was correlated with field structure, and not a single crop type, woodcock in agricultural areas across the wintering range should benefit from access to ridge and furrow topography in fields, regardless of the crop type.

## Literature Cited

Anderson, D. R., J. L. Laake, B. R. Crain, and K. P. Burnham. 1979. Guidelines for line transect sampling of biological populations. Journal of Wildlife Management 43:70-78.

Berdeen, J. B., and D. G. Krementz. 1998. The use of fields at night by wintering American woodcock. Journal of Wildlife Management 62:939-947.

Blackman, E. B., J. W. Reynolds, C. S. DePerno, C. E. Moorman, and M. N. Peterson. 2010. Earthworm species available to American woodcock (*Scolopax minor*) on the wintering grounds in eastern North Carolina, USA. Megadrilogica 14:59-64.

Clapperton, M. J., J. J. Miller, F. J. Larney, and C. W. Lindwall. 1997. Earthworm populations as affected by long-term tillage practices in southern Alberta, Canada. Soil Biology and Biochemistry 29:631-633.

Connors, J. L., and P. D. Doerr. 1982. Woodcock use of agricultural fields in coastal North Carolina. U.S. Fish and Wildlife Service, Wildlife Research Report Number 14:139-147.

Cooper, T. R., and K. Parker. 2010. American woodcock population status, 2010. U.S. Fish and Wildlife Service, Laurel, Maryland, USA.

Dessecker, D. R., and D. G. McAuley. 2001. Importance of early successional habitat to ruffed grouse and American woodcock. Wildlife Society Bulletin 29:456-465.

Duriez, O., Y. Ferrand, and F. Binet. 2006. An adapted method for sampling earthworms at night in wildlife studies. Journal of Wildlife Management 70:852-858.

Edwards, C. A., P. J. Bohlen, D. R. Linden, and S. Subler. 1995. Earthworms in Agroecosystems. Pages 185-213 *in* P. F. Hendrix, editor. Earthworm Ecology and Biogeography in North America. Lewis Publishers: Boca Raton, Florida, USA.

Edwards, C. A., and J. R. Lofty. 1972. Biology of Earthworms. Chapman and Hall Ltd, London, United Kingdom.

Edwards, C. A., and J. R. Lofty. 1982. The effect of direct drilling and minimal cultivation on earthworm populations. Journal of Applied Ecology 19:723-734.

Flickinger, E. L., and G. W. Pendleton. 1994. Bird use of agricultural fields under reduced and conventional tillage in the Texas panhandle. Wildlife Society Bulletin 22:34-42.

Glasgow, L. L. 1958. Contributions to the knowledge of the ecology of the American woodcock, *Philohela minor* (Gmelin), on the wintering range in Louisiana. Dissertation, Texas A&M University, College Station, USA.

Gutzwiller, K. J., K. R. Kinsley, G. L. Storm, W. M. Tzilkowski, and J. S. Wakeley. 1983. Relative value of vegetative structure and species composition for identifying American woodcock breeding habitat. Journal of Wildlife Management 47:535-540.

Heiniger, R. W., J. F. Spears, E. J. Dunphy, and D. T. Bowman. 2000. Crop Management. Pages 9-29 *in* R. W. Heiniger, and D. Braswell, editors. Corn Production Guide 2000. AG-590. North Carolina Cooperative Extension Service, North Carolina State University, Raleigh, North Carolina, USA.

Horton, G. I., and M. K. Causey. 1979. Woodcock movements and habitat utilization in central Alabama. Journal of Wildlife Management 43:414-420.

Kladivko, E. J., N. M. Akhouri, and G. Weesies. 1997. Earthworm populations and species distributions under no-till and conventional tillage in Indiana and Illinois. Soil Biology and Biochemistry 29:613-615.

Krementz, D. G., J. T. Seginak, and G. W. Pendleton. 1995. Habitat use at night by wintering American woodcock in coastal Georgia and Virginia. Wilson Bulletin 107:686-697.

Lilly, J. P. 1981. The blackland soils of North Carolina: their characteristics and management for agriculture. Technical Bulletin No. 270. North Carolina Agricultural Research Service, North Carolina State University, Raleigh, North Carolina, USA.

Lokemoen, J. T., and J. A. Beiser. 1997. Bird use and nesting in conventional, minimum-tillage and organic cropland. Journal of Wildlife Management 61:644-655.

Martin, P. A., and D. J. Forsyth 2003. Occurrence and productivity of songbirds in prairie farmland under conventional versus minimal tillage. Agriculture, Ecosystems, and Environment 96:107-117.

Owen, R. B., Jr., and W. J. Galbraith. 1989. Earthworm biomass in relation to forest types, soil and land use: implications for woodcock management. Wildlife Society Bulletin 17:130-136.

Plummer, M. 2010. JAGS Version 2.1.0 User Manual. Lyon, France.

Reynolds, J. W., W. B. Krohn, and G. A. Jordan. 1977. Earthworm populations as related to woodcock habitat usage in central Maine. Pages 135-146 *in* Proceedings of the sixth American woodcock symposium. D. M. Keppie, and R. B. Owen, Jr. editors. 4-6 October 1977, Fredericton, New Brunswick, Canada.

Royle, J. A., and R. M. Dorazio. 2008. Hierarchical modeling and inference in ecology: The analysis of data from populations, metapopulations, and communities. Academic Press, San Diego, California, USA.

Sahota, T. S. 2008. Alternative tillage systems to save time and fuel. Thunder Bay Agricultural Research Station. < http://tbars.net/extension.shtml>. Accessed 16 February 2011.

Smith, R. G., C. P. McSwiney, A. S. Grandy, P. Suwanwaree, R. M. Snider, and G. P. Robertson. 2008. Diversity and abundance of earthworms across an agricultural land-use intensity gradient. Soil and Tillage Research 100:83-88.

Soil Survey Staff, Natural Resources Conservation Service. 2009. United States Department of Agriculture, Web Soil Survey. <http://websoilsurvey.nrcs.usda.gov/>. Accessed 22 September 2010.

Spiegelhalter, D. J., N. G. Best, B. P. Carlin, and A. Van der Linde. 2002. Bayesian measures of model complexity and fit. Journal of the Royal Statistical Society, Series B 64:583-616.

Stamps, R. T., and P. D. Doerr. 1976. Woodcock on North Carolina wintering grounds. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 30:392-399.

Stribling, H. L., and P. D. Doerr. 1985. Nocturnal use of fields by American woodcock. Journal of Wildlife Management 49:485-491.

Tanner, M. A., and W. H. Wong. 1987. The calculation of posterior distributions by data augmentation. Journal of the American Statistical Association 82:528-540.

Thompson, F. R., III, and R. M. DeGraaf. 2001. Conservation approaches for woody, early successional communities in the eastern United States. Wildlife Society Bulletin 29:483-494.

Trani, M. K., R. T. Brooks, T. L. Schmidt, V. A. Rudis, and C. M. Gabbard. 2001. Patterns and trends of early successional forests in the eastern United States. Wildlife Society Bulletin 29: 413-424.

Uri, N. D., J. D. Atwood, and J. Sanabria. 1999. The environmental benefits and costs of conservation tillage. Environmental Geology 38:111-125.

U.S. Fish and Wildlife Service. 2004. A blueprint for the future of migratory birds:

migratory bird program strategic plan 2004-2014. Washington, D.C., USA.

U.S. Shorebird Conservation Plan. 2004. High Priority Shorebirds─ 2004. Unpublished Report,U. S. Fish and Wildlife Service, 4401 N. Fairfax Dr., MBSP 4107, Arlington, VA, 22203 U.S.A. 5 pp.

Warburton, D. B., and W. D. Klimstra. 1984. Wildlife use of no-till and conventionally tilled corn fields. Journal of Soil and Water Conservation 39:327-330.

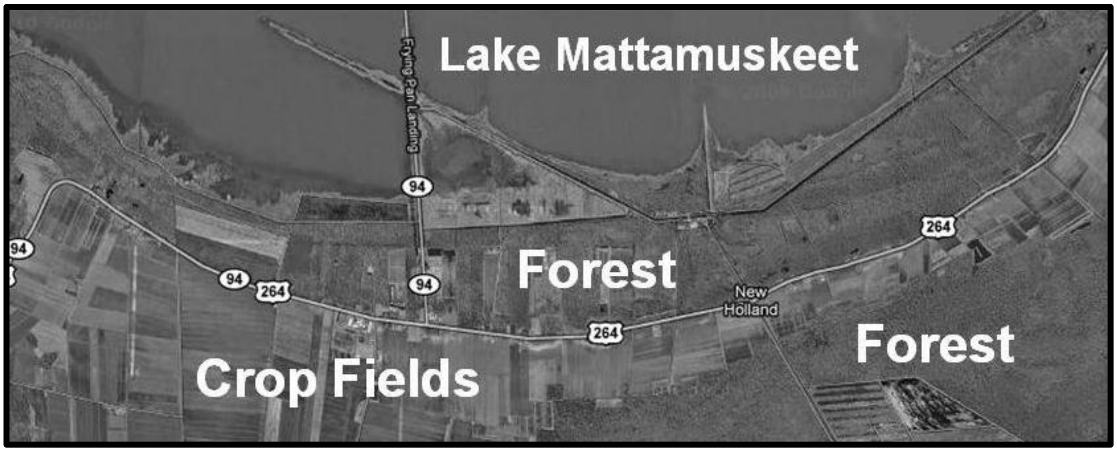

Figure 1. Study area near Lake Mattamuskeet National Wildlife Refuge and New Holland in Hyde County, North Carolina, USA, 2008-2010.

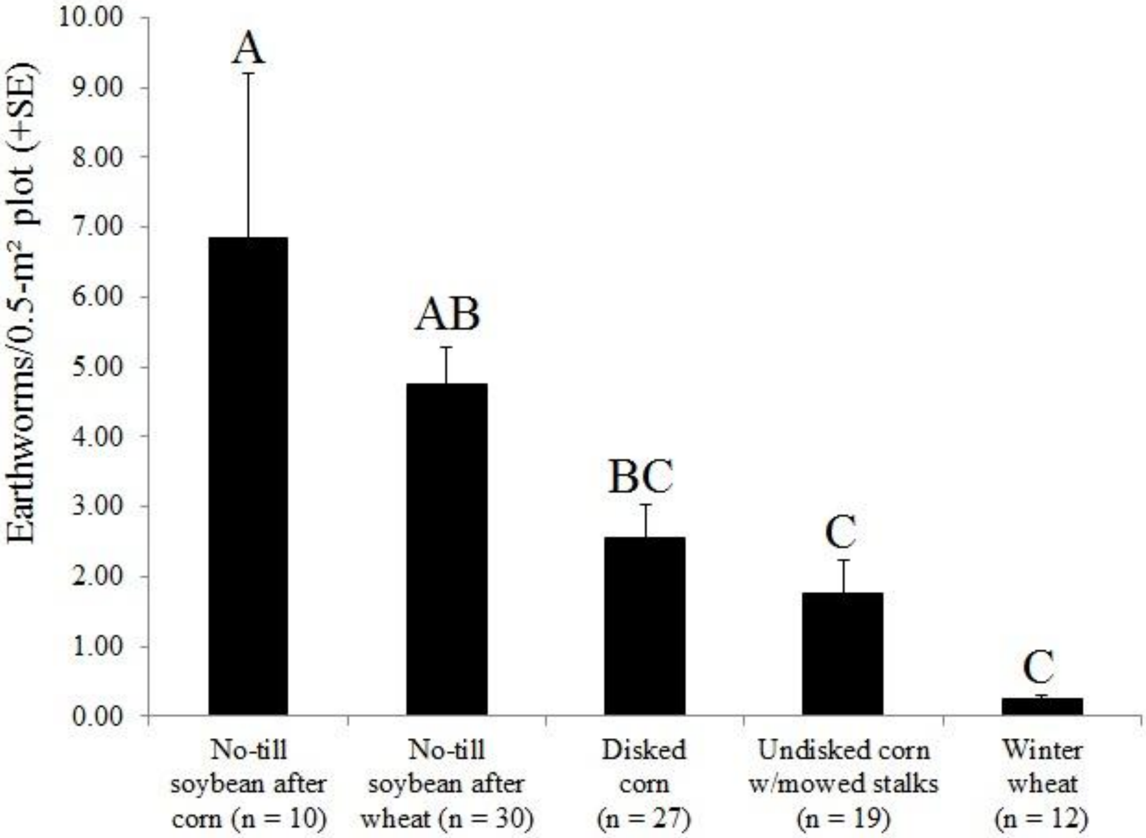

Figure 2. Average number of earthworms collected per 0.5-$m^2$ plot by crop type (+SE) in Hyde County, North Carolina, USA, 2009-2010. Crop types with different letters had different numbers of earthworms.

Table 1. Bayesian complete likelihood density model comparison of constant detection probability ($\{p_{\text{single}}\}$) versus variable detection probability based on crop type ($\{p_{\text{variable}}\}$) from American Woodcock surveys in Hyde County, North Carolina, USA, 2008-2010.

| **Model** | **DIC**[a] | **ΔDIC**[b] | **pD**[c] |
|---|---|---|---|
| $\{p_{\text{single}}\}$ | -593.0 | 0.0 | 378.5 |
| $\{p_{\text{variable}}\}$ | -580.7 | 12.3 | 405.4 |

[a] Deviance Information Criterion (DIC) (Spiegelhalter et al. 2002)

[b] Difference in DIC relative to minimum DIC

[c] pD = variance(deviance)/2

Table 2. American Woodcock per ha by crop type from Bayesian complete likelihood density model, Hyde County, North Carolina, USA, 2008-2010. Standard deviation (SD), 2.5% (Q.025) and 97.5% (Q.975) quartiles are shown. Crop types with different letters had different woodcock densities based on quartile separation.

| **Density[Crop type]** | **Mean** | **SD** | **Q.025** | **Q.975** |
|---|---|---|---|---|
| D[No-till soybean after corn]$^{A}$ | 0.86 | 0.00089 | 0.70 | 1.05 |
| D[Undisked corn w/mowed stalks]$^{B}$ | 0.46 | 0.00074 | 0.34 | 0.62 |
| D[No-till soybean after wheat]$^{C}$ | 0.23 | 0.00035 | 0.17 | 0.30 |
| D[Disked corn]$^{C}$ | 0.18 | 0.00036 | 0.12 | 0.26 |
| D[Winter wheat]$^{D}$ | 0.05 | 0.00022 | 0.02 | 0.10 |

Table 3. Mean soil pH, percent organic matter (OM), nitrate content ($NO_3$) (kg/ha), percent moisture (M), and temperature (T) (°C) per 0.5-m² sample plot, and row width (RW) (cm) and ridge height (RH) (cm) with standard errors (SE) by crop type, Hyde County, North Carolina, USA, 2008-2010. Different letters within columns indicate differences ($P < 0.05$) among crop types.

| **Crop type** | **pH** | **SE** | **OM (%)** | **SE** | **$NO_3$ (kg/ha)** | **SE** | **M (%)** | **SE** | **T (°C)** | **SE** | **RW (cm)** | **SE** | **RH (cm)** | **SE** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No-till soybean after corn | 7.36 | 0.03 | 5.15 | 0.33 | $13.84^{BC}$ | 1.34 | $36.10^{AB}$ | 1.46 | $6.17^{B}$ | 0.48 | $97.98^{A}$ | 0.76 | $9.88^{A}$ | 0.45 |
| No-till soybean after wheat | 7.33 | 0.01 | 6.98 | 1.96 | $10.30^{C}$ | 0.71 | $38.99^{A}$ | 0.80 | $6.44^{B}$ | 0.26 | $28.39^{B}$ | 2.09 | $0.90^{B}$ | 0.26 |
| Undisked corn w/mowed stalks | 7.31 | 0.02 | 7.48 | 2.21 | $12.67^{C}$ | 0.97 | $39.56^{A}$ | 1.24 | $6.38^{B}$ | 0.28 | $92.91^{A}$ | 1.13 | $10.53^{A}$ | 1.19 |
| Disked corn | 7.35 | 0.04 | 6.30 | 0.50 | $27.26^{A}$ | 4.59 | $22.27^{C}$ | 1.54 | $8.00^{A}$ | 0.72 | - | - | - | - |
| Winter wheat | 7.42 | 0.03 | 4.65 | 0.40 | $20.47^{AB}$ | 2.37 | $30.30^{BC}$ | 1.50 | $8.37^{A}$ | 0.62 | $17.16^{C}$ | 1.16 | $0.33^{B}$ | 0.16 |

## Use of Crop Fields and Forest by Wintering American Woodcock

### Abstract

Since the 1960s, American Woodcock (*Scolopax minor*) have experienced population declines due to habitat loss. Previous research on the wintering grounds indicated that woodcock roosted in bottomland forests diurnally and fed on earthworms in soybean fields at night. However, past research did not address the frequency of woodcock crop field use. We determined the frequency of woodcock crop field use and assessed movements between fields and forests using radio-telemetry. We recorded 94% of nocturnal relocations in forest, 6% of nocturnal relocations in crop fields, and 100% of diurnal relocations in forest. Although woodcock occasionally foraged in crop fields, birds primarily used bottomland forests diurnally and nocturnally. Forest patches are important foraging and roosting sites for wintering woodcock and should be conserved in agricultural landscapes.

### Introduction

Since 1968, American Woodcock (*Scolopax minor*) (hereafter referred to as woodcock) have experienced an annual population decline of 1.1%, largely due to the loss of early-successional forest habitat throughout their range (Dessecker and McAuley 2001, Cooper and Parker 2010). Fire suppression, urban development, reduced timber removal, and land abandonment have contributed to the loss of early-successional habitat in the eastern United States (Thompson and DeGraaf 2001). The declines in early-successional habitat, combined with high winter mortality (Krementz et al. 1994), make studies exploring woodcock habitat use on wintering grounds important for recovery efforts.

Research from sites across the wintering range reported woodcock using a variety of habitat types, including forested patches (Krementz et al. 1995), pastures (Glasgow 1958), forest openings (Horton and Causey 1979), and seed-tree harvests (Berdeen and Krementz 1998). Research in eastern North Carolina showed that woodcock roosted in bottomland forests during the day and used conventionally-tilled soybean fields at night to feed on earthworms (Stribling and Doerr 1985). However, Stribling and Doerr (1985) did not assess the frequency of woodcock field use, which may have changed over the past 25 years because of changes in tillage practices. Historically, conventional-till systems created soybean fields with ridge and furrow topography; however, no-till agriculture has become a common practice and soybean fields often are planted in flat, narrow rows (Stribling and Doerr 1985, Heiniger et al. 2002). These changes may have impacted woodcock behavior in agricultural landscapes, including the proportion of time birds spend in fields and forests. Therefore, it is important to document current woodcock winter habitat use to identify habitat types that should be conserved for winter survival. We used radio-telemetry to determine the frequency of woodcock field use and tracked diurnal and nocturnal woodcock movements in an agricultural landscape in eastern North Carolina.

## Study Area

We worked in the same area as previous woodcock research in eastern North Carolina (Stamps and Doerr 1976, Connors and Doerr 1982, Stribling and Doerr 1985). The study area included crop fields bordering US-264, and mature mixed bottomland forests surrounding Lake Mattamuskeet National Wildlife Refuge near New Holland in Hyde County, North Carolina (35° 26’ 36.61’’ N, 76° 10’ 10.46’’ W) (Fig. 1). Crop types were no-till soybean planted after corn, no-till soybean planted after wheat, disked corn, undisked corn with mowed stalks, winter wheat, and cotton. No-till soybean fields retained the ridge and furrow topography from the previous corn crop, while no-till soybean fields planted after wheat lacked ridge and furrow topography due to disking before wheat was planted. Similarly, undisked corn fields retained ridge and furrow topography, while disked corn fields did not.

## Methods

### *Woodcock captures, banding, and radio-transmitter attachment*

During December 2009-March 2010, we captured woodcock with hand-held fishing nets strung with mist netting by night lighting using halogen bulb headlamps (Connors and Doerr 1982, Stribling and Doerr 1985). Net baskets were 58.4 cm wide and 55.9 cm long, and net poles were 142.2 cm long. We weighed, sexed, and leg-banded each captured woodcock, and attached a 4.8-g VHF radio-transmitter (Advanced Telemetry Systems, 470 First Ave. N., Box 398, Isanti, MN) to the skin on the back between the wings using livestock ID tag cement (Nasco, 901 Janesville Ave., Fort Atkinson, WI) (Martin 1964, McAuley et al. 1993). We used a 30-cm-long bellyband to secure the transmitter around the bird's breast (McAuley et al. 1993). All capture and handling methods were approved by the Institutional Animal Care and Use Committee at North Carolina State University, Raleigh, NC (IACUC Protocol # 08-130-O).

### *Telemetry*

Every 24 hours, we triangulated each woodcock during a diurnal and nocturnal period and assigned the location via ground truthing as either crop field or bottomland forest. We collected diurnal locations between 1000 and 1600 hours EST and nocturnal locations between 1900 and 100 hours EST. We used a truck-mounted omni-directional whip antenna to locate woodcock, and used a directional hand-held H-type antenna for triangulation. We took a minimum of three bearings for each woodcock location. When a woodcock remained stationary for more than 48 hours, we determined the status of the bird on foot (e.g., alive, dead, or lost transmitter). Girard et al. (2006) suggested the accuracy of habitat use determination decreased when only one location was recorded per transmitted individual. Therefore, we removed individuals with less than two relocations from our dataset.

## Results

Between December 2009 and March 2010, we captured 37 woodcock in crop fields. We censured three birds, one due to death at the time of capture, one due to predation within 24 hours after capture, and one due to predation within three days likely from injuries received during capture. Radio-transmitters remained attached to woodcock for up to three weeks. The number of relocations we recorded per woodcock varied from zero, when a bird left the study area immediately after transmitter attachment (*n* = 2), to 30 relocations, with an average of 12 per bird. Five individuals had less than two relocations because they left the study area or lost their transmitters, and were removed from the data set (Girard et al. 2006). We recorded 100% of diurnal relocations in forest (228 relocations), 94% of nocturnal relocations in forest (179 relocations), and 6% of nocturnal relocations in crop fields (12 relocations) (Table 1). Woodcock were relocated in forest patches north and south of crop fields and always were relocated within 2500 meters of their capture field (Fig. 2).

## Discussion

Woodcock rarely used crop fields and primarily used mature bottomland forest patches. Similarly, research from across the wintering range demonstrated diurnal and nocturnal woodcock use of mature forested habitats with limited nocturnal use of open habitats (e.g., seed-tree harvests and fallow old fields [Berdeen and Krementz 1998], pastures [Glasgow 1958], or regenerating clearcuts [Krementz et al. 1995]). For example, in two studies, all diurnal woodcock relocations were in mature forested habitat (i.e., bottomland hardwoods, mixed hardwoods/pine, and pine plantations) (Horton and Causey 1979, Krementz et al. 1995). However, we detected less nocturnal use of open habitat in our study than reported from other studies. For example, two studies reported 13% and 44% of nocturnal woodcock relocations in forest openings (i.e., clearcuts, regrowth, and shrubland) (Horton and Causey 1979, Krementz et al. 1995). A third study reported 48% of nocturnal relocations in seed-tree harvests and fallow fields rather than pastures and hay fields because higher foliage volume provided protection from predators (Berdeen and Krementz 1998). Similarly, the greater amount of cover available in forest openings, seed-tree harvests, and fallow fields compared to crop fields may explain why we documented less woodcock use of open habitat than in other studies.

Relatively recent changes in tillage practices may have altered woodcock use of crop fields. Prior research in eastern North Carolina reported nocturnal woodcock use of conventionally-tilled soybean fields, but did not address frequency of use (Connors and Doerr 1982, Stribling and Doerr 1985). Conventional tillage left ridge and furrow topography in all soybean fields, where woodcock likely were protected from winter weather and concealed from predators (Connors and Doerr 1982, Stribling and Doerr 1985). During our study, ridge and furrow topography (i.e., cover) was present in no-till soybean fields planted after corn and in undisked corn fields. However, 74% of no-till soybean fields were planted after wheat and lacked ridge and furrow topography due to disking before the wheat was planted. Therefore, there is less cover available in soybean fields for wintering woodcock than was present historically. This reduction in cover may explain infrequent crop field use. Nevertheless, all soybean fields, regardless of topography, contained high food abundance in the form of earthworms, so food was not a limiting factor for woodcock in crop fields (Blackman 2011). Similarly, other research has demonstrated that no-till agriculture leaves soil communities with higher numbers of earthworms in no-till compared to tilled fields (Edwards and Lofty 1982, Smith et al. 2008).

Although trap shyness and winter weather could impact woodcock use of crop fields, they probably were not driving factors in our study. Horton and Causey (1979) reported that woodcock did not return to their capture field regularly; however, there is no mention of altered behavior due to capture in other woodcock telemetry studies (e.g., Krementz et al. 1995, Myatt and Krementz 2007). Sheldon (1967) reported that woodcock only visited fields briefly on cold, frosty nights, but transmitted individuals in our study rarely used crop fields even on warm or cold nights.

Although crop field use is uncommon, woodcock occasionally feed in crop fields and likely gain some overwintering benefit from them. Krementz et al. (1995) suggested that fields provide important roosting, courtship, and feeding sites for woodcock though they are infrequently used. Future research should compare earthworm abundance in crop fields and forest patches used by woodcock to determine the relative importance of crop fields to woodcock foraging and winter survival. Because the majority of woodcock relocations were in forested areas, forest patches should be conserved in agricultural landscapes to provide overwintering foraging and roosting sites.

## Literature Cited

Berdeen, J. B., and D. G. Krementz. 1998. The use of fields at night by American Woodcock. Journal of Wildlife Management 62:939-947.

Blackman, E. B. 2011. American Woodcock winter habitat use in an agricultural landscape. Thesis. North Carolina State University, Raleigh, NC, USA.

Connors, J. L., and P. D. Doerr. 1982. Woodcock use of agricultural fields in coastal North Carolina. U.S. Fish and Wildlife Service, Wildlife Research Report Number 14:139-147.

Cooper, T. R., and K. Parker. 2010. American Woodcock population status, 2010. U.S. Fish and Wildlife Service, Laurel, Maryland, USA.

Dessecker, D. R., and D. G. McAuley. 2001. Importance of early successional habitat to ruffed grouse and American Woodcock. Wildlife Society Bulletin 29:456-465.

Edwards, C. A., and R. Lofty. 1982. The effect of direct drilling and minimal cultivation on earthworm populations. Journal of Applied Ecology 19:723-734.

Girard, I., C. Dussault, J.-P. Ouellet, R. Courtois, and A. Caron. 2006. Balancing number of locations with number of individuals in telemetry studies. Journal of Wildlife Management 70:1249-1256.

Glasgow, L. L. 1958. Contributions to the Knowledge of the Ecology of the American Woodcock, *Philohela minor* (Gmelin), on the Wintering Range in Louisiana. Dissertation. Texas A&M University, College Station, Texas, USA.

Heiniger, R. W., J. F. Spears, E. J. Dunphy, and D. T. Bowman. 2002. Crop Management. Pages 9-29 *in* Corn Production Guide 2002-2003 (R. W. Heiniger and D. Braswell, Editors). AG-590. North Carolina Cooperative Extension Service, North Carolina State University, Raleigh, North Carolina, USA.

Horton, G. I., and M. K. Causey. 1979. Woodcock movements and habitat utilization in central Alabama. Journal of Wildlife Management 43:414-420.

Krementz, D. G., J. T. Seginak, D. R. Smith, and G. W. Pendleton. 1994. Survival rates of American Woodcock wintering along the Atlantic coast. Journal of Wildlife Management 58:147-155.

Krementz, D. G., J. T. Seginak, and G. W. Pendleton. 1995. Habitat use at night by wintering American Woodcock in coastal Georgia and Virginia. Wilson Bulletin 107:686-697.

Martin, F. W. 1964. Woodcock sex and age determination from wings. Journal of Wildlife Management 28:287-293.

McAuley, D. G., J. R. Longcore, and G. F. Sepik. 1993. Techniques for research into woodcocks: experiences and recommendations. Pages 5-11 *in* Proceedings of the Eighth American Woodcock Symposium (J. R. Longcore and G. F. Sepik, Editors). U.S. Fish and Wildlife Service Biological Report 16.

Myatt, N. A., and D. G. Krementz. 2007. Fall migration and habitat use of American Woodcock in the central United States. Journal of Wildlife Management 71:1197-

1205.

Sheldon, W. G. 1967. The book of the American Woodcock. The University of Massachusetts Press, Amherst, Massachusetts, USA.

Smith, R. G., C. P. McSwiney, A. S. Grandy, P. Suwanwaree, R. M. Snider, and G. P. Robertson. 2008. Diversity and abundance of earthworms across an agricultural land-use intensity gradient. Soil and Tillage Research 100:83-88.

Stamps, R. T., and P. D. Doerr. 1976. Woodcock on North Carolina wintering grounds. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 30:392-399.

Stribling, H. L., and P. D. Doerr. 1985. Nocturnal use of fields by American Woodcock. Journal of Wildlife Management 49:485-491.

Thompson, F. R., III, and R. M. DeGraaf. 2001. Conservation approaches for woody, early successional communities in the eastern United States. Wildlife Society Bulletin 29:483-494.

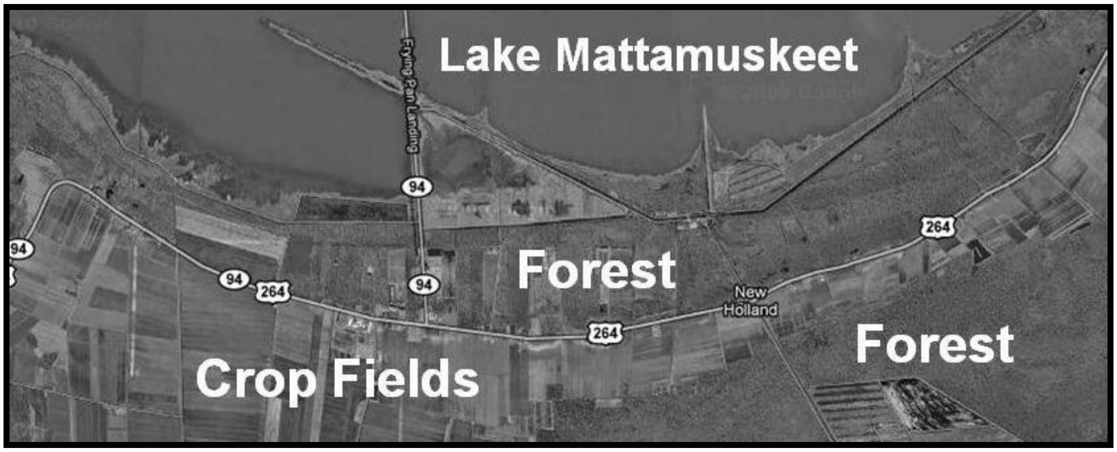

Figure 1. Study area in Hyde County, North Carolina (35° 26’ 36.61’’ N, 76° 10’ 10.46’’ W), December 2009-March 2010. We caught woodcock in crop fields south of and adjacent to US-264. We relocated woodcock in bottomland forests south of Lake Mattamuskeet National Wildlife Refuge and in the crop fields.

Figure 2. Relocations for an individual woodcock in Hyde County, North Carolina, December 2009-March 2010.

Table 1. Number of diurnal and nocturnal relocations per woodcock in crop fields and bottomland forest, Hyde County, North Carolina, December 2009-March 2010.  No diurnal relocations were in fields.

| **Woodcock ID** | **Diurnal Forest** | **Nocturnal Forest** | **Nocturnal Field** |
|---|---|---|---|
| 1 | 4 | 2 | 0 |
| 2 | 2 | 3 | 0 |
| 3 | 3 | 1 | 0 |
| 4 | 1 | 3 | 0 |
| 5 | 0 | 3 | 1 |
| 6 | 2 | 2 | 0 |
| 7 | 6 | 2 | 0 |
| 8 | 14 | 8 | 0 |
| 9 | 2 | 1 | 0 |
| 10 | 12 | 5 | 4 |
| 11 | 14 | 9 | 0 |
| 12 | 13 | 10 | 0 |
| 13 | 6 | 1 | 0 |
| 14 | 14 | 14 | 0 |
| 15 | 10 | 4 | 1 |
| 16 | 8 | 4 | 0 |
| 17 | 9 | 4 | 3 |
| 18 | 10 | 8 | 0 |
| 19 | 6 | 7 | 2 |
| 20 | 13 | 12 | 0 |
| 21 | 7 | 8 | 0 |
| 22 | 9 | 10 | 1 |
| 23 | 14 | 11 | 0 |
| 24 | 10 | 10 | 0 |
| 25 | 15 | 15 | 0 |
| 26 | 4 | 4 | 0 |
| 27 | 7 | 6 | 0 |
| 28 | 7 | 7 | 0 |
| 29 | 6 | 5 | 0 |

# Earthworm Species Available to American Woodcock on the Wintering Grounds in Eastern North Carolina

## Abstract

American Woodcock (*Scolopax minor*) are migratory shorebirds that have experienced annual population losses of 1.1% since 1968. The primary food source of woodcock on their wintering grounds is earthworms, but few studies have identified the earthworm species available. Previous wintering woodcock research in eastern North Carolina reported that woodcock foraged for earthworms in conventionally-tilled soybean fields and that 99% of earthworms consumed by woodcock were *Apporectodea* or *Diplocardia* spp. Today, most farmers have switched to no-till agriculture, which may have affected the diversity of earthworms available to woodcock. During February 2009 and February-March 2010, we collected 2102 earthworms and identified 13 species, 81.3% of which were *Apporectodea* or *Diplocardia* spp. The species richness of earthworms in our sample compared to prior research suggests the conversion from conventional-tillage to no-till agricultural practices has increased earthworm species richness on woodcock foraging grounds or that woodcock selectively feed on some earthworm species.

## Introduction

American Woodcock (*Scolopax minor*) are nocturnal, migratory shorebirds that have declined by 1.1% annually since 1968 (Cooper and Parker, 2009), largely because of the loss of early-successional habitat (Dessecker and McAuley, 2001). On their northern breeding grounds, woodcock feed on a variety of items including earthworms, insects, and vegetable matter (Sperry, 1940), whereas on the southern wintering grounds they feed almost exclusively on earthworms (Glasgow, 1958). However, while many studies have documented that woodcock forage on earthworms (Pettingill, 1939; Sheldon, 1967; Liscinsky, 1972; Owen and Galbraith, 1989), few have identified the earthworm species available to woodcock.

Although prior studies surveyed earthworm communities within the woodcock wintering range [i.e., Maryland (Reynolds, 1974), Tennessee (Reynolds et al., 1974; Reynolds, 1977a; Reynolds, 1978), North Carolina (Reynolds, 1994a), Virginia (Reynolds, 1994b), Florida (Reynolds, 1994c), Mississippi (Reynolds, 1994d), Alabama (Reynolds, 1994e), South Carolina (Reynolds, 2001), Arkansas (Reynolds, 2008a), Louisiana (Reynolds, 2008b), Kentucky (Reynolds, 2008c), Missouri (Reynolds, 2008d), Georgia (Reynolds, 2009), South Carolina (Reynolds and Reeves, 2004), east Texas (Damoff and Reynolds, 2009) and Oklahoma (Reynolds and Damoff, 2010)], to our knowledge no studies have documented the earthworm species available in land cover types known to be used by woodcock for foraging.

Stribling and Doerr (1985) noted that woodcock in eastern North Carolina moved at night from bottomland forests to feed on earthworms in adjacent agricultural fields, especially conventionally-tilled soybean fields. However, since the 1970s, farming technology has switched from conventional-tilled to no-till agriculture. Fields no longer are plowed every winter and as a result, soil communities remain intact (Smith et al., 2008). Therefore, the earthworm species present in agricultural fields may have changed with the evolving agricultural practices. Our objectives were to determine the earthworm species available to woodcock and explore whether new farming technology has impacted earthworm communities on the wintering grounds in coastal North Carolina.

## Study Area

Our research was conducted in the same fields as previous woodcock research in eastern North Carolina (Stamps and Doerr, 1976; Connors and Doerr, 1982; Stribling and Doerr, 1985). Nocturnal feeding habitat included agricultural fields south of Lake Mattamuskeet National Wildlife Refuge and US-264 near New Holland in Hyde County, North Carolina (Figure 1). Field types in our focal area included no-till soybean (*n* = 37), winter wheat (*n* = 14), disked corn (*n* = 9), undisked corn with mowed stalks (*n* = 6), conventionally-tilled soybean (*n* = 3), and cotton (*n* = 3) for a total of 72 fields in February 2009 and no-till soybean (*n* = 31), disked corn (*n* = 21), undisked corn with mowed stalks (*n*= 13), winter wheat (*n* = 7), and cotton (*n* = 1) for a total of 73 fields in February-March 2010.

## Methods

During February 2009, we collected earthworm samples from three conventionally-tilled soybean and cotton fields, and five no-till soybean, corn with mowed stalks, disked corn, and winter wheat fields, and added three extra sampling fields of common field types (i.e., no-till soybean, disked corn, and winter wheat) for a total of 35 fields. During February-March 2010, we collected earthworms at all 73 fields in our focal area. During both seasons and in each field, we collected earthworms from six 0.5-m$^2$ plots, for a total of 210 sample plots in 2009 and 438 sample plots in 2010. We spaced sample plots 15 meters apart and oriented on a diagonal to assure that sampling was conducted across rows. We collected samples between rows when present, because woodcock were observed roosting and feeding between rows. We sampled to a depth of 7.6 cm, the maximum distance that woodcock can probe into soil (Rabe et al., 1983). We collected samples from dusk until midnight to mimic woodcock feeding habits (Glasgow, 1958) and preserved earthworms in 70% ethanol to be identified to species (Dr. John W. Reynolds' Oligochaetology Laboratory, Ontario). Voucher specimens are deposited in the collections of the New Brunswick Museum, Saint John, NB, Canada.

## Results and Discussion

We identified 13 species from 2102 individual earthworms: *Aporrectodea trapezoides* (*n* = 1424), *Amynthas diffringens* (*n* = 279), *Diplocardia caroliniana* (*n* = 260), *Allolobophora chlorotica* (*n* = 72), *Bimastos parvus* (*n* = 22), *Aporrectodea turgida* (*n* = 20), *Eukerria saltensis* (*n* = 16), *Octolasian tyrtaeum* (*n* = 2), *Aporrectodea tuberculata* (*n* = 2), *Aporrectodea rosea* (*n* = 2), *Aporrectodea longa* (*n* = 1), *Amynthas hupeiensis* (*n* = 1), and *Bimastos tumidus* (*n* = 1).

We collected three state-wide common species (*Aporrectodea trapezoides*, *Amynthas diffringens*, and *Octolasion tyrtaeum*), four species common in the northern half of North Carolina (*Allolobophora chlorotica*, *Aporrectodea rosea*, *Aporrectodea turgida*, and *Bimastos tumidus*), and two species located only in coastal North Carolina (*Eukerria saltensis*, and *Amynthas hupeiensis*) (Reynolds, 1994a). The third most abundant species in our samples (*Diplocardia caroliniana*) has only been detected in the Piedmont and Blue Ridge Mountain regions of North Carolina. In addition, *Apporectodea longa* was previously only recorded in one county in the Blue Ridge region, and *Apporectodea tuberculata* was mainly detected in Blue Ridge counties, with one specimen in Chowan County in the Coastal Plain. Finally, *Bimastos parvus* was previously located only in Columbus, Granville, and Pitt Counties (Reynolds, 1994a).

The earthworm species we identified differ from the earthworm species eaten by woodcock on the breeding grounds, as would be expected based on different local environmental conditions and earthworm species' ranges. On the breeding grounds in Maine, Minnesota, New Brunswick and Quebec, woodcock only consumed *Apporrectodea tuberculata*, *Dendrobaena octaedra*, *Lumbricus rubellus* and *Dendrodrilus rubidus* (Reynolds, 1977b). Reynolds (1977b) predicted the species available to woodcock in the Southeast, namely *Aporrectodea trapezoides*, and members of the *Amynthas*, *Metaphire*, *Pheretima*, *Diplocardia*, *Bimastos*, and *Eisenoides* genera. Although we did not collect any *Metaphire*, *Pheretima* or *Eisenoides* specimens, we did collect *Aporrectodea trapezoides*, *Amynthas*, *Diplocardia*, and *Bimastos*.

At the same study sites 25 years ago, Stribling and Doerr (1985) reported that 99% of earthworms ingested by woodcock (*n* = 12) were *Apporectodea* and *Diplocardia*; 81.3% of the specimens we collected were of these two genera. It is possible that woodcock select genera *Apporectodea* and *Diplocardia* when they feed, but the small sample size of Stribling and Doerr (1985) likely was not representative of the full range of earthworm species consumed by woodcock.

Because of new farming technology, the earthworm species available in agricultural fields in eastern North Carolina may have changed since Stribling and Doerr's (1985) research. Historically, soil was tilled to plant crops, which created a ridge and furrow structure in fields. Today, no-till technology allows crops to be planted with minimal soil disturbance. In eastern North Carolina, corn fields still are planted with traditional tillage, but nearly all farmers have switched to no-till technology for soybeans. Annual tillage negatively impacts earthworms by effecting soil moisture and organic matter content, and by exposing the earthworms to predation (Edwards et al., 1995). Additionally, fertilizers and herbicides used on tilled fields can change soil pH and organic matter content, and reduce soil surface residue and cover, negatively effecting earthworm habitat quality (Smith et al., 2008). Smith et al. (2008) determined that no-till systems had higher earthworm abundance and richness than conventionally-tilled systems. Similarly, Edwards and Lofty (1982) noted that earthworm populations were 30 times higher in no-till compared to tilled fields. Thus, the widespread conventional-tillage practices used thirty years ago and the recent switch to no-till technology may explain the increased richness of our sample compared to Stribling and Doerr (1985).

## Literature Cited

Connors, J. L., and P. D. Doerr. 1982. Woodcock use of agricultural fields in coastal North Carolina. U.S. Fish and Wildlife Service, Wildlife Research Report Number 14:139-147.

Cooper, T. R., and K. Parker. 2009. American Woodcock population status, 2009. U.S. Fish and Wildlife Service, Laurel, Maryland. 15 pp.

Damoff, G.A., and J.W. Reynolds. 2009. The earthworms (Oligochaeta: Acanthodrilidae, Eudrilidae, Lumbricidae, Megascolecidae, Ocnerodrilidae, and Sparganophilidae) of east Texas, USA. Megadrilogica 13(8):113-140.

Dessecker, D. R., and D. G. McAuley. 2001. Importance of early successional habitat to ruffed grouse and American Woodcock. Wildlife Society Bulletin 29:456-465.

Edwards, C. A., and R. Lofty. 1982. The effect of direct drilling and minimal cultivation on earthworm populations. Journal of Applied Ecology 19:723-734.

Edwards, C. A., P. J. Bohlen, D. R. Linden, and S. Subler. 1995. Earthworms in Agroecosystems. Pages 185-213 *in* P. F. Hendrix, editor. Earthworm Ecology and Biogeography in North America. Lewis Publishers: Boca Raton.

Glasgow, L. L. 1958. Contributions to the Knowledge of the Ecology of the American Woodcock, *Philohela minor* (Gmelin), on the Wintering Range in Louisiana. Texas A&M University.

Liscinsky, S. A. 1972. The Pennsylvania woodcock management study. Pennsylvania Game Commission Research Bulletin 171.

Owen, R. B., Jr., and W. J. Galbraith. 1989. Earthworm biomass in relation to forest types, soil and land use: implications for woodcock management. Wildlife Society Bulletin 17:130-136.

Pettingill, O. S., Jr. 1939. Additional information on the food of the American Woodcock. Wilson Bulletin 51:78-82.

Rabe, D. L., H. H. Prince, and D. L. Beaver. 1983. Feeding-site selection and foraging strategies of American Woodcock. The Auk 100:711-716.

Reynolds, J. W. 1974. The earthworms of Maryland (Oligochaeta: Acanthodrilidae, Lumbricidae, Megascolecidae and Sparganophilidae. Megadrilogica 1(11):1-12.

____________. 1977a. The earthworms of Tennessee (Oligochaeta). III. Komarekionidae, with notes on distribution and biology. Megadrilogica 3(4):65-69.

____________. 1977b. Earthworms utilized by the American Woodcock. Proc. Woodcock Symp. 6:161-169.

____________. 1978. The earthworms of Tennessee (Oligochaeta). IV. Megascolecidae, with notes on distribution, biology and a key to the species in the state. Megadrilogica 3(7):117-129.

____________. 1994a. Earthworms of North Carolina (Oligochaeta: Acanthodrilidae, Komarekionidae, Lumbricidae, Megascolecidae, Ocnerodrilidae and Sparganophilidae). Megadrilogica 5(6):53-72.

____________. 1994b. Earthworms of Virginia (Oligochaeta: Acanthodrilidae, Komarekionidae, Lumbricidae, Megascolecidae and Sparganophilidae). Megadrilogica 5(8):77-94.

____________. 1994c. Earthworms of Florida (Oligochaeta: Acanthodrilidae, Eudrilidae, Glossoscolecidae, Lumbricidae, Megascolecidae, Ocnerodrilidae, Octochaetidae and Sparganophilidae). Megadrilogica 5(12):125-141.

____________. 1994d. Earthworms of Mississippi (Oligochaeta: Acanthodrilidae, Lumbricidae, Megascolecidae, Ocnerodrilidae and Sparganophilidae). Megadrilogica 6(3):21-33.

____________. 1994e. Earthworms of Alabama (Oligochaeta: Acanthodrilidae, Eudrilidae, Lumbricidae, Megascolecidae and Sparganophilidae). Megadrilogica 6(4):35-46.

____________. 2001. The earthworms of South Carolina (Oligochaeta: Acanthodrilidae, Lumbricidae, Megascolecidae, Ocnerodrilidae and Sparganophilidae). Megadrilogica 8(7):25-36.

____________. 2008a. The earthworms of Arkansas, USA revisited (Oligochaeta, Lumbricidae). Megadrilogica 11(11):115-130.

____________. 2008b. The earthworms of Louisiana, USA revisited (Oligochaeta, Acanthodrilidae, Lumbricidae, Lutodrilidae, Megascolecidae and Sparganophilidae). Megadrilogica 12(3):31-60).

____________. 2008c. The earthworms of Kentucky, USA (Oligochaeta, Acanthodrilidae, Komarekionidae, Lumbricidae, Megascolecidae and Sparganophilidae). Megadrilogica 12(5):73-88.

____________. 2008d. The earthworms (Oligochaeta: Acanthodrilidae, Lumbricidae, Megascoecidae, and Sparganophilidae) of Missouri, USA, revisited. Megadrilogica 12 (6):89-104.

____________. 2009. The earthworms (Oligochaeta: Acanthodrilidae, Eudrilidae, Lumbricidae, Megascolecidae, Ocnerodrilidae, and Sparganophilidae) of Georgia, USA. Megadrilogica 13(7):85-111.

Reynolds, J.W., and G.A. Damoff. 2010. The earthworms (Oligochaeta: Acanthodrilidae,, Lumbricidae, Megascolecidae and Sparganophilidae) of Oklahoma, USA. Megadrilogica 13(12):173-193.

Reynolds, J.W., and W.K. Reeves. 2004. Additional earthworms records (Oligochaeta: Acanthodrilidae, Lumbricidae, Megascolecidae, Ocnerodrilidae and Sparganophilidae) from South Carolina. Megadrilogica 9(12):99-110.

Reynolds, J.W., E.E.C. Clebsch and W.M. Reynolds. 1974. The earthworms of Tennessee (Oligochaeta). I. Lumbricidae. Contr. N. Amer. Earthworms, No. 3, Bull. Tall Timbers Res. Stn., No. 17, *viii* + 133 pp.

Sheldon, W. G. 1967. The book of the American Woodcock. The University of Massachusetts Press: Amherst. 227 pp.

Smith, R. G., C. P. McSwiney, A. S. Grandy, P. Suwanwaree, R. M. Snider, and G. P. Robertson. 2008. Diversity and abundance of earthworms across an agricultural land-use intensity gradient. Soil and Tillage Research 100:83-88.

Sperry, C. C. 1940. Food habits of a group of shorebirds: woodcock, snipe, knot and dowitcher. U.S. Biological Survey, Wildlife Research Bulletin 1.

Stamps, R. T., and P. D. Doerr. 1976. Woodcock on North Carolina wintering grounds. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 30:392-399.

Stribling, H. L., and P. D. Doerr. 1985. Nocturnal use of fields by American Woodcock. Journal of Wildlife Management 49:485-491.

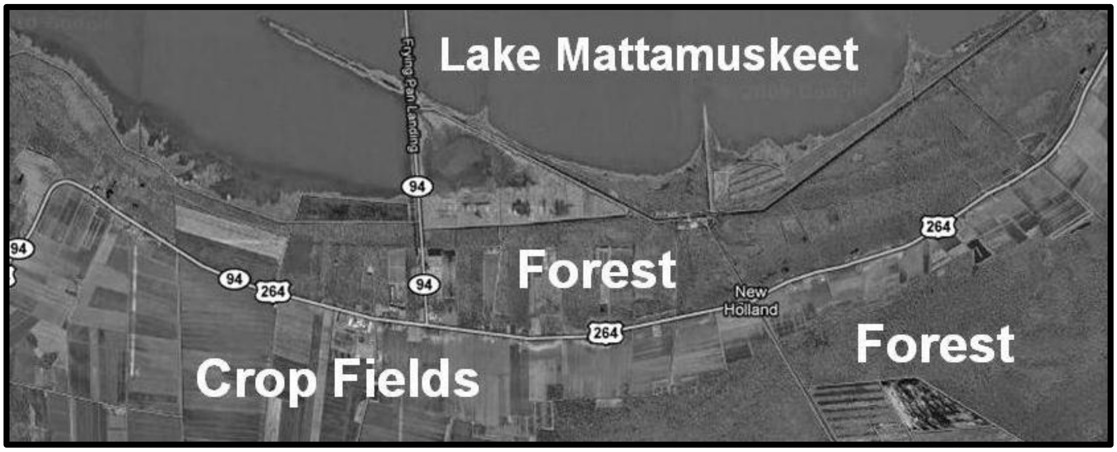

Figure 1. Study site near New Holland in eastern North Carolina, 2009-2010. Woodcock nocturnal foraging habitat included crop fields south of Lake Mattamuskeet National Wildlife Refuge and US-264.

# Avian Influenza Testing of American Woodcock in an Agricultural Landscape

## Abstract

The potential for migratory bird species to transfer pathogenic Eurasian strains of avian influenza to the Americas has created international concern over monitoring efforts. Avian influenza has been isolated in multiple migratory shorebird species, and those that spend time in agricultural areas are more likely to share the virus with poultry. *Scolopax minor* (American Woodcock) are migratory and winter in agricultural landscapes throughout coastal North Carolina. Thirty nine woodcock were tested during February 2009 and December-March 2009-10 for Type A avian influenza virus; all tests were negative. To our knowledge, this is the first study to evaluate woodcock for avian influenza. Wildlife disease surveillance, especially testing of novel species, is critical to monitor and control virus emergence and spread between wild and domestic populations.

## Introduction

Avian influenza is a disease management challenge of the 21st century because of the virus' capacity to infect diverse mammalian and avian species, and implication in poultry disease and mortality (Arzt et al. 2010). Further, there are global concerns about the transfer of avian influenza strains from Eurasia to the Americas. For example, Makarova et al. (1999) believed Eurasian H2 was transmitted to the Americas by avian hosts. Additionally, migratory birds have contributed to the spread of H5N1 (i.e., a highly pathogenic strain of avian influenza) in Asia and Europe (Dierauf et al. 2006).

Surveillance of multiple species is critical to detect virus spread (Pearce et al. 2010). Since 1961, avian influenza has been documented in at least 88 wild bird species, with most isolations occurring in Anseriformes (ducks, geese and swans) and Charadriiformes (shorebirds) (Stallknecht and Shane 1988). Recently, monitoring of ducks, shorebirds, and gulls has identified several avian influenza strains including H1 through H13 subtypes and a newly described H16 subtype (Krauss et al. 2007). Also, studies in the eastern United States detected Eurasian lineages of avian influenza in virus isolates from shorebirds (Jackwood and Stallknecht 2007; Makarova et al. 1999), highlighting the role of migratory shorebirds in transporting avian influenza strains across geographic boundaries.

Avian influenza virus dispersal has important implications for human health, especially when the virus enters agricultural areas with domestic poultry operations. Wild birds can contract avian influenza from and/or spread it to poultry, and subtypes H5, H7 and H9 can become pathogenic in poultry and infect humans (Arzt et al. 2010, Krauss and Webster 2010). Dormitorio et al. (2009) detected avian influenza in migratory shorebirds in Alabama, Georgia and Florida and suggested further testing in the southeastern United States to ensure that H5 and H7 are not transmitted to poultry. Consequently, avian species that occupy agricultural areas are worthy of influenza monitoring.

*Scolopax minor* (American Woodcock) (hereafter referred to as woodcock) is a migratory shorebird adapted to living in forested and agricultural habitats. Individuals migrate between breeding grounds in eastern Canada and north central and northeastern regions of the United States to wintering grounds in the southeastern and south central states (Sheldon 1967). Woodcock on the wintering grounds roost and feed in bottomland forests and open fields, including crop fields (Stribling and Doerr 1985a). Since 1968, woodcock have experienced annual population declines of 1.1% (Cooper and Parker 2009), primarily because of the loss of early-successional forest habitat (Dessecker and McAuley 2001). Other documented threats to woodcock include predation (Krementz and Berdeen 1997), hunting mortality (Krementz et al. 1994), parasites (Hiller et al. 2007), and disease (Docherty et al. 1994).

Docherty et al. (1994), to our knowledge, was the only study to test woodcock for diseases and detected woodcock reovirus, which caused mortalities in the late 1980s and early 1990s. As the human population expands and habitat is lost throughout the eastern United States, diseases may become more detrimental to woodcock. Also, because of the capacity to infect wild birds, domestic species, and humans, the potential for avian influenza in woodcock is a threat to humans and other species of wildlife. Additionally, no woodcock population has been tested for avian influenza. Recently, Belant and Deese (2010) emphasized the critical role of wildlife disease surveillance because of human health and safety, economic, and ecological considerations. Therefore, our objective was to test for avian influenza in woodcock wintering in an agricultural landscape of eastern North Carolina.

## Study Area and Methods

Our study was conducted during February 2009 and December-February 2009-10 across 72 agricultural fields south of Lake Mattamuskeet National Wildlife Refuge and US 264 near New Holland in Hyde County, North Carolina (35°26’36.61’’N, 76°10’10.69’’W). At night, we spotted woodcock eye shine using halogen bulb headlamps and captured birds on foot using lighting and hand-held fishing nets strung with mist netting (Stribling and Doerr, 1985a).

Following the protocol established by Loth et al. (2008), we used the Avian Influenza Virus Type A Antigen Test kit (FluDetect) (Synbiotics Corporation, Kansas City, MO, USA) to test for H antigen types and collected samples using oropharyngeal swabs. We only tested for type A, and not B or C, because type A virus is known to cause infection in wild birds (Alexander 2000). The FluDetect antigen test is a rapid and reliable method of avian influenza detection with high sensitivity and specificity. It is critical for detecting and controlling avian influenza outbreaks in wild birds and domestic poultry, and is a useful screening method for avian influenza (Loth et al. 2008). We collected one oropharyngeal swab (25-800 D 50 sterile polyester tipped applicators, Puritan Medical Products Company, Guilford, ME, USA) from each bird and placed eight drops of extraction buffer in a test tube, swirled the swab in the buffer 5-10 times, and pressed the swab against the test tube to remove all liquid. We placed the samples on ice and tested all samples within 24 hours of collection. We used test strips immediately upon removal from the vial and read the results within 15 minutes, as recommended by the manufacturer.

## Results and Discussion

We tested 39 woodcock during February 2009 (*n* = 9) and December-February 2009-10 (*n* = 30). All samples were negative for type A avian influenza virus. We only tested for type A, and not B or C, because type A virus is known to cause infection in wild birds (Alexander, 2000). Our study was conducted on the wintering grounds and likely represents woodcock breeding populations from diverse geographic areas of northeastern North

America.  Stribling and Doerr (1985b) captured woodcock in the same study area we sampled and recovered bands from Louisiana, North Carolina, New Jersey, Pennsylvania, New York, Massachusetts, New Hampshire, Vermont, Maine, Quebec, Ontario, and Nova Scotia.  Thus, disease testing on the wintering grounds is useful for efficiently obtaining health information on the woodcock population as a whole.  Additionally, many states (e.g., Alabama, Georgia, and Virginia) within woodcock wintering grounds contain areas of high poultry production in the United States (Carter et al., 2007).

Although our results were negative, it is critical to test populations for avian influenza infection to monitor disease spread (Belant and Deese 2010). Additionally, Dormitorio et al. (2009) specifically recommended increased testing of migratory shorebirds in areas with nearby poultry production. Further, the antigen test kit we used was shown to have a diagnostic sensitivity of 0.71 and a specificity of 0.98 indicating the test is reliable for detecting type A avian influenza from oropharyngeal swabs (Loth et al. 2008). In 1992, North Carolina was ranked 7th in the United States for egg production, 4th for broilers, and 1st for turkey production (Carter et al. 2007). The poultry and caged bird trade, human movements, and migrations by wild birds are the most common means of avian influenza transmission (Alexander 2000). In fact, global poultry avian influenza infections have increased from 23 million between 1959-1998 to over 200 million cases between 1999-2004 (Capua and Alexander 2006). Therefore, wild bird species that spend time in agricultural areas (e.g., woodcock) have an increased likelihood of transmitting avian influenza to nearby poultry farms, or contracting the virus from already infected poultry. Additional testing of woodcock for avian influenza on other wintering grounds, especially in agricultural areas, is recommended.

## Literature Cited

Alexander, D. J. 2000. A review of avian influenza in different bird species. Veterinary Microbiology 74: 3-13.

Arzt, J., W. R. White, B. V. Thomsen, and C. C. Brown. 2010. Agricultural diseases on the move early in the third millennium. Veterinary Pathology 47: 15-27.

Belant, J. L., and A. R. Deese. 2010. Importance of wildlife disease surveillance. Human Wildlife Interactions 4: 165-169.

Capua, I., and D. J. Alexander. 2006. The challenge of avian influenza to the veterinary community. Avian Pathology 35: 189-205.

Carter, T. A., P. A. Curtis, and K. Zering. 2007. The North Carolina Poultry Industry. North Carolina Cooperative Extension Service, College of Agriculture and Life Sciences, North Carolina State University. ncsu.edu/depts/poulsci/tech_ manuals/poultry_industry .html (accessed July 2010).

Cooper, T. R., and K. Parker. 2009. American woodcock population status, 2009. U.S. Fish and Wildlife Service, Laurel, Maryland. 15 pp.

Dessecker, D. R., and D. G. McAuley. 2001. Importance of early successional habitat to ruffed grouse and American woodcock. Wildlife Society Bulletin 29: 456-465.

Dierauf, L. A., W. B. Karesh, H. S. Ip, K. V. Gilardi, and J. R. Fischer. 2006. Avian influenza virus and free-ranging wild birds. Journal of the American Veterinary Medical Association 228: 1877-1882.

Docherty, D. E., K. A. Converse, W. R. Hausen, and G. W. Norman. 1994. American woodcock (*Scolopax minor*) mortality associated with a reovirus. Avian Diseases 38: 899-904.

Dormitorio, T. V., J. J. Giambrone, K. Guo, and G. R. Hepp. 2009. Detection and characterization of avian influenza and other avian paramyxoviruses from wild waterfowl in parts of the southeastern United States. Poultry Science 88: 851-855.

Hiller, B. J., I. F. Sidor, S. De Guise, and J. S. Barclay. 2007. Prevalence and ultrastructure of sarcocystis in American woodcock harvested in Connecticut. Journal of Parasitology 93: 1529-1530.

Jackwood, M. W., and D. E. Stallknecht. 2007. Molecular epidemiologic studies on North American H9 avian influenza virus isolates from waterfowl and shorebirds. Avian Diseases 51: 448-450.

Krauss, S., C. A. Obert, J. Franks, D. Walker, K. Jones, P. Seiler, L. Niles, S. Paul Pryor, J. C. Obenauer, C. W. Naeve, L. Widjaja, R. J. Webby, and R. G. Webster. 2007. Influenza in migratory birds and evidence of limited intercontinental virus exchange. PLoS Pathogens 3: e167.

Krementz, D. G., and J. B. Berdeen. 1997. Survival rates of American woodcock wintering in the Georgia piedmont. Journal of Wildlife Management 61: 1328-1332.

Krementz, D. G., J. T. Seginak, D. R. Smith, and G. W. Pendleton. 1994. Survival rates of American woodcock wintering along the Atlantic coast. Journal of Wildlife Management 58: 147-155.

Loth, L., W. B. Prijono, H. Wibawa, and T. B. Usman. 2008. Evaluation of two avian influenza type A rapid antigen tests under Indonesian field conditions. Journal of Veterinary Diagnostic Investigation 20: 642-644.

Makarova, N. V., N. V. Kaverin, S. Krauss, D. Senne, and R. G. Webster. 1999. Transmission of Eurasian avian H2 influenza virus to shorebirds in North America. Journal of General Virology 80: 3167-3171.

Pearce, J. M., A. M. Ramey, H. S. Ip, and R. E. Gill, Jr. 2010. Limited evidence of trans-hemispheric movement of avian influenza viruses among contemporary North American shorebird isolates. Virus Research 148: 44-50.

Sheldon, W. G. 1967. The book of the American woodcock. The University of Massachusetts Press, Amherst, Massachusetts. 227 pp.

Stallknecht, D. E., and S. M. Shane. 1988. Host range of avian influenza virus in free living birds. Veterinary Research Communications 12: 125-141.

Stribling, H. L., and P. D. Doerr. 1985a. Nocturnal use of fields by American woodcock. Journal of Wildlife Management 49: 485-491.

__________________________ . 1985b. Characteristics of American woodcock wintering in eastern North Carolina. North American Bird Bander 10: 68-72.