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Spring Migration Ecology of American Woodcock (Scolopax minor) in the Central Management Region of the United States

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Spring Migration Ecology of American Woodcock (*Scolopax minor*) in the Central Management Region of the United States

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Biology

by

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Michigan State University
Bachelor of Science in Fisheries and Wildlife, 2009

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ABSTRACT

American woodcock (*Scolopax minor*) is a migratory game bird in population decline since the start of monitoring in 1968. Researchers are interested in gaining knowledge of spring migration ecology to improve migration habitat and mitigate population decline. I captured six woodcock with mist and hand nets on nocturnal habitat and marked them with VHF (very high frequency) transmitters in northern Arkansas. I documented the distance they traveled between nocturnal and diurnal habitats (n=27), and documented diurnal vegetation characteristics at sites used (n=25). I found that woodcock moved an average of 370 m (SE 25.31 m) with the longest movement being 651 m. Diurnally, woodcock used mature hardwood landcover types, with an average canopy cover of 89% (SE 2.42), average bare soil of 19% (SE 3.14), ground vegetation density of 2.18 (SE 0.14), and mid story vegetation density of 2.19 (SE 0.14).

I used citizen scientists to conduct crepuscular surveys for woodcock (n=860) in Arkansas, Missouri, Iowa, and Illinois and used survey areas to describe woodcock habitat with large-scale LANDFIRE vegetation data layers. Survey areas where woodcock were detected had less agriculture (specifically row crops) and more hardwood cover, especially where tree cover was 70%-80%, than present in the study area. Survey areas where woodcock were detected also had higher patch size coefficients of variance that indicates large ranges of patch sizes and high habitat variability within close proximity to survey locations. My results on woodcock habitat use during spring migration are important for managers to identify areas and habitat types to conserve and manage to improve migration habitat and mitigate further population decline.

ACKNOWLEDGEMENTS

Thank you to everyone who made my research possible, Dr. David G. Krementz, my advisor, and my committee members, Drs. John David (JD) Willson and Jason A. Tullis, I appreciate you always being available to answer my questions and give me direction. The Missouri Department of Conservation, Robert E. Talbot Conservation Area, Arkansas Game and Fish Commission, the U.S. Forest Service, Wedington Wildlife Management Area, and U.S. Fish and Wildlife Service, Wapanocca National Wildlife Refuge for the permission to trap and track woodcock. Thank you also to the University of Arkansas, the US Geological Survey Arkansas Cooperative Fish and Wildlife Research Unit, Arkansas Audubon Society Trust and Ozark Society Incorporated, Harold & Margaret Hedges Scholarship in Ornithology for financial support.

I would like to thank all of the volunteers who helped collect data for this study. Without the cooperation from outdoor enthusiasts, naturalists, local birding groups and Audubon Societies, universities, state and federal agencies and private organizations in Arkansas, Missouri, Iowa and Illinois, this study would not have been possible. Thank you, your dedication and enthusiasm was impressive.

Thank you to W.C. Johnson for the support and my lab-mates, Chris Reddin, Tyler Pittman, Auriel Fournier (Jon), John Herbert (Kristen), Robert Fournier, Chris Middaugh (Summer and Ruth), Joe Moore (Liz), and Nicky Graham for the many happy hours, endless woodcock jokes, constant support, and free labor. You all made my time here easier. Thank you to my family, without you I would not be here. Last, I would like to thank my wonderful husband, Jeremy Wood, for being supportive and reassuring even when we had to be 700 miles apart. You are amazing.

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INTRODUCTION

American woodcock (*Scolopax minor*, hereafter called woodcock) are an important and widespread game bird ranging mostly to the east of the Great Plains. Woodcock populations have significantly declined in both management regions since the start of regular population monitoring (Cooper and Rau 2014). Researchers monitor and manage woodcock based on two large areas, the Eastern and Central Management Regions (Owen et al. 1977, Coon et al. 1977). To monitor woodcock populations, researchers use an index derived from the woodcock singing-ground surveys (SGS), which exploit the males' courtship displays. In 2006, the Migratory Shore and Upland Game Bird Support Task Force set research priorities for management of woodcock (Case et al. 2010). Case et al. (2010) identified the need to increase knowledge of woodcock habitat use during migration. Most studies have occurred on the northern breeding grounds and the wintering grounds; few have looked at habitat use along their migration routes.

Woodcock habitat use during fall migration shifts from using early successional habitat in the north to a mix of early successional and mature forests in the south (Myatt and Krementz 2007). Myatt and Krementz (2007) found fall migrating woodcock used upland oak, pine, or pine-hardwood forests. Krohn et al. (1977) found fall migrating woodcock in Cape May, New Jersey spent the night in areas with fertile soils including abandoned fields, alfalfa stands, and weedy pastures, optimal for feeding.

Researchers have studied spring migration on smaller spatial scales than fall migration, with regional studies done by Newman (2012) in central Kentucky and by Long and Locher (2013) in central Arkansas. Newman (2012) documented nocturnal roost site habitat in central Kentucky as characterized by short vegetation and shallow leaf litter, with silt loam soils. Long and Locher (2013) found woodcock in central Arkansas used pine stands with herbaceous cover between 70-80% and flattened herbaceous and shrub cover between 50-60%. No large-scale habitat use studies have explored habitat use across the Central Region during spring migration.

Frequently, woodcock move between different nocturnal and diurnal habitats. During the spring males conduct courtship displays-generally in open fields-at dusk and remain to roost throughout the night, and return to cover at dawn to spend the day. Researchers have studied these local movements on the northern breeding grounds and wintering grounds, but not successfully along the migration routes. Wintering woodcock of the coastal plain of Georgia moved an average of 708 m between nocturnal and diurnal habitat (Krementz et al. 1995), another study in Georgia found wintering male woodcock moved an average of 525 m, while females moved an average of 230 m (Berdeen and Krementz 1998). In the Alabama Piedmont woodcock moved an average of 183 m (Horton and Causey 1979). Blackman found wintering woodcock in eastern North Carolina never moved greater than 2500 m (2011). A study in east Texas found that males traveled an average of 393 m, while females traveled an average 319 m (Berry 2006). Owen and Morgan (1975) found immature woodcock in Maine traveled the farthest between nocturnal and diurnal habitats, an average of 332 m. Another study in Maine found the distance traveled between nocturnal and diurnal habitats varied by gender and age class but also by time of year (June-October) with distances ranging from 137 m to 1020 m (Sepik and Derleth 1993). Singing males in Pennsylvania traveled an average of 364 m (Hudgins et al. 1985). These local movements are an important component to understanding woodcock habitat use.

Ornithologists have used citizen scientists to collect data as early as 1900 for the Christmas Bird Count, 1966 for the Breeding Bird Surveys (Dickinson et al. 2010), and 1936 for the American woodcock singing-ground surveys (Owen et al. 1977). Researchers continue to use citizen scientists as a tool to cover expansive regions and collect extensive data with little to no cost. The use of citizen scientists is becoming more and more common. For example, the Cornell Lab of Ornithology coordinates over 600 citizen scientist projects (Dickinson et al. 2010). Also in 2002, eBird was started, a real-time website that allows birders to submit checklists and share information regarding bird species, distribution, abundance and timing across the globe (eBird 2015). Although eBird relies on surveillance data collection, it is a successful example of the power of citizen scientists, but often, direct target monitoring is more effective in evaluating a specific hypothesis (Dickinson et al. 2010). This research utilized a target monitoring approach, by designing surveys and protocols for volunteers to target woodcock. We used eBird data for characterizing migration phenology for this study.

My objectives were to document the distance spring migrating woodcock moved between nocturnal and diurnal habitat, and to describe habitat woodcock used during spring migration in Arkansas, Missouri, Iowa and Illinois-states that lie between woodcock breeding and wintering ranges in the Central Management Region. To document distance traveled between nocturnal and diurnal habitat we marked woodcock on the singing grounds (nocturnal habitat) with VHF transmitters. I relocated marked birds in their diurnal cover to estimate how far woodcock travel from nocturnal to diurnal habitats. I used these distance estimates to buffer volunteer survey locations (nocturnal habitat) and describe the habitat of these migratory stopover points using large-scale LANDFIRE (2010) vegetation GIS (geographic information system) data layers. This new information on spring migration- habitat use is critical for better management of public and private lands for woodcock.

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CHAPTER I

LOCAL MOVEMENTS OF SPRING MIGRATING WOODCOCK IN NORTHERN ARKANSAS

Cari Elizabeth Sebright

ABSTRACT.--- American woodcock (*Scolopax minor*) are a migratory game bird in population decline since the start of monitoring in 1968. Little is known about habitat use of woodcock during spring migration. I captured and marked six woodcock with transmitters in northern Arkansas during spring migration to study habitat use then. I found that woodcock moved an average of 370 m (SE 25.31 m) between diurnal and nocturnal locations, with the longest movement being 651 m. All marked woodcock moved between nocturnal and diurnal habitat. Diurnally woodcock used mature hardwood landcover types, with an average canopy cover of 88.67% (SE 2.42), average bare soil of 19.4% (SE 3.14), and ground vegetation density index (a scale of 1-5) of 2.18 (SE 0.14) and mid story vegetation density index of 2.19 (SE 0.14). Traveling only a few hundred meters between diurnal and nocturnal habitat suggests that land managers especially need to focus their habitat efforts for woodcock immediately surrounding nocturnal habitat. Habitat management in the diurnal cover surrounding nocturnal fields needs to include dense stands of mature hardwood with sparse understory cover.

INTRODUCTION

American woodcock (*Scolopax minor*, hereafter called woodcock) are an elusive and intriguing game bird. Based on the singing-ground survey index woodcock have declined significantly throughout their range since the start of the singing-ground surveys in 1968 (Cooper and Rau 2014). In 2006, the Migratory Shore and Upland Game Bird Support Task Force set research priorities for management of many species, including, woodcock (Case et al. 2010). Case et al. (2010) identified the need to increase knowledge of woodcock habitat use during migration.

Frequently, woodcock move between different nocturnal and diurnal habitats. In the spring, males conduct courtship displays, generally in open fields, at dusk and remain in those fields to roost throughout the night, and return to different habitat at dawn to spend the day. Researchers have documented local movements on the wintering and breeding grounds (Krementz et al. 1995, Berdeen and Krementz 1998, Blackman 2011, Berry 2006, Owen and Morgan 1975, Sepik and Derleth 1993, Horton and Causey 1979, Hudgins et al. 1985), but not successfully along migration routes. Local movements are an important component to understanding woodcock habitat use.

Most habitat use studies of woodcock have occurred on either the breeding grounds or the wintering grounds. Only two studies have looked at woodcock habitat use along their spring migration routes. Newman (2012) used nocturnal surveys to characterize woodcock spring migration nocturnal roost site habitat in central Kentucky as short vegetation and shallow leaf litter, with silt loam soils, most woodcock were found in old fields that had been managed by strip mowing or spring/fall burning. Long and Locher (2013) used crepuscular surveys and found woodcock in central Arkansas used pine stands with herbaceous cover between 70-80% and flattened herbaceous and shrub cover between 50-60%. No study has documented large-scale habitat patterns during spring migration.

Two studies looked at woodcock habitat during fall migration. Myatt and Krementz (2007) found during fall migration habitat shifts from successional habitat in the north to a mix of early successional and mature forests in the south. Myatt and Krementz (2007) also found fall migrating woodcock used upland oak, pine, or pine-hardwood forests. Krohn et al. (1977) found fall migrating woodcock in Cape May, New Jersey spent the night in areas including abandoned fields, alfalfa stands, and weedy pastures with fertile soils, optimal for feeding.

Since few studies have looked at spring migration habitat of woodcock, my goal for this chapter was to increase understanding of spring habitat from marked woodcock. My objectives for this chapter were to: 1) document the distance traveled by woodcock between nocturnal and diurnal habitat, and 2) collect vegetation data at known diurnal woodcock locations. To do this, I captured and marked woodcock with VHF (very high frequency) transmitters on the singing grounds (nocturnal habitat) and relocated them until they left the study area.

METHODS

Study Area.---I captured woodcock in northwest Arkansas on Wedington Wildlife Management Area (WMA) and in northeast Arkansas on Wapanocca National Wildlife Refuge (NWR) (Fig. 1). Wedington WMA is part of the Ozark National Forest and is mostly comprised of hardwood forest with open fields, and some early successional habitat (AGFC 2015). The U.S. Fish and Wildlife Service manage Wapanocca NWR to provide habitat for migratory birds. Wapanocca NWR is comprised of lowland hardwood and hardwood forests, agricultural fields and early successional habitat (USFWS 2015).

Telemetry.---I captured woodcock (IACUC # 14019) between mid-January and mid-March at Wedington WMA in 2014 and during the same period at Wapanocca NWR in 2015 using 36 millimeter mist nets during their crepuscular displays (McAuley et al. 1993a) and with hand nets, and spotlighting on foot when conditions allowed (Glasgow 1958) . Captured woodcock were aged, weighed, sexed (Martin 1964) and fitted with VHF transmitters ≤ 4.2 grams, attached with 3M Vetbond on the back between the wings (Fig. 2). This transmitter placement does not affect woodcock behavior (McAuley et al. 1993b).

I located marked woodcock using a 3-element Yagi antenna and circled at approximately 20 m to determine the woodcock’s exact location and minimize disturbance (McAuley 1993*a*). I attempted to locate each bird at least once diurnally and confirmed nocturnal fields. I recorded the UTM coordinates at each woodcock location and measured vegetation characteristics at diurnal locations, after the bird left the area, and at a point 50-100 m in a random cardinal direction from the marked bird's location. I determined the size class of the over-story trees and horizontal density 10 m from the point in all 4 cardinal directions at the ground (0-0.5 m) and mid story (0.5-2 m) vegetation levels by classifying the density on a scale of 1-5 (Myatt and Krementz 2007). I used the following scales: 1) little or no standing vegetation, 2) 20-40% cover, 3) 40-60% cover, 4) 60-80% cover, and 5) nearly impenetrable thicket with dense standing vegetation (Myatt and Krementz 2007). I used a 1 x 1m quadrat (Daubenmire 1959) at the marked bird's location to determine percent bare soil and percent canopy cover with a convex spherical densitometer (Myatt and Krementz 2007).

RESULTS

In spring 2014, I marked five woodcock on Wedington WMA and in spring 2015, I marked one woodcock on Wapanocca NWR. Of the marked woodcock three where adult female, two juvenile male, and one adult male. The average weight of the females was 205 g and average weight of the males was 146 g. I recorded 27 diurnal locations (24 in 2014 and 3 in 2015). The average distance moved between nocturnal and diurnal habitats was 370 m (SE 25.31 m) with a median distance of 353 m and no bird traveling more than 651 m. The woodcock marked on Wapanocca NWR moved farther on average than the woodcock marked on Wedington WMA (Fig. 3). All marked woodcock moved daily between nocturnal and diurnal habitat. Only one woodcock changed nocturnal fields during the time I monitored. A juvenile male that moved approximately 2.5 km to another nocturnal field after it was released, it remained at the new field for the duration of monitoring.

I collected habitat data at 25 diurnal locations. Woodcock were more often located in hardwood landcover types (n=15), than in shrubland (n=9), or open grassy fields (n=1).

Woodcock locations were more often in areas where the size class of the over-story trees was mature (n=17), than in pole (n=3), or sapling (n=5) size classes. Woodcock locations had ground densities that ranged from 1.25-3.75, with a mean of 2.18 (SE 0.14), and a median of 2. Ground densities used were more dense than what was available (Fig. 4). Mid-story densities ranged from 1.25-3.25, with a mean of 2.19 (SE 0.14), and a median of 2.25. Mid-story densities used were more dense than what was available (Fig. 4). Bare soil ranged from 5%-75%, with a mean of 19.4% (SE 3.14), and a median of 10%. Bare soil use was similar to what was available (Fig. 5). Canopy cover ranged from 59.75%-100%, with a mean of 88.67% (SE 2.42), and a median of 92.5%. Canopy cover use was similar to what was available (Fig. 5).

DISCUSSION

I found that spring migrating woodcock in northern Arkansas moved an average of 370 m (SE 25.31 m) between nocturnal and diurnal habitats. My findings are consistent with those of other studies conducted on the breeding and wintering grounds. Male woodcock in Pennsylvania traveled an average of 364 m between nocturnal and diurnal habitats (Hudgins et al. 1985), while in the Alabama Piedmont woodcock moved an average of 183 m (Horton and Causey 1979). In Georgia, wintering male woodcock moved an average of 525 m, while females moved an average of 230 m (Berdeen and Krementz 1998). A study in east Texas found that males traveled an average of 393 m, while females traveled an average 319 m (Berry 2006). Owen and Morgan (1975) found immature woodcock in Maine traveled farther than any other age class between nocturnal and diurnal habitats, an average of 332 m. Sepik and Derleth (1993) found in Maine that the distance traveled between nocturnal and diurnal habitats not only varied by gender and age class but also by time of year (June-October) with distances ranging from 137 m to 1020 m. The farthest distance traveled, 1020 m, was by adult males in July (Sepik and

Derleth 1993). Two studies did record more extreme daily movements, one in the coastal plain of Georgia found that wintering woodcock moved an average of 708 m (Krementz et al. 1995), and Blackman (2011) found wintering woodcock in eastern North Carolina were always located diurnally within 2500 m of nocturnal fields. Despite the differences in daily movements between regions and age/sex classes, the distance 300 - 400 m appears frequently in the literature, and is not unique solely to spring migration.

My findings were similar to those of Myatt and Krementz (2007) in that they found fall migrating woodcock in and north of the Ozark Mountains more often in mature hardwood rather than early successional habitats. However, they documented lower canopy cover, with an average of 55.9% (SD 38.307), lower ground vegetation density, with an average of 1.98 (SD 0.756), and a higher mid-story vegetation density, with an average of 2.75 (SD 1.308) (Myatt and Krementz 2007). In central Arkansas Long and Locher (2013), found woodcock used pines stands with 70-80% herbaceous, and 50-60% flattened herbaceous (herbaceous vegetation with broken stems, lying parallel to the ground) and shrub cover. I did not locate any marked woodcock in northern Arkansas in pine stands and our mid-story and ground vegetation densities were lower than found by Long and Locher (2013). Newman (2012) researched exclusively nocturnal habitat, his findings are not comparable to our findings for diurnal habitat.

My data represent the only measurements of daily distances traveled between nocturnal and diurnal habitat by woodcock during spring migration. This information should help land managers target key woodcock habitats during spring migration

ACKNOWLEDGEMENTS

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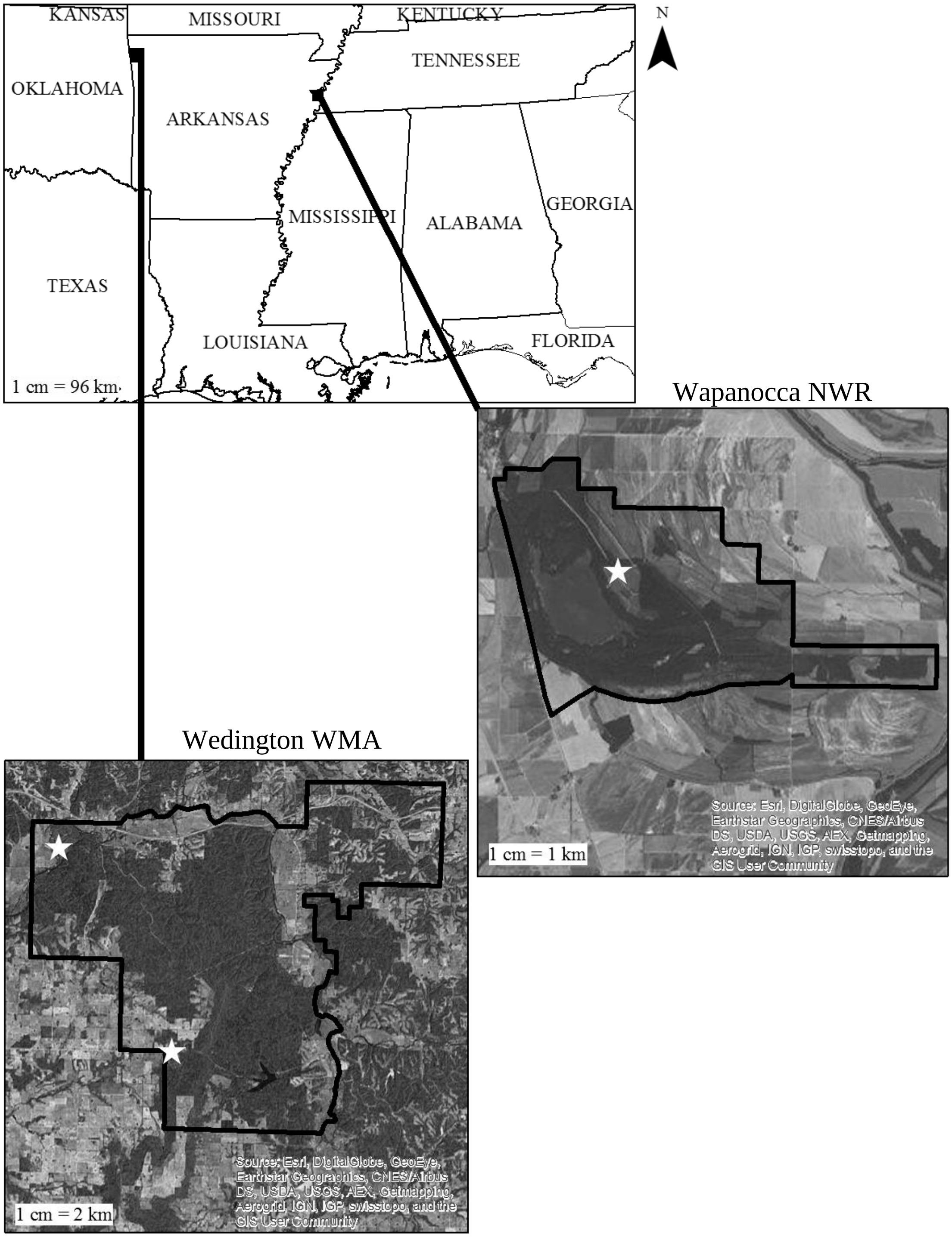

FIG. 1. Woodcock capture locations, indicated by a star, for Wedington Wildlife Management Area (WMA), and Wapanocca National Wildlife Refuge (NWR) in northern Arkansas for 2014 and 2015.

FIG. 2. Transmitter placement on American woodcock captured at Wedington Wildlife Management Area, northwest Arkansas in 2014. Photo taken by H. Tyler Pittman of the Arkansas Cooperative Fish and Wildlife Research Unit.

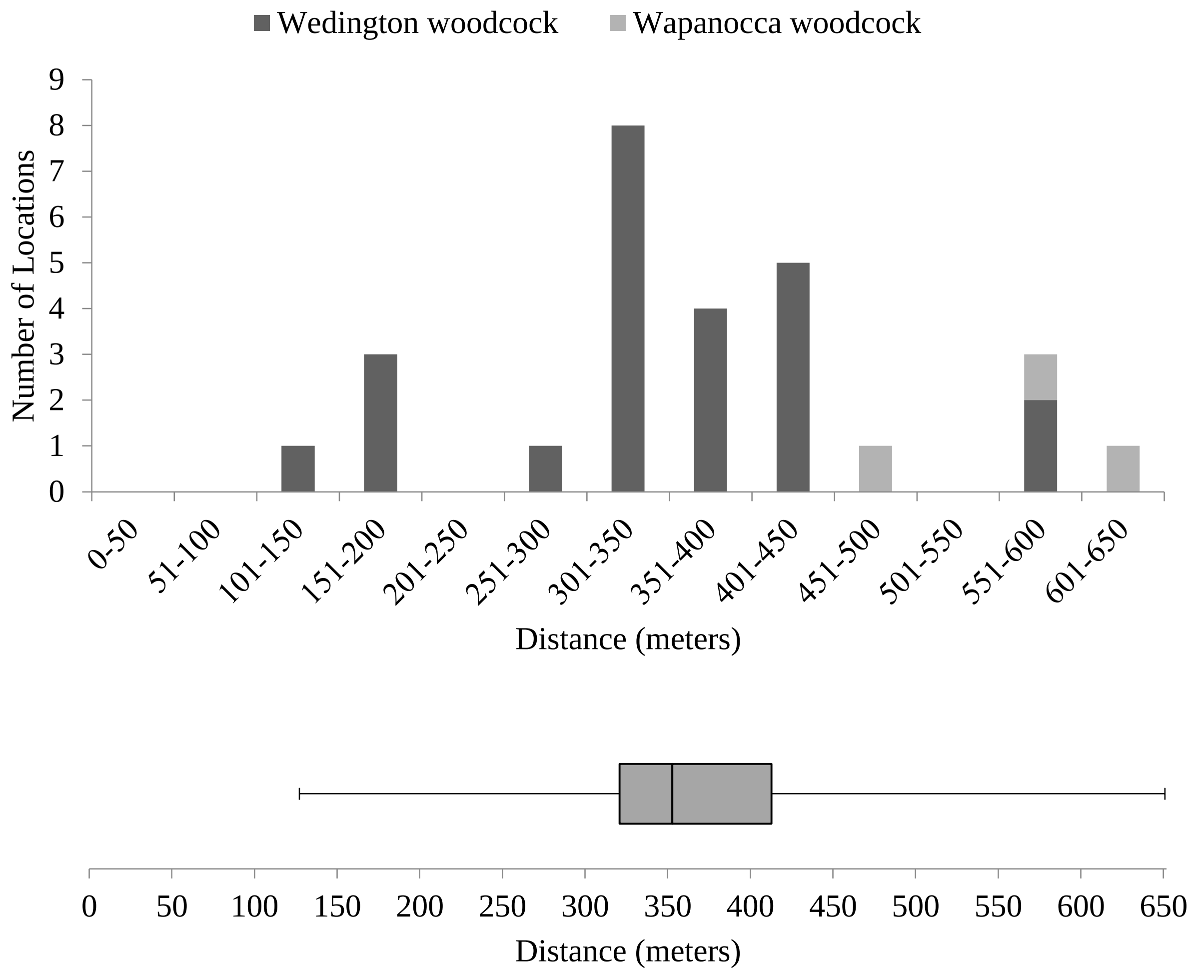

FIG. 3. Frequency histogram and box plot of distances traveled between nocturnal and diurnal locations (n=27) of six marked American woodcock in northern Arkansas on Wedington WMA and Wapanocca NWR during spring migration 2014 and 2015.

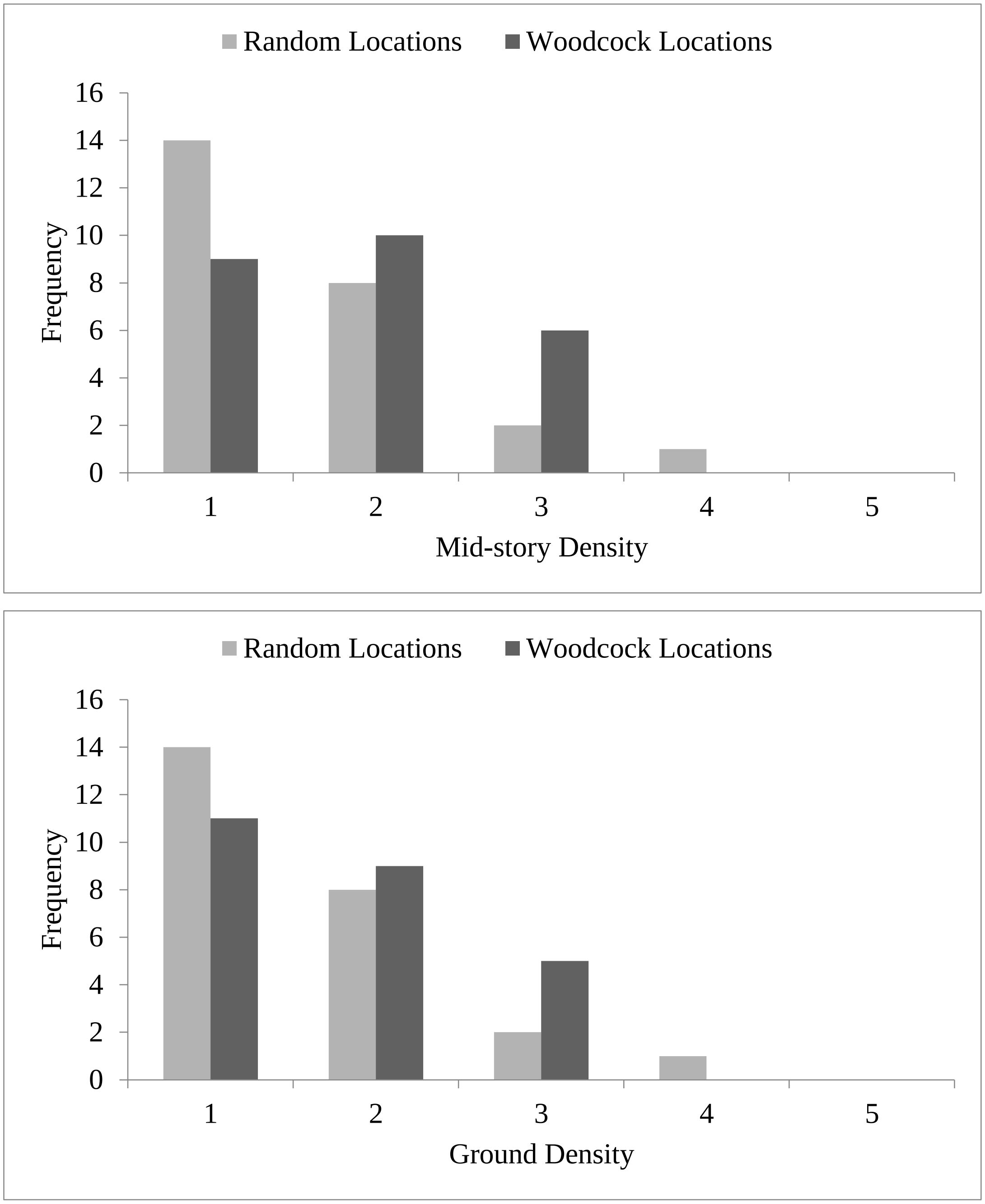

FIG. 4. Frequency of American woodcock locations and random locations (n=25) from six marked birds in northern Arkansas on Wedington WMA and Wapanocca NWR during spring migration 2014 and 2015. Mid-story and ground densities were visually classified on a scale of 1-5, where 1= little or no standing vegetation, 2= 20-40% cover, 3= 40-60% cover, 4= 60-80% cover, and 5= nearly impenetrable thicket with dense standing vegetation.

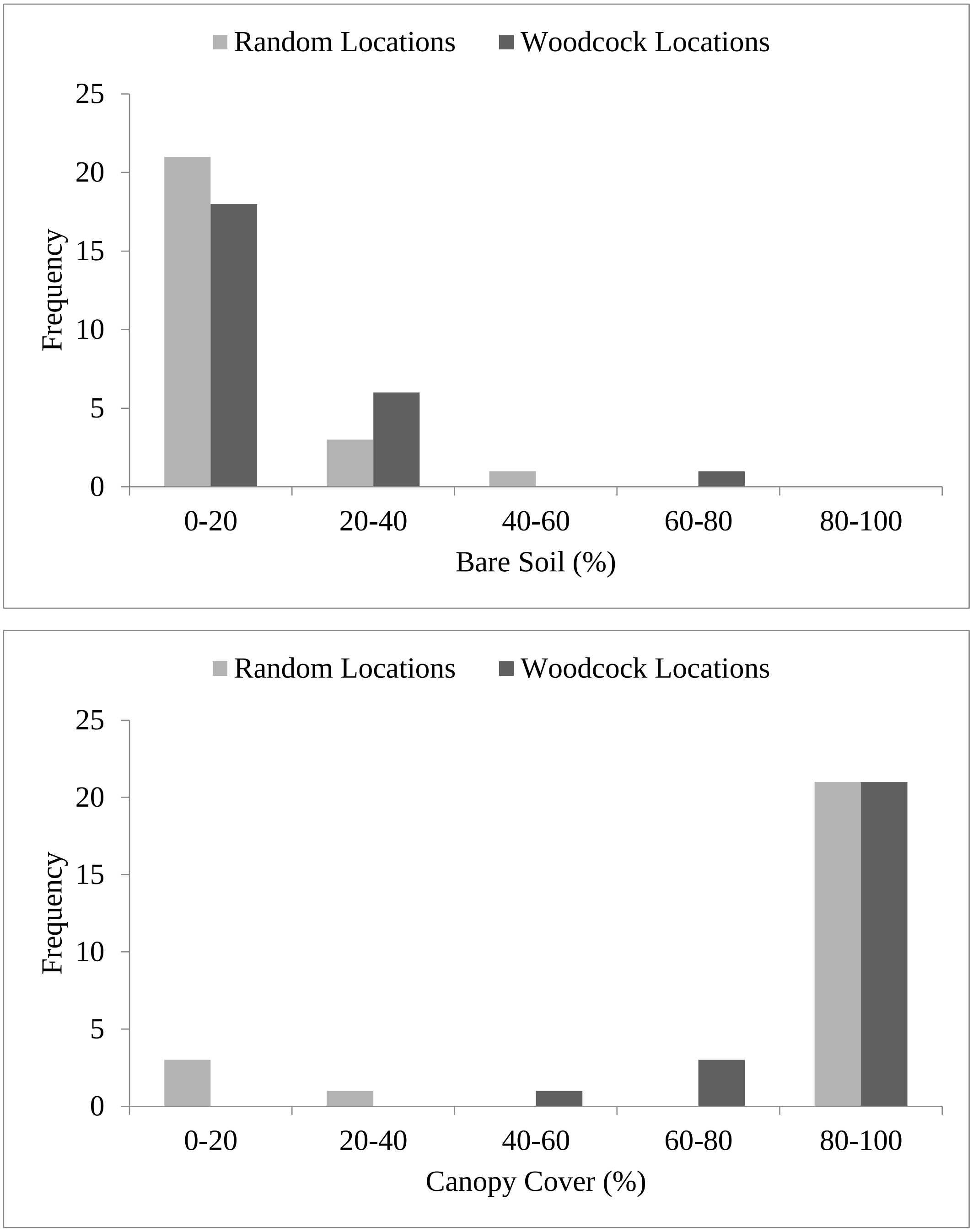

FIG. 5. Frequency of American woodcock locations and random locations (n=25) with bare soil and canopy cover percentages from six marked birds in northern Arkansas on Wedington WMA and Wapanocca NWR during spring migration 2014 and 2015.

APPENDIX A: Research Compliance Protocol Letter

UNIVERSITY OF ARKANSAS

Office of Research Compliance

MEMORANDUM

TO: David Krementz

FROM: Craig N. Coon, Chairman
Institutional Animal Care
And Use Committee

DATE: December 16, 2013

SUBJECT: IACUC Protocol **APPROVAL**
Expiration date : **March 31, 2016**

The Institutional Animal Care and Use Committee (IACUC) has **APPROVED** Protocol **#14019- "Spring Migration Ecology of American Woodcock (Scolopax minor) in the Central Management Region of the United States**". You may begin this study immediately.

The IACUC encourages you to make sure that you are also in compliance with other UAF committees such as Biosafety, Toxic Substances and/or Radiation Safety if your project has components that fall under their purview.

In granting its approval, the IACUC has approved only the protocol provided. Should there be any changes to the protocol during the research, please notify the IACUC in writing [via the Modification Request form] **prior** to initiating the changes. If the study period is expected to extend beyond **03-31-2016** you may request an extension via the Modification Request form until 12-13-2016. By policy the IACUC cannot approve a study for more than 3 years at a time.

The IACUC appreciates your cooperation in complying with University and Federal guidelines for research involving animal subjects.

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CHAPTER II

HABITAT USE OF SPRING MIGRATING WOODCOCK IN THE CENTRAL MANAGEMENT REGION

Cari Elizabeth Sebright

ABSTRACT.---Spring migration ecology is a knowledge gap for American woodcock (*Scolopax minor*). I used citizen scientists to conduct crepuscular surveys for woodcock (n=860) in Arkansas, Missouri, Iowa, and Illinois and used survey areas to describe woodcock habitat with large-scale LANDFIRE vegetation data layers. Survey areas where woodcock were detected had less agriculture (specifically row crops) and more hardwood cover, especially where tree cover was 70%-80%, than present in the study area. Survey areas where woodcock were detected also had higher patch size coefficients of variance, this indicates, large ranges of patch sizes and high habitat variability within close proximity to survey locations. My results on woodcock habitat use during spring migration are important for managers to identify areas and habitat types to conserve and manage migration habitat and mitigate further population decline.

INTRODUCTION

American woodcock (*Scolopax minor*, hereafter called woodcock) are an important and widespread, mostly east of the Great Plains, game bird. Woodcock populations have declined in both management regions since the start of the start of regular population monitoring (Cooper and Rau 2014). Researchers monitor and manage woodcock based on two regions, the Eastern and Central Management Regions (Owen et al. 1977, Coon et al. 1977, Fig. 1). To monitor woodcock populations, researchers use an index derived from the woodcock singing-ground surveys (SGS), which exploit the males' courtship displays. In 2006, the Migratory Shore and Upland Game Bird Support Task Force set research priorities for management of woodcock (Case et al. 2010). One priority information need is to better understand woodcock habitat use during migration (Case et al. 2010).

Woodcock often use different nocturnal and diurnal habitat. Open areas whether they be forest openings, old fields or grasslands provide crepuscular display areas for males (Keppie and

Whiting 1994). Diurnal habitat is generally associated with young hardwood, mixed forest and shrubs, though it is acknowledged that habitat likely varies daily, seasonally, and with soil moisture (Keppie and Whiting 1994, Dwyer et al. 1988). Habitat type is important but so is the variety and juxtaposition of those habitats. The daily movements woodcock make are an important component to understanding woodcock habitat use.

No large-scale studies have explored spring migration ecology of woodcock. Two regional studies looked at habitat use during spring migration on smaller spatial scales (Newman 2012, Long and Locher 2013). Newman (2012) used nocturnal surveys to document nocturnal roost site habitat in central Kentucky as having short vegetation and shallow leaf litter, with silt loam soils. Long and Locher (2013) used crepuscular surveys to explore woodcock habitat use in pine stands in central Arkansas and found woodcock there used pine stands with high herbaceous cover (70-80%) and flattened herbaceous and shrub cover between 50-60%. Myatt and Krementz (2007) studied large-scale patterns of woodcock habitat use during fall migration across the Central Management Region, the only large-scale published fall migration study. During fall migration, woodcock shift from using early successional habitat in the north to a mix of early successional and mature forests in the south (Myatt and Krementz 2007). Myatt and Krementz (2007) also found woodcock used upland oak, pine, or pine-hardwood forests. They identified priority areas for management: west central Louisiana encompassing part of eastern Texas, south central Arkansas, north central Mississippi, east of the Mississippi Alluvial Valley, and Missouri, north of Saint Louis and into west central Illinois (Myatt and Krementz 2007). Krohn et al. (1977) documented that woodcock preferred nocturnal habitat of recently abandoned fields, alfalfa stands and weedy pastures during fall migration on Cape May, New Jersey.

Ornithologists have used citizen scientists to collect data as early as 1900 for the Christmas Bird Count, in 1966 for the Breeding Bird Surveys (Dickinson et al. 2010), and in 1936 for the American woodcock SGS (Owen et al. 1977). Researchers continue to use citizen scientists as a tool to cover expansive regions and collect extensive data with little to no cost. The use of citizen scientists is becoming more and more common. For example, the Cornell Lab of Ornithology coordinates over 600 citizen scientist projects (Dickinson et al. 2010). Also in 2002, eBird was started, a real-time website that allows birders to submit checklists and share information regarding bird species, distribution, abundance and timing across the globe (eBird 2015).

My objective was to describe woodcock habitat use during spring migration in Arkansas, Missouri, Iowa and Illinois, all states that lie between woodcock breeding and wintering ranges in the Central Management Region. Since this is the first attempt to describe large-scale habitat patterns along spring migration, I took a qualitative approach, opting to gather more information from a more expansive area, than to use a formal model base approach. This information on habitat use by woodcock during spring migration should be useful for better woodcock management on public and private lands.

METHODS

Study Area.---The Central Management Region (Coon et al. 1977) of the United States of America, analogous to the central portion of the Mississippi Flyway, has an eastern boundary of the Appalachian Mountains and western of the Great Plains. I focused my survey efforts in Arkansas, Missouri, Iowa and Illinois, states that primarily lie between winter and breeding ranges (Fig. 1). Topography and habitat vary greatly across the study area. The study area is composed of six bird conservation regions, with diverse habitats: including the West Gulf

Coastal Plain/Ouachitas, Mississippi Alluvial Valley, Central Hardwoods, Eastern Tallgrass Prairie, Prairie Hardwood Transition, and Prairie Potholes. Habitat in Arkansas transitions from mostly pine, pine/hardwood, hardwood and pine plantations to hardwoods in southern Missouri. In central Missouri and northward, hardwood forests gradually transition into open grasslands and agriculture.

American Woodcock Surveys.---I used citizen scientists and volunteers from federal and state agencies to conduct surveys from 15 January to 20 April during spring migration in 2014 and 2015. Peak abundance times were determined using eBird's explore data option and looking at the historical abundance graphs for woodcock in each state (eBird 2013). In Arkansas, peak abundance range from February to mid-March, Missouri early February to 1 April, and Iowa and Illinois mid-February to mid-April (eBird 2013). I did not conduct surveys after 31 March in Arkansas, 9 April in Missouri and Illinois or after 19 April in Iowa to avoid overlap with breeding season and to focus on migration.

I used point counts and driving route surveys to survey woodcock. I employed both survey types to appeal to agency employees as well as birders, and to optimize the coverage and aid in surveying as many different habitat types as possible across the study area. Volunteers conducted surveys at locations of their choice, i.e., sampling was haphazard.

Point count surveys started 22 minutes after sunset for dusk surveys (Tautin 1983 and Tappe et al. 1989) and 60 minutes before sunrise for dawn surveys regardless of cloud cover (Tappe et al. 1989). Observers remained at the location for the complete 30-minute survey period (Tautin 1983).

Each surveyor recorded number of woodcock detected by sight and sound, UTM coordinates, temperature, wind direction, wind speed and humidity when available. During the survey period, observers recorded the number of uniquely detected woodcock. Acceptable detection types were visual and auditory observations. Auditory observations included individuals heard by flight song, a fast, repetitive chirping, frequently accompanied by wing twitter, the result of air passing by the first three primary feathers, creating a whistling sound (Keppie and Whiting 1994, Sheldon 1967). Defensive cackle, an aggressive call intended for rival males, described as a hoarse cac-cac-cac-cac; and peents which is a nasally, insect-like call, generally described as a buzzing peeeent, or wheent (Keppie and Whiting 1994 and Sheldon 1967).

Driving routes did not exceed 5.8 km with 10 listening stops. Stops were at least 0.6 km apart and surveyors listened for 2 minutes at each stop (Tautin 1983). Observers arrived early and started the first survey (listening stop 1) at the start time. Observers surveyed from outside the vehicle with the vehicle turned off for the 2-minute listening window. Driving route surveys followed the same start and end times as point count surveys, and data were collected at each listening stop as though it was an individual point count.

Analysis.--- I combined both years of data because of low sample size in 2015. By chance, most of the driving route surveys were conducted in the southern portion of the study area, so I excluded driving routes for all states except Arkansas, and in Arkansas, I analyzed them separately. I analyzed surveys across the entire study area, and each state individually for the benefit of managers, using basic descriptive statistics to describe habitat patterns.

I did not include any surveys conducted outside the survey window for each state as stated in the above survey protocols. I used the remaining surveys, combined with eBird data (eBird Basic Dataset 2014 and 2015) to graph the presence and absence of woodcock by date for each year separately with in latitudinal bands, doing so removed any surveys that volunteers conducted before woodcock were present by latitude (Bergh 2011). Latitudinal band one included latitudes 33, 34, and 35, latitudinal band two included latitudes 36, 37, and 38, latitudinal band three included latitudes 39, 40, and 41, and latitudinal band four included latitudes 42, and 43. Based on these representations of woodcock presences by latitude, 2014 surveys were removed if they were not conducted between 15 January and 19 March in latitudinal band one, 15 January and 9 April in latitudinal band two, 18 February and 9 April in latitudinal band three, and 15 March and 19 April in latitudinal band four. I removed 2015 surveys if they were not conducted between 20 January and 27 March in latitudinal band one, 27 January and 8 April in latitudinal band two, 13 February and 9 April in latitudinal band three, and 11 March and 19 April in latitudinal band four. I did not include any surveys conducted: 1) when temperatures were below -6.6 C (Tappe 1989, D.G. Krementz, USGS Arkansas Cooperative Fish and Wildlife Research Unit, personal communication) or when not documented, 2) when surveyors quantified precipitation as more than a sprinkle or mist (Tautin et al. 1983 and Bergh 2011) or not documented, 3) when winds exceeded 19 km/hr (Bergh 2011, Tappe 1989) or not documented, and 4) when surveyors indicated high background noise (Bergh 2011). Due to the difficulties of calculating detection probability with citizen scientists, my approach did not formally address detection probability, but I used the above methods to maximize the likelihood of detection from the surveys reported.

I also grouped resulting single surveys and driving route listening points (n=474, and n=654 respectively) by relative abundance category, locations with no woodcock detected (0), some woodcock detected (1-8), and many woodcock detected (>8) (Fig. 2). This method takes into account the potential counting bias of volunteers identifies areas of greater use. Pilot work suggested that fields used by woodcock tend to fall into these three categories, allowing me to compare the habitat attributes of the area surrounding high use and low or no use survey points. Though I have higher confidence in comparing the areas with no woodcock to those with many, comparisons between areas with no woodcock and some still can provide information on woodcock habitat.

To describe habitat use, I used Landfire (2010) vegetation data with a spatial resolution of 30 m, these data not only provide landcover physical descriptions similar to National Land Cover Dataset (NLCD) categories, but also provides information on vegetation structure. Detection distances of woodcock vary based on habitat type and environmental conditions (Bergh 2011). To deal with uncertainty in knowing exactly where a detected woodcock was located first, I opted to describe habitat that occurred in concentric bands surrounding the surveyor. I settled on two bandwidths, 322 m and 700 m. The maximum distance a woodcock can be heard, regardless of habitat, is 322 m (Bergh 2011), and the average distance a woodcock moved between nocturnal and diurnal habitats was 370 m (SE 25.31 m) (unpublished data). The distance of 322 m would have to include nocturnal habitat, because volunteers conducted surveys during the nocturnal period. I used a buffer size of 700 m because 322 m is the maximum distance a woodcock can be heard (Bergh 2011), plus, average distance a woodcock moved between nocturnal and diurnal habitats was 370 m (SE 25.31 m) (unpublished data), I then rounded the buffer size up to 700 m. This distance should include nocturnal and diurnal habitat.

I used Patch Analyst 5.1 (Rempel et al. 2012) in ArcGIS, spatial statistics to document the habitat in the buffered areas around each survey location broken down by each relative abundance category (none, some, and many). I calculated the total class area, total landscape area, and patch size coefficient of variance for each input file. Input files consisted of Landfire existing vegetation type (physical description) and existing vegetation cover datasets

(LANDFIRE 2010) within 700 m buffered areas around survey locations. I grouped surveys by relative abundance category so each relative abundance category was analyzed together. I chose these three metrics because they allowed me to calculate the proportion of each landcover class present as well as, the variety and juxtaposition of each patch of landcover class. I originally analyzed the 322 m buffered area as well as the 700 m buffered area, but the patterns were similar (unpublished data), so I just presented the 700 m buffered areas, to encompass total habitat instead of trying to separate out diurnal from nocturnal habitat.

I produced kernel density estimates from ArcMap 10.1 spatial analyst toolbox (ESRI 2012) on surveys, combined with eBird data (eBird 2015) for time periods: January and February, March, and April. I used total woodcock detected as the population field parameter and kept the other default parameters for the tool (ESRI 2012). I used these maps to spatially represent spring phenology, and identify hot spots of woodcock use across the study area in 2014. Survey data conducted in 2015 were not included due to low sample size.

RESULTS

During spring migration in 2014 and 2015, 268 volunteers conducted 1,341 crepuscular surveys across the study area. After data cleaning 474 point count surveys and 386 driving route points remained in the total study area. In Arkansas there were 114 point count surveys and 386 driving route points, in Missouri 147 point count surveys, in Iowa 57 point count surveys, and in Illinois 156 point count surveys (Fig. 3). Of the 860 (n=649 in 2014 and n=211 in 2015) surveys used, surveyors detected no woodcock on 433 surveys, some woodcock on 389 surveys, and many woodcock on 38 surveys. Thus the average surveys either had none or only some woodcock detected on them. Sites with many woodcock detected were rare at best.

Total Study Area.---There were four dominate habitat types, that made up at least 10% of the study area or made up at least 10% of the survey areas where woodcock were detected; agricultural, developed, hardwood, and riparian (Fig. 4). The most dominate canopy coverage categories were row crop, tree cover 70%-80%, and tree cover 80%-90% (Fig. 6). Survey areas where woodcock were detected were most commonly composed of less agriculture, specifically row crops, and more hardwood, especially when tree cover was 70%-80% than was present in the study area.

The patch size coefficient of variance for both habitat type and coverage classes were very large (Fig. 5 and Fig. 7). Overall the survey areas that detected woodcock had lower values than those that did not (Fig. 5 and Fig. 7).

Individual States.---Individual state patterns were similar to the total study area patterns with some exceptions (Table 1 and Table 2). In addition to the dominate habitat types found in the total study area, in Arkansas conifer and conifer-hardwood were also found at percentages greater than or equal to 10%. Survey areas that detected woodcock were negatively associated with conifer habitat, for both types of surveys in Arkansas, but were positively associated with conifer-hardwoods in point count surveys but not in driving route surveys (Table 3). In Illinois and Iowa herbaceous coverage classes were found to be more dominate than most tree coverage classes and survey areas that detected woodcock were positively associated with either herb cover 60%-70%, herb cover 90%-100%, or both (Table 4).

Kernel Density.---Using survey data from 2014 combined with eBird data of the same time period, I ran kernel density estimates for January and February, March, and April. The outputs show hot spots of woodcock across the study area over for each time period (Fig. 8).

DISCUSSION

My results show the survey areas with detected woodcock were most commonly composed of less agriculture, specifically row crops, and more hardwood, especially when tree cover was 70%-80%, than was found across the study area. Myatt and Krementz (2007) found that during fall migration, woodcock used upland oak, pine, or pine-hardwood forests and that habitat use during fall migration shifted from early successional habitat in the north to a mix of early successional and mature forests in the south. I found that woodcock used areas that contained conifer proportional to what was present in the study area and conifer-hardwood proportional or more than what was present, suggesting that woodcock were using areas with more hardwood than conifer. This pattern held true when I summarized states separately, but other more state specific trends also arose. In Iowa and Illinois, where forested areas were less abundant, woodcock used any area with trees at a much higher proportion than in Missouri and Arkansas, despite percent tree cover. In Iowa, I found riparian habitats in survey areas where woodcock were present at much higher proportions than was present in the state. This suggests that riparian areas provide much needed habitat when other suitable habitat is limited. Myatt and Krementz (2007) defined potential diurnal habitat as woody wetlands, shrubland, deciduous forest, evergreen forest, mixed forest, orchard-vineyard-other, and transitional, based on NLCD cover classes (Fig. 9). This suggests that the positive association of forested areas to woodcock presence is driven by the importance of diurnal habitat.

I found overall high patch size coefficient of variance but slightly lower values for areas where woodcock were present. This suggests that patchy landscapes are positively associated with areas where woodcock were present. Having variability of habitat types and patch sizes in close proximity to one another may allow woodcock to move among habitats more efficiently when needed habitat components are lacking (Dwyer et al. 1988).

I found that woodcock did not use pine stands as often as hardwood anywhere in the study area, however I was unable to determine understory characteristics with the dataset I used. Long and Locher (2013) conducted a study on pine stand use by woodcock, using crepuscular surveys as an index for woodcock abundance, in the West Gulf Coastal Plain of central Arkansas, an area of predominately pine and mixed pine-hardwood forests. They found woodcock in central Arkansas used pine stands with herbaceous cover between 70-80% and flattened herbaceous and shrub cover between 50-60% (Long and Locher 2013). Newman (2012) used nocturnal spotlight surveys to characterize spring migration nocturnal roost habitat in central Kentucky. He found nocturnal roost habitat was characterized by short vegetation, shallow litter, and silt loam soil (Newman 2012). Most woodcock were found in old fields that had been managed by strip mowing or spring/fall burning (Newman 2012). Both of these studies focused on specific small-scale characteristics of regional woodcock migration habitat, but the general large-scale patterns of spring migration habitat are unknown.

Shrubland (early successional) habitat is not well represented in LANDFIRE data, maybe because shrubland makes up a small proportion of the area, or perhaps the analysis used to create LANDFIRE data does not detect shrubland well. The reason is unknown, but I noticed that shrubland was poorly represented in my analysis. This made comparing our findings to Myatt and Krementz (2007) findings that fall migrating woodcock in the north use early successional habitat difficult. Long and Locher (2013) and Newman (2012) characterized specific small-scale habitat characteristics that are important, but I was unable to address those characteristics using current methodology.

Kernel density outputs show the hot spots where woodcock were detected across the study area (Fig. 8). There are obvious correlations with high populations of people (e.g. Chicago), but it shows the general locations of woodcock and areas that may be important for woodcock during migration. The hot spots for woodcock were almost exclusively in eastern Iowa, west and northern Iowa seem to be areas avoided by woodcock, potentially due to low potential habitat (Fig. 9). However sampling in Iowa was also skewed toward southeast Iowa (Fig. 3), volunteers conducted surveys in other regions, but most were in the southeast and southcentral. Myatt and Krementz (2007) identified priority areas for woodcock management in the central region (Fig. 10); my results do not show hot spots in the same geographic areas that Myatt and Krementz (2007) identified. This is partially because the region in Missouri that Myatt and Krementz (2007) identified was not sampled by volunteers and the region in southern Arkansas did not have as many surveys conducted as other parts of the state (Fig. 3). Human populations and surveyors preference for survey locations likely influenced our results more than we hoped. It is also possible that woodcock use different areas during spring migration than during fall migration.

MANAGEMENT IMPLICATIONS

My data gives the first landscape level account of what habitats woodcock are using during spring migration. My results indicate that managers should be aware of the importance of diurnal habitat for migrating woodcock. Hardwood forests, especially when canopy cover is 70%-80% are important and in general, areas with hardwood trees are more important during spring migration than areas without trees, but having high variability of habitat types and patch sizes in close proximity to one another, less habitat fragmentation, may allow woodcock to move among habitats more efficiently when needed habitat components are lacking.

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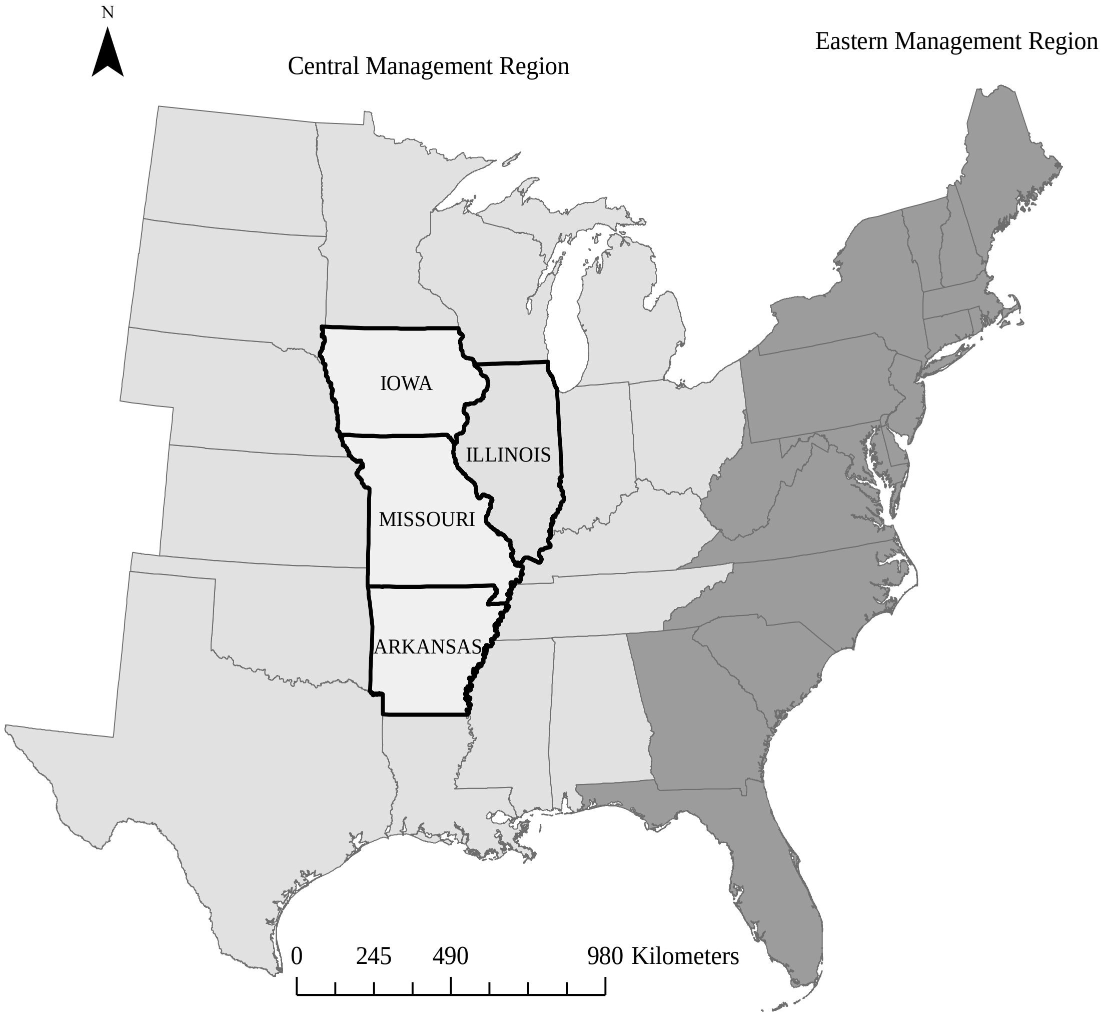

FIG. 1. Study area, overlaid on the American woodcock management regions, where volunteers surveyed American woodcock during spring migrations of 2014 and 2015.

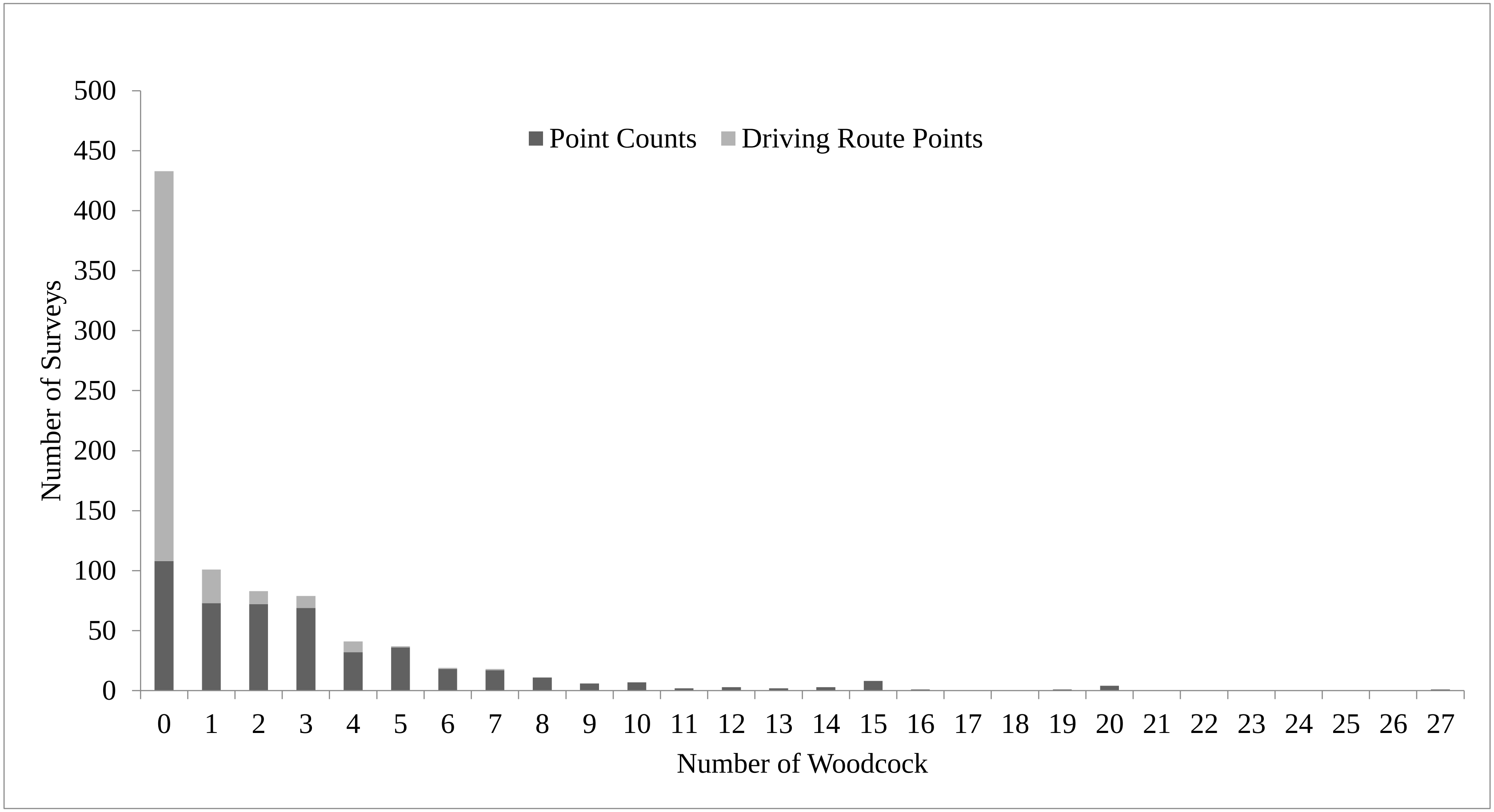

FIG. 2. Frequency histogram of American woodcock numbers from surveys (n=860) conducted by volunteers during spring migrations of 2014 and 2015.

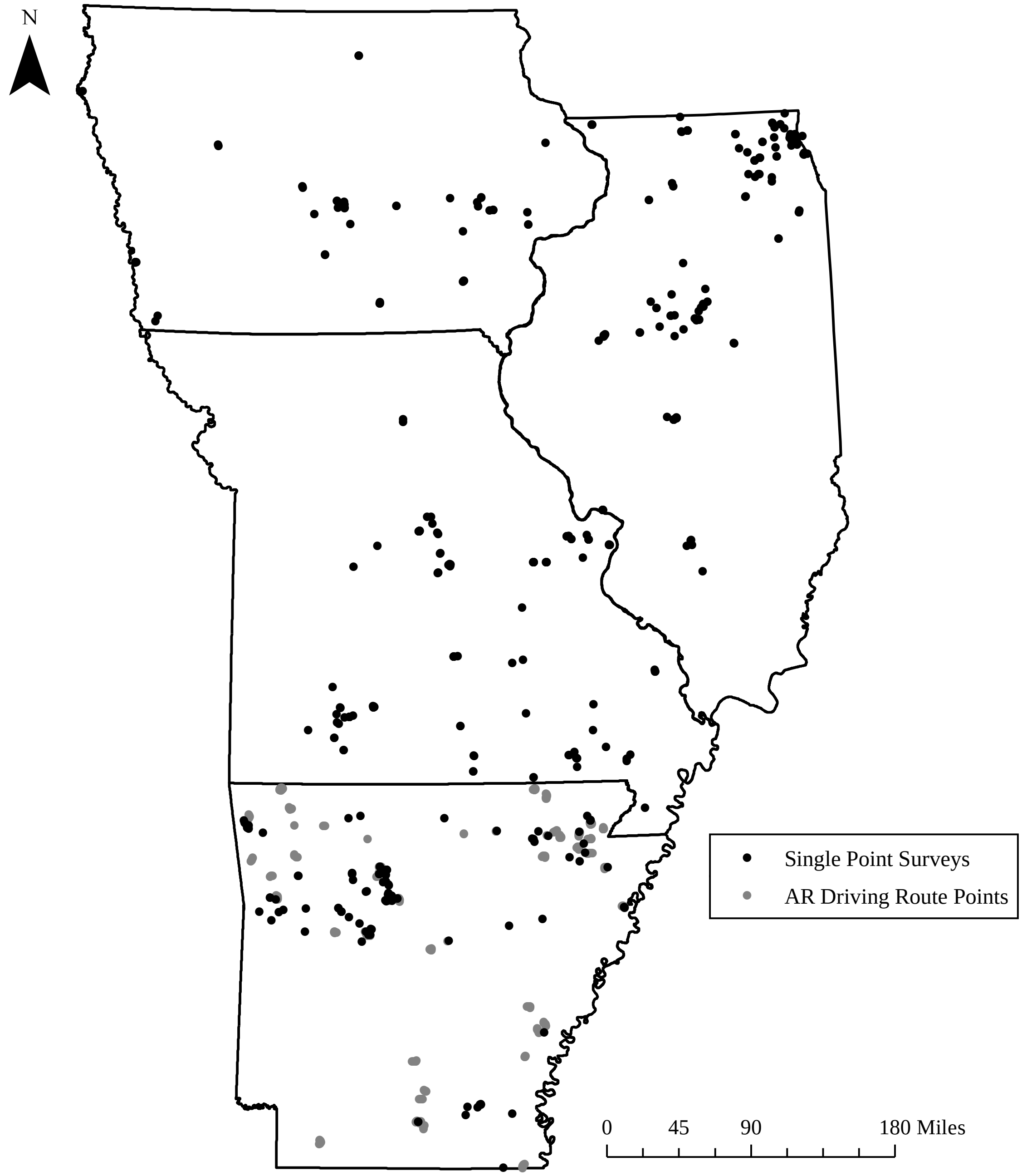

FIG. 3. Locations where volunteers surveyed American woodcock using either point count surveys or driving route surveys during spring migrations of 2014 and 2015.

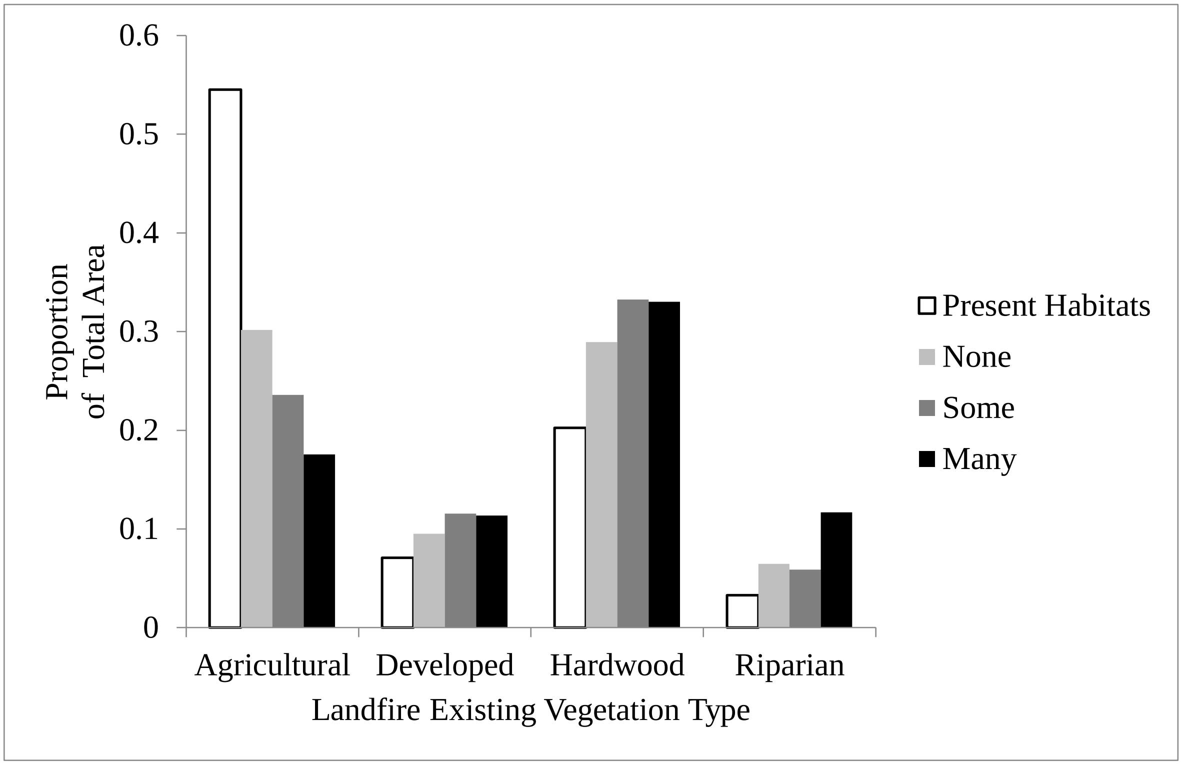

FIG. 4. This graph displays present habitat using Landfire data across the entire study area (AR, MO, IA, and IL) and the proportion of each habitat type from 700 meter buffered survey locations where none (zero), some (1-8) and many (9+) American woodcock were detected by volunteers (for habitats that comprised ≥ 10% of the area).

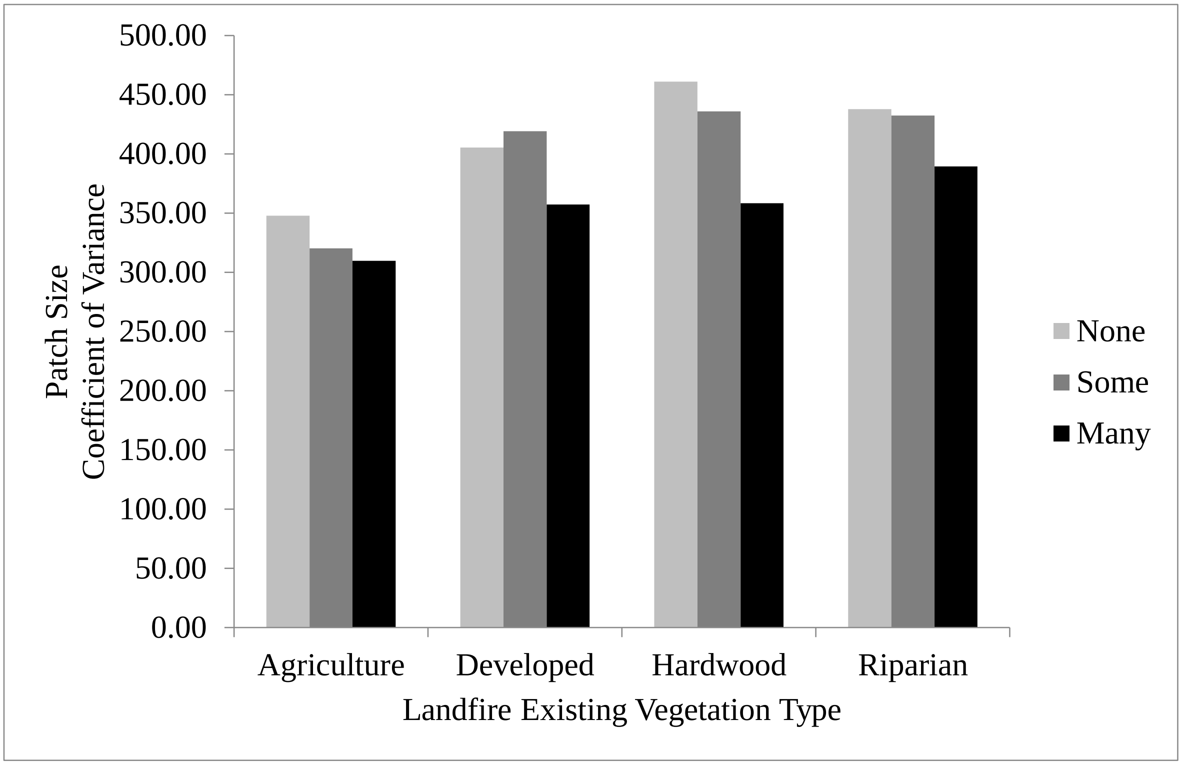

FIG. 5. This graph displays the patch size coefficient of variance using Landfire data within 700 meter buffered survey locations where none (zero), some (1-8) and many (9+) American woodcock were detected by volunteers (for habitats that comprised ≥ 10% of the area).

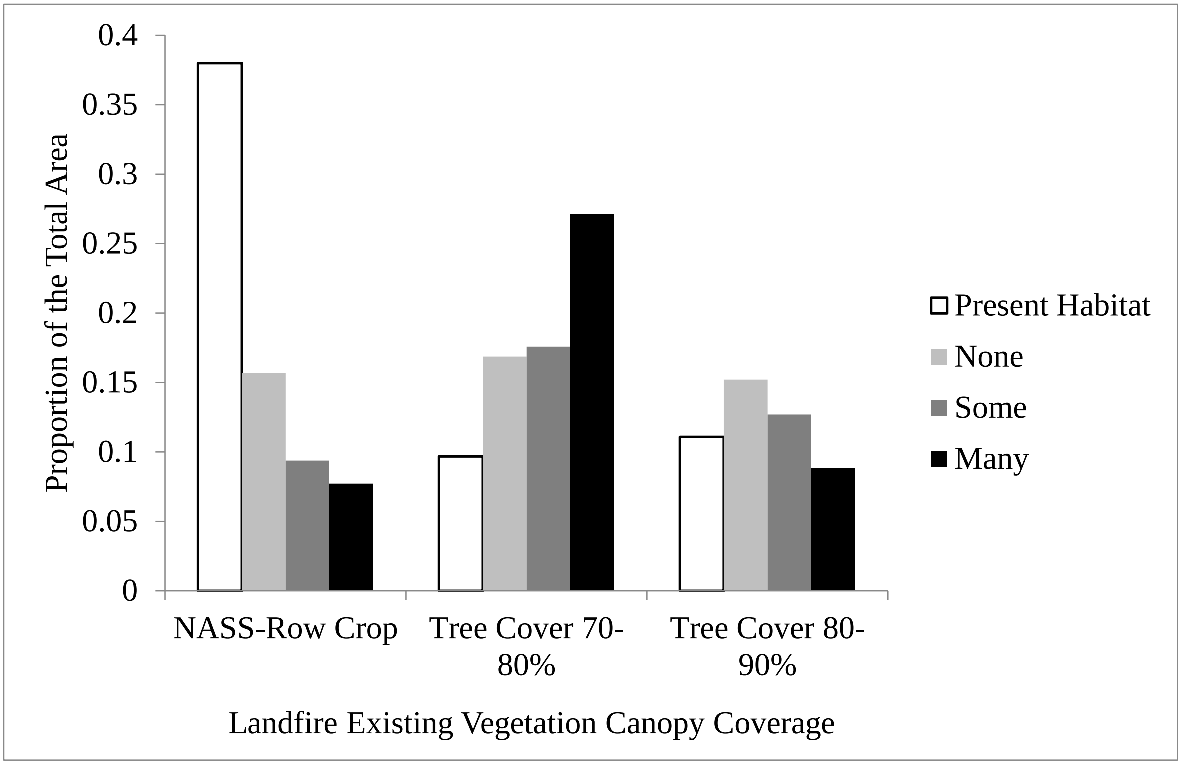

FIG. 6. This graph displays present coverage using Landfire data across the entire study area (AR, MO, IA, and IL) and the proportion of each coverage category from 700 meter buffered survey locations where none (zero), some (1-8) and many (9+) American woodcock were detected by volunteers (for coverage classes that comprised ≥ 10% of the area).

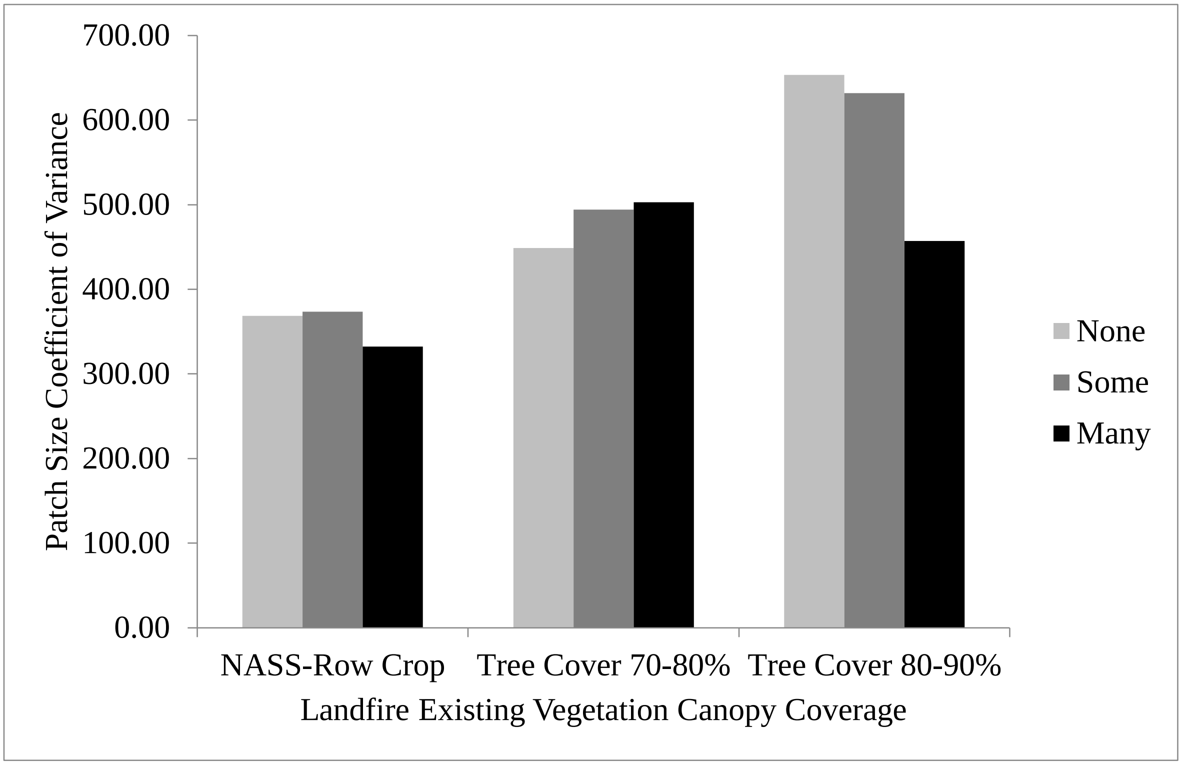

FIG. 7. This graph displays the patch size coefficient of variance using Landfire data within 700 meter buffered survey locations where none (zero), some (1-8) and many (9+) American woodcock were detected by volunteers (that comprised ≥ 10% of the area).

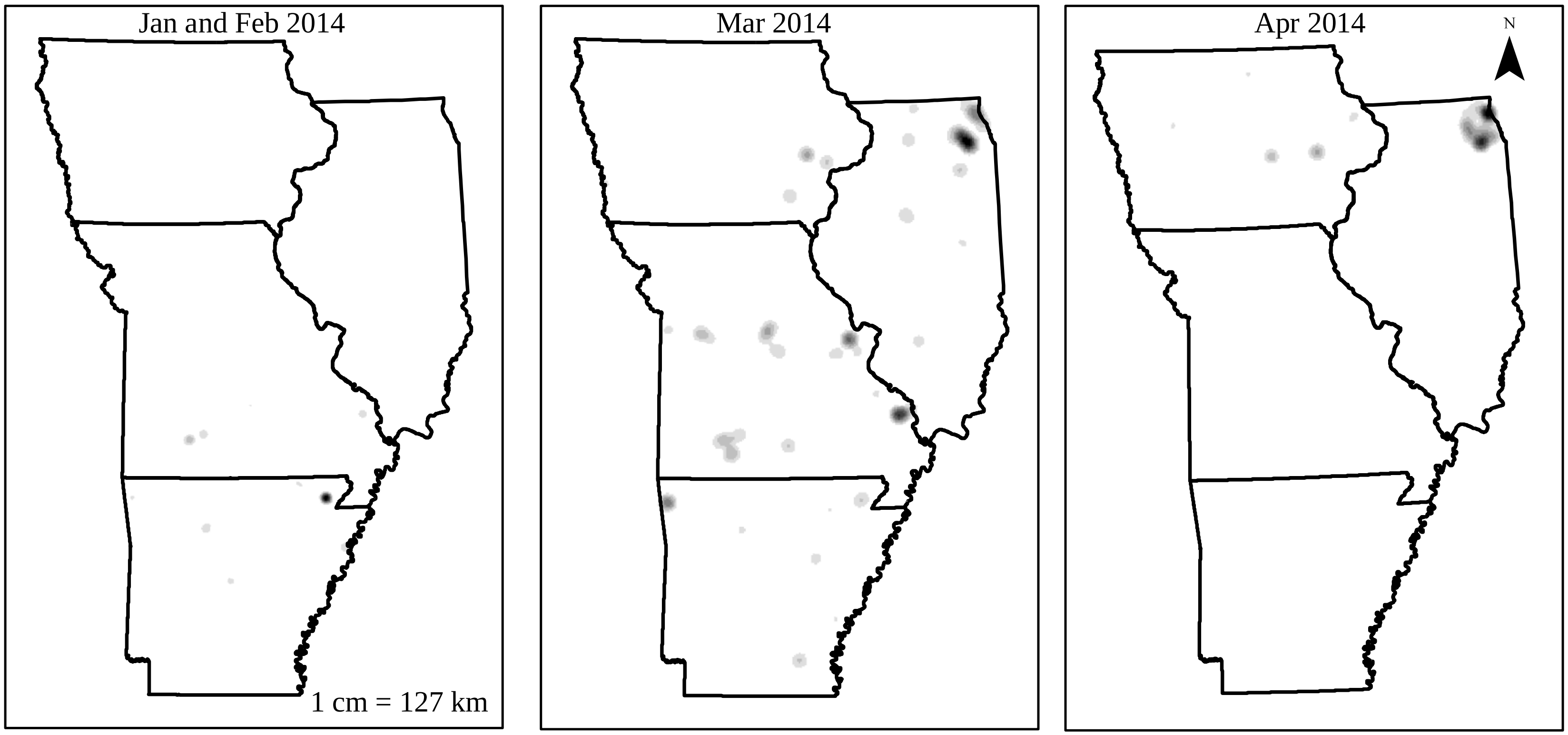

FIG. 8. Kernel Density outputs from survey data, combined with eBird data (eBird 2014) for January and February, March, and April 2014 in Arkansas, Missouri, Iowa and Illinois.

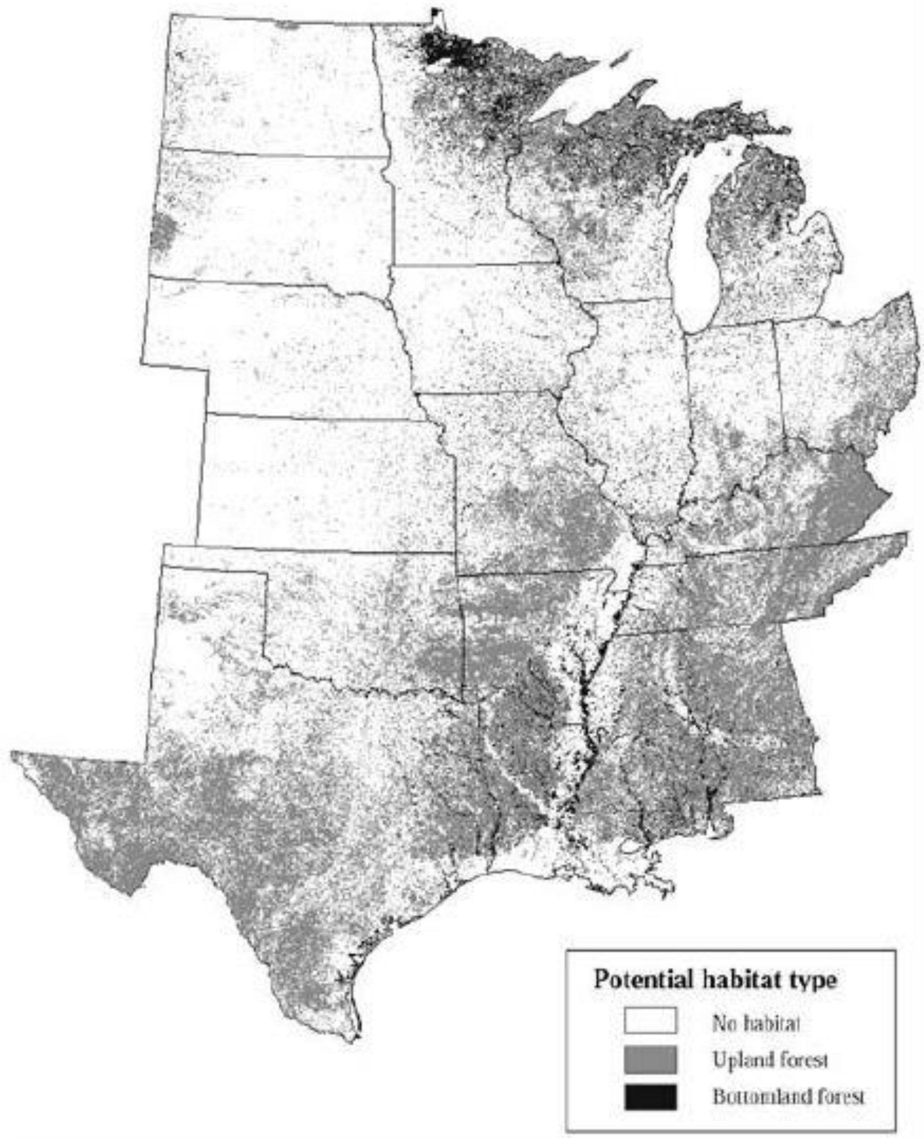

FIG. 9. Areas of potential diurnal American woodcock habitat determined from 1992 National Land Cover Data (NLCD) by Myatt and Krementz (2007)

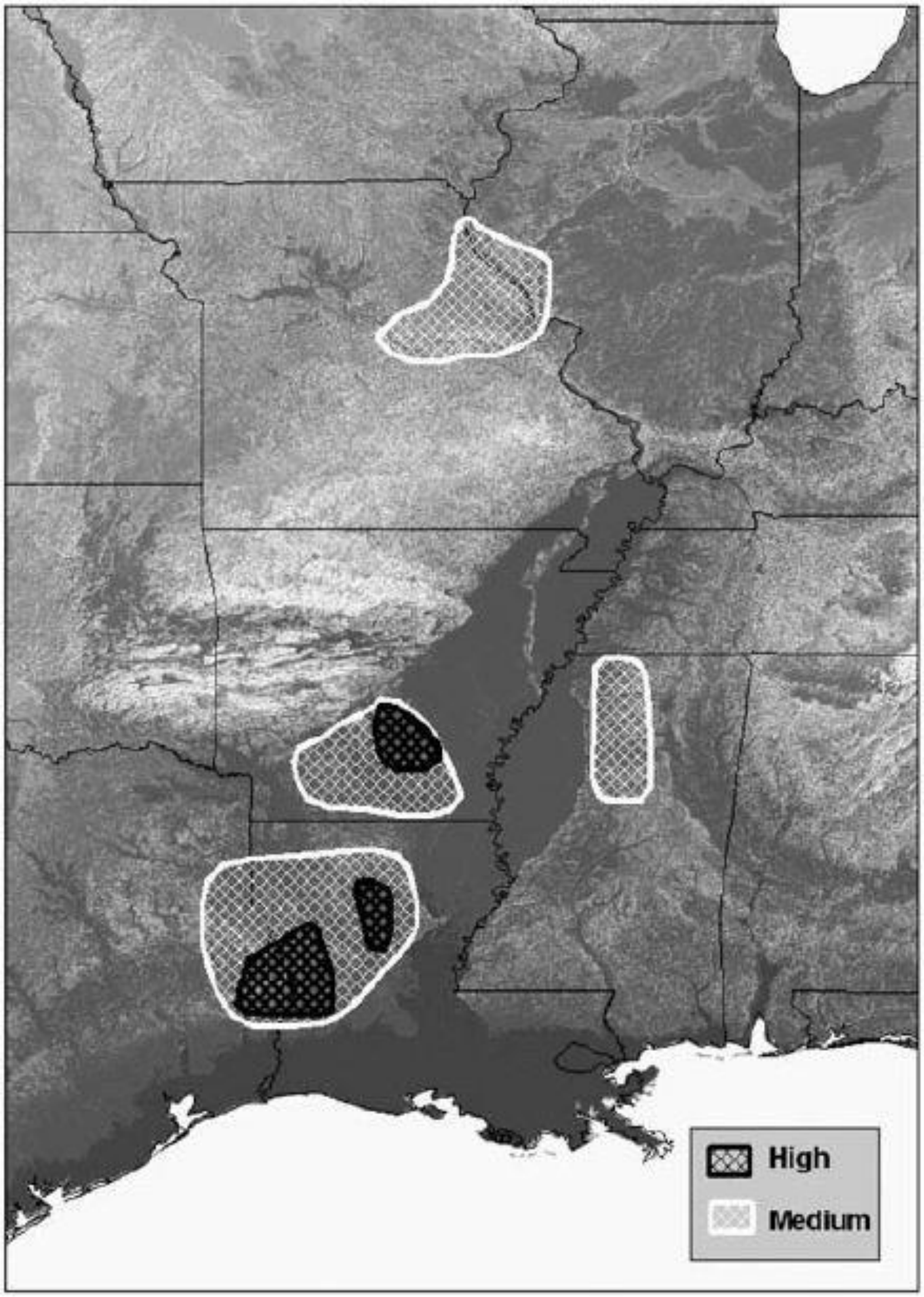

FIG. 10. Priority areas for American woodcock management determined by Myatt and Krementz (2007) from radio marked American woodcock locations from 2001 to 2003.

TABLE 1. This table shows the percentages of habitats (for habitats that comprised ≥ 10% of the area) that are present in each state and found in the 700 meter buffered survey locations where none (zero), some (1-8) and many (9+) American woodcock were detected by volunteers. Determined using Landfire data for each state in the study area (AR, MO, IA, and IL).

	Agricultural	Conifer	Conifer-Hardwood	Developed	Hardwood	Riparian
Arkansas	33:27:24:10	17:7:4:10	4:12:10:19	3:3:3:3	26:33:37:27	8:6:10:21
Missouri	51:30:31:23	0:1:0:0	3:2:2:3	4:8:6:9	33:39:45:48	2:5:2:3
Illinois	65:39:20:20	0:0:0:0	1:2:1:2	7:20:18:19	13:22:28:35	2:3:4:7
Iowa	69:29:19:16	0:0:0:0	2:13:6:9	14:17:18:14	7:11:16:8	2:16:13:25

[a] The first number indicates the percentage of each state made up of each habitat type, the second is the percentage of the survey area where no woodcock were detected made up of each habitat, the third is the percentage of the survey area where some woodcock were detected, and the last the percentage of survey areas where many woodcock were detected.

[b] Present: None: Some: Many

[c] The zeros (0) indicate less than 1% or none.

TABLE 2. This table shows the percentages of coverage classes (for coverage classes that comprised $\geq$ 10% of the area) that are present in each state and found in the 700 meter buffered survey locations where none (zero), some (1-8) and many (9+) American woodcock were detected by volunteers. Determined using Landfire data for each state in the study area (AR, MO, IA, and IL).

	Row Crop	Tree Cover 10-20%	Tree Cover 70-80%	Tree Cover 80-90%	Herb Cover 60-70%	Herb Cover 90-100%
Arkansas	16:10:4:0	2:2:2:10	17:19:25:35	20:22:20:9	6:8:6:7	4:1:4:0
Missouri	17:7:2:5	0:0:0:0	9:16:11:22	19:22:27:21	6:10:12:6	3:3:3:4
Illinois	60:32:16:15	0:1:0:0	9:17:21:32	3:2:2:2	0:3:2:0	4:8:10:12
Iowa	63:26:17:9	0:0:0:1	4:11:10:5	0:0:0:0	4:11:9:10	1:1:2:5

[a] The first number indicates the percentage of each state made up of each habitat type, the second is the percentage of the survey area where no woodcock were detected made up of each habitat, the third is the percentage of the survey area where some woodcock were detected, and the last the percentage of survey areas where many woodcock were detected.

[b] Present: None: Some: Many

[c] The zeros (0) indicate less than 1% or none.

TABLE 3. This table shows the percentages of habitats (for habitats that comprised ≥ 10% of the area) that are present in Arkansas and found in the 700 meter buffered survey locations where none (zero), some (1-8) and many (9+) American woodcock were detected by volunteers in point count verses driving route surveys. Determined using Landfire data.

	Agricultural	Conifer	Conifer-Hardwood	Developed	Hardwood	Riparian
Arkansas (Point Count)	33:27:24:10	17: 7: 4:10	4:12:10:19	3:3:3:3	26:33:37:27	8:6:10:21
Arkansas (Driving Route)	33:34:26:0	17:13:16:0	4:9:8:0	3:4:4:0	26:24:31:0	8:7:7:0

[a] The first number indicates the percentage of Arkansas made up of each habitat type, the second is the percentage of the survey area where no woodcock were detected made up of each habitat, the third is the percentage of the survey area where some woodcock were detected, and the last the percentage of survey areas where many woodcock were detected. Volunteers did not detect many woodcock during any driving route surveys.

[b] Present: None: Some: Many

[c] The zeros (0) indicate less than 1% or none.

TABLE 4. This table shows the percentages of habitats (for habitats that comprised ≥ 10% of the area) that are present in Arkansas and found in the 700 meter buffered survey locations where none (zero), some (1-8) and many (9+) American woodcock were detected by volunteers in point count verses driving route surveys. Determined using Landfire data.

	Row Crop	Tree Cover 10-20%	Tree Cover 70-80%	Tree Cover 80-90%	Herb Cover 60-70%	Herb Cover 90-100%
Arkansas (Point Count)	16:10:4:0	2:2:2:10	17:19:25:35	20:22:20:9	6:8:6:7	4:1:4:0
Arkansas (Driving Route)	16:16:7:0	2:3:4:0	17:18:23:0	20:19:20:0	6:8:7:0	4:2:0:0

[a] The first number indicates the percentage of Arkansas made up of each habitat type, the second is the percentage of the survey area where no woodcock were detected made up of each habitat, the third is the percentage of the survey area where some woodcock were detected, and the last the percentage of survey areas where many woodcock were detected. Volunteers did not detect many woodcock during any driving route surveys.

[b] Present: None: Some: Many

[c] The zeros (0) indicate less than 1% or none.

CONCLUSION

American woodcock (*Scolopax minor*, hereafter woodcock) in northern Arkansas travel an average of 370 m (SE 25.31 m) between nocturnal and diurnal habitats during spring migration. This is similar to daily movements found on the wintering and breeding grounds (Berdeen and Krementz 1998, Berry 2006, Owen and Morgan 1975, Sepik and Derleth 1993, Horton and Causey 1979, Hudgins et al. 1985). Marked woodcock used mature hardwood stands with mostly closed canopies ($\bar{x}$=88.67%, SE 2.42), mid-range mid-story and ground densities ($\bar{x}$=2.19 and $\bar{x}$=2.18 SE 0.14), and low bare soil ($\bar{x}$=19.4%, SE 3.14) during the day.

Woodcock across the study area (Arkansas, Missouri, Iowa, and Illinois) were found in areas associated with limited agriculture, specially row crops, and positively associated with riparian areas and hardwood stands when tree cover was 70%-80%. I found woodcock in Iowa using more riparian areas, perhaps because other suitable habitat was limited.

These findings give managers information to identify areas and habitat types to conserve and manage, and the proximity of those habitats to benefit woodcock optimally, to improve migration habitat and mitigate population decline. Future studies should focus on specific nocturnal habitat, to support Newman's (2012) findings that woodcock spring migration nocturnal roost habitat in central Kentucky, is characterized by short vegetation and shallow leaf litter, with silt loam soils. Further research would clarify the influence of habitat and age/sex classes to local movements for woodcock during spring migration.

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