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# Nocturnal Habitat Selection During Spring Migration by American Woodcock (Scolopax minor) in Central Kentucky

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**by**

**ANDREW K. NEWMAN**

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# in Central Kentucky

**by**

**ANDREW K. NEWMAN**

**Submitted to the Faculty of the Graduate School of**
**Eastern Kentucky University**
**in partial fulfillment of the requirements**
**for the degree of**
**MASTER OF SCIENCE**
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# ABSTRACT

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**Nocturnal Use of Fields by American Woodcock (*Scolopax minor*) During Spring Migration in Central Kentucky.**

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American woodcock (*Scolopax minor*) have experienced long-term population declines due to habitat loss. While significant research has occurred on breeding and wintering grounds, little is known about spring migratory ecology. This study assessed nocturnal roosting habitat of American woodcock through the use of night spotlighting techniques. The study was conducted on the Blue Grass Army Depot and the Central Kentucky Wildlife Management Area, both located in Madison County, Kentucky. A total of 84 field, 421 ha, of four habitat types, burned, grazed, hayed, old/fallow, were searched for woodcock. Roost sites were marked and the vegetation of each site was compared between age classes, sexes, and between occupied and random unoccupied locations. The following vegetation parameters were assessed: percent cover (bare soil, grass, forbs/gramanoids, shrub/sapling/vine, and litter), litter depth, dominant plant height, dominant plant species, distance to escape cover, and percent vertical cover. There was no significant difference ($P > 0.05$) between sexes or age classes for any of the habitat variables assessed. Logistic regression analysis indicated the best predicators of whether a woodcock would be present at a roost site were percent bare, grass, graminoids, and woody vegetation, litter depth, dominant height of vegetation, distance to escape cover, visual obstruction of escape cover from 0-20cm, and distance to field edge.  To predict density of woodcocks in each field I used step-wise regression analysis, which indicated the best model for predicting woodcock density per field incorporated percent litter at roost site, litter depth, distance to escape cover, visual obstruction of escape cover from 0-20 cm, and visual obstruction of escape cover from 50-100cm.  Woodcock selected fields and roost sites with varying heights of vegetation that satisfied ecological needs during spring migration, i.e. resting, loafing, breeding, foraging, predator and weather avoidance.

**KEY WORDS.** American woodcock, Kentucky, management, nocturnal habitat, spring migration, *Scolopax minor*

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# INTRODUCTION

The American Woodcock (*Scolopax minor*) is a small migratory game bird of the Order Charadriiforme, Family Scolopacidae (Mendall and Aldous 1943). Woodcock range throughout the eastern United States, typically breeding in the northern part of the species range and wintering in the southeast and Gulf States (Sheldon 1967). The species has suffered long-term declines at a rate of 1.1% per year (Cooper and Parker 2009). These declines are likely contributed to extensive habitat loss throughout their range, but particularly loss of early successional habitat in northern breeding areas and bottomland hardwoods in the south. With continued declines, wildlife professionals are beginning to work with landowners to restore both nesting and wintering habitat for American woodcock.

# LITERATURE REVIEW

While other members of the Scolopacidae family are denizens of marshes, beaches, and other open habitat; woodcock prefer dense thickets and fields of upland and bottomland forest (Straw et al. 1994). Several characteristics allow woodcock to flourish in this untraditional habitat for a shorebird. Mottled browns, blacks and tans allow for cryptic camouflage against leaf litter while short wings allow for quick and agile flight amongst dense cover (Straw et al. 1994). Bill anatomy allows for the distal portion to be open while probing the ground for earthworms and soil/leaf litter invertebrates (Sheldon 1967).

Woodcock populations appear to be divided into two distinctive regions based on band return data, i.e., Eastern and Central regions (Owen et al. 1977). The Appalachian Mountains serve as the dividing zone for the two regions. Since the inception of the North American Woodcock Singing-ground Survey (SGS) in 1968, it has been determined that both regional populations have suffered long-term declines; at a rate of 1.1% per year (Cooper and Parker 2009).

Woodcock declines are postulated to be due to extensive habitat loss on breeding and wintering grounds, as well as along migration routes, e.g., only 2.8 million ha of an original 10 million ha of bottomland hardwood forest exist in the Lower Mississippi River Alluvial Valley (King and Keeland 1999). The Lower Mississippi and Atchafalaya River basins constitute some of the most important woodcock wintering habitat (Straw et al. 1994). Drainage and clearing of these forested wetlands not only reduces daytime cover but also impedes feeding by allowing surrounding soil to harden quickly; thus becoming inaccessible to the foraging woodcock’s bill (Sheldon 1967). Mechanized farming has also played a major role in habitat declines in all areas inhabited by woodcock. Increased farming efficiency has resulted in clean fencerows, brushless fields and pastures, fewer fallow fields, and more acres farmed (Sheldon 1967). Brooks and Birch (1988) suggested changing landowner and social attitudes, farm abandonment, increased fire suppression, changing management techniques, and increased urbanization have resulted in fewer stands of young growth forest vital to nesting woodcock. Changes in forest management have resulted in fewer tracts of early-successional habitat; e.g., only 8% of New England forests provide suitable habitat for woodcock (Brooks and Birch 1988).

Woodcock are relatively early spring migrants with initiation dates beginning in late January and early February (Sheldon 1967, Straw et al. 1994). Several factors influence departure timing; gonadal recrudescence (Roberts 1980, Olinde and Prickett 1991), photoperiod (Coon et al. 1976, Meunier et al. 2008), moon phase, and weather (Krementz et al. 1994). Krementz et al. (1994) concluded there are no sex- or age- specific constraints upon migration initiation. Birds begin arriving on northern breeding areas in late March to early April; often experiencing snow cover and adverse weather (Sheldon 1967, Straw et al. 1994). Extreme weather exposure during migration, courtship, and nesting can result in higher metabolic rates, which can lead to poor body condition and increased mortality (Mendall and Aldous 1943, Sheldon 1967, Rabe et al. 1983). Early migration places bioenergetic strains on birds, yet arrival on breeding grounds at this time generally coincides with increased earthworm availability during nesting and brood rearing periods (Rabe et al. 1983).

The nocturnal use of fields by woodcock during winter, spring (breeding), and summer has been well documented (Mendall and Aldous 1943, Sheldon 1967, Krohn 1970, Dunford and Owen 1973, Hale and Gregg 1976, Stribling and Doerr 1985, Krementz et al. 1995, Berdeen and Krementz 1998), though rates of use may vary between season and sex (Owen and Morgan 1975a, Horton and Causey 1979, Stribling and Doerr 1985, Krementz et al. 1995). Woodcock use fields for the following functions: feeding, breeding, roosting, predator avoidance, and thermoregulation, with varying patterns based on season (Krohn 1970, Sheldon 1967, Stribling and Doerr 1985, Krementz et al. 1995, Berdeen and Krementz 1998). Birds rarely fly greater than >1 km to nocturnal fields (Krementz et al. 1995, Berdeen and Krementz 1998).

Field types utilized by woodcock during winter include clear cuts, fallow fields, pastures, agriculture, and pine plantations (Horton and Causey 1979, Stribling and Doerr 1985, Straw et al. 1994, Krementz et al. 1995, Berdeen and Krementz 1998). Glasgow (1958 *cited in* Straw et al. 1994) suggest that a majority of fields used during winter consist of herbaceous or brushy canopy (0.5-1m high) with sparse ground cover and enough soil moisture to keep earthworms in the upper soil strata. Dominant canopy species include bitterweed (*Helenium tenuifolium*), goatweed (*Croton capitatus*), coneflower (*Rudbeckia* spp.), St. Andrew's cross (*Hypericum* spp.), winged sumac (*Rhus copallina*), blackberry (*Rubus* spp.), rose (*Rosa* spp.), and small early successional trees (Glasgow 1958 *cited in* Straw et al. 1994). Understory species often consist of bluestems (*Andropogon* spp.), panic grass (*Panicum* spp.), bullgrass (*Paspalum* spp.), carpet grass (*Axonopus affinis*), and sedges (*Carex* spp.) (Glasgow 1958 *cited in* Straw et al. 1994). Wintering woodcock in Texas exhibited increased foraging rates in response to the following habitat variables: increased foliage density at 0.25-0.75m, increased bare soil, light ground litter, soil moisture, and low foliage density at 0.0-0.25m (Boggus and Whiting 1982 *cited in* Berdeen and Krementz 1998). In the Georgia Piedmont during the winter, Berdeen and Krementz (1998) found higher densities of woodcock in medium to large-sized seed tree-clearcuts and fallow-old fields that exhibited the following habitat conditions: greater foliage volumes at the 0.8-2.0m strata, more bare soil, and proximity to diurnal habitat. Moderately broken canopies and exposed soil appears to allow for ease of walking and foraging by woodcock while enhancing predator avoidance, especially from owls (Straw et al. 1994). Connors and Doerr (1982 *cited in* Krementz et al. 1995) and Horton and Causey (1979) both observed non-random distribution of woodcock in fields and noted that birds prefer edges which likely allow quick movement into dense cover.

In northern breeding areas, field usage during the spring is primarily for the establishment of woodcock singing grounds and courtship. Male territories have been noted in clearcuts, forest openings, gravel pits, roads, pastures, agricultural fields, lawns, and fallow fields (Mendall and Aldous 1943, Sheldon

1967, Straw et al. 1994). Field sizes exhibit great variability during spring with single males using openings as small as <10m in width (Straw et al. 1994). Gutzwiller et al. (1983) speculated that structural rather than compositional vegetation features dictate singing ground site selection. Potential vegetation structural components in determining singing ground selection may include: amount of litter cover, density of small and large woody shrubs, distance to water, and age of vegetation (Kinsley et al. 1982 *cited in* Straw et al. 1994). Tall vegetation surrounding openings may reduce or negate certain field usage (Gutzwiller and Wakeley 1982 *cited in* Straw et al. 1994). Proximity to quality nesting and brooding habitat may be vital in the establishment of singing ground locations (Dwyer et al. 1988). Males stay on singing grounds all night, and will display throughout the night during peak breeding season if sufficient moonlight is available (Sheldon 1967). Females visit singing grounds frequently prior to nesting and sporadically once a nest has been initiated (McAuley et al. 1993).

There is relatively little known about habitat preferences, migratory routes, and rates of migration for spring migrating woodcock. To my knowledge, all studies have focused on fall migration by investigating band return data (Sheldon 1967, Krohn et al. 1977, Myatt and Krementz 2007a) and by determining migration initiation by analyzing radio-telemetry data (Coon et al. 1976, Sepik and Derleth 1993, Meunier 2005). Krementz and Myatt's (2007b) study of large scale migratory patterns during fall migration suggested woodcock often select more mature stands of upland forest for stopover sites than would be expected based on breeding or wintering habitat preferences. Their study also suggested that due to the low soil moisture of diurnal roosts, woodcock might have been feeding extensively during nocturnal periods. To my knowledge, no one has investigated habitat use by woodcock during spring migration in Kentucky. There have been only three woodcock studies conducted in Kentucky, which mainly focused on nesting (Russell 1959, Abel and Ritchison 1999, Harris et al. 2009). The purpose of this study was to investigate spring nocturnal habitat preferences used by migratory woodcock in central Kentucky.

# STUDY AREA

This study was conducted in central Kentucky at the 747 ha Central Kentucky Wildlife Management Area (CKWMA) and the 5,907 ha Bluegrass Army Depot (BGAD). Both sites (Figure 1) are located in Madison County, Kentucky (37° 38'N, 84° 12'W). The CKWMA is managed by the Kentucky Department of Fish and Wildlife Resources and the BGAD is operated by the United States Army. The two study sites are located in the southern edge of the Bluegrass Region in the foothills of the Kentucky Knobs, which lies in the Interior Low Plateaus physiographic province (Quarterman and Powell 1978). The area is composed of broad flats and gentle slopes along wide ridge tops with moderately steep slopes along some drainages (Norment 1991). The surrounding area is mainly agricultural but there are extensive woodlands in the mountains to the southeast (Belthoff 1987). Soil types (Figures 2 and 3) include the silt loams of the Lawrence-Mercer-Robertsville soil association (USDA 1973). Within this association, Beasley silt loam, Brassfield silt loam, Caleast silt loam, Elk silt loam, Mercer silt loam, and Shelbyville silt loam are considered well drained soil types; Mercer silt loam and Nicholson silt loam are moderately well drained; Lawerence silt loam somewhat poorly drained; Blago silt loam, Melvin silt loam, and Robertsville silt loam poorly drained; and Dunning silty clay loam very poorly drained (USDA 1973).

Small streams and ponds are located throughout the CKWMA, and there are three primary drainages (Muddy Creek, Hays Fork, Gravel Lick) within the area. The three streams usually contain water even in drought (Norment 1991). The BGAD also contains several small streams and ponds as well as several lakes (Jones 2000).

Climate within the area encompassed by both study sites is comprised of warm humid summers and moderately cold winters with precipitation throughout the year (USDA 1973). Drought periods are not uncommon in late summer and

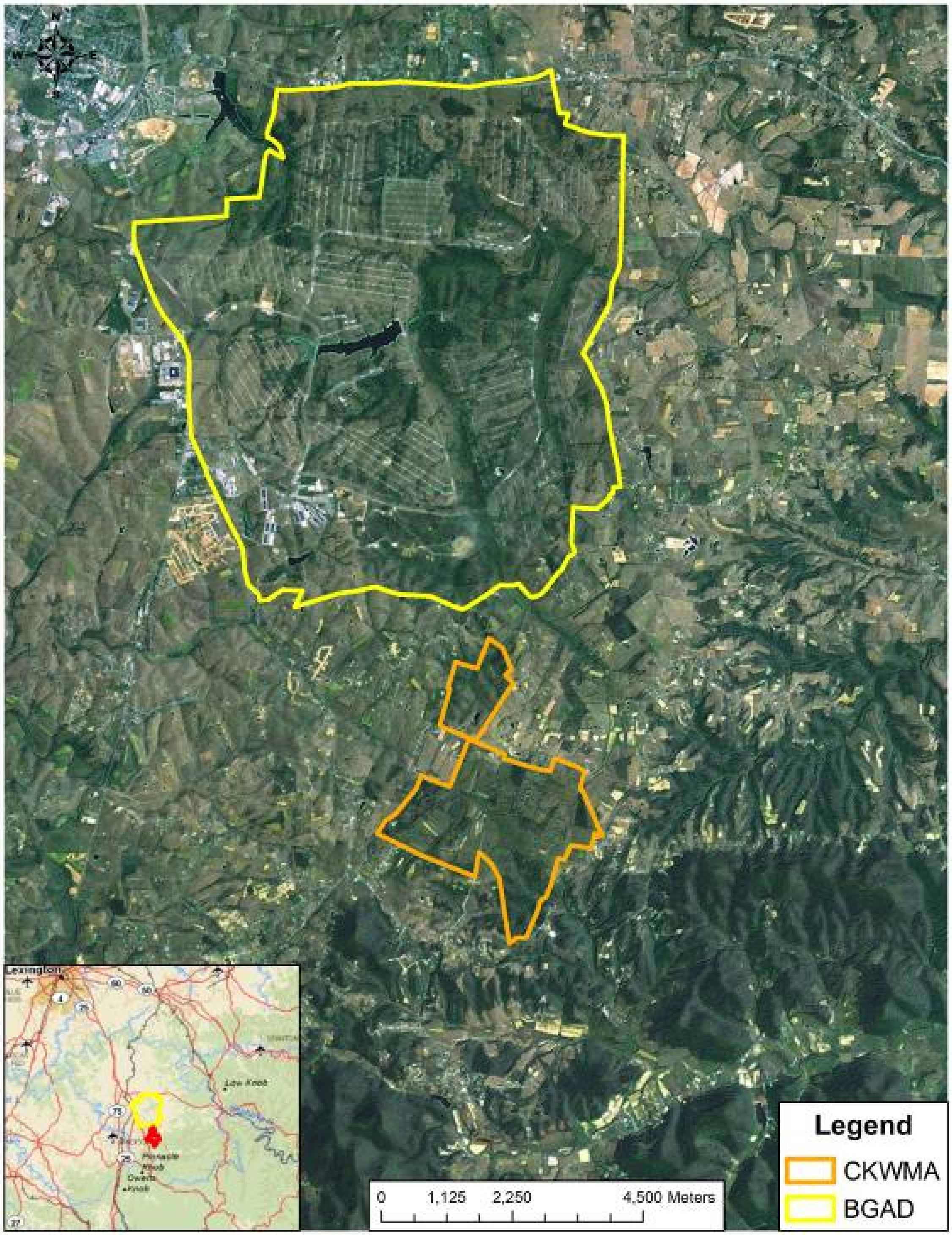


**Figure 1. Location Map of Blue Grass Army Depot and Central Kentucky Wildlife Management Area, Madison County, Kentucky.**

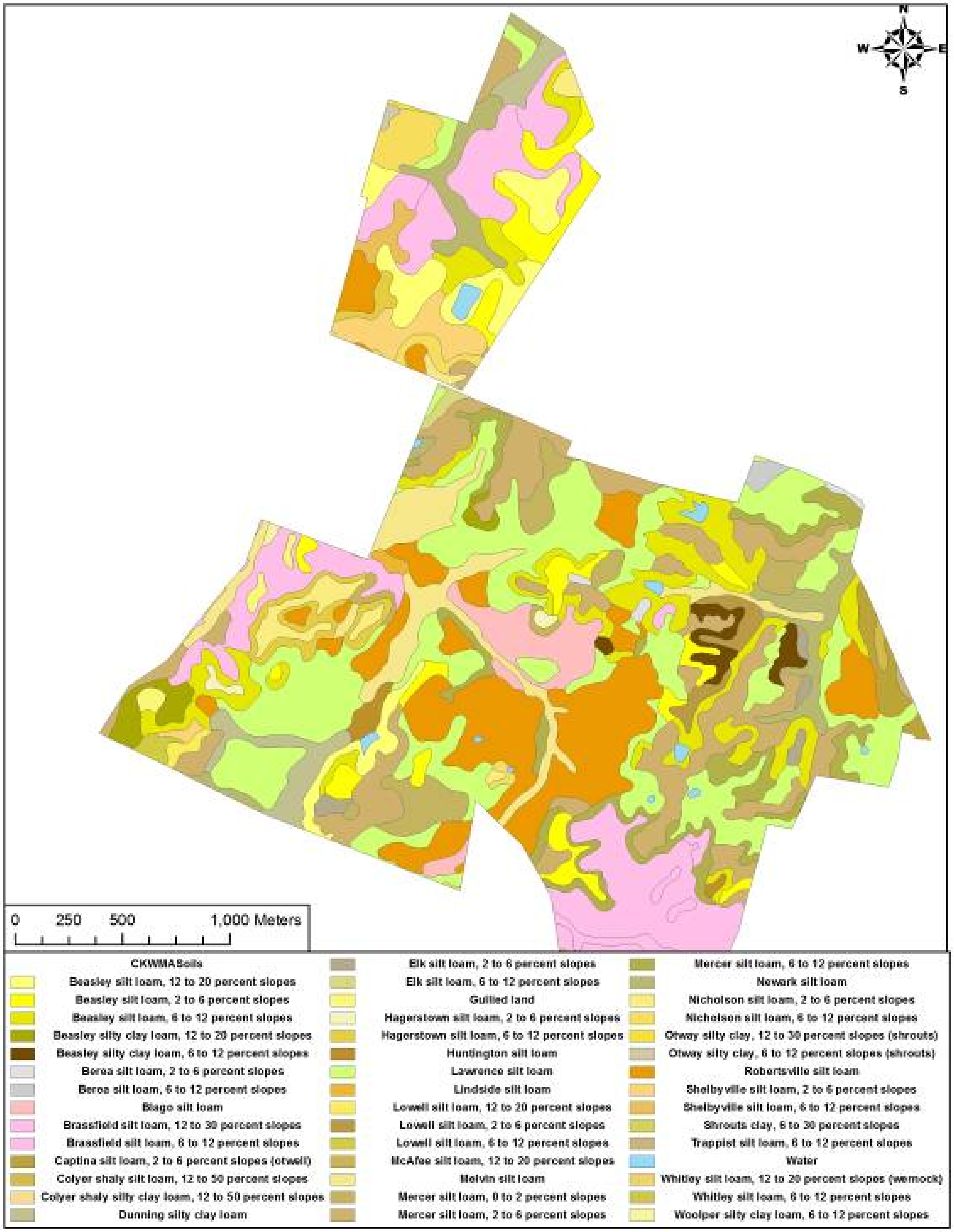


**Figure 2. Soils Map for Central Kentucky Wildlife Management Area, Madison County, Kentucky.**

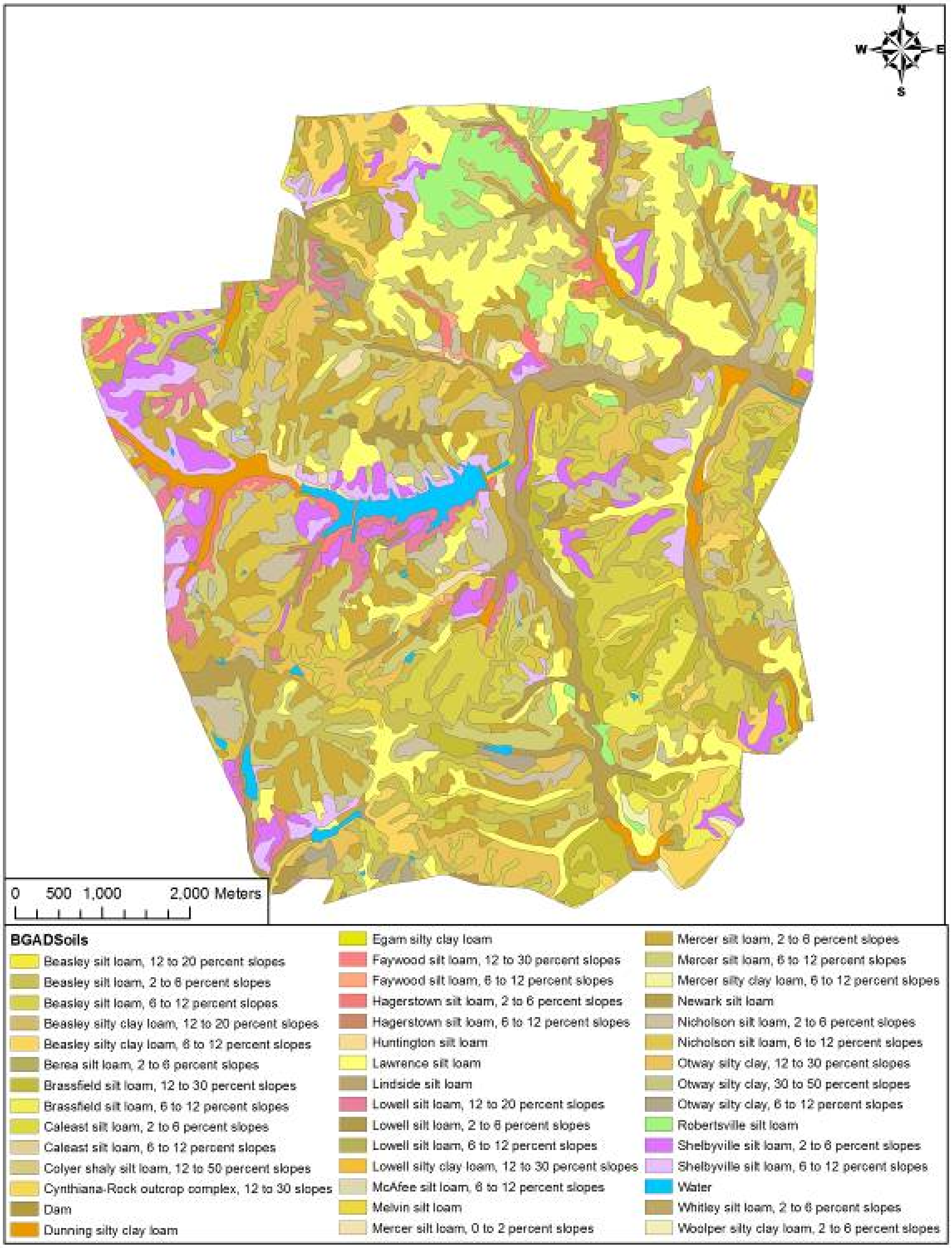


**Figure 3. Soils Map for Blue Grass Army Depot, Madison County, Kentucky.**

fall. When snowfall does occur it rarely accumulates for more than a few days (USDA 1973). The growing season averages 200 days (Jones 2000).

The CKWMA (Figure 4) land cover consists of small deciduous woodlots and thickets interspersed with managed fields. A majority of fields are maintained for upland games species through a series of management techniques including herbicide application, strip mowing, and prescribed burning. The BGAD (Figure 4) land cover consists of 70% pasture, 12% bottomland forest, 12% upland forest, and 6% development and open water (Jones 1991). The BGAD is managed for agriculture, wildlife, and timber harvest. Local farmers annually lease 2,832 ha (47% land area) for livestock grazing and hay production (Jones 2000). Leased areas are located throughout the installation.

Woodlots at both study sites have been disturbed in the past and are currently in various stages of plant succession. Dominant tree species include shagbark hickory (*Carya ovata*), southern red oak (*Quercus falcate*), Shumard oak (*Q. alba*), and sweet gum (*Liquidambar stryaciflua*). Overstory species include bitternut hickory (*C. cordiformis*), shellbark hickory (*C. laciniosa*), black gum (*Nyssa sylvatica*), black oak (*Q. velutina*), post oak (*Q. stellata*), red oak (*Q. rubra*), chinquapin oak (*Q. muehlenbergii*), black walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*), and American sycamore (*Plantanus occidentalis*) (Beltoff 1987, Sparks 1990, Jones 2000). Eastern red cedar (*Juniperus virginiana*) is the dominant conifer and occurs in open areas in woodlots and fields (Beltoff 1987, Sparks 1990, Jones 2000).

Common understory species on the CKWMA and BGAD consist of American elm (*Ulmus americana*), slippery elm (*U. rubra*), flowering dogwood (*Cornus florida*), redbud (*Cercis canadensis*), Carolina buckthorn (*Rhamnus caroliniana*), ironwood (*Ostrya virginiana*), and saplings of the dominant species. Vines are common in woodlots and can form dense thickets. Common species include grape (*Vitis* spp.), poison ivy (*Rhus radicans*), Virginia creeper (*Parthenocissus quinquefolia*), honeysuckle (*Lonicera japonica*), and trumpet-vine (*Campsis radicans*) (Beltoff 1987, Sparks 1990, Jones 2000).

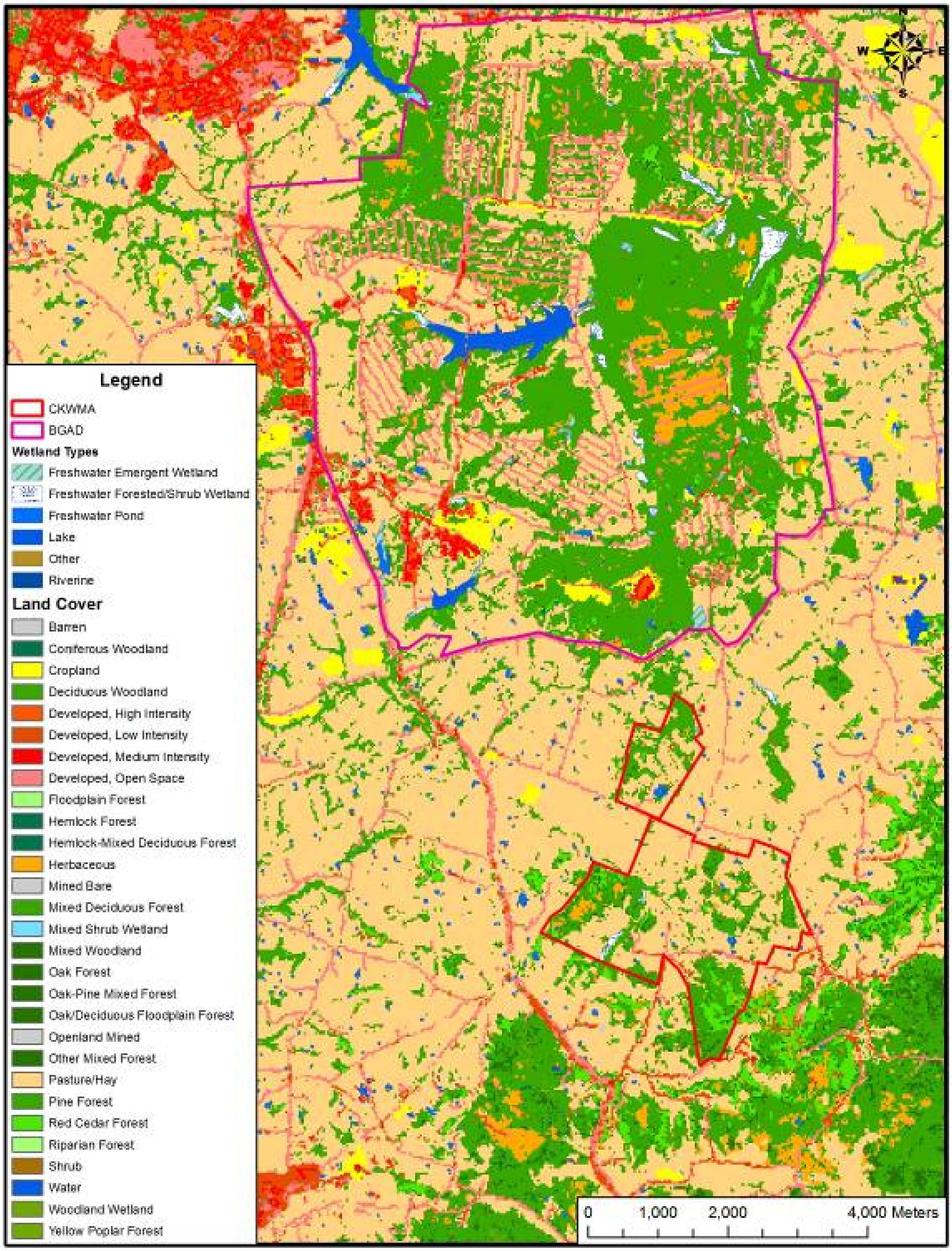


**Figure 4. 2001 National Land Cover/ Land Use Dataset and National Wetland Inventory Map for the Blue Grass Army Depot and Central Kentucky Wildlife Management Area, Madison County, Kentucky.**

Edges and thickets are comprised of black locust (*Robinia pseudoacacia*), honey locust (*Gleditsia tricanthos*), persimmon (*Diospyros virginiana*), and eastern red cedar (Beltoff 1987, Sparks 1990, Jones 2000).

Fields on both study sites are dominated by fescue (*Festuca* elatior) (Jones 2000, Edwards pers. comm. 2010). Other prominent grass species include broom sedge (*Andropogon* spp.), foxtail (*Setaria* spp.) and panic grass (*Panicum* spp.; Jones 2000). Through prescribed burnings the BGAD has established fields dominated by warm season grasses such as Indian grass (*Sorghastrum nutans*), Big Bluestem (*Andropogon gerardii*), and Little Bluestem (*Schizachyrium scoparium*) (Thomas Edwards pers. comm. 2010). Dominant herbaceous/woody cover consists of *Lespedeza cuneata, Rubus* spp., thistle (*Cirsium* spp.), goldenrod (*Solidago* spp.), Eastern red cedar, ironweed (*Vernoia altissima*), and saplings (Jones 2000, Edwards pers. comm. 2010).

# METHODS

Fields within each study area were designated as a specific habitat type. Habitat type categories include grazed (BGAD, 2 fields totaling 15.5 ha), hayed (BGAD, 7 fields totaling 42.8 ha), burned (BGAD, 2 fields totaling 16.8 ha), and old/fallow fields (BGAD, 9 fields totaling 40.0 ha, CKWMA, 64 fields totaling 306.4 ha, grand total 346.4 ha). Myatt and Krementz (2007b) recorded average stopover duration of woodcock during fall migration to be 4 days, so I searched individual fields for woodcock every 3 to 4 days. To search for roosting woodcock, crews of two or three people drove ATVs in study fields at night and used a spotlight (Q-beam, 500,000 candle power). Roosting woodcock were considered any bird that selected a field to carry out basic biological needs, e.g. foraging, resting, reproduction. Woodcock roost sites were flagged with surveyors tape and the location was determined using a global positioning system (GPS) unit. Flushed birds were followed and resulting location noted to prevent recounting individuals. If possible, woodcock were captured with a fish net (hoop diameter >1m and handle >3m). Captured birds were sexed and aged via morphological characteristics [i.e. wing chord, bill length, body weight (Sepik 1994)], banded with U.S. Fish and Wildlife Service. Stribling and Doerr (1985) suggest that moist soil on the bill is an indicator of soil probing and foraging, so I recorded the presence or absence of moist soil on the bill of each captured bird. Capture and marking procedures employed in this study were reviewed and approved by Eastern Kentucky University's Institutional Animal Care and Use Committee as Protocol 07-2010.

A series of landscape and vegetation characteristics were assessed at each woodcock roost site. The following landscape measurements were determined for each field: habitat type, field size, and soil type. I used ARCVIEW GIS version 9.3 (Environmental Systems Research Institute 2008) to determine distance from roost site to field edge. Vegetation characteristics measured at roost sites included ocular percent cover using a PVC $1m^2$ plot [cover categories= bare soil, grass/graminoids, forbs, woody (shrub/sapling/vine), and litter], litter depth measured at the center of the plot, dominant plant height (based on dominant species in plot), dominant plant species in plot, and distance to escape cover. Percent vertical cover (visual obstruction) was determined using a Robel pole [divided into heights of 0-20cm, 20-50cm, 50-100cm, and 100-150cm (Toledo et al. 2008)] placed 1m into escape cover at the closest perpendicular distance from the center of roost plot. Escape cover was defined as any vegetation that offered sufficient vertical and horizontal cover to conceal a woodcock. Dominant plant species, determined by percent aerial coverage, were recorded at escape cover locations. Random plots (n = 136) were established in study fields at CKWMA using ARCVIEW GIS's random point script (Environmental Systems Research Institute 2008). The same criterion of vegetation characteristics for roost plots were used to sample random points. Random points were not measured at BGAD due to logistical constraints related to access.

Soil moisture on the bill was used to approximate the percentage of woodcock that were actively feeding; i.e., earthworm biomass increases in upper soil strata during nocturnal periods (Duriez et al. 2006). Dominant plant species at roost sites and escape cover sites were used to determine species associated with nocturnal habitat. Differences in habitat preferences between sex and age classes were analyzed using the two-sample t-test.

All statistical modeling was generated by R Project version 2.13.1 (R Development Core Team 2008). To test for differences in habitat characteristics between individual used roost sites and random unused sites, I used step-wise logistic regression to model presence (roost)/ absence (random) data. A logistic regression built on a binary system assigns variables a given value of 0 or 1; an event happened or did not (in this analysis a 0 was assigned for woodcock absent from a point and 1 for presence of woodcock at a point). A logistic curve is built from presence/absence data and the model allows for the prediction that the point should have a roosting woodcock present. Roost/random point data from 2011 were used to test the model. These points allowed for the testing of the accuracy of the resulting prediction model and number of correct/incorrect predictions recorded. The strength of the model was gauged by its ability to correctly predict presence/absence of 2011 collection data.

To explain relative woodcock densities, I used multiple linear regression was used to explain the variation in density (response variable) among study field using habitat variables (explanatory variables) collected from the same fields. Relative woodcock densities were determined by summing all woodcock recorded in each field and dividing this number by the total area of the field yielding a woodcock per hectare measurement. Akaike Information Criterion (Akaike 1974) values (herein AIC) were used to determine a best fit model(s). Lower AIC values indicate a model of better fit than higher ones. The final models of the logistic regression and multiple linear regression heuristically compared to identify consistent patterns between the models.

# RESULTS

During the 2010 field season a total of 254 woodcock were flushed from field sites (Figures 5 and 6). Seventy-three woodcock were captured, sexed, aged, and presence of moist soil on the bill noted. Of the 73 birds captured, 40 were males (18 after second-year birds, 20 second-year, and 2 of unknown age) and 30 female (16 after second-year, 12 second year, and 2 of unknown age). Three birds were recorded as unknown sex and age. Moist soil on the bill was present on 42 out of 65 (64%) birds examined for this attribute. The first woodcock observed was on February 21, 2010; with peak numbers recorded the second week of March 2010. During the 2011 field season a total of 115 woodcock were flushed (Figure 7). No age or sex data was collected in 2011 due to unfavorable weather conditions for trapping (i.e. full moon).

A total of 211 woodcock roost locations (Table 1) and 136 random locations (Table 2) were assessed for landscape and vegetation characteristics during the 2010 field season. A total of 115 woodcock roost sites were assessed for vegetation characteristics during 2011 (Table 3). Random locations were not assessed in 2011 due to limited amount of field time available. Fescue (*Festuca* sp.) exhibited the highest percent occurrence (62%) at roost sites (Table 4); while blackberry (39%) exhibited the highest percent occurrence at escape cover sites (Table 5). Of the woodcock roost sites located in this study (n=254), the majority (63%) occurred on moderately well-drained to well-drained soils.

There was no significant difference in habitat variables assessed at roost sites between woodcock sexes (Table 6) or age classes (Table 7). Multiple linear regression analysis indicated the best model for predicting woodcock density per field incorporated percent litter at roost site, litter depth, distance to escape cover, visual obstruction of escape cover from 0-20cm, and visual obstruction of escape cover from 50-100cm (Tables 8 and 9). Because of security and access issues no random sites were sampled at the BGAD study area; hence, only roost sites at the CKWMA were used in the logistic regression model. Logistic regression analysis indicated the best predicators of woodcock

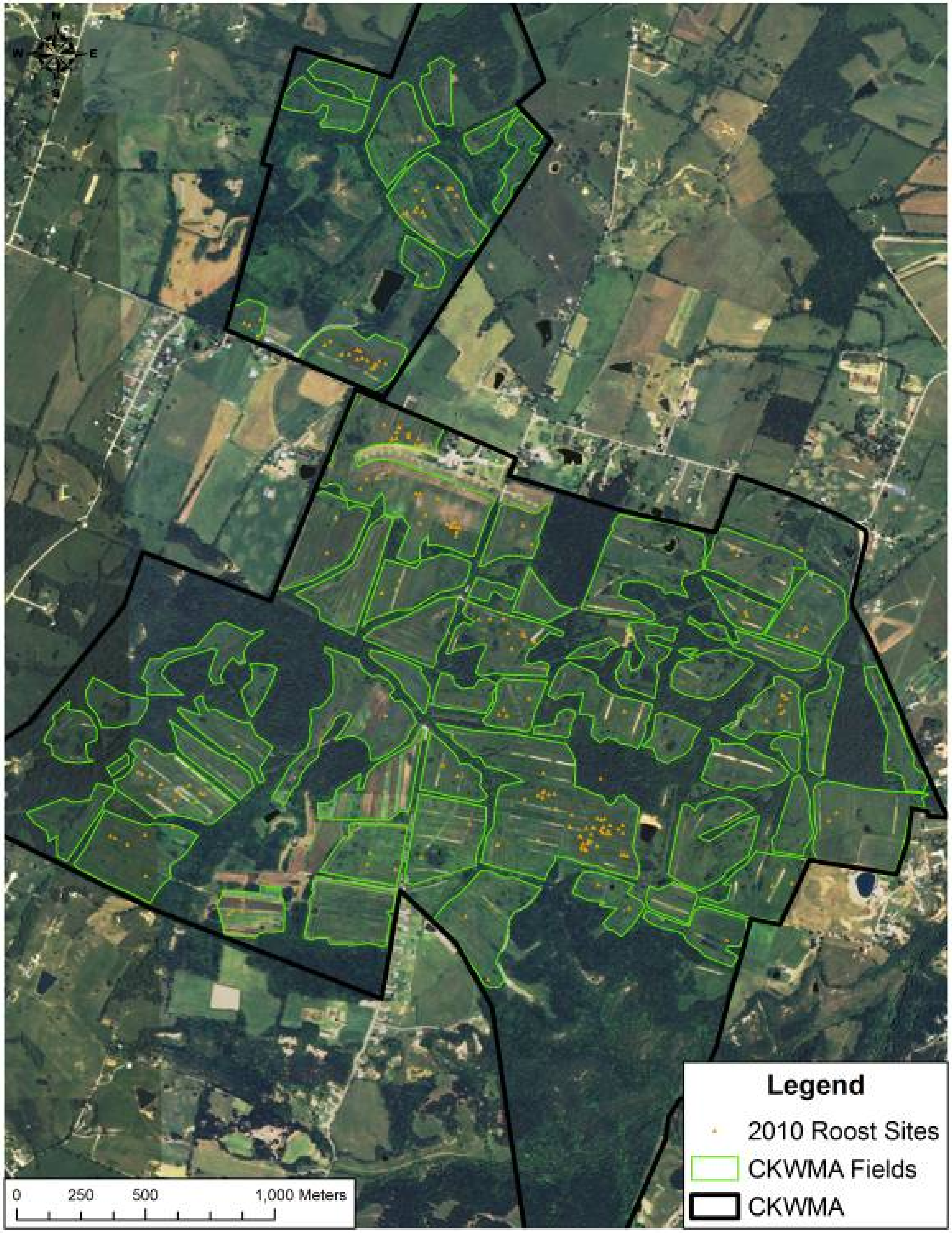


**Figure 5. Location of 2010 Roost Sites at Central Kentucky Wildlife Management Area, Madison County, Kentucky.**

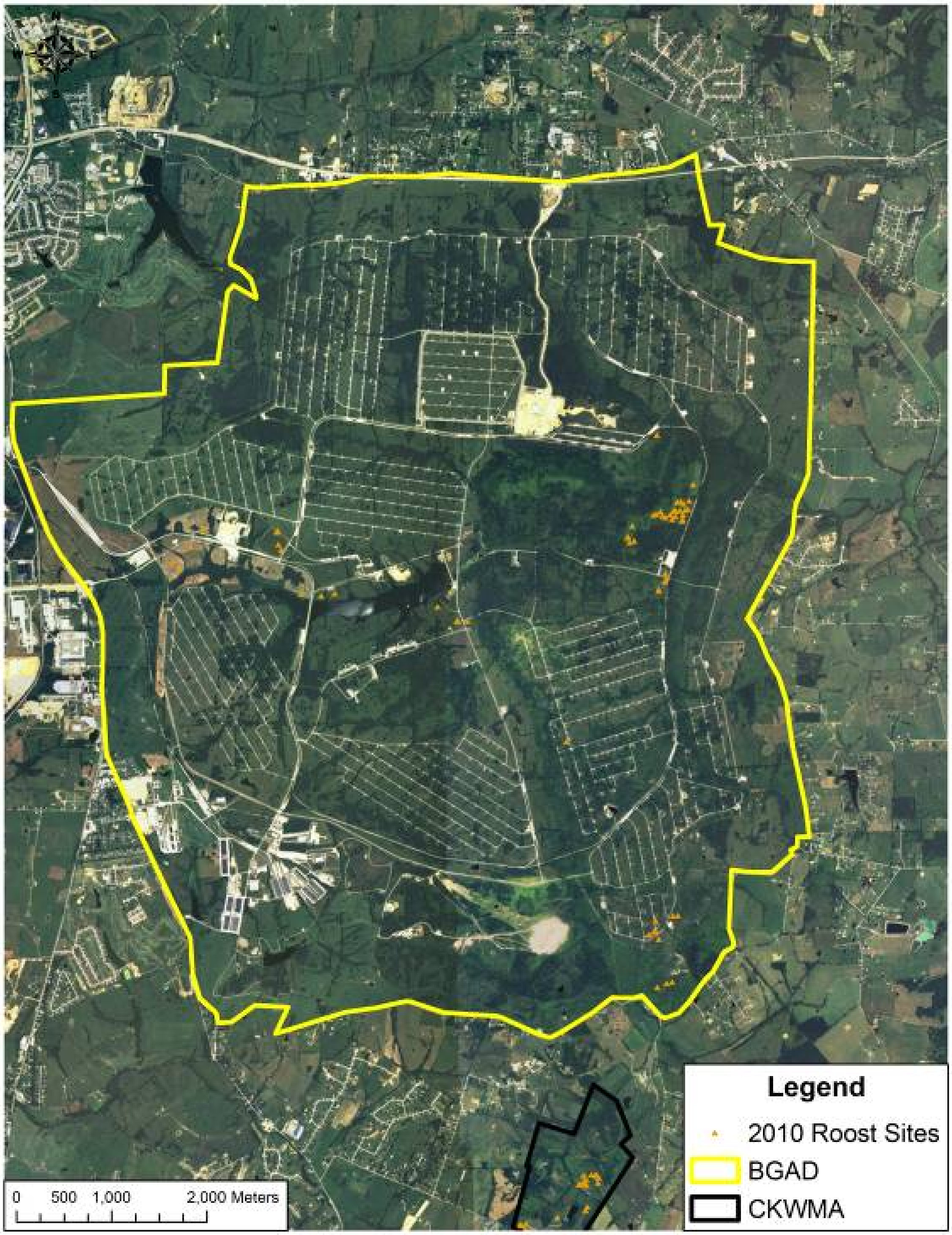


**Figure 6. Locations of 2010 roost sites at the Blue Grass Army Depot, Madison County, Kentucky.**

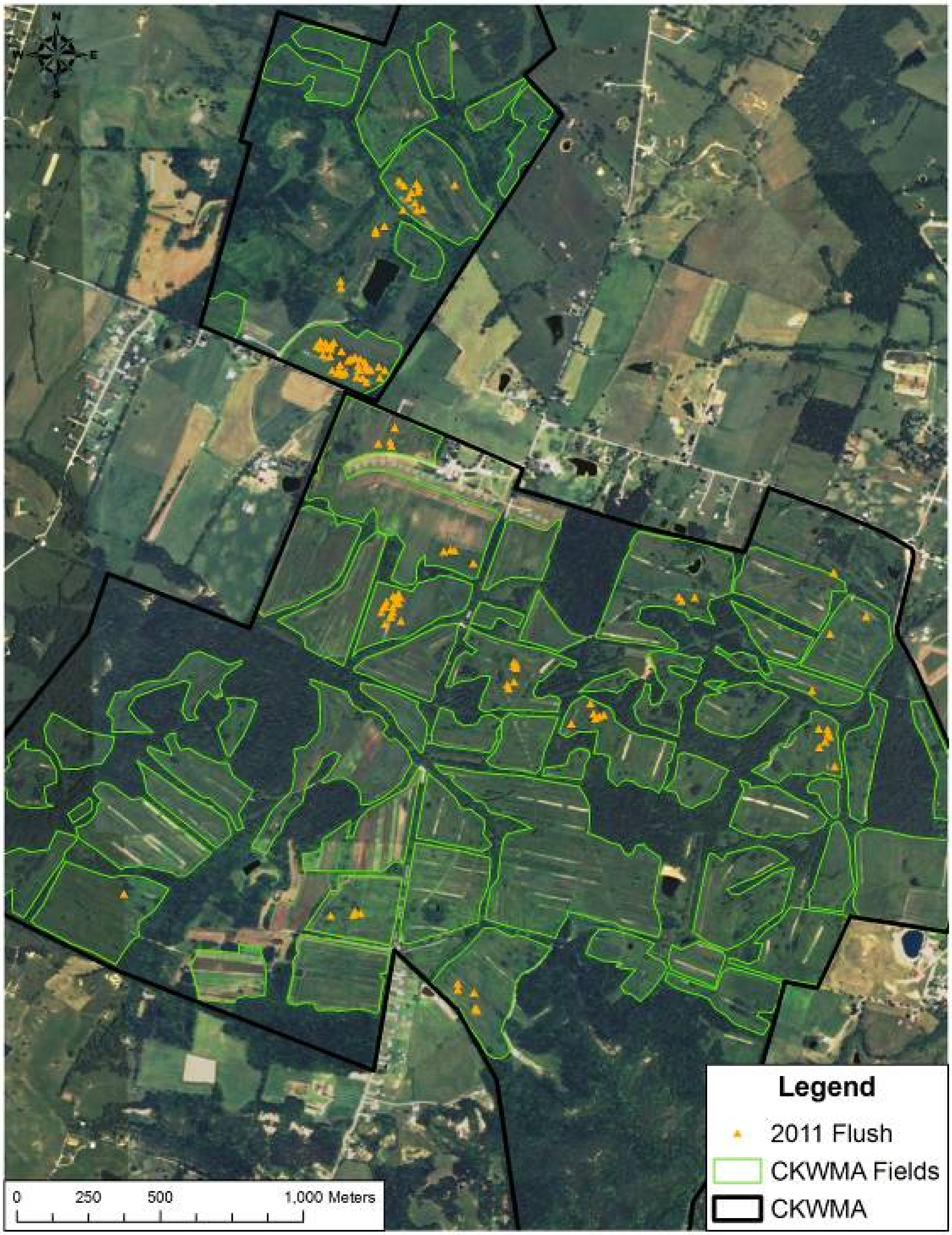


**Figure 7. Location of 2011 roost sites at the Central Kentucky Wildlife Management Area, Madison County, Kentucky.**

**Table 1. Mean (+ SD) habitat variables associated with roost sites at the Central Kentucky Wildlife Management Area and Blue Grass Army Depot, Madison County, KY, used at night by migrating American woodcock, February – April 2010.**

| Variable | Mean | SD |
|---|---|---|
| % Ground Cover at Roost Site | | |
| Bare | 14.881 | 23.430 |
| Grass/Graminoids | 18.881 | 19.947 |
| Forbs | 3.895 | 9.488 |
| Woody | 6.649 | 10.733 |
| Litter | 55.715 | 24.731 |
| Litter Depth at Roost Site (cm) | 2.851 | 2.954 |
| Dominant Plant Height (cm) | 20.229 | 35.090 |
| Distance to Escape Cover (m) | 2.384 | 2.624 |
| Visual Obstruction at Escape Cover | | |
| 0-20 cm | 43.853 | 27.595 |
| 20-50 cm | 36.085 | 20.534 |
| 50-100 cm | 21.947 | 15.465 |
| 100-150 cm | 8.682 | 13.563 |
| Distance to Field Edge (m) | 66.753 | 35.973 |

**Table 2. Mean (+ SD) habitat variables associated with random sites at the Central Kentucky Wildlife Management Area, Madison County, KY, February – April 2010.**

| Variable | Mean | SD |
|---|---|---|
| % Ground Cover at Roost Site | | |
| Bare | 7.433 | 13.624 |
| Grass/Graminoids | 24.117 | 22.924 |
| Forbs | 4.764 | 10.315 |
| Woody | 10.220 | 18.109 |
| Litter | 53.647 | 26.486 |
| Litter Depth at Roost Site (cm) | 8.055 | 5.009 |
| Dominant Plant Height (cm) | 32.220 | 37.343 |
| Distance to Escape Cover (m) | 4.055 | 6.580 |
| Visual Obstruction at Escape Cover | | |
| 0-20 cm | 66.433 | 28.699 |
| 20-50 cm | 46.904 | 24.998 |
| 50-100 cm | 27.764 | 20.200 |
| 100-150 cm | 13.632 | 19.894 |
| Distance to Field Edge (m) | 44.697 | 37.344 |

**Table 3. Mean (+ SD) habitat variables associated with roost sites at the Central Kentucky Wildlife Management Area, Madison County, KY, used at night by migrating American woodcock, March – April 2011.**

| Variable | Mean | SD |
|---|---|---|
| % Ground Cover at Roost Site | | |
| Bare | 4.573 | 9.256 |
| Grass/Graminoids | 14.469 | 14.731 |
| Forbs | 11.786 | 15.305 |
| Woody | 2.521 | 2.400 |
| Litter | 66.661 | 21.190 |
| Litter Depth at Roost Site (cm) | 4.421 | 1.930 |
| Dominant Plant Height (cm) | 8.886 | 10.783 |
| Distance to Escape Cover (m) | 1.338 | 0.668 |
| Visual Obstruction at Escape Cover | | |
| 0-20 cm | 34.678 | 28.118 |
| 20-50 cm | 15.808 | 16.672 |
| 50-100 cm | 6.739 | 7.922 |
| 100-150 cm | 2.191 | 3.581 |
| Distance to Field Edge (m) | 62.346 | 26.878 |

**Table 4. Percent occurrence of dominant plant species at roost sites at the Central Kentucky Wildlife Management Area and Blue Grass Army Depot, Madison County, KY, used at night by migrating American woodcock, February – April 2010.**

| Scientific Name | Common Name | Percent Occurrence |
|---|---|---|
| *Allium vineale* | Wild Garlic | 1.0% |
| *Andropogon elliotti* | Elliott's Broomsedge | 1.0% |
| *Andropogon virginicus* | Broomsedge Bluestem | 3.5% |
| *Aster sp.* | Aster species | 0.5% |
| *Eleocharis sp.* | Spikerush | 1.5% |
| *Festuca sp.* | Fescue | 62.0% |
| *Juncus sp.* | Rush | 3.5% |
| *Lonicera japonica* | Japanese Honeysuckle | 1.5% |
| *Lonicera maackii* | Bush Honeysuckle | 1.0% |
| *Panicum sp.* | Panic Grass | 0.5% |
| *Rhus sp.* | Sumac | 0.5% |
| *Rubus sp.* | Blackberry | 11.0% |
| *Salix sp.* | Willow | 0.5% |
| *Lespedeza cuneata* | Serecia Lespedeza | 1.5% |
| *Seteria sp.* | Foxtail | 1.0% |
| *Solidago sp.* | Goldenrod | 1.0% |
| *Taraxacum sp.* | Dandelion | 0.5% |
| *Trifolium sp.* | Clover | 1.5% |
| *Triticum sp.* | Wheat | 0.5% |
| *Vernonia sp.* | Ironweed | 0.5% |
| No vegetation | | 5.0% |

**Table 5. Percent occurrence of dominant plant species at escape cover locations at the Central Kentucky Wildlife Management Area and Blue Grass Army Depot, Madison County, KY, used at night by migrating American woodcock, February – April 2010.**

| Scientific Name | Common Name | Percent Occurrence |
|---|---|---|
| *Acer rubrum* | Red Maple | 0.5% |
| *Andropogon elliotti* | Elliott's Broomsedge | 0.5% |
| *Andropogon virginicus* | Broomsedge Bluestem | 9.0% |
| *Aster sp.* | Aster | 2.0% |
| *Cirsium sp.* | Thistle | 1.5% |
| *Cornus sp.* | Dogwood | 6.5% |
| *Fraxinus pennsylvanica* | Green Ash | 1.0% |
| *Juncus sp.* | Rush | 1.4% |
| *Juniperus virginiana* | Eastern Red Cedar | 1.0% |
| *Liquidambar styraciflua* | Sweetgum | 1.5% |
| *Lonicera maackii* | Bush Honeysuckle | 2.0% |
| *Panicum sp.* | Panic Grass | 0.5% |
| *Platanus occidentalis* | Sycamore | 2.0% |
| *Rhus sp.* | Sumac | 3.5% |
| *Robinia pseudoacacia* | Black Locust | 2.5% |
| *Rosa multiflora* | Multi-flora Rose | 0.5% |
| *Rubus sp.* | Blackberry | 39.0% |
| *Salix sp.* | Willow | 1.0% |
| *Lespedeza cuneata* | Serecia Lespedeza | 11.5% |
| *Solidago sp.* | Goldenrod | 8.5% |
| *Sorghastrum nutans* | Indiangrass | 0.5% |
| *Sorghum bicolor* | Sorghum | 0.5% |
| *Sorgum halepense* | Johnson Grass | 0.5% |
| *Vernonia sp.* | Ironweed | 1.5% |

**Table 6. Mean (+ SD) habitat variables associated with roost sites at the Central Kentucky Wildlife Management Area and Blue Grass Army Depot, Madison County, KY, used at night by migrating male and female American woodcock, February – April 2010.**

| Variable | Female (n=40) | Male (n=50) | SD | t | df | P-Value |
|---|---|---|---|---|---|---|
| % Ground Cover at Roost Site | | | | | | |
| Bare | 15.870 | 13.480 | 24.178 | 0.466 | 88 | 0.641 |
| Grass/Graminoids | 19.720 | 20.100 | 22.401 | -0.078 | 88 | 0.937 |
| Forbs | 1.475 | 3.120 | 6.546 | -1.184 | 88 | 0.239 |
| Woody | 8.225 | 5.980 | 12.544 | 0.843 | 88 | 0.401 |
| Litter | 54.575 | 57.520 | 25.216 | -0.550 | 88 | 0.583 |
| Litter Depth at Roost Site (cm) | 2.543 | 3.420 | 3.502 | -1.179 | 88 | 0.241 |
| Dominant Plant Height (cm) | 18.437 | 19.960 | 33.609 | -0.213 | 88 | 0.831 |
| Distance to Escape Cover (m) | 1.868 | 2.590 | 1.993 | -1.728 | 88 | 0.087 |
| Visual Obstruction at Escape Cover | | | | | | |
| 0-20 cm | 47.850 | 42.080 | 28.057 | 0.969 | 88 | 0.334 |
| 20-50 cm | 34.825 | 33.800 | 17.945 | 0.269 | 88 | 0.788 |
| 50-100 cm | 21.275 | 19.820 | 14.269 | 0.480 | 88 | 0.631 |
| 100-150 cm | 5.976 | 7.080 | 9.471 | -0.550 | 88 | 0.583 |
| Distance to Field Edge (m) | 74.128 | 64.563 | 36.763 | 1.212 | 88 | 0.228 |

**Table 7. Mean (+ SD) habitat variables associated with roost sites at the Central Kentucky Wildlife Management Area and Blue Grass Army Depot, Madison County, KY, used at night by migrating second year (2Y) and after second year (A2Y) American woodcock, Februar**

| Variable | A2Y mean (n=22) | 2Y mean (n=17) | SD | t | df | P-Value |
|---|---|---|---|---|---|---|
| % Ground Cover at Roost Site | | | | | | |
| Bare | 5.770 | 9.000 | 7.770 | -0.090 | 37 | 0.928 |
| Grass/Graminoids | 27.220 | 21.000 | 22.920 | 0.841 | 37 | 0.405 |
| Forbs | 3.770 | 4.176 | 9.372 | -0.133 | 37 | 0.894 |
| Woody | 9.360 | 6.700 | 16.422 | 0.501 | 37 | 0.619 |
| Litter | 53.860 | 62.110 | 24.015 | -1.064 | 37 | 0.294 |
| Litter Depth at Roost Site (cm) | 2.430 | 3.610 | 2.543 | -1.440 | 37 | 0.158 |
| Dominant Plant Height (cm) | 9.386 | 14.588 | 13.786 | -1.168 | 37 | 0.250 |
| Distance to Escape Cover (m) | 2.770 | 1.990 | 1.818 | 1.320 | 37 | 0.192 |
| Visual Obstruction at Escape Cover | | | | | | |
| 0-20 cm | 46.270 | 53.350 | 25.218 | -0.869 | 37 | 0.390 |
| 20-50 cm | 31.681 | 38.647 | 18.136 | -1.189 | 37 | 0.241 |
| 50-100 cm | 17.727 | 20.294 | 15.254 | -0.521 | 37 | 0.605 |
| 100-150 cm | 4.360 | 4.000 | 8.089 | 0.139 | 37 | 0.890 |
| Distance to Field Edge (m) | 72.490 | 64.760 | 46.155 | 0.513 | 37 | 0.611 |

**Table 8. Multiple linear regression models and corresponding AIC values comparing relative American woodcock in fields to habitat variables.**

| Model | AIC Value |
|---|---|
| density= bare + grass + gram + woody + litter + lit. depth + dom. Ht + DEC + VO0-20 + VO 20-50 + 50-100 + VO 100-150 + field size + dis. Edge | -37.69 |
| density= bare + grass + gram + woody + litter + lit. depth + dom. Ht + DEC + VO0-20 + 50-100 + VO 100-150 + field size + dis. Edge | -39.69 |
| density= bare + gram + woody + litter + lit. depth + dom. Ht + DEC + VO0-20 + 50-100 + VO 100-150 + field size + dis. Edge | -41.55 |
| density= bare + gram + woody + litter + lit. depth + dom. Ht + DEC + VO0-20 + 50-100 + field size + dis. Edge | -43.28 |
| density= gram + woody + litter + lit. depth + dom. Ht + DEC + VO0-20 + 50-100 + field size + dis. Edge | -44.93 |
| density= gram + woody + litter + lit. depth + DEC + VO0-20 + 50-100 + field size + dis. Edge | -46.43 |
| density= gram + litter + lit. depth + DEC + VO0-20 + 50-100 + field size + dis. Edge | -47.86 |
| density= litter + lit. depth + DEC + VO0-20 + 50-100 + field size + dis. Edge | -49.13 |
| density= litter + lit. depth + DEC + VO0-20 + 50-100 + dis. Edge | -49.79 |
| density= litter + lit. depth + DEC + VO0-20 + 50-100 | -50.84 |

Model Variable Descriptions: bare-% bare ground cover at roost site; grass- % grass/graminoids ground cover at roost site; gram- % forbs ground cover at roost site; % woody ground cover at roost site; litter- % litter ground cover at roost site; lit. depth- litter depth at roost site (cm); dom.Ht- dominant plan height (cm); DEC- distance to escape cover (m); VO- visual obstruction at escape cover, dis. Edge- distance from roost site to field edge (m)

**Table 9. Multiple linear regression final model ANOVA table comparing relative American woodcock in fields to habitat variables.**

| Number | Step | df | Deviance Resid. | df | Resid. Dev. | AIC |
|---|---|---|---|---|---|---|
| 1 | | | | 46 | 20.109 | -37.69 |
| 2 | VO20-50 | 1 | 0.001 | 47 | 20.109 | -39.69 |
| 3 | Grass | 1 | 0.045 | 48 | 20.155 | -41.55 |
| 4 | VO100-150 | 1 | 0.0916 | 49 | 20.246 | -43.28 |
| 5 | Bare | 1 | 0.114 | 50 | 20.361 | -44.93 |
| 6 | Dom. Ht. | 1 | 0.167 | 51 | 20.528 | -46.43 |
| 7 | Woody | 1 | 0.192 | 52 | 20.721 | -47.86 |
| 8 | Gram | 1 | 0.251 | 53 | 20.971 | -49.13 |
| 9 | Field Size | 1 | 0.466 | 54 | 21.438 | -49.79 |
| 10 | Dis. Edge | 1 | 0.337 | 55 | 21.775 | -50.84 |

Model Variable Descriptions: bare-% bare ground cover at roost site; grass- % grass/graminoids ground cover at roost site; gram- % forb ground cover at roost site; % woody ground cover at roost site; litter- % litter ground cover at roost site; lit. depth- litter depth at roost site (cm); dom.Ht- dominant plan height (cm); DEC- distance to escape cover (m); VO- visual obstruction at escape cover, dis. Edge- distance from roost site to field edge (m)

presence were percent bare, grass, graminoids and woody vegetation, litter depth, dominant height of vegetation at the roost site, distance to escape cover, visual obstruction of escape cover from 0-20cm, and distance to field edge (Tables 10 and 11). The logistic regression based on 2010 data correctly predicted 111 of 115 (96.5%) roost sites from the 2011 field season.

**Table 10. Logistic regression models and corresponding AIC values comparing presence/absence of American Woodcock to habitat variables.**

| Model | AIC Value |
|---|---|
| Presence= bare + grass + gram + woody + litter + lit. depth + dom. Ht + DEC + VO0-20 + VO 20-50 + 50-100 + VO 100-150 + field size + dis. Edge | 279.03 |
| Presence= bare + grass + gram + woody + litter + lit. depth + dom. Ht + DEC + VO0-20 + VO 20-50 + VO 100-150 + field size + dis. Edge | 277.16 |
| Presence= bare + grass + gram + woody + litter + lit. depth + dom. Ht + DEC + VO0-20 + VO 20-50 + VO 100-150 + dis. Edge | 275.55 |
| Presence= bare + grass + gram + woody + lit. depth + dom. Ht + DEC + VO0-20 + VO 20-50 + VO 100-150 + dis. Edge | 274.12 |
| Presence= bare + grass + gram + woody + lit. depth + dom. Ht + DEC + VO0-20 + VO 20-50 + dis. Edge | 272.99 |
| Presence= bare + grass + gram + woody + lit. depth + dom. Ht + DEC + VO0-20 + dis. Edge | 271.83 |

Model Variable Descriptions: bare-% bare ground cover at roost site; grass- % grass/graminoids ground cover at roost site; gram- % forb ground cover at roost site; % woody ground cover at roost site; litter- % litter ground cover at roost site; lit. depth- litter depth at roost site (cm); dom.Ht- dominant plan height (cm); DEC- distance to escape cover (m); VO- visual obstruction at escape cover, dis. Edge- distance from roost site to field edge (m)

**Table 11. Final Logistic Regression Model ANOVA Table comparing presence/absence of American woodcock to habitat variables.**

| Number | Factor | df | Deviance Resid. | df | Resid. Dev. | AIC |
|---|---|---|---|---|---|---|
| 1 | Intercept | | | 331 | 249.034 | 279.0343 |
| 2 | VO 50-100 | 1 | 0.122 | 332 | 249.156 | 277.1565 |
| 3 | Field Size | 1 | 0.395 | 333 | 249.552 | 275.5523 |
| 4 | % Litter | 1 | 0.571 | 334 | 250.124 | 274.124 |
| 5 | VO 100-150 | 1 | 0.868 | 335 | 250.992 | 272.992 |
| 6 | VO 20-50 | 1 | 0.836 | 336 | 251.828 | 271.828 |

Model Variable Descriptions: bare-% bare ground cover at roost site; grass- % grass/graminoids ground cover at roost site; gram- % forb ground cover at roost site; % woody ground cover at roost site; litter- % litter ground cover at roost site; lit. depth- litter depth at roost site (cm); dom.Ht- dominant plan height (cm); DEC- distance to escape cover (m); VO- visual obstruction at escape cover, dis. Edge- distance from roost site to field edge (m)

# DISCUSSION

American woodcock migrating through central Kentucky during spring nocturnally roosted in fields that exhibited specific vegetative and habitat characteristics. Woodcock density increased in fields exhibiting woody/ herbaceous species interspersed with patches of lightly vegetated areas. Similar results have been recorded elsewhere, including in Georgia, Maine, Pennsylvania, Texas, and West Virginia, but this is one of the first such reports of habitat use for birds enroute during spring migration (Glasgow 1958 *cited in* Straw et al. 1994, Sheldon 1967, Boggus and Whiting 1982 *cited in* Straw et al. 1994, Gutzwiller and Kinsley 1983, Berdeen and Krementz 1998, Gregg et al. 2000). In contrast to Connors and Doerr (1982 *cited in* Krementz et al. 1995) and Horton and Causey (1979) who reported locating woodcock roosting mainly near field edges, I found birds were often located in a field's interior. The highest concentrations of birds observed in this study were located in old fields that had been managed via strip mowing and spring/ fall burning; whereas hayed and pasture land were used less frequently.

In this study, woodcock roosting in short vegetation were in close proximity to herbaceous and woody cover. Similar to Glasgow (1958 *cited in* Straw et al. 1994) and Boggus and Whiting (1982 *cited in* Straw et al. 1994), I found the tall herbaceous and woody vegetation around roost sites exhibited lower foliage densities from 0-20cm and much denser vegetation in the upper strata (>20cm). The sparse vegetation from 0-20cm probably allows for ease of mobility underneath a dense canopy. Berdeen and Krementz (1998) noted the importance of the structure of vegetation between 1 to 2m in determining the use of fields at night by woodcock. Similarly, I found roost sites were generally located in close proximity to woody and herbaceous vegetation that provided a degree of cover for woodcock.

I found a majority of birds located in the center of old fields; with birds only utilizing edges if fields contained short (<4 in), mowed grass. Connors and Doerr

(1982 *cited in* Krementz et al. 1995) and Horton and Causey (1979) observed woodcock in close proximity to field edge, speculating birds would rapidly walk or fly into diurnal cover if disturbed. Berdeen and Krementz (1998) documented use of field edge in pastures and hayfields. Any woody vegetation located in the interior of a field was readily used as roosting cover by birds observed in this study. Larger fields have been postulated to be attractive to woodcock because they provide more interior area to occupy (Berdeen and Krementz 1998). Woodcock exhibited similar preferences for field interior in this study. The use of field interior may decrease predator encounter rates, as larger fields increase a predator's time and effort in searching for prey items.

Tall herbaceous/woody vegetation within the interior of a field or along field edges may provide several advantages for woodcock utilizing fields at night Overhead horizontal cover likely provides better protection from raptors, specifically owls. Horizontal cover may also aid in predator avoidance by allowing birds to walk away from mammalian predators or to avoid detection with their cryptic pattern. Vegetation capable of reducing the influence of wind may provide a microclimate which enhances the ability of woodcock to conserve energy on cold nights. In absence of herbaceous/woody vegetation, such as in pastures and hayed fields, bunch grasses (i.e., *Andropogon* spp., *Schizachyrium* spp. and *Sorghastrum* spp.) can provide horizontal and vertical cover. Cool-season, sod-forming grasses do not exhibit the same structural characteristics as bunch grasses, and so woodcock will probably avoid this habitat type.

Several woodcock in this study where observed in dense stands of blackberry and saplings during diurnal periods. Abel and Ritchison (1999) noted woodcock nesting in dense sapling thickets in old-field habitat at the CKWMA. While nests in northern breeding areas are often located in dense, hardwood cover (Mendall and Aldous 1943), woodcock exhibit a wide variation in nest site selection (Sheldon 1967). Olinde (2000) observed increased gonadal recrudescence by mid- to late- February, and increased nesting along migratory routes during warm springs. In this study, old fields were readily used by migrating woodcock as nocturnal roosting habitat; however, these same areas may also be being utilized as diurnal and nesting habitat.

While soils noted at woodcock roost sites in this study varied in terms of drainage classification, most soils consisted of a silt loam composition. Hendrix et al. (1998) and Guild (1951 *in* Edwards and Bohlen 1996) suggest the type and structure of soil influences earthworm abundance, with loams and silt soils often-exhibiting higher concentrations of earthworms. Smith et al. (2008) found higher numbers of earthworms in old fields than in disturbed agricultural areas. Stribling and Doerr (1985) suggested the presence of residual litter may increase earthworm populations by providing organic forage and favorable microclimates during periods of freezing temperatures. In this study, I noted the presence of moist soil noted on the bills of roosting woodcock as an indicator of foraging during spring migration. Sixty-four percent of woodcock captured exhibited moist soil on their bills. In North Carolina, Stribling and Doerr (1985) noted that 12 of 14 woodcock that exhibited moist soil on their bills had earthworms in their proventriculus and or stomach. Earthworm availability increases in the upper soil strata during nocturnal periods, especially during periods of low ambient temperatures (Owen and Galbraith 1989, Duriez et al. 2006). During this study, it appears that a large number of woodcock actively foraged during nocturnal periods to coincide with increased availability of earthworms in the upper soil strata.

While rates of nocturnal feeding vary amongst seasons, higher rates of feeding are required during spring due to increased basal metabolic rates resulting from migration, low ambient temperatures, and reproductive effort (Rabe et al. 1983). Vander Haegen (1992 *cited in* Vander Haegen et al. 1994) observed female woodcock became active in both diurnal and nocturnal periods, apparently in an attempt to build up nutrient reserves required for nesting. Due to their larger body size, females are more capable of withstanding sub-zero temperatures and low food abundance (Gregg 1984 *cited in* Longcore et al. 2000). Yet, use of lipid reserves by females to cope with these hardships often delayed nesting by 3-4 weeks (Vander Haegen et al. 1993). Additional lipid reserves acquired during spring migration could help off-set adverse weather on breeding grounds and increase reproductive fitness. The combination of short vegetation, shallow litter, and favorable soils for high earthworm abundance appear to be factors influencing nocturnal roost selection by woodcock migrating through Kentucky in the spring.

# MANAGEMENT IMPLICATIONS

American woodcock appear to select for specific nocturnal habitat preferences during spring migration. Although two very different birds in aspects of their natural history, some of the management approaches useful for maintaining or enhancing habitat used by migrating American woodcock in Kentucky are very similar to the techniques proposed for managing bobwhite quail (*Colinus virginianus*) in the Commonwealth (Morgan and Robinson 2008). The maintenance of fields interspersed with plant communities in early-to-mid stages of plant succession appear to be of greatest value as nocturnal roosting habitat to woodcock migrating through Kentucky in the spring. Several management practices, e.g., prescribed burning, strip mowing, and grazing can be utilized to create the mosaic of desired plant assemblages important to woodcock and quail. Prescribed burning in the spring can benefit woodcock by removing excess litter. This would allow for greater access to feeding and courtship areas. Strip mowing would provide roost areas while the un-mowed portions could serve as escape cover. Short-duration grazing could be used to thin out thick stands of grass and create openings for feeding. Implementing these management practices in fields near undisturbed areas would provide woodcock access to woody vegetation and the vertical and horizontal cover needed for predator avoidance. Since woodcock rarely fly long distances to nocturnal habitat, field management efforts should be focused on larger fields within 300m of appropriate diurnal habitat. Management efforts focused in central and northern Kentucky would be beneficial to woodcock that migrate across the predominately agricultural areas of western Ohio and Indiana where appropriate habitat is currently scarce (Myatt and Krementz 2007b).

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