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# Avian Response to Production Stands of Native Warm-Season Grasses in the Mid-South

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I am submitting herewith a thesis written by Andrew Steven West entitled "Avian Response to Production Stands of Native Warm-Season Grasses in the Mid-South." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

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# Avian Response to Production Stands of Native Warm-Season Grasses in the Mid-South

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# Abstract

Grassland birds have declined more than any other guild of birds in North America, largely due to loss and degradation of native grasslands. The Conservation Reserve Program (CRP) has restored some native warm-season grasses (NWSG), but grassland birds continued to decline (-1.1% annually) partly due to the limited acreage converted (1% of southeastern US). Using NWSG in production settings provides profit incentive to landowners while reducing dependency on government programs. Studies examining these production practices and their effect on grassland birds east of the Great Plains are limited. During 2009 – 2010, I surveyed 102 NWSG fields in Kentucky and Tennessee being used for production purposes (control, biofuel, seed, hay, and pasture treatments) to assess bird use and vegetation characteristics. Landscape cover around each field (250, 500, and 1000 m) was digitized from aerial photography. Using analysis of variance (ANOVA), I compared bird (relative abundance, species diversity, and species richness) and vegetation (average height, litter depth, vertical cover, litter cover, and vegetation cover) metrics across the five treatments. Relative abundance for all species, species diversity, and species richness were all greater for seed production fields ($P < 0.05$); other treatments did not differ. Field sparrows (*Spizella pusilla*) were less abundant ($P < 0.05$) in biofuel than control, hay and graze treatments, whereas eastern meadowlarks (*Sturnella magna*) and dickcissels (*Spiza americana*) were more abundant in seed fields. Average vegetation height, vertical cover, percent litter, percent forbs and percent woody plants differed ($P < 0.05$) among treatments. Using Program Mark, I modeled occupancy for field sparrow, red-winged blackbird (*Agelaius phoeniceus*), eastern meadowlark, and northern bobwhite (*Colinus virginianus*) using vegetation and landscape cover as covariates.  Treatment was influential in field sparrow and eastern meadowlark models, but not those for red-winged blackbird and northern bobwhite. Occupancy for field sparrow and northern bobwhite were affected by woody cover (+), for red-winged blackbird by vegetation height (-), and for eastern meadowlark by litter depth (+) or percent NWSG (+). All four species were negatively affected by forest within 250-m.  Use of NWSG in production could increase the amount of available habitat and thus, help conservation efforts for grassland birds.

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Before European settlement, native grasslands were extensive, covering 162 million ha of which 60 million ha were tall grass prairies (Samson and Knopf 1996). Only about 4% of tall grass prairies remain today making it one of the most endangered ecosystems in the United States (Samson and Knopf 1996). The primary ecological drivers that maintained this ecosystem included fire, set by lightening or Native Americans, grazing from large migratory herbivores such as bison (*Bos bison*), and drought (Collins 1987, Askins et al. 2007). Fire prevention policies and the near-extinction of the bison have greatly reduced disturbance in grasslands. In addition to the loss of disturbance, intensive agriculture practices including monoculture row crops, irrigation systems, herbicides, hay fields and pastures consisting of exotic grasses like fescue (*Lolium arundinaceum*) and bermudagrass (*Cynodon dactylon*) now dominate much of the land once occupied by native prairies, leaving little habitat for native grassland species.

The degradation and fragmentation of remaining grasslands have contributed to the decline of grassland-dependant species including birds (Johnson and Igl 2001). Conversion of grassland to row-crops and urban development has lead to fragmentation of remaining habitats. Fragmentation limits area-sensitive species such as, the greater prairie chicken (*Typanuchus cupido*) and Henslow's sparrow (*Ammodrasmus henslowii*), that require large tracts of contiguous habitat for nesting and breeding (Herkert 1994, Johnson and Igl 2001, Svedarsky et al. 2003). Fragmentation also creates more edge, leading to increased predation and parasitism of native wildlife (Johnson and Temple 1990, Burger et al. 1994).

Disturbance is vital in grassland communities for stimulating seed germination, maintaining plant diversity, and suppressing tree invasion. Fire reduces litter and canopy cover, stimulating seed germination and thus increasing species richness, primarily through increases in forbs (Collins 1987). Contemporary agriculture management practices may partially mimic natural disturbances, but outcomes are not always positive. Grazing can alter the composition of the grassland due to the patchiness of grazing patterns (Collins 1987), but can also cause cover decline, which increases erosion and nutrient loss (Harrington and Kathol 2009). Mowing is a popular management tool used to encourage new growth but over time will increase thatch, which will eventually suppress the seed bank and decrease useable space for wildlife (Harper 2007). These disturbances help prevent aforestation and the resulting closed-canopy systems while promoting early successional habitat (Brennan and Kuvlesky 2005).

The dramatic reduction of this ecosystem has resulted in many grassland species being listed as threatened or endangered, or as candidates for such lists (Samson and Knopf 1994). Grassland bird populations have declined more than any other guild of birds in North America (Sauer et al. 2008). In the eastern and central US, 15 of 25 grassland species showed a strong negative tend of -1.1% annually (Murphy 2003). There are several conservation organizations that have made grassland birds the focal point of conservation initiatives. Partners in Flight has identified grassland birds, such as Bachman's (*Aimophila aestivalis*) and Henslow's sparrows, as species needing immediate conservation action (Rich et al. 2004). The National Bobwhite Conservation Initiative (NBCI) has made its goal to optimize northern bobwhite (*Colinus virginianus*) densities based on habitat area goals (National bobwhite technical committee 2011). If current trends continue, an eco-sociopolitical nightmare (much like with the spotted owl) could develop with grassland birds (Brennan and Kuvlesky 2005).

A number of US Department of Agriculture (USDA) programs address restoration of grassland habitat. The 1985 Food Security Act (Farm Bill) established the Conservation Reserve Program (CRP), which takes highly erodible cropland out of production to prevent soil erosion. Landowners enrolled in CRP programs can receive annual rental payments and cost-share assistance for planting resource-conserving vegetation (predominately grasses). The Farm Bill recognizes the importance of wildlife populations and provides incentives to landowners to establish cover beneficial to wildlife on these highly erodible lands. Programs such as CRP, Wildlife Habitat Incentives Program (WHIP), Grassland Reserve Program (GRP), and Environmental Quality Incentive Program (EQIP) all encourage the use of native warm-season grasses (NWSG). The NBCI regards CRP as one of the key strategy in restoring northern bobwhite and other grassland birds (National bobwhite technical committee 2011).

CRP has restored some grasslands habitat with associated increases in grassland bird populations. (King and Savidge 1995, Fletcher and Koford 2003, Galligan et al. 2006, Herkert 2007). Johnson and Schwartz (1993) observed that many of the grassland birds that are in decline were common in program fields. Fletcher and Koford (2002) compared native prairies to CRP fields in northern Iowa. Over their two-year study, 30 species of breeding birds were observed in both the prairie and CRP fields with 37 total species across all sites. Densities were generally similar between the two treatments suggesting that CRP fields could have positive affects on grassland bird communities. Using Breeding Bird Survey (BBS) data, Riffell et al. (2008) examined the relationship between CRP and 15 grassland bird species and developed regression models for seven different ecological regions.  Of the 108 total models, 49 models contained significant variables related to CRP, and all but one of these had a positive relationship between CRP and grassland birds.

Despite such successes, grassland bird populations continue to decline throughout the US (Murphy 2003, Wilson and Brittingham 2007, Sauer et al. 2008).  According to the BBS, the period from 1980 (just before CRP started) through 2007, 40% of grassland birds (n = 28) experienced significant population declines (Sauer et al. 2008).  That this decline continued despite enrolling 13.4 million ha in CRP in the continental US and 1.2 million ha of CRP in the southeastern US, is a reflection of the fact that this area represents only 2% and 1% of the total landscape of these two regions, respectively (U.S. Department of Agriculture 2009).  Furthermore, much of the CRP in the southeastern US was planted in exotic grasses (CP1), primarily tall fescue, or dense pine plantations, neither of which provide suitable habitat for species like the Northern Bobwhite (Burger 2006).

About 70% of the land in the lower 48 states is privately owned and about half of that is used for crop production or pasture (Gray and Teels 2006).  Therefore, any significant changes to the landscape will require participation of these private landowners.  Their management priorities revolve around generating acceptable financial returns (Burger 2006).  Reverting back to less-intensive agriculture practices is probably not realistic (Peterjohn 2003).

Other options for large-scale grassland restoration include using NWSG in production settings that allows the landowner to profit from the crop.  Switchgrass

(*Panicum virgatum*), a plant native to North American prairies that requires only limited fertilization and can grow on marginal land (Parrish and Fike 2005, Bies 2006), has been identified as the most promising source for biofuel feedstock production in the US (Fike et al. 2006). One analysis indicates that there may be the potential for 5 to 16 million ha of switchgrass to be grown in the US (Ugarte et al. 2003). Cuttings for biofuel feedstock are usually in the fall after the growing season, typically November, which provides optimal growth potential for the grasses. Because of this late cutting, habitat is provided for songbirds throughout the breading season (Roth et al. 2005). Murray and Best (2003) examined bird abundance in biofuels fields in Iowa that were strip harvested, fully harvested, and uncut (harvesting occurred from November to February). Abundance of 18 grassland species did not differ among treatments except for grasshopper sparrow (*Ammodramus savannarum*) and sedge wren (*Cistothorus platensis*); grasshopper sparrows were more abundant in total-harvested fields whereas sedge wrens were more abundant in non-harvested fields. A study estimating bird abundance in Iowa reported an increase of bird abundance in biomass fields (strip- and total-harvest) versus CRP fields (Murray et al. 2003).

Haying and grazing operations are another opportunity to use NWSG in a production setting. Because NWSG are $C_4$ grasses that mature in summer when cool-season grasses ($C_3$) are dormant, they can be valuable for forage (White 1986, Parrish and Fike 2005, Mousel et al. 2006). Growing primarily in the summer, NWSG has 70-80% of their growth after June 1; cool-season grasses (CSG) produce >75% of their growth before June 1 (Mulkey et al. 2008). They are also more efficient than CSG at using nitrogen and are less susceptible to drought (Rasnake and Lacefield 2004, Mulkey et al.

2008). Cattle weight gains on NWSG in the summer exceed those on CSG (Barnhart 1994). Walk and Warner's (2000) study in Illinois showed grazed fields (both NWSG and CSG) having greater relative abundance of birds than undisturbed fields. In Oklahoma and Kansas, Powell (2008) and Coppedge et al. (2008) both showed greater bird diversity and richness on pastures that were patched burned than traditional burns due to the mosaic that is formed in the pasture.

For hay, NWSG are typically harvested later in the summer providing more habitat for wildlife. Depending on the grass species, initial harvests can occur from late May to late June while still producing high yields (8.98-17.96 metric tons/hectare/year; Rasnake and Lacefield 2004). Because of later cutting dates with NWSG, early nesting opportunities for grassland birds are better than that provided by CSG, which are typically cut in early May. Giuliano and Daves (2002) compared hay fields of CSG to NWSG in Pennsylvania and observed that the latter had greater richness and abundance of breeding birds. Nest success and number of nesting species was also greater in these NWSG fields. Giocomo (2005) simulated the impact of mowing dates on nest success of grasshopper and Henslow's sparrows in NWSG fields at Ft. Campbell, KY based on nesting data he collected at that site. Grasshopper sparrow and Henslow's sparrows appeared to be a source population when mowing after August 1$^{st}$ only. Changing mowing dates can improve nest success depending on the species. If NWSG established as forage or for biofuel feedstock production replaces just 10% of the crop and pastureland in the southeast, there would be 3.4 million more hectares (Wilson and Brittingham 2007) of potentially improved habitat for grassland birds. This would be an area of grasslands substantially larger than what has been provided by CRP in the region to date.

There are few studies evaluating the relationship between managed NWSG and bird populations and these have been conducted primarily within the Great Plains (Sample et al. 1998, Roth et al. 2005, Fuhlendorf et al. 2006, Coppedge et al. 2008, Powell 2008). In the southeastern US where the landscape context is considerably different, most studies have examined grassland birds in NWSG that are fallow or minimally disturbed (i.e., CRP; Dykes 2005, Burger 2006, Riffell et al. 2008). There have been no studies to date exploring the use of NWSG production management practices and the comparative responses of grassland birds.

In this study, I will examine NWSG in Kentucky and Tennessee that are being exposed to different production management practices including biofuel feedstock production, seed production, and forage production including both grazing and haying. I will assess habitat and monitor avian community responses to these different management practices. More specifically, I will:

1. compare vegetation parameters in production stands (biofuel feedstock, seed production, and forage practices) and fallow fields (CRP, CREP, etc.) of native warm-season grasses;
2. compare breeding bird richness, diversity, and occupancy in production stands and fallow fields of native warm-season grasses; and
3. develop models to examine the relationship between breeding bird abundance, richness, diversity, and occupancy and habitat at both the field and landscape scales for production stands and fallow fields of native warm-season grasses.

Three sites were chosen based on the availability of treatment types with suitable replication available within the site; controls (unmanaged or fallow NWSG) were available at all three sites and provided a common basis for comparison.  While it would have been preferable to have all treatments represented equally at all sites, at the time I conducted this study, that situation did not exist due to the limited occurrence of such production fields within eastern landscapes.  In the following chapter I will examine vegetation characteristics of each treatment type based on ten variables.  For the nine target bird species, total detections, species richness and diversity will also be examined across treatment types.  In Chapter Three, I will examine the influence of both field- and landscape-level habitat on occupancy of individual fields and production types.

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# II. Grassland Bird Response to Production Stands of Native Warm-Season Grasses in the Mid-South

**ABSTRACT**

Grassland birds have declined more than any other guild in the US, primarily due to loss and degradation of native grasslands. Despite establishment of native warm-season grasses (NWSG) through the Farm Bill (e.g., Conservation Reserve Program), grassland birds have continued to decline. Agricultural uses of NWSG (hay, pasture, and biofuel feedstock) could result in extensive use of NWSG due to the market-based incentives they provide to landowners. Studies examining these production practices and their effect on grassland birds east of the Great Plains are limited. We examined breeding grassland bird use of 102 production fields of NWSG including control (fallow; n = 37), forage (pasture and hay; n = 7 and 22, respectively), seed (n = 21), and biofuel (n = 15) production fields in Kentucky and Tennessee during 2009 – 2010 breeding seasons. A total of 2,145 birds were detected with field sparrows (43%; *Spizella pusilla*) and red-winged blackbirds (27%; *Agelaius phoeniceus*) being most abundant. For all species combined, seed production fields had the highest (P <0.05) relative abundance (5.32 birds/visit), richness (2.46 species/visit), and Shannon diversity (0.70). For individual species, most treatments did not differ from the control with respect to relative abundance. Average vegetation height and vertical cover was highest (P <0.05) in biofuel fields (130.7 cm and 14.4 dm, respectively) and lowest in grazed fields (46.8 cm and 5.5 dm, respectively). Control fields (CRP) were highest (P <0.05) in percent cover for litter, forbs, and woody plants. Based on AIC models, forbs cover had the most influence on relative abundance, species richness and diversity. Overall, the lack of strong differences of breeding bird among treatment types suggests that production stands could be a viable approach for increasing useable NWSG for native grassland birds.

## INTRODUCTION

Grasslands bird populations have declined more than any other guild of birds in the United States (Samson and Knopf 1994, Murphy 2003, Sauer et al. 2008). According to the breeding survey in Kentucky and Tennessee since 1966, grassland birds have been declining at a rate of -2.48 and -2.47 respectfully (Sauer et al. 2008). This is predominantly due to the lost of grassland habitat through intensive agriculture and urbanization (Johnson and Igl 2001, Peterjohn 2003). Today, only about 4% of the once 60 million hectare tall grass prairie still remains (Samson and Knopf 1996). Declines in species such as Henslow's sparrow (*Ammodramus henslowii*), bobolink (*Dolichonyx oryzivorus*), grasshopper sparrow (*Ammodramus savannarum*), dickcissel (*Spiza americana*), greater prairie chicken (*Tympanuchus cupido*), and northern bobwhite (*Colinus virginianus*) have drawn the attention of many conservation groups who are concerned that if action is not taken soon, some of these species may become endangered (Dimmick et al. 2002, Svedarsky et al. 2003, Askins et al. 2007).

The most substantial effort to restore grassland habitats to date has come through Farm Bill programs such as the Conservation Reserve Program (CRP; Johnson and Schwartz 1993, Warner et al. 2000, Gill et al. 2006, Veech 2006, Riffell et al. 2008). The CRP has been an important and successful tool for conservation of grasslands and grassland birds (Delisle and Savidge 1997, Wilson and Brittingham 2007). Despite these successes, grassland birds continue to decline (Murphy 2003, Sauer et al. 2008). This continued decline may, in part, be attributed to the limited area enrolled in CRP (1.15 million ha or 1% of landscape) within the southeastern USA (U.S. Department of Agriculture 2009). Of that 1%, only 33.1% is in grassland practices and only 3.9% actually are in NWSG (Burger 2000). In contrast to this limited footprint for CRP, cropland and pasture in the southeastern US encompasses 18.8 million ha (17%) and 16.7 million ha (15%), respectfully. Of the continental US landscape, about 70% is privately owned and still engaged in production agriculture (Gray and Teels 2006, With et al. 2008). Because of the extent of private ownership of the region's landbase, economically viable approaches for increasing use of native warm-season grasses (NWSG) on the landscape should be explored. The use of NWSG as a biofuel feedstock and conversion of some forage production to NWSG has the potential to influence habitat on millions of hectares (McLaughlin et al. 1999, Barnes 2004).

Disturbance is vital in grassland communities for seed germination, encouraging plant diversity, and suppressing tree invasion. Fire reduces litter and canopy cover stimulating seed germination and thus, increasing species richness, primarily through increases in forbs (Sauer 1950, Hulbert 1969, Collins 1987). Mowing is a tool widely-used for managing grasslands in the eastern US, but repeated use will increase thatch that will eventually suppress the seed bank and decrease useable space for wildlife (Harper 2007). Cutting before seed-head emergence is ideal for high quality hay and maximum re-growth potential (Mitchell et al. 1994). However, the time of cutting can greatly affect grassland bird fecundity (Dale et al. 1997, Giocomo 2005). But proper management of NWSG haying and grazing still leaves 20-30 cm of residual vegetation, which is more than is typically left (<5 cm) with cool-season grass hay production (Capel 1995, Walk and Warner 2000, Giuliano and Daves 2002). Grazing can alter the composition of the grassland due to the patchiness of grazing patterns (Collins 1987, Coppedge et al. 2008). Many grassland plant species evolved under grazing pressures and depending on intensity of grazing can generate plant growth through tillers and rhizomes (Milchunas et al. 1988). All of these disturbances help prevent aforestation and the resulting closed-canopy systems, and promote early successional habitat (Brennan and Kuvlesky 2005).

Murray and Best's (2003) research on biofuel fields revealed similar breeding bird species richness and relative abundance in harvested versus nonharvested fields. On the other hand, Walk and Warner (2000) reported bird relative abundance was greater in disturbed fields (such as grazed and hayed NWSG) than in undistured NWSG. Gill et al. (2006) examined the response of grassland birds to disturbance on CRP fields in Maryland and found that fires stimulated vigorous groth of grasses but emergence of exotic species was faster on burned than unburned fields. Grassland birds including, horned lark (*Eremophila alpestris*), grasshopper sparrow, vesper sparrow (*Pooecetes gramineus*), northern bobwhite, and dickcissel, started colonizing the NWSG fields within 2-years of planting. Grasshopper sparrows responded positivly to the disturbance created by the burning with an high annual return rates of breeding pairs. CRP fields, by contrast, are realitively undisturbed with only one reqired disurbance during the ten year contract (McCoy et al. 2001a, Dykes 2005).

To date, research regarding bird responses to grassland management has predominantly been conducted in the Great and central Plains. Studies on biofuel (Murray and Best 2003, Roth et al. 2005) and forage (Coppedge et al. 2008, Powell 2008) production have been conducted in southwest Wisconsin and Oklahoma where native grasses dominate the landscape. We are aware of only two studies east of the Mississippi River that have examined bird responses to any of these practices (Walk and Warner 2000, Giuliano and Daves 2002) and none in the southeastern US where landscape and climate differ. Therefore, we examined NWSG in Kentucky and Tennessee under different management regimes including, biofuel feedstock, seed, and forage (grazing and haying) production. Specifically, we assessed how species abundance, total abundance, species richness, and diversity for grassland birds during the breeding season were affected by these different management practices. We also examined how vegetation composition and structure differed among these same production practices and how these vegetation patterns influenced avian community metrics.

**STUDY AREA**

Three study areas were chosen based on presence of NWSG managed for biofuel feedstock, seed, or forage production (treatments). Because of the limited amount of NWSG currently used in these enterprises in the region, no one of our sites had all treatments represented. Most study fields were on privately-owned, actively-managed farms. Sites included: McMinn and surrounding counties (MCMINN), in the Southern Appalachian Ridge and Valley region, in southeastern Tennessee; and Hart (HART) and Monroe Counties (MONROE), both in the Pennyroyal region of south-central Kentucky (Figure 2.1). MCMINN was 57% forested and 20% crops; HART was 43% forested and 31% in crops; and MONROE was 26% forested and 34% in crops (Vilsack 2009, US Department of Agriculture 2011). All three sites have an average temperature of 21°C and an average rainfall of 142 mm during the field season each year (National Climatic Data Center 2011).

All three sites had unmanaged NWSG fields that were in CRP, CREP, or managed similarly to fields enrolled in those programs, and remained undisturbed during the course of the study and served as a control (CONTROL). CONTROL were predominately planted in a mixture of big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*). Planting rates varied based on agency and year of planting, but all were fully stocked stands. CONTROLS have been established for >6 years and have been burned at least once since establishment. In addition, each location had at least one other treatment level represented. MCMINN included switchgrass (*Panicum virgatum*) being grown as a biofuel feedstock (BIOFUEL) and hay fields (HAY) planted in a mixture of big bluestem, indiangrass, and/or switchgrass that were harvested for hay. We examined fields being managed for commercial NWSG seed production (SEED) including, big bluestem, indiangrass, and little bluestem, at HART. MONROE featured eastern gamagrass (*Tripsacum dactyloides*) that was hayed (HAY) or grazed (GRAZE).

To minimize any biases associated with area-sensitive species, we constrained our sample to 2–12 ha fields. All fields were >250 m apart and were at least one full growing season post-establishment. Only SEED fields were burned during the course of the study; they were burned annually (February – March) as a part of normal production operations to remove old vegetation that could interfere with seed harvest and to suppress weeds. HAY fields were harvested during June each year, SEED during August - October, and BIOFUEL during early winter (November – January). All GRAZE fields were rotationally grazed and had at least one rotation during May – June. While intensity and duration varied with landowner, all fields were managed for production.

## METHODS

### Grassland Bird Surveys

We surveyed each field three times during the breeding season annually, once during each of three periods: 10 – 30 May, 1 – 15 June, and 16 June – 1 July, 2009 and 2010. We used 10-minute 100-m fixed-radius point counts for target bird species. We placed points in the center or on ridges or high spots within the fields (when feasible) to optimize detection of birds (Lanham and Guynn 1998, Jobes et al. 2004). Points were located >25 m from field edges and >250 m from other points and located by GPS to ensure the same point was sampled all six visits. Due to field size, and to ensure equal sampling effort, each field had one point only. We recorded 12 focal species, nine of primary interest and three of secondary interest, during the survey period (Table 2.1). Primary species seen or heard within a 100-m radius were recorded using a removal method (Farnsworth et al. 2002) while secondary species were recorded as present only. We conducted surveys from sunrise to 10:00 AM with each survey starting 2 minutes after arrival at the point. Surveys were not conducted in precipitation, fog, or high wind (>20 km/h). Each year, 2 observers were at each site (only 1 at Monroe, KY) and each observer visited each field at their site at least once. Due to limited resources and the lack of existing research on grassland birds in the region, we decided to focus on a broad assessment of breeding birds rather than a more limited scope that provided more thorough information such as fecundity.

**Vegetation Measurements**

We measured vegetation annually between 1 June – 11 July to reflect habitat conditions of the field during the breeding season. Hay fields that were harvested before vegetation measurements were taken and grazed fields that were never grazed in a given year were dropped for that year.

We measured vegetation along a systematic grid centered on the point-count location and that started in a randomly selected cardinal direction (N, E, S, or W) and distance (0-25m) from the bird sampling point. From that first randomly located point, each subsequent vegetation sampling point was located along the transect at an interval based on field size as follows: 2 – 3 ha fields, 35 m; 3 – 4 ha fields, 40 m; 4 –5 ha fields, 45m; and >5 ha fields, 50 m between points. A minimum of 12 such vegetation plots were sampled per field. At each plot, a 20-m perpendicular line was established to sample herbaceous species, litter depth, ground cover, average vegetation height, and cover density (Figure 2.2). We recorded plant species at 1.0 m interval for a total of 20 samples per transect, 240 per field; plants were identified to species whenever possible. More than one plant may have been recorded at each point due to layering of vegetation. We recorded ground cover (bare or litter) and average vegetation height (cm) at 5-m intervals, starting at the 0-m mark, for a total of five measurements per transect, 60 per field. Litter depth (cm) was measured at the first location where litter was present, starting from both ends of the 20-m transect moving toward the center and from the center moving out in each direction for a total of four per transect, 48 per field. We measured cover density using a Robel pole (Robel et al. 1970) placed at the center of each transect. The 2-m pole had marks every 10 cm with alternating colors and a black line indicating the mid-point of each decimeter; the lowest visible mark (to the half decimeter) was recorded. Observations were taken four meters away from the pole, 1 meter off the ground, and from the four cardinal directions.

**Statistical Analyses**

We calculated bird diversity for each visit during each year using a Shannon-Wiener diversity index (Wilhm 1968). Means for vegetation measurements were taken across all 12 sampling points within each field. We calculated means for bird detections across all three visits for each field in each year. We used averages in subsequent analysis unless otherwise stated.

Because not all treatments was at all site locations, we used an incomplete block design (Bose 1942) to account for the fact that our sites had different treatments. We analyzed means for vegetation variables under a randomized block model using a one-way analysis of variance (ANOVA) with a split-plot (year) with replication of the whole plot (production type). Total bird detections (relative abundance), species richness, species diversity, and relative abundance for individual species were examined using the same model. Site was a blocking factor in both analyses. We used PROC MIXED in SAS (Institute 2004) to test for differences among treatments and Fisher's least significance difference (LSD) test for post-ANOVA means separation with $\alpha = 0.05$. Treatment and year were fixed effects while site was a random effect. Transformations (square root – litter depth, red-winged blackbird; arcsin/square root – cool-season grass, legumes; rank – eastern meadowlark, northern bobwhite, grasshopper sparrow, prairie warbler, and dickcissel) were used where necessary to improve normality and homogeneity of variance. Treatment, year, and treatment by year interactions were examined in all ANOVA models.

Relationships between relative abundance, species richness, and diversity index to vegetation variables and site (Table 2.2) were analyzed using logistic, generalized linear models (PROC GENMOD) in SAS (Institute 2004) to detect linear trends between birds and vegetation. We used a correlation matrix to identify collinear variables so that no variables with a correlation coefficient >0.7 were tested simultaneously giving us repeating results (Delisle and Savidge 1997). We evaluated candidate models and selected the best models with Akaike's information criterion (AIC; Burnham and Anderson 2002).

**RESULTS**

We sampled 90 fields in 2009 and 87 in 2010 for 102 total fields (Table 2.3) that ranged from 1.6-12.1 ha (mean 4.1 ha). Due to management changes or access restriction, 12 fields used in 2009 were not available in 2010. New fields were added wherever possible that met all of our other criteria. None of the secondary species were detected in either year. Due to the low occurrences of Henslow's sparrows and horned larks (*Eremophila alpestris*), ANOVA's were not conducted for these individual species; however, they were included in relative abundance, species richness, and species diversity analyses.

**Avian**

We detected 919 and 1230 birds of all species during 2009 and 2010, respectively. Field sparrow (*Spizella pusilla*) was the most frequently detected species (42%) followed by red-winged blackbird (*Agelaius phoeniceus*; 27%) in both years (Table 2.4). SEED had the greatest relative abundance, species richness and diversity (Table 2.5) among all treatments ($P < 0.05$); the remaining four categories were not different with respect to any of these measures. Field sparrow, eastern meadowlark (*Sturnella magna*), and dickcissel (*Spiza americana*) were the only species for which we detected differences among treatment types ($P < 0.05$, Table 2.5). Both eastern meadowlark and dickcissel were more abundant on SEED fields, while field sparrows were less abundant in BIOFUEL fields. Only relative abundance for all species and for field sparrows had a year effect ($P < 0.05$) with 2010 having more detections in both cases. No year-by-treatment interactions were detected for any of the species or community metrics ($P > 0.01$).

**Vegetation**

Average vegetation height and vertical density were greatest ($P < 0.0001$) in BIOFUEL and lowest in GRAZE (Table 2.6). CONTROL had the highest percent litter, forbs, and woody plants ($P < 0.0001$). Litter depth and cover for other species did not differ among treatments.

Among vegetation measures, only litter depth (greater in 2010) and vegetation height (greater in 2009) differed between years. Year-by-treatment interactions were detected for vertical density ($P < 0.01$), average height ($P < 0.001$), and forb cover ($P < 0.05$). Vegetation in SEED was taller and denser in 2009 than HAY, where HAY was taller and denser in 2010 than SEED. Forb cover was greatest for HAY in 2009 and for CONTROL fields in 2010. GRAZE forb cover was lower in 2010 than in 2009, dropping below BIOFUEL.

**Models**

Twelve variables were initially examined but only ten occurred in final models. Forb cover was negatively correlated with NWSG cover (-0.805, $P < 0.0001$) and vegetation height was positively correlated with vertical density (0.900, $P < 0.0001$). Both forb cover and average vegetation height had a lower $\Delta AIC_c$ score than NWSG cover and vertical density, respectively, so they were dropped from the models.

Forb cover received the most support in all AIC models (Table 2.7). The 95% confidence interval for forb cover did not include zero (Table 2.8). Forb decreased abundance by a multiplicity of 0.58, species richness by 0.62 and diversity index by 0.87. Top models for relative abundance, species richness, and diversity index did not include site.

## DISCUSSION

Overall, our results showed little variation among the five treatment types we examined with respect to relative abundance, species richness, and species diversity for all species or for four of the seven individual species with large enough sample sizes to test. On the other hand, vegetation varied among treatments, but those differences did not seem to impact bird use. Year, which only had an effect for 4 of the 22 variables we tested, did not appear to be an important factor in our results.

The undisturbed CONTROL was intermediate for relative abundance for all individual species and for all species combined with respect to relative abundance, species richness, and species diversity. Our CONTROL fields were either in CRP, CREP, or were managed similarly to such fields. Previous studies have demonstrated mixed results with CRP. King and Savidge (1995) in Nebraska compared CP1 (cool-season) to CP2 (NWSG) and found no difference between treatments for total bird, grasshopper sparrow, or dickcissel relative abundance. However, abundance for bobolink was greater in CP1 fields, while common yellowthroat (*Geothlypis trichas*) and sedge wren (*Cistothorupsla tensis*) were greater in CP2 fields. McCoy et al. (2001b), working in Missouri, also compared these two CP's and found abundance for grasshopper sparrows, eastern meadowlark, Henslow's sparrow, and American goldfinch were greater in CP1 fields, while abundance for common yellowthroat and fecundity for dickcissels and red-winged blackbirds were greater in CP2 fields. King and Savidge (1995) found no difference for northern bobwhite and meadowlarks between areas with high CRP (>20%) and areas with low CRP (<5%). Nevertheless, all of these workers reported that unmanaged NWSG provided beneficial habitat for grassland birds. However, these studies compared fallow fields to each other and not to production stands. In our study, CONTROL had the most litter, forb, and woody cover among all treatments. This was an expected result considering these fields were not disturbed, thus allowing thatch to accumulate and succession to proceed unabated; in other treatments, disturbance retarded succession and litter was removed through harvests.

Field sparrows were the only species that had lower relative abundance in BIOFUEL than in the other production categories; all other bird metrics for BIOFUEL were similar to other treatments. Murray and Best (2003) studied biofuel (switchgrass) production fields (total harvest, strip harvested) cut during the dormant season (November – March) and controls (CRP) in Wisconsin and reported relative abundance for only 2 of 18 observed species (grasshopper sparrow and sedge wren) differed among treatments. Grasshopper sparrow relative abundance was greatest in total harvested fields and sedge wren in nonharvested fields. Roth et al. (2005), also working in Wisconsin, studied biofuel fields (switchgrass) harvested during August and those that remained unharvested and found no difference in total grassland bird relative abundance and richness. Although tall grass species (sedge wren and Henslow's sparrow) were not seen on harvested fields, mid- and short-grass species (grasshopper sparrow, eastern meadowlark, and savannah sparrow [*Passerculus sandwichensis*]) were more relative abundant on harvested fields. Grasshopper sparrow relative abundance in our study did not differ between BIOFUEL and other treatments, but the low number of detections we had for this species may have limited our ability to observe differences. Although field sparrows did not differ in abundance or nest success in biofuel fields in Iowa, models developed by Murray et al. (2003) for those fields predicted field sparrows would decline by 9% on fully harvested biofuel fields. It is unclear why field sparrow's relative abundance would be lower in BIOFUEL than other treatments but that does not seem to be unusual based on other studies. Other studies specifically examining this production type are, to our knowledge, lacking. Due to the late cutting (all BIOFUEL in our study was cut during the dormant season, November – January), grassland birds were not disturbed during the breeding season, which may explain why few differences were found for most species in our and other studies. Species needing second-year growth (i.e., Henslow's sparrow and sedge wrens), on the other hand, will probably not be favored in this system.

In our study, BIOFUEL fields had the tallest and densest vegetation of all the treatments. Lowland varieties of switchgrass, the primary species in BIOFUEL, are taller than other NWSG. Furthermore, BIOFUEL was treated annually with nitrogen (67 kg $ha^{-1}$) to increase biomass and, therefore, vegetation density, as a normal part of production practices.

Species richness, diversity, and relative abundance for all species combined and for eastern meadowlark and dickcissel were all greater in SEED than other treatments. In the case of dickcissel, the greater relative abundance may be explained by the fact that they are generally more common at this study site because it is located well within the species' range whereas the other sites were more peripheral to that range; we did, however, record dickcissels at the other two sites. Horned lark was only located on SEED, again, perhaps as a function of species' range. Eastern meadowlark favors greater percentage of NWSG (Roseberry and Klimstra 1970) which may be why their relative abundance was greater for SEED. The late harvest in SEED, like BIOFUEL, allows for grassland birds to breed all season without disturbance (unlike HAY). Skinner (1975) found fields combined for seed had more species and individuals than control fields. We are aware of no other studies that have examined seed production. SEED fields were lowest in amount of litter and forb cover. The low amount of forb cover is not surprising given the operational application of herbicides to minimize contamination of harvested NWSG seed by those of weeds. Annual burning after seed collection eliminated thatch left in seed production fields.

In GRAZE, bird metrics were similar to all other treatments although the standard error was greater for GRAZE, probably due to the limited availability of this treatment type or the high variability inherent with grazing. Skinner's (1975) work in Missouri compared fields that were idle, hayed, combined for seed, and grazing at four intensities. Grazed fields at all intensities had as many or more species and individuals than all other treatments. Walk and Warner's (2000) work in Illinois compared annual weeds fields and burned, hayed, mowed, grazed, and undisturbed fields of both NWSG and cool-season grasses. Eastern meadowlark and dickcissel were more abundant in grazed NWSG fields than other treatments and no species was less abundant in grazed fields versus other treatments. In ranking all eleven of their treatments by relative abundance of grassland birds, grazed NWSG ranked highest. Giuliano and Daves' (2002) study in Pennsylvania compared NWSG and cool-season grass hay and grazed fields and found bird relative abundance and richness was greater in NWSG than cool-season grasses. They did not use any unmanaged fields or have any controls in their study. Despite the apparent value of grazing as a disturbance agent, we did not observe any differences between grazing and the other treatment types. This may be due to the fact that the dominant grass in GRAZE was eastern gammagrass where others studies have examined more complex mixtures of NWSG (i.e., big bluestem, indiangrass, and switchgrass). Gammagrass grows more in larger clumps than other NWSG and may not provide the same structure. GRAZE had the lowest vegetation height and vertical density. The active grazing during the season kept grasses shorter than other treatments. Forb cover was intermediate between that for CONTROL and SEED treatments.

HAY did not differ from CONTROL for any bird metrics. However, hay fields may be a sink for grassland birds (Giocomo et al. 2008, Luscier and Thompson 2009). Luscier and Thompson (2009) examined hay cuttings in northwestern Arkansas for cool season grasses and found early cuttings (26 – 31 May) were detrimental to nest survival for field sparrows, red-winged blackbirds, and dickcissels and resulted in decreased grassland bird densities. However, they reported that impacts associated with late cuttings (17 – 26 June) were trivial. These dates coincide with cutting dates of NWSG in our study; NWSG also are typically harvested at higher residual height than cool-season hay fields, a practice that may result in reduced impact on active nests (Walk and Warner 2000, Giuliano and Daves 2002). Because we took vegetation surveys before hay cutting, most variables were similar to other treatments. Giuliano and Daves (2002) examined hayed and grazed NWSG vs. cool-season grasses and found bird relative abundance and richness was greater in NWSG than cool-season grasses. Furthermore, they reported that nest success and fledging rates were greater in NWSG than cool-season grasses. Most cutting in our study occurred toward the end of the survey season so we believe the precut vegetation was what birds were exposed to for a majority of the breading season. In comparison to CONTROL, HAY had less vertical density, litter cover, and woody cover due to the yearly cutting and removal of grasses.

Based on our models relating bird and vegetation metrics, percent forb cover was the single most important explanatory variable. Amount of forb cover had a negative relationship with bird abundance, species diversity, and species richness. Goldenrods (*Solidago sp.*) were the most abundant forb for both years followed by common ragweed (*Ambrosia artemisiifolia*). Skinner's (1975) fields, that were forb-dominated, and Walk and Warner's (2000) fields, only annual forbs, were both negatively effected bird abundance as well. Forbs are not as useful as grasses for nesting structure or concealment so grassland birds may avoid areas dominated by forbs. A moderate scattering of forbs across the field may be ideal (Skinner 1975). We believe SEED, with its greater numbers of birds combined with lower forb cover (and higher NWSG cover), may have exerted a great deal of influence on our model. Conversely, NWSG cover, which had an inverse relationship with forb cover, had a positive relationship with bird abundance, species diversity, and species richness. However, the beta value for forbs and

NWSG was small, indicating that there was little change in relative abundance for birds as forb cover changed.

NWSG fields have been shown to be beneficial for grassland bird species (King and Savidge 1995, Best et al. 1997, Dykes 2005). The use of NWSG in production settings could potentially increase the amount of habitat available for grassland birds on the landscape. Other studies have reported similar results to ours with production fields being as abundant in grassland birds as control NWSG fields. Roth et al. (2005) did not detect a difference in harvested versus unharvested biofuel fields for species richness and relative abundance. Powell (2008) demonstrated that eastern meadowlark, upland sandpiper, and grasshopper sparrows favored fields exposed to low-intensity grazing compared to burning alone, a condition that approximates CRP fields. Walk and Warner (2000) found that bird relative abundance for five species (eastern meadowlark, dickcissel, Henslow's sparrow, grasshopper sparrow, and field sparrow) was greater on grazed NWSG fields than on nine other field types including, undisturbed cool-season grass and NWSG fields. With the exception of field sparrow relative abundance on BIOFUEL, we saw no difference in production stands versus CONTROL, suggesting that any of the production practices for NWSG can provide desirable habitat for grassland birds.

Our approach focused on a broad assessment of major production systems for NWSG in the Mid-South where biofuel feedstock and forage production practices relying on these grasses are starting to expand. Due to limited time and resources, we were not able to evaluate reproductive parameters. Our work does, however, provide the basis for more intensive studies of productivity in the future. Also, because use of NWSG in production systems is still a new venture in the Mid-South, and sites are not widely available, replication of all practices at all sites was not possible. Use of unmanaged and quite similar control fields at each site, however, provided us with a basis for comparison among the various treatments. We also did not include cool-season grass fields in this study because previous studies have shown that NWSG had better responses for grassland birds (Walk and Warner 2000, Giuliano and Daves 2002) and our resources were limited. We also realize that a majority of the species using our fields are habitat generalists. Nevertheless, specialist species that we detected showed little or no preference among field types. Additional research is needed to further understand the contribution that NWSG can make to grassland bird conservation when the grass is being managed for production objectives and how those contributions are affected by landscape context.

## MANAGEMENT IMPLICATIONS

There are two important implications in using NWSG in production stands. The first is disturbance. Historical disturbance regimes in natural tall-grass prairie were based on both fire and grazing. Although contemporary managers commonly use fire in fallow NWSG stands, grazing is still lacking as a widespread disturbance agent in NWSG managed primarily for wildlife habitat. Harvesting in the other production types (biofuels, seed, and hay) may slow woody encroachment while also removing litter, something that does not occur when simply mowing where cut vegetation remains in place. These disturbances will keep grass fields from succeeding into scrub-shrub habitat and ultimately, into forested habitat. The second major implication is that production-based uses of NWSG allow markets to increase availability of desirable grassland bird habitat. Production practices provide landowners incentive to not only plant NWSG, but also to maintain it in a manner that provides regular disturbances. As CRP fields come out of contract, landowners can maintain grassland habitat on those fields instead of converting them into rotational crops. This would also be a good way to provide grazing opportunities with NWSG since establishment costs would have already been incurred. Normally, it takes two or three years to establish NWSG stands and this time interval may be a disincentive to many landowners who can not afford to loose forage during those establishment years.  Use of NWSG based on markets can also reduce uncertainty associated with Farm Bill funding and improve the efficiency of delivering wildlife habitat on a large scale.

The use of market-based NWSG production fields could potentially impact an extensive area.  If just 10% of pastures in the southeastern USA were converted to NWSG, that would create 1.5 million ha (U.S. Department of Agriculture 2009) compared to 1.2 million ha of CRP (only 3.9% of which is in NWSG).  In addition, biofuel feedstock has been predicted to result in as much as 7.8 million ha, much of which would be in the southeastern USA (Ugarte et al. 2003). This vast acreage could make an important contribution to stopping or even reversing the decline grassland species.

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# Appendix

Table 2.1. Grassland bird species targeted for breeding-season monitoring in fields with production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010.

| Common name | Scientific name | Species code | Conservation Status [a] |
|---|---|---|---|
| Primary species | | | |
| Dickcissel | *Spiza americana* | DICK | Manage |
| Eastern meadowlark | *Sturnella magna* | EAME | |
| Field sparrow | *Spizella pusilla* | FISP | |
| Grasshopper sparrow | *Ammodramus savannarum* | GRSP | Manage |
| Henslow's sparrow | *Ammodramus henslowii* | HESP | Immediate action |
| Horned lark | *Eremophila alpestris* | HOLA | |
| Northern bobwhite | *Colinus virginianus* | NOBO | |
| Prairie warbler | *Dendroica discolor* | PRAW | Manage |
| Red-winged blackbird | *Agelaius phoeniceus* | RWBL | |
| Secondary species | | | |
| Bachman's sparrow | *Aimophila aestivalis* | BASP | Immediate action |
| Bobolink | *Dolichonyx oryzivorus* | BOBO | |
| Loggerhead shrike | *Lanius ludovicianus* | LOSH | |

[a] Conservation Status based on Partners in Flight North American Landbird Conservation Plan; The Continental Plan (Rich et al 2004).

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Table 2.2. Candidate models and associated number of parameters (K) for each under an information-theoretic modeling approach for three dependent variables (relative abundance, species richness, and diversity index) for breeding songbirds detected in production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010.

| Potential models | K |
|---|---|
| % Native Warm Season Grasses | 3 |
| % Cool Season Grass | 3 |
| % Forb | 3 |
| % Legumes | 3 |
| % Woody Plants | 3 |
| % Other Warm Season Grasses | 3 |
| Average Height | 3 |
| Average Litter Depth | 3 |
| Vertical Density | 3 |
| % Litter | 3 |
| Site | 4 |
| null | 2 |

Table 2.3. Number of native warm-season grass fields monitored during the breeding season for grassland birds by site and production type in Kentucky and Tennessee, 2009 - 2010.

| Site<br>Treatment | Year<br>2009 | <br>2010 | Independent Fields |
|---|---|---|---|
| Hart Co., KY | | | |
| CONTROL | 18 | 18 | 18 |
| SEED | 19 | 19 | 21 |
| Monroe Co., KY | | | |
| CONTROL | 5 | 5 | 6 |
| GRAZE | 7 | 3 | 7 |
| HAY | 5 | 6 | 7 |
| McMinn Co., TN | | | |
| CONTROL | 8 | 11 | 13 |
| BIOFUEL | 15 | 14 | 15 |
| HAY | 13 | 11 | 15 |
| Total | 90 | 87 | 102 |

Table 2.4. Total number of detections by species based on point-counts conducted during the breeding season in production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010.

| | Year | | |
|---|---|---|---|
| Species | 2009 | 2010 | Total |
| Field sparrow (*Spizella pusilla*) | 369 | 550 | 919 |
| Red-winged blackbird (*Agelaius phoeniceus*) | 246 | 339 | 585 |
| Eastern meadowlark (*Sturnella magna*) | 93 | 104 | 197 |
| Northern bobwhite (*Colinus virginianus*) | 78 | 98 | 176 |
| Grasshopper sparrow (*Ammodramus savannarum*) | 67 | 63 | 130 |
| Prairie warbler (*Dendroica discolor*) | 38 | 50 | 88 |
| Dickcissel (*Spiza americana*) | 13 | 25 | 38 |
| Henslow's sparrow (*Ammodramus henslowii*) | 10 | 1 | 11 |
| Horned lark (*Eremophila alpestris*) | 1 | 0 | 1 |
| Bachman’s sparrow (*Aimophila aestivalis*) | 0 | 0 | 0 |
| Bobolink (*Dolichonyx oryzivorus*) | 0 | 0 | 0 |
| Loggerhead shrike (*Lanius ludovicianus*) | 0 | 0 | 0 |
| Total | 915 | 1230 | 2,145 |

Table 2.5. Means and standard errors (SE) for relative abundance, species richness, and species diversity for all species combined and relative abundance for seven species of grassland birds detected during the breeding season in production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010.

| Variable/Species | CONTROL | | BIOFUEL | | SEED | | GRAZE | | HAY | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | x̄ (S.E) | | x̄ (S.E) | | x̄ (S.E) | | x̄ (S.E) | | x̄ (S.E) | | P [a] |
| Mean relative abundance | 3.52 (0.31) | B [b] | 3.57 (0.50) | B | 5.32 (0.60) | A | 4.07 (0.62) | B | 3.99 (0.44) | B | <0.001 |
| Species richness | 1.54 (0.10) | B | 1.51 (0.13) | B | 2.46 (0.24) | A | 1.90 (0.37) | B | 1.88 (0.17) | B | <0.001 |
| Shannon-Weiner Diversity Index | 0.36 (0.04) | B | 0.34 (0.05) | B | 0.70 (0.09) | A | 0.40 (0.14) | B | 0.49 (0.07) | B | <0.001 |
| FISP [c] | 1.94 (0.16) | A | 1.16 (0.21) | B | 1.25 (0.02) | AB | 2.33 (0.46) | A | 2.17 (0.23) | A | 0.002 |
| RWBL | 0.91 (0.21) | | 1.74 (0.44) | | 1.54 (0.23) | | 0.73 (0.32) | | 0.57 (0.17) | | 0.512 |
| EAME | 0.10 (0.03) | B | 0.14 (0.05) | B | 0.96 (0.21) | A | 0.57 (0.25) | B | 0.36 (0.13) | B | <0.001 |
| NOBO | 0.35 (0.07) | | 0.24 (0.07) | | 0.25 (0.08) | | 0.10 (0.07) | | 0.51 (0.12) | | 0.066 |
| GRSP | 0.03 (0.01) | | 0.18 (0.07) | | 0.64 (0.17) | | 0.20 (0.13) | | 0.29 (0.09) | | 0.498 |
| DICK | 0.00 (0.00) | B | 0.01 (0.01) | B | 0.32 (0.10) | A | 0.03 (0.03) | B | 0.00 (0.00) | B | <0.001 |
| PRAW | 0.18 (0.04) | | 0.10 (0.04) | | 0.30 (0.10) | | 0.10 (0.05) | | 0.07 (0.03) | | 0.156 |

[a] Results of ANOVA comparing five production types.

[b] Means within rows with the same letters are not significantly different ( P >0.05, Fisher's least significant difference test).

[c] See table 1 for bird species code.

Table 2.6. Means and standard errors (SE) for ten vegetation measures for production stands of native warm-season grasses in Kentucky and Tennessee, 2009 - 2010.

| Variable | CONTROL x̄ (S.E) | | BIOFUEL x̄ (S.E) | | SEED x̄ (S.E) | | GRAZE x̄ (S.E) | | HAY x̄ (S.E) | | P [a] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Height (cm) | 72.8 (3.9) | B [b] | 130.7 (6.0) | A | 48.3 (4.4) | C | 46.8 (8.3) | D | 76.5 (4.9) | BC | <0.001 |
| Litter Depth (cm) | 5.0 (0.3) | | 1.5 (0.2) | | 1.4 (0.3) | | 1.3 (0.1) | | 2.0 (0.2) | | 0.154 |
| Vertical Density (Rich et al.) | 9.2 (0.4) | B | 14.4 (0.8) | A | 5.9 (0.5) | C | 5.5 (0.7) | D | 8.5 (0.6) | C | <0.001 |
| Cover (%) | | | | | | | | | | | |
| Litter | 96.7 (0.7) | A | 76.3 (3.0) | B | 53.5 (6.4) | C | 79.9 (3.7) | B | 73.7 (4.4) | B | <0.001 |
| NWSG | 25.2 (2.2) | | 58.5 (2.9) | | 79.8 (2.5) | | 36.5 (5.0) | | 40.4 (3.3) | | 0.121 |
| Cool-season grass | 7.6 (1.9) | | 7.3 (0.9) | | 21.6 (5.1) | | 11.7 (1.8) | | 0.8 (0.2) | | 0.142 |
| Forbs | 42.0 (2.5) | A | 17.9 (2.3) | C | 6.6 (1.4) | D | 17.5 (3.9) | BC | 26.5 (2.3) | AB | <0.001 |
| Woody | 6.5 (0.8) | A | 0.6 (0.2) | C | 1.2 (0.4) | B | 0.01 (0.01) | C | 1.2 (0.3) | C | <0.001 |
| Legumes | 3.0 (1.1) | | 9.3 (1.0) | | 16.3 (4.0) | | 10.0 (1.9) | | 5.4 (1.2) | | 0.307 |
| Other warm-season grass | 4.9 (1.8) | | 1.5 (0.4) | | 1.1 (0.5) | | 4.6 (1.2) | | 0.6 (0.4) | | 0.964 |

[a] Results of test for treatment effects from one-way analysis of variance in random block design with split-plot on year.

[b] Means within rows with the same letters are not significantly different ( P >0.05, Fisher's least significant difference test).

Table 2.7. Model results for breeding bird abundance, species richness, and diversity index (dependent variables) versus vegetation metrics (independent variables) during the breeding season in production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010. Models sorted by Akaike's information criterion adjusted for small sample size ($AIC_c$) and only models with a $\Delta AIC_c$ of <4 are shown. Number of parameters (K) and model weights ($w_i$) are also shown.

| Model | K | AICc | ΔAICc | $w_i$ |
|---|---|---|---|---|
| Relative Abundance | | | | |
| Forbs (%) | 3 | 375.62 | 0.00 | 0.48 |
| Null | 2 | 378.41 | 2.79 | 0.12 |
| Height | 3 | 379.14 | 3.52 | 0.08 |
| Other Warm-Season Grasses (%) | 3 | 379.51 | 3.89 | 0.07 |
| Cool Season Grasses (%) | 3 | 379.68 | 4.06 | 0.06 |
| Species Richness | | | | |
| Forbs (%) | 3 | 26.54 | 0.00 | 0.77 |
| Height | 3 | 31.80 | 5.25 | 0.06 |
| Null | 2 | 32.26 | 5.72 | 0.04 |
| Cool Season Grasses (%) | 3 | 32.51 | 5.97 | 0.04 |
| Diversity Index | | | | |
| Forbs (%) | 3 | -316.21 | 0.00 | 0.61 |
| Cool Season Grasses (%) | 3 | -312.16 | 4.05 | 0.08 |
| Null | 2 | -312.01 | 4.20 | 0.08 |

Table 2.8. Regression coefficients (β), standard error (SE), and 95% confidence intervals (95% CI) for top models for breeding bird abundance, species richness, and diversity index (dependent variables) versus vegetation metrics (independent variables) during the breeding season in production stands of native warm-season grasses in Kentucky and Tennessee in 2009 – 2010.

| Parameter | β | SE | 95% CI | |
|---|---|---|---|---|
| Relative Abundance | | | | |
| Forbs (%) | -0.58 | 0.27 | -1.12 | -0.04 |
| Height | -0.16 | 0.14 | -0.44 | 0.12 |
| Other Warm-Season Grasses (%) | 0.80 | 0.74 | -0.65 | 2.25 |
| Cool Season Grasses (%) | -0.55 | 0.65 | -1.82 | 0.72 |
| Species Richness | | | | |
| Forbs (%) | -0.62 | 0.23 | -1.08 | -0.17 |
| Height | -0.18 | 0.11 | -0.40 | 0.04 |
| Cool Season Grasses (%) | -0.69 | 0.55 | -1.76 | 0.38 |
| Diversity index | | | | |
| Forbs (%) | -0.87 | 0.37 | -1.59 | -0.14 |
| Cool Season Grasses (%) | -1.22 | 0.92 | -3.03 | 0.59 |

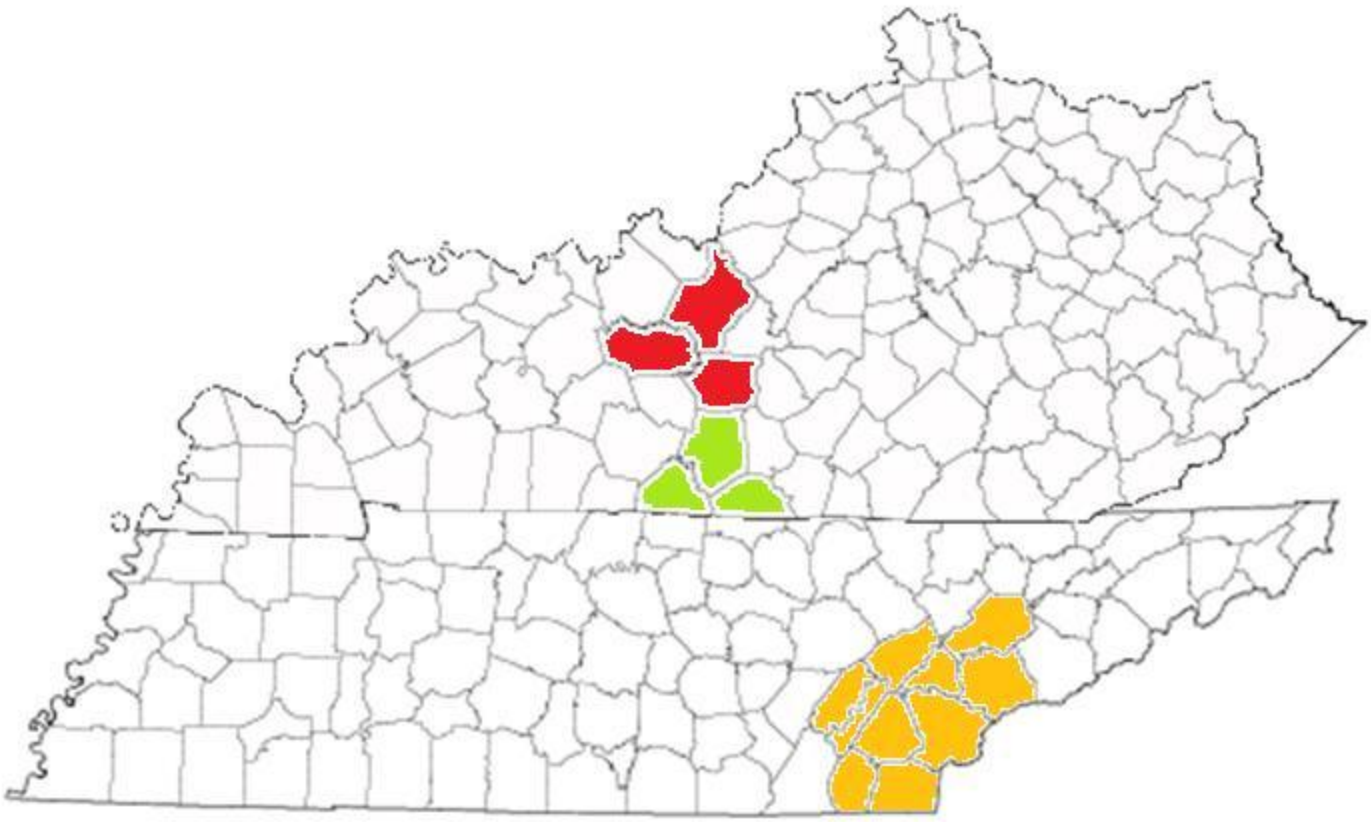

Figure 2.1. Site locations for production stands of native warm-season grasses studied in Kentucky and Tennessee during 2009 – 2010. Highlighted counties contained at least one field. Hart County, Kentucky site is represented in red, Monroe County, Kentucky site in green, and McMinn County, Tennessee site in orange.

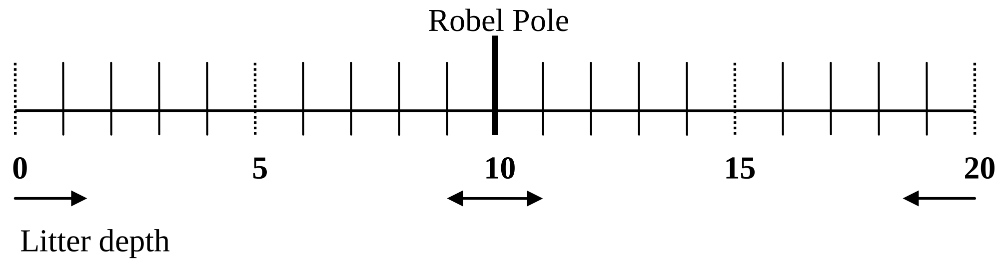


Figure 2.2. Schematic diagram of vegetation measurement protocol at each plot within production stands of native warm-season grasses study in Kentucky and Tennessee, 2009 – 2010. A 20-meter tape was stretched perpendicular to the transect. At each meter intercept (thin vertical lines), plants were identified to species. Ground cover was measured at the 0-, 5-, 10-, 15-, and 20-meter intercepts. Litter depth was measured from the ends working in until litter was found and from the center out (arrows). A Robel pole (dark vertical line at 10) was placed at transect center to measure cover density (from 4 m away and 1 m above ground surface) in the four cardinal directions.

# III. Grasslands Bird Occupancy of Production Stands of Native Warm-Season Grass in the Mid-South

**ABSTRACT**

Grassland birds have declined more than any other guild in the US, primarily due to loss and degradation of native grasslands. Farm Bill programs have restored some native warm-season grasses (NWSG), but populations continue to decline. Other uses for NWSG focused on agricultural production such as hay, pasture and biofuel feedstock, may have the potential to affect substantially more area due to market-based incentives they provide to landowners. Therefore, we examined breeding grassland bird use of 102 production fields of NWSG including control (fallow; n = 37), forage (grazing and haying; n = 7 and 22, respectively), seed (n = 21), and biofuel (n = 15) in Kentucky and Tennessee during 2009 – 2010 breeding seasons. We used a multi-season, robust design occupancy model in Program Mark to determine occupancy and detection rates for grassland birds. A three-tiered approach that included treatment type, field-level vegetation metrics, and landscape composition at 250-, 500-, and 1000-m scales was used to develop models for field sparrow (*Spizella pusilla*), red-winged blackbird (*Agelaius phoeniceus*), eastern meadowlark (*Sturnella magna*), and northern bobwhite (*Colinus virginianus*). Important variables included treatment (field sparrow and eastern meadowlark), percent woody cover (field sparrow and northern bobwhite), average vegetation height (red-winged blackbird), and average litter depth and percent NWSG cover (eastern meadowlark). For all four species, forest composition within 250 m had a negative impact ($\beta$ <-1.97). Our data suggest that NWSG production fields could be an alternative approach for providing habitat for declining grassland bird populations but nesting studies need to be done.

## INTRODUCTION

Grasslands bird populations have declined more than any other guild of birds in the United States (Samson and Knopf 1994, Murphy 2003, Sauer et al. 2008). Based on Breeding Bird Survey data, grassland birds have been declining at a rate of -2.48 and -2.47, respectively, in Kentucky and Tennessee since 1966 (Sauer et al. 2008). This is predominantly due to the lost of grassland habitat through intensive agriculture and urbanization (Johnson and Igl 2001, Peterjohn 2003). Only about 4% of the once 60 million ha tall grass prairie still remains (Samson and Knopf 1996). These declines in grassland birds have caused many conservation groups to be concerned that if action is not taken soon, some of these species may become endangered (Dimmick et al. 2002, Svedarsky et al. 2003, Askins et al. 2007). Despite the success of various conservation efforts, such as the Conservation Reserve Program (CRP), in restoring grassland habitats (Johnson and Schwartz 1993, Warner et al. 2000, Veech 2006, Riffell et al. 2008), grassland bird populations in the Mid-South have continued to decline (Murphy 2003, Sauer et al. 2008). Much of this decline can be attributed to the limited area directly impacted by CRP (Table 3.1) within this region that is actually in native warm-season grasses (NWSG; U.S. Department of Agriculture 2009).

About 70% of the US landscape is privately owned and still heavily engaged in production agriculture (Gray and Teels 2006, With et al. 2008). Because of the extent of private ownership of the region’s landbase, economically viable approaches for increasing use of native warm-season grasses (NWSG) on the landscape should be explored. The use of NWSG as a biofuel feedstock and conversion of some forage production to NWSG could influence habitat on millions of hectares (McLaughlin et al. 1999, Barnes 2004).

Documenting the occupancy (detection or non-detection data) of a species is less expensive and time consuming than estimating abundance or density (MacKenzie et al. 2002). The use of occupancy models has been useful in determining occupancy rates of target species and factors affecting those rates (Olson et al. 2005, Nicholson and Van Manen 2009). Most uses of this model focus on one target species and not on multiple species within a community. For bird populations in general, few occupancy models have been developed previously due to a lack of rigorous methodology and imperfect detection (Royle 2006). However, Mackenzie et al. (2003) described an approach that allows for imperfect detection and spatial variation in site occupancy to be modeled. The use of multiple years and differences in field levels are new to developing occupancy models. Covariates now allow investigators to address such heterogeneous differences (Royle 2006). Using this approach, we developed occupancy models for grassland birds during the breeding season within NWSG fields in Kentucky and Tennessee that were exposed to different production management practices including biofuel feedstock, seed, and forage (including both grazing and haying) production practices. In addition, we examined the influence of field- and landscape-level variables on occupancy of grassland birds within these production stands of NWSG.

**STUDY AREA**

Three study areas were chosen based on presence of NWSG managed for biofuel feedstock, seed, or forage production (treatments). Because of the limited amount of NWSG currently used in these enterprises in the region, no one of our sites had all treatments represented.  Most study fields were on privately-owned, actively-managed farms.  Sites included: McMinn and surrounding counties (MCMINN), in the Southern Appalachian Ridge and Valley region, in southeastern Tennessee; and Hart (HART) and Monroe Counties (MONROE), both in the Pennyroyal region of south-central Kentucky (Figure 2.1).   MCMINN was 57% forested and 20% crops; HART was 43% forested and 31% in crops; and MONROE was 26% forested and 34% in crops (Vilsack 2009, US Department of Agriculture 2011).  All three sites have an average temperature of 21°C and an average rainfall of 142 mm during the field season each year (National Climatic Data Center 2011).

All three sites had unmanaged NWSG fields that were in CRP, CREP, or managed similarly to fields enrolled in those programs, and remained undisturbed during the course of the study and served as a control (CONTROL).  CONTROL were predominately planted in a mixture of big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*).  Planting rates varied based on agency and year of planting, but all were fully stocked stands. CONTROLS have been established for >6 years and have been burned at least once since establishment.  In addition, each location had at least one other treatment level represented. MCMINN included switchgrass (*Panicum virgatum*) being grown as a biofuel feedstock (BIOFUEL) and hay fields (HAY) planted in a mixture of big bluestem, indiangrass, and/or switchgrass that were harvested for hay.  We examined fields being managed for commercial NWSG seed production (SEED) including, big bluestem, indiangrass, and little bluestem, at HART.  MONROE featured eastern gamagrass (*Tripsacum dactyloides*) that was hayed (HAY) or grazed (GRAZE).

To minimize any biases associated with area-sensitive species, we constrained our sample to 2–12 ha fields. All fields were >250 m apart and were at least one full growing season post-establishment. Only SEED fields were burned during the course of the study; they were burned annually (February – March) as a part of normal production operations to remove old vegetation that could interfere with seed harvest and to suppress weeds. HAY fields were harvested during June each year, SEED during August - October, and BIOFUEL during early winter (November – January). All GRAZE fields were rotationally grazed and had at least one rotation during May – June. While intensity and duration varied with landowner, all fields were managed for production practices.

## METHODS

### Grassland Bird Surveys

We surveyed each field three times during the breeding season annually, once during each of three periods: 10 – 30 May, 1 – 15 June, and 16 June – 1 July, 2009 and 2010. We used 10-minute 100-m fixed-radius point counts for target bird species. We placed points in the center or on ridges or high spots within the fields (when feasible) to optimize detection of birds (Lanham and Guynn 1998, Jobes et al. 2004). Points were located >25 m from field edges and >250 m from other points and located by GPS to ensure the same point was sampled all six visits. Due to field size, and to ensure equal sampling effort, each field had one point only. We recorded 12 focal species, nine of primary interest and three of secondary interest, during the survey period (Table 2.1). Primary species seen or heard within a 100-m radius were recorded using a removal method (Farnsworth et al. 2002) while secondary species were recorded as present only. We conducted surveys from sunrise to 10:00 AM with each survey starting 2 minutes after arrival at the point. Surveys were not conducted in precipitation, fog, or high wind (>20 km/h). Each year, 2 observers were at each site (only 1 at Monroe, KY) and each observer visited each field at their site at least once. Due to limited resources and the lack of existing research on grassland birds in the region, we decided to focus on a broad assessment of breeding birds rather than a more limited scope that provided more thorough information such as fecundity.

**Vegetation Measurements**

We measured vegetation annually between 1 June – 11 July to reflect habitat conditions of the field during the breeding season. Hay fields that were harvested before vegetation measurements were taken and grazed fields that were never grazed in a given year were dropped for that year.

We measured vegetation along a systematic grid centered on the point-count location and that started in a randomly selected cardinal direction (N, E, S, or W) and distance (0-25m) from the bird sampling point. From that first randomly located point, each subsequent vegetation sampling point was located along the transect at an interval based on field size as follows: 2 – 3 ha fields, 35 m; 3 – 4 ha fields, 40 m; 4 –5 ha fields, 45m; and >5 ha fields, 50 m between points. A minimum of 12 such vegetation plots were sampled per field. At each plot, a 20-m perpendicular line was established to sample herbaceous species, litter depth, ground cover, average vegetation height, and cover density (Figure 2.2). We recorded plant species at 1.0 m interval for a total of 20 samples per transect, 240 per field; plants were identified to species whenever possible. More than one plant may have been recorded at each point due to layering of vegetation. We recorded ground cover (bare or litter) and average vegetation height (cm) at 5-m intervals, starting at the 0-m mark, for a total of five measurements per transect, 60 per field. Litter depth (cm) was measured at the first location where litter was present, starting from both ends of the 20-m transect moving toward the center and from the center moving out in each direction for a total of four per transect, 48 per field. We measured cover density using a Robel pole (Robel et al. 1970) placed at the center of each transect. The 2-m pole had marks every 10 cm with alternating colors and a black line indicating the mid-point of each decimeter; the lowest visible mark (to the half decimeter) was recorded. Observations were taken four meters away from the pole, 1 meter off the ground, and from the four cardinal directions.

**Landscape Measurements**

Aerial photographs (1:12,000), taken in 2008, were used to quantify cover types on the landscape surrounding each field (USDA/FSA 2008). Photographs were ground-truthed in 2010 to ascertain current land-use practices for each discrete land cover unit (e.g., field or forest stand). We then digitized the photographs and land cover polygons and overlaid three concentric circles (250-, 500-, and 1000-m, radii), centered on the bird sampling point (Fletcher and Koford 2002, White et al. 2005). Within each circle, landscape composition (percent land cover; Fletcher and Koford 2002) was determined. Land cover was classified into one of seven categories: NWSG, pasture, hay, woods, developed, crops, or water (Veech 2006). Because hay and pasture could not be differentiated based on aerial photos alone, and ground truthing was not always possible, we combined hay and pasture into a single category, forage. Only a single year of landscape cover was used in our models due to the fact that we only had photography for one year and because change that occurred during the two years of the study among the broad cover types were likely to have been minimal.

**Statistical Analyses**

Because we had two primary sampling periods (years), we used a multi-season, robust design occupancy model in Program MARK (White and Burnham 1999). This sampling structure is equivalent to Pollock's robust design where population closure is assumed within primary sampling periods but open between periods (Pollock 1982). Secondary periods were visits within each year. Some points were not utilized both years for various reasons but occupancy modeling for missing data is allowed (MacKenzie et al. 2002). Covariates were incorporated into the model for each field based on annual averages for field-level metrics and landscape cover percentages at each of the three scales (25, 50, and 1,000 m) for that field. We calculated bird occupancy for species that had enough data to allow for model building in the program without large standard errors that cross zero.

Our models were developed sequentially in three stages. We started with modeling occupancy ($\Psi$) and detections probabilities ($p_i$) using Akaike's Information Criterion for small sample adjustment ($AIC_c$) to determine which model had the most support (Burnham and Anderson 2002). We compared time (within season), year, treatment, site, and null models for best fit. Field-level vegetation metrics were then added as covariates into the best model(s), thus building the second tier of our analysis. Similarly, landscape-level metrics were then added to the best field-level model(s) (Table 3.3). Model averaging was used to determine occupancy and detection probability.

Confidence intervals were used for comparing differences among treatments for occupancy.

## RESULTS

### Grassland Birds

We sampled 102 different fields (90 in 2009 and 87 in 2010) that ranged from 1.6-12.1 ha (mean 4.1 ha). Due to management changes or access restriction, 12 fields used in 2009 were not available in 2010. New fields that met all of our other criteria were added wherever possible. We detected 919 and 1230 birds of all species during 2009 and 2010, respectively (Table 3.4). No Secondary species were detected in either year. In both years, field sparrow (*Spizella pusilla*) was the most frequently detected species (42%) followed by red-winged blackbird (*Agelaius phoeniceus*; 27%), eastern meadowlark (*Sturnella magna*; 9%), and northern bobwhite (*Colinus virginianus*; 8%) (Table 3.4). Only the top four species had enough detections to enable us to build occupancy models.

### Vegetation and Landscape Composition

Vegetation height ranged from 24.8 cm (GRAZE, 2010) to 142.0 cm (BIOFUEL, 2010; Table 3,5). BIOFUEL had the tallest and densest vegetation both years. Litter depth was highest in CONTROL for both years (4.4 and 5.5 cm), while for all other treatments it was <2.6 cm. Percent NWSG cover ranged from 17.8% (CONTROL, 2010) to 82.4% (SEED, 2009), while forb cover ranged from 6.1% (SEED, 2009) to 48.3% (CONTROL, 2010). Woody vegetation ranged from 8.1% (CONTOL, 2010) to 0% (GRAZE, 2009 and 2010). Height appeared to bee shorter in 2010 for all treatments but BIOFUEL which increase in 2010 and also increased in vertical density. Litter cover appeared to be lower in 2009 for SEED and HAY than in 2010 and percent NWSG was lower in CONTROL for 2010 than 2009. For landscape cover, Crop had the least cover for all distances (<8%) and was ultimately dropped from our models (Table 3.6). NWSG composition at the 250-m scale for all treatments was >26%, but dropped to below 25% at greater distances. Forest was >30% for all treatments at all distances. Forage ranged from 11% to 39% in all distances. Forest percentages we measured were similar to county-level estimates, but our estimates of crop cover were lower than those at the county level suggesting that our sites were more grass-dominated.

**Detection Probabilities**

For both field sparrow and eastern meadowlark, treatment was the best model for detection probability; time was the best model for red-winged blackbird and northern bobwhite (Table 3.7). Site and year was not influential in the model for any species. For both field sparrow and eastern meadowlark, detection probability was lowest in BIOFUEL (64% and 4% respectfully] and highest in forage treatments (GRAZE [87% and 65% respectfully] and HAY [88% and 64% respectfully]; Table 3.8). Red-winged blackbird had greater detection probability early in the season, while northern bobwhite was highest later in the season. With all species, detections appeared to have been greater the second year than in the first (Table 3.8). The only important field-level variable for field sparrow and northern bobwhite was woody plant cover. Vegetation height was important for red-winged blackbird and average litter depth or NWSG cover for eastern meadowlark. Although the field-level covariates supported in our models varied among species, the landscape covariate, percent forest within 250-m, was in all top models. This effect was negative (<1.9) for every species (Table 3.9).

**Occupancy**

Occupancy varied among treatments for field sparrow and eastern meadowlark but not for red-winged blackbird and northern bobwhite (Table 3.10). Occupancy for field sparrows was greater in GRAZE (1.0) than other treatments (based on non-overlapping confidence intervals) but all were fairly high. Occupancy for eastern meadowlark in SEED (0.77) was greater than in HAY (0.14; based on non-overlapping confidence intervals) but not different from anything else.

## DISCUSSION

Our study was designed to examine differences in occupancy rates among bird species for five types of production stands of native warm-season grasses. Because of small sample sizes, only four of the nine species detected could be used in program MARK without unacceptably high standard errors. No single field-level covariate stood out for all four species. This is not surprising since all four species have different habitat requirements and are associated with grasslands in varying stages of succession. However, for landscape variables a single metric, percent of forest within 250-m, had a negative effect on occupancy rates of all four species.

For our initial models, those that evaluated Site, Treatment, Year and Time of season, plus the null model, only Treatment or Time were retained. Field sparrow and eastern meadowlark occupancy rates were sensitive to treatment (i.e., production type) while red-winged blackbird and northern bobwhite were not. This is similar to our previous study that found differences among treatments for field sparrows and eastern meadowlarks, but not for red-winged blackbirds and northern bobwhites (West 2011). Models for the latter two species were improved over the null models by inclusion of

Time (i.e., sampling period within year). This relationship seems understandable given the early nesting season for red-winged blackbirds and the later nesting season for northern bobwhites. Field sparrow occupancy rates in BIOFUEL were lower than in other treatments and those for eastern meadowlark greater in forages (GRAZE and HAY) than in other treatments. It is not clear to us what was driving these differences for these two species. Previous study looking at relative abundance did find field sparrows lower in BIOFUEL than other treatments (West 2011).

Influential field-level variables varied among species but were retained in the top model for all species except eastern meadowlark. Percent woody cover was in the best second-tier models for both field sparrow and northern bobwhite. Models for both species had positive beta estimates for percent woody cover, except for field sparrow in 2010, which was marginally below zero, but confidence intervals did cross zero for both species in both years. Regardless, both species are associated with later successional grasslands so the affinity for woody cover is not surprising (Burger et al. 1994, Coppedge et al. 2001, McCoy et al. 2001). For red-winged blackbird, height of herbaceous vegetation was retained in the top field-level model. Beta estimates were conflicting between years with 2009 being negative and 2010 being positive but with a confidence interval that over-lapped zero. Research regarding red-winged blackbird habitat associations have yielded conflicting results for field-level characteristics. Fletcher and Koford (2002) reported vegetation height was positively related to relative abundance for red-winged blackbirds, while Delisle and Savidge (1997) found no correlations for red-winged blackbird relative abundance and vegetation measurements. Eastern meadowlark did not have a field-level variable in its top model but did have a models with litter depth and NWSG cover with delta AIC <2.0. The beta estimate for litter depth was positive in 2009 but negative in 2010 with confidence intervals in both years that included zero, suggesting a weak relationship. Delisle and Savidge (1997) also found a negative correlation with meadowlark abundance and litter depth.

Forest cover at 250-m had more of an effect than any other landscape variable, with a negative relationship with species occupancy. Since the species observed are, at least, grassland facultative, it is expected that with increased percent forest, the occupancy of these species would decrease. Along these lines, it would be expected that increased hay/forage or NWSG would have a positive effect on occupancy. Indeed, amount of forage within 1000-m and 500-m was the next closest variable for field sparrow, northern bobwhite, and eastern meadowlark, with a positive $\beta$ for all three species. Red-winged blackbird had NWSG at 250-m as its next important variable, which had a positive effect on the species as well. Crop had little support in preliminary models and was dropped from all final models. The limited amount of cropland available around each field (<7% in all cases) may explain the lack of influence associated with this variable.

Landscape variables generally improved all models over those with just field-level variables. Both field sparrow and eastern meadowlark had a top model (i.e., $\Delta$ AIC <2.0) without a field-level variable included. All four species' occupancy rates were negatively associated with proportion of forest cover within 250-m. This negative trend for forest cover has been previously documented for grassland species (Fletcher and Koford 2002, Cunningham and Johnson 2006, Winter et al. 2006) which is understandable, since increased percent forest would result in decreased useable space.

Scale also varied among past studies. Fletcher and Koford (2002) only evaluated landscape at a single scale (1600 m) but their models all were improved when landscape-level variables were added to models that otherwise only included habitat measurements. Winter et al (2006) examined nest success of bobolink (*Dolichonyx oryzivorus*), clay-color sparrow (*Spizella pallida*), and savanna sparrow (*Passerculus sandwichensis*) at 200-m and 1000-m scales and also found that landscape-level variables improved the models but that percent of trees and shrubs within 200-m had a negative effect on nest success for bobolinks and savanna sparrows. Cunningham and Johnson (2006) considered a wide range of landscape scales (200, 400, 800, 1200, and 1600 m) and found that adding landscape information improved the ability of their models to predict presence for 17 of 19 species they studied. Models that included variables at larger scales (800 – 1600 m) were more frequently competitive among these individual species, although variables at smaller scales were also important.

Although field-level variables are important, the greater landscape around fields plays a significant role in habitat selection by birds (Fletcher and Koford 2002, Cunningham and Johnson 2006, Winter et al. 2006). This was certainly the case in our study, with landscape-scale variables affecting models for all species we examined. Importance of field-level variables varied based on the biology of the individual species. Incorporating NWSG, whether fallow or managed, appears to cover the range of variability needed to provide habitat for these birds. Amount of forest in close proximity seems to play a major role in diminishing the value of an area for the four species we examined, while more extensive forage grasses enhance the value of an area. Urban and crop land uses had little importance, which may have been due to the undeveloped nature of the study sites, and the dominance of grazing as the agricultural economy instead of crops (Table 3.6). Since forage (hay/graze) was the next prominent model after forest, and had the highest positive trend with occupancy, open spaces with high grass cover can have a positive impact of grassland bird populations. Additional research is needed to further understand the contribution that NWSG can make to grassland bird conservation when the grass is being managed for production objectives and how those contributions are affected by landscape context.

**MANAGEMENT IMPLICATIOINS**

The use of NWSG in production practices is a potential way of affecting the landscape on a much larger scale than CRP alone. This benefits not only the landowner by allowing them to realize a profit from their land, but also minimizes dependency on the government, and the inherent variability in budget cycles and funding availability, for establishing grassland habitat. Disturbance is also important factor in grassland ecosystems. Historical disturbance regimes in natural tall-grass prairie were based on both fire and grazing. Although contemporary managers commonly use fire in fallow NWSG stands, grazing is still lacking as a widespread disturbance agent in NWSG managed primarily for wildlife habitat. Harvesting in the other production types (biofuels, seed, and hay) may slow woody encroachment while also removing litter, something that does not occur when simply mowing where cut vegetation remains in place. These disturbances will keep grass fields from succeeding into forested habitat. Although there were some slight differences among treatments, overall, our species were responding positively to NWSG being used for production purposes. If just 10% of pastures in the southeastern USA were converted to NWSG, that would create 1.5 million ha (U.S. Department of Agriculture 2009) compared to 1.2 million ha of CRP (only 3.9% of which is in NWSG). In addition, biofuel feedstock has been predicted to result in as much as 7.8 million ha, much of which would be in the southeastern USA (Ugarte et al. 2003). And because landscape scale variables were supported in all top models, increasing NWSG across the landscape may help reverse the negative trend of grassland bird populations.

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## Appendix

Table 3.1. Land use (1000s of ha) in 2007 for states in the southeastern USA according to National Resources Inventory (2003 Annual National Resources Inventory: Land Use; U.S. Department of Agriculture, Natural Resource Conservation Service).

| State | Cropland | CRP | Pasture | Range | Forest | Other | Total |
|---|---|---|---|---|---|---|---|
| Alabama | 899 | 185 | 1,402 | 30 | 8,713 | 181 | 11,409 |
| Arkansas | 2,986 | 63 | 2,091 | 15 | 6,109 | 156 | 11,421 |
| Florida | 1,166 | 34 | 1,470 | 1,067 | 5,330 | 1,092 | 10,158 |
| Georgia | 1,617 | 122 | 1,137 | 0 | 8,888 | 343 | 12,107 |
| Kentucky | 2,093 | 115 | 2,121 | 0 | 4,286 | 224 | 8,840 |
| Louisiana | 2,067 | 92 | 995 | 90 | 5,385 | 1,198 | 9,826 |
| Mississippi | 1,904 | 316 | 1,315 | 0 | 6,810 | 190 | 10,534 |
| North Carolina | 2,121 | 35 | 757 | 0 | 6,292 | 356 | 9,559 |
| South Carolina | 902 | 69 | 433 | 0 | 4,519 | 316 | 6,240 |
| Tennessee | 1,676 | 103 | 2,014 | 0 | 4,789 | 256 | 8,839 |
| Virginia | 1,116 | 17 | 1,193 | 0 | 5,285 | 238 | 7,849 |
| West Virginia | 308 | 0 | 583 | 0 | 4,253 | 102 | 5,246 |
| Total | 18,855 | 1,150 | 15,512 | 1,201 | 70,659 | 4,652 | 112,029 |
| Percentage | 17 | 1 | 14 | 1 | 63 | 4 | 1 |

Table 3.2. Grassland bird species targeted for breeding-season monitoring in fields with production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010.

| Common name | Scientific name | Species code |
|---|---|---|
| Primary species | | |
| Dickcissel | *Spiza americana* | DICK |
| Eastern meadowlark | *Sturnella magna* | EAME |
| Field sparrow | *Spizella pusilla* | FISP |
| Grasshopper sparrow | *Ammodramus savannarum* | GRSP |
| Henslow's sparrow | *Ammodramus henslowii* | HESP |
| Horned lark | *Eremophila alpestris* | HOLA |
| Northern bobwhite | *Colinus virginianus* | NOBO |
| Prairie warbler | *Dendroica discolor* | PRAW |
| Red-winged blackbird | *Agelaius phoeniceus* | RWBL |
| Secondary species | | |
| Bachman's sparrow | *Aimophila aestivalis* | BASP |
| Bobolink | *Dolichonyx oryzivorus* | BOBO |
| Loggerhead shrike | *Lanius ludovicianus* | LOSH |

Table 3.3. Potential candidate models for grassland bird occupancy of production stands of native warm-season grasses in Kentucky and Tennessee, 2009 - 2010.

| Potential Models |
| --- |
| Treatment |
| Site |
| Time of Season |
| Year |
| Treatment + Site |
| Null |

| Field-level metrics (2009 and 2010) |
| --- |
| % Native warm-season grass cover |
| % Cool-season grass cover |
| % Forb cover |
| % Woody plant cover |
| % Litter cover |
| Average vegetation height |
| Average litter depth |
| Vertical density |

| Landscape-level metrics (250-, 500-, 1000-m) |
| --- |
| % Forest |
| % Native warm-season grasses |
| % Urban |
| % Forage (hay and pasture) |

Table 3.4. Total number of detections by species based on point-counts conducted during the breeding season in production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010.

| | Year | | |
|---|---|---|---|
| Species | 2009 | 2010 | Total |
| Field sparrow (*Spizella pusilla*) | 369 | 550 | 919 |
| Red-winged blackbird (*Agelaius phoeniceus*) | 246 | 339 | 585 |
| Eastern meadowlark (*Sturnella magna*) | 93 | 104 | 197 |
| Northern bobwhite (*Colinus virginianus*) | 78 | 98 | 176 |
| Grasshopper sparrow (*Ammodramus savannarum*) | 67 | 63 | 130 |
| Prairie warbler (*Dendroica discolor*) | 38 | 50 | 88 |
| Dickcissel (*Spiza americana*) | 13 | 25 | 38 |
| Henslow's sparrow (*Ammodramus henslowii*) | 10 | 1 | 11 |
| Horned lark (*Eremophila alpestris*) | 1 | 0 | 1 |
| Bachman’s sparrow (*Aimophila aestivalis*) | 0 | 0 | 0 |
| Bobolink (*Dolichonyx oryzivorus*) | 0 | 0 | 0 |
| Loggerhead shrike (*Lanius ludovicianus*) | 0 | 0 | 0 |
| Total | 915 | 1,230 | 2,145 |

Table 3.5. Means and standard errors (SE) for ten vegetation measures for production stands of native warm-season grasses in Kentucky and Tennessee, 2009 - 2010.

| Variable | CONTROL | BIOFUEL | SEED | GRAZE | HAY |
|---|---|---|---|---|---|
| | x̄ (S.E) | x̄ (S.E) | x̄ (S.E) | x̄ (S.E) | x̄ (S.E) |
| **2009** | | | | | |
| Height (cm) | 85.9 (3.4) | 120.1 (5.4) | 66.0 (4.1) | 56.2 (8.4) | 82.0 (5.3) |
| Litter Depth (cm) | 4.4 (0.3) | 1.1 (0.1) | 1.3 (0.4) | 1.2 (0.1) | 1.4 (0.1) |
| Vertical Density (Rich et al.) | 93.9 (4.6) | 120.9 (7.2) | 64.9 (5.7) | 64.4 (6.3) | 76.9 (6.2) |
| Cover (%) | | | | | |
| Litter | 97.0 (0.6) | 72.7 (3.7) | 42.7 (7.7) | 80.8 (2.4) | 66.1 (4.0) |
| NWSG | 33.3 (2.3) | 56.1 (3.1) | 82.4 (2.5) | 39.3 (5.8) | 42.2 (3.6) |
| Cool-season grass | 8.0 (1.0) | 10.2 (2.4) | 0.8 (0.2) | 17.7 (5.2) | 9.1 (1.5) |
| Forbs | 35.1 (2.2) | 16.9 (2.7) | 6.1 (1.3) | 20.1 (3.9) | 14.4 (2.0) |
| Woody | 4.7 (0.6) | 0.4 (0.1) | 1.1 (0.4) | 0.0 (0.0) | 1.5 (0.3) |
| Legumes | 9.7 (1.0) | 1.8 (0.7) | 4.3 (0.9) | 14.5 (3.1) | 10.3 (3.1) |
| Other warm-season grass | 1.3 (0.3) | 7.6 (2.3) | 0.8 (0.5) | 1.5 (0.6) | 5.1 (1.3) |
| **2010** | | | | | |
| Height (cm) | 60.9 (3.8) | 142.0 (6.0) | 30.6 (2.5) | 24.8 (1.0) | 70.7 (4.3) |
| Litter Depth (cm) | 5.5 (0.0) | 1.9 (0.3) | 1.5 (0.2) | 1.5 (0.2) | 2.6 (0.3) |
| Vertical Density (Rich et al.) | 89.9 (4.2) | 168.0 (6.6) | 52.3 (3.7) | 34.3 (2.1) | 93.2 (5.9) |
| Cover (%) | | | | | |
| Litter | 96.5 (0.8) | 80.2 (1.9) | 64.4 (4.2) | 77.8 (6.6) | 81.6 (4.5) |
| NWSG | 17.8 (1.7) | 61.0 (2.6) | 77.2 (2.5) | 30.0 (0.8) | 38.4 (3.1) |
| Cool-season grass | 6.8 (0.7) | 4.7 (0.8) | 0.7 (0.2) | 30.6 (4.2) | 14.4 (2.0) |
| Forbs | 48.3 (2.5) | 19.0 (2.0) | 7.0 (1.4) | 11.4 (4.0) | 25.9 (1.9) |
| Woody | 8.1 (0.8) | 0.8 (0.2) | 1.2 (0.4) | 0.0 (0.0) | 1.0 (0.2) |
| Legumes | 8.9 (1.1) | 4.3 (1.4) | 6.5 (1.5) | 20.6 (6.3) | 9.6 (2.2) |
| Other warm-season grass | 1.7 (0.4) | 2.0 (0.7) | 0.3 (0.2) | 0.2 (0.1) | 4.1 (1.0) |

Table 3.6. Means and standard errors for percent landscape cover measures at different levels for production stands of native warm-season grasses in Kentucky and Tennessee, 2009 - 2010.

| Cover | Control | Biofuel | Seed | Graze | Hay |
|---|---|---|---|---|---|
| Forest | | | | | |
| 1000 m | 44.9 (1.5)[a] | 39.7 (3.4) | 45.6 (4.9) | 50.2 (6.2) | 42.0 (2.0) |
| 500 m | 44.6 (1.8) | 30.8 (3.3) | 39.6 (5.2) | 46.4 (5.8) | 41.4 (2.2) |
| 250 m | 41.9 (2.3) | 29.8 (3.0) | 33.1 (4.6) | 48.1 (5.2) | 34.3 (2.7) |
| NWSG | | | | | |
| 1000 m | 12.0 (1.7) | 6.1 (1.0) | 11.9 (1.3) | 1.7 (0.4) | 4.6 (0.5) |
| 500 m | 19.9 (1.6) | 17.6 (2.8) | 24.6 (2.7) | 5.8 (1.1) | 11.8 (1.3) |
| 250 m | 32.3 (2.0) | 35.9 (3.1) | 42.2 (3.5) | 23.8 (4.4) | 25.8 (2.8) |
| Urban | | | | | |
| 1000 m | 6.7 (0.8) | 18.7 (2.4) | 7.1 (1.0) | 6.2 (2.9) | 7.9 (1.1) |
| 500 m | 5.7 (1.0) | 16.4 (2.5) | 7.5 (1.3) | 6.5 (2.8) | 4.5 (0.8) |
| 250 m | 5.6 (0.5) | 16.6 (2.7) | 5.7 (1.1) | 1.7 (0.5) | 1.7 (0.5) |
| Forage | | | | | |
| 1000 m | 27.4 (1.8) | 30.2 (2.7) | 28.1 (3.3) | 34.0 (3.9) | 38.6 (2.0) |
| 500 m | 21.8 (1.7) | 29.6 (3.5) | 22.1 (2.9) | 35.4 (5.9) | 34.6 (2.8) |
| 250 m | 11.2 (1.7) | 14.6 (2.7) | 16.3 (2.4) | 25.6 (5.1) | 32.4 (3.0) |
| Crop | | | | | |
| 1000 m | 3.1 (0.5) | 4.6 (1.0) | 7.6 (1.5) | 6.4 (1.7) | 4.8 (0.8) |
| 500 m | 3.1 (0.9) | 4.7 (1.1) | 5.5 (1.4) | 5.1 (3.3) | 5.2 (1.4) |
| 250 m | 3.1 (1.1) | 2.3 (0.6) | 2.4 (0.8) | 0.3 (0.3) | 4.9 (1.6) |

[a] Standard error in parenthesis.

Table 3.7. Top 10 ranked models for grassland bird occupancy at treatment, field, and landscape scales for production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010. Models sorted by Akaike's information criterion adjusted for small sample size ($AIC_c$) and only models with a $\Delta AIC_c$ of <4 are shown. Number of parameters (K) and model weights ($w_i$) are also shown.

| Models | K | AICc | ΔAICc | wi |
|---|---|---|---|---|
| Field Sparrow | | | | |
| {Treat + Woody + Forest 250m} | 19.00 | 542.17 | 0.00 | 0.23 |
| {Treat + Forest 250m} | 17.00 | 543.37 | 1.20 | 0.13 |
| {Treat + Woody + Forage 1000m} | 19.00 | 544.18 | 2.01 | 0.08 |
| {Treat + Forage 1000m} | 17.00 | 544.62 | 2.45 | 0.07 |
| {Treat + Woody + Forage 500m} | 19.00 | 544.72 | 2.54 | 0.06 |
| {Treat + Forbs + Forest 250m} | 19.00 | 544.79 | 2.61 | 0.06 |
| {Treat + Forbs + Forest 1000m} | 19.00 | 545.34 | 3.16 | 0.05 |
| {Group+Forbs+ Hay/Graze 1000m} | 19.00 | 545.84 | 3.66 | 0.04 |
| {Group+ Hay/Graze 500m} | 17.00 | 546.01 | 3.83 | 0.03 |
| {Group+Woody+ Forest 1000m} | 20.00 | 546.25 | 4.07 | 0.03 |
| Red-winged Blackbird | | | | |
| {Time + Height + Forest 250m} | 12.00 | 545.05 | 0.00 | 0.70 |
| {Time + NWSG + Forest 250m} | 12.00 | 548.51 | 3.46 | 0.12 |
| {Time + Cool Season Grass + Forest 250m} | 12.00 | 549.41 | 4.36 | 0.08 |
| {time+ Forest 250 } | 10.00 | 550.00 | 4.95 | 0.06 |
| {time+Forbs+ Forest 250} | 12.00 | 550.75 | 5.70 | 0.04 |
| {time+ Height+ NWSG 250m} | 12.00 | 562.68 | 17.64 | 0.00 |
| {time+NWSG+ NWSG 250m} | 12.00 | 562.81 | 17.76 | 0.00 |
| {time+CoolSeasonGrass+ Urban 500m} | 12.00 | 563.22 | 18.17 | 0.00 |
| {time+ NWSG 250 } | 10.00 | 563.30 | 18.26 | 0.00 |
| {time+ Urban 500 } | 10.00 | 563.46 | 18.41 | 0.00 |

(Table 3.7 Continued)

| | | | | |
|---|---|---|---|---|
| Eastern Meadowlark | | | | |
| {Treat + Forest 250m} | 19.00 | 404.77 | 0.00 | 0.38 |
| {Treat + Litter Depth + Forest 250m} | 20.00 | 405.85 | 1.08 | 0.22 |
| {Treat + NWSG + Forest 250m} | 21.00 | 406.32 | 1.54 | 0.18 |
| {Treat + Forest 500m} | 20.00 | 407.18 | 2.40 | 0.12 |
| {Treat + Litter + Forest 250m} | 21.00 | 408.51 | 3.73 | 0.06 |
| {Treat+NWSG+ Forest 500m} | 22.00 | 410.87 | 6.09 | 0.02 |
| {Treat+LitterDepth+ Forest 500m} | 22.00 | 412.03 | 7.26 | 0.01 |
| {Treat+ Litter+ Forest 500m} | 22.00 | 412.23 | 7.46 | 0.01 |
| {Treat+ Litter+ Hay/Graze 500m} | 22.00 | 415.07 | 10.29 | 0.00 |
| {Treat+ Hay/Graze 500m} | 20.00 | 415.19 | 10.42 | 0.00 |
| | | | | |
| Northern Bobwhite | | | | |
| {Time + Woody + Forest 250m} | 12.00 | 464.51 | 0.00 | 0.84 |
| {Time + Cool-season Grass + Forest 250m} | 12.00 | 469.43 | 4.92 | 0.07 |
| {Time + Forest 250m} | 10.00 | 469.83 | 5.32 | 0.06 |
| {Time+ Litter+ Forest 250m} | 12.00 | 472.58 | 8.07 | 0.01 |
| {Time+ Height+ Forest 250m} | 12.00 | 474.15 | 9.64 | 0.01 |
| {Time+ Woody+ Forest 1000m} | 12.00 | 475.65 | 11.14 | 0.00 |
| {Time+ Forest 1000m} | 10.00 | 481.57 | 17.06 | 0.00 |
| {Time+ CoolSeasonGrass+ Forest 1000m} | 12.00 | 483.62 | 19.11 | 0.00 |
| {Time+ Litter+ Forest 1000m} | 12.00 | 484.78 | 20.27 | 0.00 |
| {Time+ Height+ Forest 1000m} | 12.00 | 484.98 | 20.47 | 0.00 |

Table 3.8. Detection probability ($p_n$) and standard errors (SE) for grassland birds during the breeding season on production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010.

| | 2009 | | | 2010 | | |
|---|---|---|---|---|---|---|
| Treatment | $p_1$(SE) | $p_2$(SE) | $p_3$(SE) | $p_1$(SE) | $p_2$(SE) | $p_3$(SE) |
| | | | Field sparrow | | | |
| CONTROL | 0.79 (0.06) | 0.79 (0.06) | 0.79 (0.06) | 0.90 (0.03) | 0.90 (0.03) | 0.90 (0.03) |
| BIOFUEL | 0.64 (0.10) | 0.64 (0.10) | 0.64 (0.10) | 0.58 (0.09) | 0.58 (0.09) | 0.58 (0.09) |
| SEED | 0.66 (0.12) | 0.66 (0.12) | 0.66 (0.12) | 0.84 (0.06) | 0.84 (0.06) | 0.84 (0.06) |
| GRAZE | 0.87 (0.08) | 0.87 (0.08) | 0.87 (0.08) | 0.91 (0.10) | 0.91 (0.10) | 0.91 (0.10) |
| HAY | 0.88 (0.05) | 0.88 (0.05) | 0.88 (0.05) | 0.84 (0.06) | 0.84 (0.06) | 0.84 (0.06) |
| | | | Red-winged blackbird | | | |
| CONTROL | 0.75 (0.07) | 0.53 (0.08) | 0.47 (0.08) | 0.78 (0.07) | 0.69 (0.07) | 0.51 (0.08) |
| BIOFUEL | 0.75 (0.07) | 0.53 (0.08) | 0.47 (0.08) | 0.78 (0.07) | 0.69 (0.07) | 0.51 (0.08) |
| SEED | 0.75 (0.07) | 0.53 (0.08) | 0.47 (0.08) | 0.78 (0.07) | 0.69 (0.07) | 0.51 (0.08) |
| GRAZE | 0.75 (0.07) | 0.53 (0.08) | 0.47 (0.08) | 0.78 (0.07) | 0.69 (0.07) | 0.51 (0.08) |
| HAY | 0.75 (0.07) | 0.53 (0.08) | 0.47 (0.08) | 0.78 (0.07) | 0.69 (0.07) | 0.51 (0.08) |
| | | | Eastern meadowlark | | | |
| CONTROL | 0.18 (0.14) | 0.18 (0.14) | 0.18 (0.14) | 0.21 (0.11) | 0.21 (0.11) | 0.21 (0.11) |
| BIOFUEL | 0.04 (0.06) | 0.04 (0.06) | 0.04 (0.06) | 0.13 (0.05) | 0.13 (0.05) | 0.13 (0.05) |
| SEED | 0.49 (0.12) | 0.49 (0.12) | 0.49 (0.12) | 0.51 (0.12) | 0.51 (0.12) | 0.51 (0.12) |
| GRAZE | 0.65 (0.16) | 0.65 (0.16) | 0.65 (0.16) | 0.84 (0.17) | 0.84 (0.17) | 0.84 (0.17) |
| HAY | 0.64 (0.18) | 0.64 (0.18) | 0.64 (0.18) | 0.47 (0.13) | 0.47 (0.13) | 0.47 (0.13) |

(Table 3.8 Continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Northern bobwhite | | | |
| CONTROL | 0.19 (0.06) | 0.41 (0.09) | 0.41 (0.09) | 0.23 (0.06) | 0.55 (0.10) | 0.38 (0.09) |
| BIOFUEL | 0.19 (0.06) | 0.41 (0.09) | 0.41 (0.09) | 0.23 (0.06) | 0.55 (0.10) | 0.38 (0.09) |
| SEED | 0.19 (0.06) | 0.41 (0.09) | 0.41 (0.09) | 0.23 (0.06) | 0.55 (0.10) | 0.38 (0.09) |
| GRAZE | 0.19 (0.06) | 0.41 (0.09) | 0.41 (0.09) | 0.23 (0.06) | 0.55 (0.10) | 0.38 (0.09) |
| HAY | 0.19 (0.06) | 0.41 (0.09) | 0.41 (0.09) | 0.23 (0.06) | 0.55 (0.10) | 0.38 (0.09) |

Table 3.9. Field and landscape variable estimates (β) and 95% confidence interval for AIC models >2 for grassland birds on production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010.

| Models | β | Confidence Interval | |
|---|---|---|---|
| Field Sparrow | | | |
| Treat + Woody + Forest 250m | | | |
| Woody 2009 | 11.48 | -0.65 | 23.61 |
| Woody 2010 | -0.85 | -8.82 | 7.12 |
| Forest 250m | -1.97 | -3.15 | -0.79 |
| Treat + Forest 250m | | | |
| Forest 250m | -1.98 | -3.17 | -0.79 |
| Red-winged Blackbird | | | |
| Time + Height + Forest 250m | | | |
| Height 2009 | -1.42 | -2.38 | -0.47 |
| Height 2010 | 0.34 | -0.31 | 0.98 |
| Forest 250m | -3.38 | -4.58 | -2.17 |
| Eastern Meadowlark | | | |
| Treat + Forest 250m | | | |
| Forest 250m | -4.23 | -5.69 | -2.77 |
| Treat + Litter Depth + Forest 250m | | | |
| Litter Depth 2009 | 0.05 | -0.07 | 0.17 |
| Litter Depth 2010 | -0.08 | -0.23 | 0.08 |
| Forest 250m | -4.28 | -5.76 | -2.79 |
| Treat + NWSG + Forest 250m | | | |
| NWSG 2009 | 0.26 | -1.49 | 2.00 |
| NWSG 2010 | -1.83 | -3.92 | 0.27 |
| Forest 250m | -4.36 | -5.82 | -2.90 |
| Northern Bobwhite | | | |
| Time + Woody + Forest 250m | | | |
| Woody 2009 | 6.36 | -3.29 | 16.01 |
| Woody 2010 | 3.95 | -2.73 | 10.63 |
| Forest 250m | -4.41 | -5.79 | -3.03 |

Table 3.10. Breeding-season occupancy ($\Psi$) estimates and standard errors (SE) for four species of grassland birds in production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010.

| Treatment | $\Psi$ | SE | Confidence interval (95%) | |
|---|---|---|---|---|
| Field Sparrow | | | | |
| CONTROL | 0.87 | 0.07 | 0.68 | 0.95 |
| BIOFUEL | 0.86 | 0.12 | 0.46 | 0.98 |
| SEED | 0.53 | 0.14 | 0.27 | 0.77 |
| GRAZE | 1.00 | 0.00 | 1.00 | 1.00 |
| HAY | 0.95 | 0.06 | 0.67 | 0.99 |
| Red-winged Blackbird | | | | |
| CONTROL | 0.60 | 0.06 | 0.48 | 0.71 |
| BIOFUEL | 0.60 | 0.06 | 0.48 | 0.71 |
| SEED | 0.60 | 0.06 | 0.48 | 0.71 |
| GRAZE | 0.60 | 0.06 | 0.48 | 0.71 |
| HAY | 0.60 | 0.06 | 0.48 | 0.71 |
| Eastern Meadowlark | | | | |
| CONTROL | 0.44 | 0.28 | 0.08 | 0.88 |
| BIOFUEL | 0.26 | 0.52 | 0.00 | 0.99 |
| SEED | 0.77 | 0.15 | 0.39 | 0.95 |
| GRAZE | 0.70 | 0.19 | 0.28 | 0.93 |
| HAY | 0.14 | 0.08 | 0.04 | 0.38 |
| Northern Bobwhite | | | | |
| CONTROL | 0.50 | 0.09 | 0.34 | 0.67 |
| BIOFUEL | 0.50 | 0.09 | 0.34 | 0.67 |
| SEED | 0.50 | 0.09 | 0.34 | 0.67 |
| GRAZE | 0.50 | 0.09 | 0.34 | 0.67 |
| HAY | 0.50 | 0.09 | 0.34 | 0.67 |

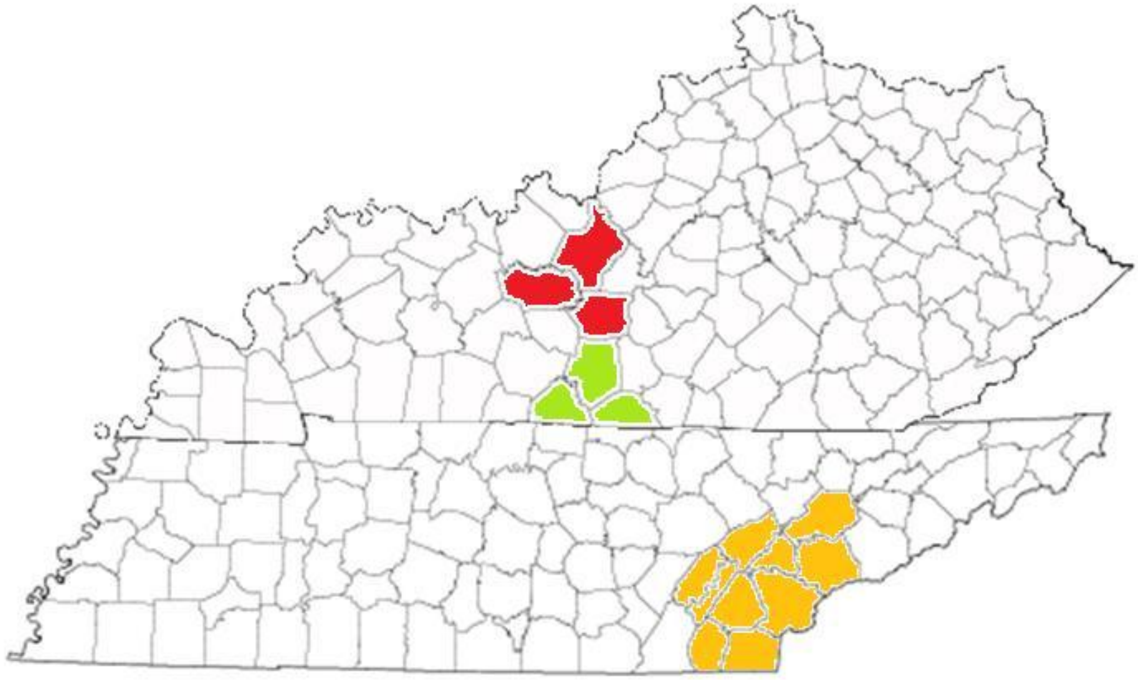

Figure 3.1. Site locations for production stands of native warm-season grasses studied in Kentucky and Tennessee during 2009 – 2010. Highlighted counties contained at least one field. Hart County, Kentucky site is represented in red, Monroe County, Kentucky site in green, and McMinn County, Tennessee site in orange.

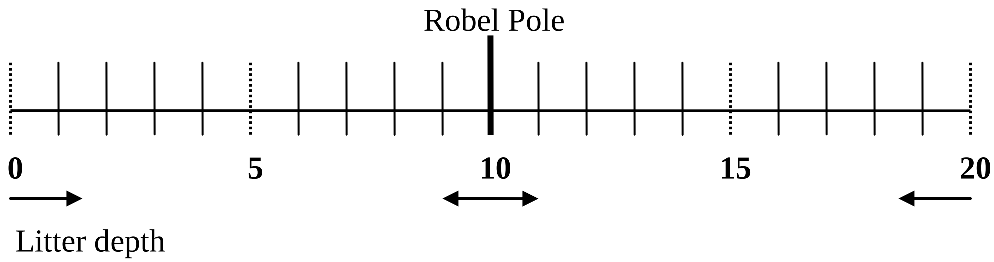


Figure 3.2**.** Schematic diagram of vegetation measurement protocol at each plot within production stands of native warm-season grasses study in Kentucky and Tennessee, 2009 – 2010. A 20-meter tape was stretched perpendicular to the transect. At each meter intercept (thin vertical lines), plants were identified to species. Ground cover was measured at the 0-, 5-, 10-, 15-, and 20-meter intercepts. Litter depth was measured from the ends working in until litter was found and from the center out (arrows). A Robel pole (dark vertical line at 10) was placed at transect center to measure cover density (from 4 m away and 1 m above ground surface) in the four cardinal directions.

# IV. Conclusion

NWSG fields have been shown to be beneficial for grassland bird species. The use of NWSG in production settings could potentially increase the amount of habitat available for grassland birds on the landscape. Other studies have reported similar results to mine with grassland birds being as abundant in production fields being as in control NWSG fields. With the exception of field sparrow relative abundance on BIOFUEL, I saw no difference in production stands versus CONTROL with regards to grassland bird use. My results suggest that any of the production practices for NWSG can provide desirable habitat for grassland birds.

Although field-level variables are important, the greater landscape around fields plays a significant role in habitat selection by birds. This was certainly the case in my study, with landscape-scale variables affecting models for all species we examined. Importance of field-level variables varied based on the biology of the individual species. Whether fallow or managed, NWSG appears to cover the range of variability needed to provide habitat for these birds. Amount of forest in close proximity played a role in diminishing the value of an area for the four species we examined, while more extensive forage grasses enhanced the value of an area. Models that included forage (hay/graze) were the next most prominent model after those that included forest, and had the highest positive trend with occupancy, suggesting that open spaces with high grass cover can make important contributions to grassland bird conservation.

There are two important implications in using NWSG in production stands. The first is disturbance. Historical disturbance regimes in natural tall-grass prairie were based on both fire and grazing. Although contemporary managers commonly use fire in fallow NWSG stands, grazing is still lacking as a widespread disturbance agent in NWSG managed primarily for wildlife habitat. Harvesting in the other production types (biofuels, seed, and hay) may slow woody encroachment while also removing litter, something that does not occur when simply mowing where cut vegetation remains in place. These disturbances will help keep grass fields from succeeding into scrub-shrub habitat and ultimately, into forested habitat. The second major implication is that production-based uses of NWSG allow markets to increase availability of desirable grassland bird habitat. Production practices provide landowners incentive to not only plant NWSG, but also to maintain it in a manner that provides regular disturbances. As CRP fields come out of contract, landowners can maintain grassland habitat on those fields instead of converting them back into rotational crops. This would also be a cost-effective way to provide grazing opportunities with NWSG since establishment costs would have already been incurred. Normally, it takes two or three years to establish NWSG stands and this time interval may be a disincentive to many landowners who can not afford to loose forage during those establishment years. Use of NWSG based on markets can also reduce uncertainty associated with Farm Bill funding and improve the efficiency of delivering wildlife habitat on a large scale.

The use of market-based NWSG production fields could potentially impact an extensive area. If just 10% of pastures in the southeastern USA were converted to NWSG, that would create 1.5 million ha compared to 1.2 million ha of CRP (only 3.9% of which is in NWSG). In addition, biofuel feedstock has may result in as many as 7.8 million ha, much of which would be in the southeastern USA. This vast acreage could make an important contribution to stopping or even reversing the decline grassland habitat. And because landscape scale variables were supported in all top models, increasing NWSG across the landscape may help reverse the negative trend of grassland bird populations.  Additional research is needed to further understand the contribution that NWSG can make to grassland bird conservation when the grass is being managed for production objectives and how those contributions are affected by landscape context.

## VITA

Andrew S. West is from Owensboro, Kentucky. He attended Murray State University in Murray, KY where he earned his Bachelors of Science degree in Biology with a concentration in wildlife biology. He wrote this thesis for his Masters of Science degree in Wildlife Science at the University of Tennessee.