# DISTRIBUTION AND REPRODUCTIVE SUCCESS OF NATIVE GRASSLAND BIRDS IN RESPONSE TO BURNING AND FIELD SIZE AT FORT CAMPBELL MILITARY RESERVATION: SPECIAL FOCUS ON HENSLOW'S AND GRASSHOPPER SPARROWS

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# ABSTRACT

Grassland birds have declined sharply over the last 30 years, based on Breeding Bird Survey (BBS) data. Development, agricultural practices, and fire suppression have reduced native warm season grass fields, which provide habitat for nesting grassland birds. Fort Campbell Military Reservation, located on the Kentucky-Tennessee border, has maintained a significant amount of native grass fields for training exercises primarily through prescribed burning. Research on the effects of different burn rotations on eastern grassland avifauna productivity is not well documented.

Grassland bird nests were located and monitored at Fort Campbell during the breeding seasons of 1999 and 2000, focusing on Henslow's sparrow (*Ammodramus henslowii*) and grasshopper sparrow (*Ammodramus savannarum*). Nesting success was calculated using the Mayfield method (1975). Vegetation characteristics were collected at Henslow's and grasshopper sparrow nests, male perch sites, and random points to identify key parameters related to nesting and territory habitat, and nesting success. Thirty native grassland fields were selected for avian censusing using standard 10-minute point counts to document distribution related to field size and burn history.

Forty-nine Henslow's sparrow nests were located and monitored in 1999 and 2000. Mayfield nest success estimate for Henslow's sparrow was 18.7% in 2000. Mean clutch size for Henslow's sparrow was 4.2. Henslow's sparrows fledged an average of 1.5 young per nest and 3.8 per successful nest. Brown-headed cowbird (*Molothrus ater*) parasitism rate was 2.0%.

Fifty-four grasshopper sparrow nests were located and monitored during both field seasons. Mayfield nest success estimates were 41.8% and 38.2% for 1999 and 2000, respectively. Mean clutch size was 4.4. Grasshopper sparrows fledged an average of 2.9 young per nest and 4.0 per successful nest. Grasshopper sparrows had 1.9% of their nests parasitized by brown-headed cowbirds. Predation was the primary reason for nest failure for both sparrows and primary nest predators appeared to be snakes.

A total of 512 grassland bird nests overall, representing 30 species, were located and monitored in 1999 and 2000. Mayfield nest success estimates of other priority concern species in 2000 included dickcissel (*Spiza americana*) (n=42; 26.5%), eastern meadowlark (*Sturnella magna*) (n=17; 12.1%), field sparrow (*Spizella pusilla*) (n=87; 15.4%), indigo bunting (*Passerina cyanea*) (n=32; 28.3%), prairie warbler (*Dendroica discolor*) (n=31; 36.5%), and yellow-breasted chat (*Icteria virens*) (n=30; 24.4%).

Cool season grass coverage ($P = 0.0377$) and native warm season grass coverage ($P = 0.0485$) were greater at Henslow's sparrow occupied sites than unoccupied sites in 1999. Field size was larger ($P < 0.0001$), native warm season grass coverage was greater ($P = 0.0007$), and grass height was taller ($P = 0.0196$) at occupied sites than unoccupied sites in 2000.

Field size was larger ($P < 0.0001$) and woody vegetation was greater ($P < 0.0001$) at male Henslow's sparrow perch sites than random points in 1999. Woody vegetation was greater ($P < 0.0001$), field size was larger ($P < 0.0001$), and legume coverage was less at perch sites in 2000. Time since field was last burned was longer ($P < 0.0001$), native warm season grass coverage was greater ($P = 0.0003$), field size was larger (P =

0.0011), and litter depth was less (P = 0.0012) at Henslow's sparrow nest sites than random locations, in 2000. Percent native warm season grass (P = 0.0086) and litter depth (P = 0.0236) were significantly greater at successful Henslow's sparrow nests than unsuccessful nests.

Grasshopper sparrow perch sites were located in larger fields (P < 0.0001) with lower grass height than random sites, in 1999 and 2000. Field size was larger (P = 0.0006), forb coverage was less (P = 0.0233), and legume coverage was greater (P = 0.0467) at nest sites than random sites in 1999. Field size was larger (P < 0.0001), grass height was lower (P = 0.0008), and forb coverage was lower (P = 0.0185) at grasshopper sparrow nest sites in 2000. Logistic regression analysis detected no differences in habitat characteristics between successful and unsuccessful grasshopper sparrow nests.

A total of 57 and 87 species, respectively, were counted within 50 m and from unlimited distance from 714 fixed radius plots during both years. One hundred twenty four bird species (breeding and non-breeding) were detected over the entire reservation during 1999 and 2000. Indigo bunting, common yellowthroat (*Geothlypis trichas*), field sparrow, and yellow-breasted chat were the most abundant birds in native grass fields. Other species of concern were documented including Bachman's sparrow (*Aimophila aestivalis*), Bell's vireo (*Vireo bellii*), black-billed cuckoo (*Coccyzus erythropthalmus*), bobolink (*Dolichonyx oryzivorus*), and lark sparrow (*Chondestes grammacus*).

Mean avian richness, abundance, and diversity were all lower in 1999 than in 2000. Avian richness was marginally greater in the smallest and largest size-class fields burned one year previously. In 1999, richness was less in later counts (June 16 – July 15)

whereas, in 2000, richness was greater during this same count period. Mean abundance did not differ among burn class or field size individually although there was a significant interaction between these two parameters. Abundance appeared to be greatest in the largest fields burned one year ago. Diversity was greater in the smaller fields early in the season and diversity was greater in the medium and larger fields later in the season.

Twenty of the most abundant species on the point counts were used for analysis of field size and field burn class. Dickcissel, Henslow's sparrow, and northern bobwhite (*Colinus virginianus*) were all positively associated with larger fields (> 50 ha) whereas indigo bunting, yellow-breasted chat, and prairie warbler were more abundant in smaller fields (< 15 ha). White-eyed vireo (*Vireo griseus*), prairie warbler, blue-gray gnatcatcher (*Polioptila caerulea*), and Henslow's sparrow were located in older burn class fields. Field sparrow, common yellowthroat, American goldfinch (*Carduelis tristis*), eastern kingbird (*Tyrannus tyrannus*), northern cardinal (*Cardinalis cardinalis*), and indigo bunting were more abundant in fields that had been recently burned.

Key management issues that need to be addressed to more effectively manage for grassland birds at Fort Campbell include 1) more effective burning to control woody vegetation; 2) management to create more large fields (>100 ha); and 3) conversion of cool-season grass hayfields to native warm season grasses.

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# CHAPTER 1

# INTRODUCTION

Grassland birds have experienced greater population declines than any other group of birds monitored by the Breeding Bird Survey (BBS) in the last 30 years (Peterjohn and Sauer 1999). Significant declines have been detected in grassland bird populations since 1966 when the BBS began monitoring breeding bird populations. Grassland birds have shown a greater overall decline than forest neotropical migrants (Figure 1),[*] which have garnered a lot more attention from researchers (Askins 1993, 1999, Knopf 1994, Peterjohn and Sauer 1999). While only 2 out of 40 (5%) species of forest migratory birds decreased greater that 2% per year between 1966 and 1994, 9 out of 14 (64%) grassland species east of the Mississippi River declined more than 2% per year, ranging from 2.2 to 9.3% (Askins 1999). Henslow's sparrow, for example, had the greatest decline per year at 9.3%.

Decline in grassland bird populations can primarily be linked to the degradation in quality and outright loss of grassland habitat (Askins 1993, Knopf 1994, Peterjohn and Sauer 1999, Vickery et al. 1999). North America once contained approximately 3.6 million $km^2$ (1.4 million square miles) of native prairie habitat (Ryan 1986). North America grasslands are some of the most imperiled ecosystems (Dept of Interior Grassland Bird Working Group 1996) with eastern grasslands being the hardest hit. Greater than 99% of the tallgrass prairies east of the Missouri River have been lost making this a "critically endangered ecosystem" (Noss et al. 1995). For example, Illinois originally contained 103,600 $km^2$ of native prairie, but grasslands have been reduced to only 10.4 $km^2$ (Mlot 1990).

The dramatic decrease of native grasslands in the 20th century can mainly be attributed to the clearing of land for agriculture and discontinued use of fire as a grassland management tool (Herkert et al. 1996). Farmers converted native grasslands to cool season forages for livestock and/or plowed grasslands for crop production. More recently, increasing urbanization and a shift from pastures and small grains to row crops of corn and soybeans have continued the decline in grass-dominated habitats (Rodenhouse et al. 1995). Greater than 99% of the native prairies in Wisconsin and Minnesota have been lost to agriculture (Johnson and Temple 1990).

Grassland ecosystems require some form of disturbance for maintenance, including burning, grazing, mowing, or using herbicides (Ryan 1986). Regular burning reduces woody encroachment and improves habitat suitability by rejuvenating grassland vegetation. Burning also maintains grasslands by removing or reducing litter depth, which in turn stimulates growth of new grasses. Some studies have documented an increase in insect abundance on newly burned fields (Hurst 1971, Lewis and Harshbarger 1986, Evans 1988), which may benefit avian productivity. Fire ecologists believe fire suppression has contributed to unhealthy forests and grassland ecosystems. The "Smokey Bear" campaign successfully instilled a negative attitude toward wild fire in the public's mind, making it harder to use fire as a management tool.

Land managers have taken a renewed interest in prescribed burning as a means of habitat improvement in recent years. Prescribed burning can play a positive role in

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* All tables and figures can be found in Appendix A.

changing the structure and composition of vegetation in grassland ecosystems. Native Americans, for example, used burning as a mechanism to keep grasslands in early succession. There is very little data, however, regarding how eastern avifauna responds to burning. Many unanswered questions exist about how to best manage grassland burning (Collins and Wallace 1990) including: 1) What is the best season to burn? 2) How often should grasslands be burned (i.e. how often did fires occur historically)? 3) What is the best burning regime with grazing or mowing? Immediate and long-term research addressing these questions is needed to provide baseline data for management decisions on priority species and to preserve key habitat.

Military lands are one exception to the regional loss of native grasslands because some of these installations have maintained significant acreage in native grasses to facilitate military training. For example, Fort Campbell Military Reservation (FCMR), located in Tennessee and Kentucky, has maintained over 10,000 ha of native grass-dominated habitat. Native grasslands at Fort Campbell are one of the largest remnant grasslands east of the Mississippi River. Other military installations have significant land areas currently in cool season grasses (e.g., Fort Knox, KY), but have great potential for native grassland restoration if suitable management strategies are developed. Arnold Engineering Development Center (AEDC), a military installation in TN, has restored roughly 250 ha to native grasses with positive results (J. Lamb, pers. comm.).

Military installations have been directed to inventory and manage native flora and fauna under their domain by regulations from the Biodiversity Initiative (U.S. Army 1995). Some military lands contain large blocks of undeveloped land set aside for training purposes that also provide excellent habitat for wildlife. These installations have a tremendous opportunity to provide for the basic military mission and contribute significantly to regional wildlife conservation goals simultaneously.

Military exercises that occur on Fort Campbell include airborne training into open drop zones, ground-based infantry and light-mechanized training, and various artillery ranges. These exercises, which use helicopters extensively, require open lands to facilitate related training activities. Native grasslands provide ideal conditions for such training exercises because the grasslands are durable, provide for great visibility, and can be cost-effectively managed with the use of fire. Thus, the habitat conditions that provide for suitable conditions for training activities also coincidentally provide excellent conditions for grassland birds.

The goals of providing for wildlife habitat and meeting the military training mission can lead to potential conflicts. For example, grassland birds may be provided suitable habitat but may also be subject to disturbance from troop and vehicle movement, prescribed burning, helicopter downdrafts, and artillery explosions. Such disturbances may cause direct nest mortality or indirectly impact vegetation and soil, which ultimately may affect habitat quality and nesting success.

Before European settlement in the late 1700's, the grasslands, which now include Fort Campbell, were burned on a regular basis by the Native Americans who used fire to hunt game (Baskin et al. 1994). This area around FCMR was referred to as the "Big Barrens," or just barrens, by the early settlers because of the desolate look of the vast, grass-dominated fields with stunted trees and shrubs caused by the burning (Chester

1988). Estimates of the historical size of this area, which has been mostly converted to agriculture, ranged from 1.0-1.2 million ha (Shull 1921, McInteer 1946, Mengel 1965). Outside of FCMR, less than 400 ha of the original native warm season grass barrens exist in Kentucky today (Larkin 1997).

Historical accounts attest to wildlife in the barrens during the pre-settlement period. Long extirpated from Tennessee, the greater prairie-chicken (*Tympanuchus cupido*) originally was reported from the KY-TN barrens region by early travelers. While traveling to Nashville in April 1810, the prominent ornithologist Alexander Wilson observed many prairie-chickens in the south-central portion of Kentucky in the barren prairies (Wilson 1811). Ganier (1933) considered this species to be a native bird of Tennessee based on Wilson's report and the secondhand reports of one captured only a few kilometers from Nashville (Nicholson 1997). Mengel (1965) considered the prairie-chicken "formerly a common permanent resident of the original prairies of southern and western Kentucky." Although the exact historical range in Kentucky was never documented, Mengel believed that it probably coincided with the original barrens outline. Disappearance of the greater prairie-chicken from the region may have been partly a result of loss of habitat, although over-harvesting was most likely the reason (Nicholson 1997). Research is currently underway at Fort Campbell to see if prairie-chicken populations can be restored there successfully (B. Hatcher and E. Clebsch, pers. comm.).

Other historic accounts documented the characteristics of the flora and fauna of the grasslands of the region. Ramsey (1853) described prairies around Nashville, Tennessee as "luxuriant growth of native grasses, pastured over as far as the eye could see, with numerous herds of deer, elk, and buffalo." In February 1777, Captain Timothe de Monbreun, a French hunter and trapper from Illinois, traveling down the Cumberland River near Palmyra, TN (Montgomery County) reported seeing large herds of buffalo on the trip (Kellogg 1939). Buffalo were killed by Colonel John Donelson and his party next to the Cumberland River near the Kentucky-Tennessee line (close to present day Fort Campbell) on March 30, 1780 (Williams 1928).

Many ornithologists have contended that when the northeastern forests were cleared during the last part of the 19th and early part of the 20th centuries, western grassland bird populations expanded to the East Coast to fill the gap (Askins 1999). However, recent research on the vegetation history of eastern North America has revealed that grasslands and barrens existed in the East before European settlement (Baskin and Baskin 1981, Delcourt and Delcourt 1981, Deselm and Murdoch 1993). This suggests that isolated populations of grassland birds probably existed in the East and perhaps fueled their expansion at the end of the 19th century.

As the eastern region reforested, grassland bird populations and ranges began to retract in response to the decrease in grasslands. An increase in woody vegetation, along with agricultural and development pressure, combined to further depress grassland bird populations. Many eastern populations of grassland birds have approached local extirpation (Vickery 1992).

Large-scale habitat loss and steep declines in grassland bird populations regionally have created the need for proactive monitoring and management approaches for grassland birds. Valuable data needed for making practical management decisions, however, are lacking. State and federal wildlife agencies have identified grassland bird management as a top priority (Pruitt 1996, Hunter 1998, Ford et al. 2000), but lack data necessary for developing biologically sound management strategies for some of these declining avian species. The objectives of this project were to help fill in these gaps in information on grassland birds, specifically:

1) Document avian use of native grasslands during the breeding season.

2) Document reproductive success of key target species:
   - Henslow's sparrow
   - Grasshopper sparrow

3) Relate distribution and reproductive success of grassland birds to habitat characteristics and prescribed burning.

# CHAPTER 2

# STUDY AREA

The study was conducted on Fort Campbell Military Reservation, a 41,842 ha U.S. Department of Defense installation located on the Tennessee-Kentucky state line. FCMR lies in the Pennyroyal Plain subsection of the Highland Rim Section of the Interior Low Plateaus Physiographic Province (Quarterman and Powell 1978) in northwestern middle Tennessee (Montgomery and Stewart counties) and southwestern central Kentucky (Christian and Trigg counties) (Figure 2). Approximately two-thirds of the post lies in Tennessee, which is roughly 13 km north of Clarksville and 80 km northwest of Nashville. Land Between the Lakes National Recreation Area (LBL) is located approximately 16 km west of the base.

FCMR is one of the largest military installations in the world at 425 square kilometers and supports the 3rd largest military population in the Army. Fort Campbell is home to the 101st Airborne Division - the only air assault division in the world. Helicopters are the primary means of transportation for the division and provide the backbone for tactical, logistical, and combat training. Approximately 4,800 ha of the installation make up the cantonment area leaving greater than 37,200 ha of the reservation as woodland and grassland for training. These training areas remain undeveloped providing habitat for wildlife.

Topography is flat to gently rolling with oak-hickory (*Quercus-Carya*) forests, planted pines (*Pinus* spp.), and leased agricultural fields (hay, corn, millet, and soybeans) interspersed among native grass fields. Soils consist mostly of silty loams including Crider, Dickson, Hammack-Baxter, Mountview, Nicholson, Pembroke, and Pickwick (Elder and Springer 1978, TN; Froedge 1980, KY). These soils are fertile, deep, and well drained, formed from weathered limestone, and occur on flat to gently sloping uplands. Elevation ranges from 160-200 m above sea level at the study site (Chester et al. 1997). Mean annual temperature for the area is 15.7° C and mean annual precipitation is 120.5 cm (Dickson 1978).

Barrens are grass-dominated, treeless areas occurring on the hilly, karst topography in west central Kentucky and northwestern Tennessee (Chester et al. 1997). The barrens contained native warm season grasses (NWSG) such as little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), indiangrass (*Sorghastrum nutans*), and broomsedge (*Andropogon virginicus*).

A vegetation study of 22 prairie-grass barrens at FCMR by Chester et al. (1997) revealed the dominant plant as little bluestem. Ninety-one percent of the flora in these stands were native and consisted of 342 vascular taxa. On average, Chester et al. (1997) found 145 taxa per barren. Of the 311 native species identified, none were endemic to the big barrens region (Chester et al. 1997). *Asteraceae*, *Poaceae*, *Fabaceae*, *Rosaceae*, *Cyperaceae*, and *Lamiaceae* families accounted for 55% of the flora. Other major vegetation taxa included *Panicum*, *Quercus*, *Eupatorium*, *Helianthus*, *Hypericum*, *Lespedeza*, *Carex*, *Asclepias*, *Solidago*, *Andropogon*, *Aster*, and *Desmodium* (Chester et al. 1997).

**History**

The barrens vegetation at Fort Campbell did not come into existence until about 2000 years before present (BP) based on fossil pollen recovered from sediment core samples (Wilkins et al. 1991). Prior to 2000 BP, the big barrens region remained forested resulting in deep soils developed under this vegetation. The climax vegetation of the barrens area would therefore be forest (Deselm 1994) in contrast to the prairies of the Midwest, which would climax to grassland. Creation of the barrens was likely a result of several hundred years of burning by Native Americans.

Most of the barrens were cultivated during the 1800's and early 1900's, based on USDA soil maps (Baskin et al. 1999). Today virtually all of the historic barrens outside of Fort Campbell have been converted to crop or livestock production. Land for Fort Campbell was purchased in 1941 to provide a place for infantry and artillery training in preparation for World War II. Because Fort Campbell was purchased before the wide spread use of fescue (*Festuca arundinacea*), most of the grasslands on the reservation have remained in native grasses. A regular burning rotation was initiated in 1954 by the Forestry Branch to maintain open fields for training, reduce fuel loads, improve game habitat, and prepare some areas for reforestation (Scott 1958). Since Fort Campbell initiated the burning rotation, native grasses have re-emerged from the seed bank to recreate the historic barrens.

**Field Selection**

I randomly selected 30 fields based on size and burn history from ArcView coverages provided by the Fort Campbell forestry division (Table 1; Figure 3). I assigned individual fields to one of three size classes: 5-15 ha, 25-35 ha, or greater than 50 ha based on the range of field sizes available. Field selection was further stratified by burn history: burned this year, burned one year ago, or burned ≥ 2 years ago. Two of the fields selected were burned greater than 4 years ago. Grassland fields used in the study were located in the rear area of the base outside the "impact zones," which have restricted access for all human activity. Fields were excluded from study if the percent of native warm season grasses was low or if fields had a lot of bare ground because of military activities. Fields censused in 1999 were re-censused in 2000, but with a different burn class designation. Two new fields were added in 2000 to keep a relatively consistent number of sites in each burn class between years.

Fort Campbell provides an ideal study site to research the effects of burning on the reproductive success and distribution of grassland birds. The barrens at Fort Campbell provide an authentic replication of the historical prairies, which existed before settlement. Current burning rotations of 1-3 years (J. Jones pers. comm.) mimics structure of historical barrens by keeping the vegetation in early succession. Fort Campbell has embraced natural resource management and integrated it with the military mission. Management of this landscape to meet military objectives in the past, which included controlled fire, has protected native grasslands. As a result, the base supports an important and unique grassland wildlife community that has largely disappeared across the region.

# CHAPTER 3

## HENSLOW'S SPARROW NESTING SUCCESS AND HABITAT CHARACTERISTICS

State and federal wildlife agencies have identified the Henslow's sparrow a species of management concern (Pruitt 1996) as populations have declined approximately 91% over the last 30 years (BBS data, Peterjohn et al. 1994). Data from Christmas Bird Counts indicate the Henslow's sparrow is declining on wintering grounds as well (Pruitt 1996). Southeast Partners in Flight (PIF) gives the Henslow's sparrow a high priority score of 27 out of 30 points (Ford et al. 2000) and cite the "importance of fire frequency and seasonality" on Henslow's sparrows (and other grassland birds) as one of the top research priorities (Hunter 1998).

Loss of habitat and reduction of habitat quality have been primary reasons cited as the cause for Henslow's sparrow population declines (Hands et al. 1989, Smith 1992, Pruitt 1996, Herkert 1997, Peterjohn and Sauer 1999, Winter 1999). Historically, native grasslands presumably provided optimal Henslow's sparrow breeding habitat. Conversion of native grasslands to non-native pastures and crop fields has reduced habitat dramatically. Greater than 99% of the tallgrass prairie east of the Missouri River has been lost (Noss 1995). Most of this loss occurred before the twentieth century (Knopf 1988).

Habitat degradation is also believed to have contributed to the decline of Henslow's sparrows. Discontinued use of fire as a management tool has allowed grassland habitat to succeed to shrub/scrub and forest habitat. Conversion of native grasslands to non-native grasslands may provide poorer quality habitat, with lower productivity for Henslow's sparrows. Use of these secondary habitats may not be suitable for sustaining populations. Use of idle grasslands, not in agricultural production, has been documented for the Henslow's sparrow (Skinner et al. 1984, Zimmerman 1988, Sample 1989, Herkert 1994a), but it is not known if these grasslands support source or sink populations.

Conservation Reserve Program (CRP) fields appeared to be source habitats for some grassland bird species in Missouri, and sink habitat for others (McCoy et al. 1999). Because CRP fields are not burned, mowed, or grazed, they may provide alternative habitat for Henslow's sparrows. In Illinois, an increase in Henslow's sparrow populations in counties was correlated with high CRP enrollment (Herkert 1997). Koford (1999) examined density and fledging success in CRP fields in west-central Minnesota and found those fields to be suitable breeding habitat.

Habitat fragmentation may impact grassland birds similar to the effect observed in woodland species (Donovan et al. 1995). Herkert (1994a,b,c), Vickery et al. (1994), and Winter and Faaborg (1999) have all reported area sensitivity, greater densities in larger fields, in some grassland species.

The apparent decline in Henslow's sparrow populations has sparked great concern for this grassland species. Henslow's sparrow was put on the National Audubon Society Blue List in 1974 where it remained until 1981 (Pruitt 1996). The species was then taken off the Blue List and put in the Special Concern category from 1982-1986 (Tate 1986).

In 1987, the U. S. Fish and Wildlife Service (USFWS) classified the Henslow's sparrow as a Species of Management Concern along with 29 other species (USFWS 1987). In 1991, the sparrow was listed by the USFWS as a C-2 candidate species for possible Endangered Species Act (ESA) protection (USFWS 1996). Canada listed the Henslow's sparrow as endangered in 1993 (Pruitt 1996). In 1998, the Henslow's sparrow was petitioned to be listed as Threatened under the ESA (USFWS 1997). The petition was denied because it was deemed unwarranted; currently the sparrow remains on the USFWS list as a Species of Management Concern. Some indication of population stabilization and/or a slight increase may have been detected (USFWS 1998). However, this increase may represent an increase in observer awareness of this species and therefore increased detection.

Henslow's sparrow is state ranked as endangered, threatened, or in need of management in 17 states (Pruitt 1996). Illinois, Iowa, Massachusetts, Minnesota, New Hampshire, New Jersey, and Vermont have listed the sparrow as endangered. It is listed as threatened in Indiana, Maryland, New York, Virginia, and Wisconsin. Connecticut, Kentucky, Michigan, and Pennsylvania have listed the Henslow's sparrow as a Species of Special Concern while Tennessee has recently added it as a species In Need of Management.

Henslow's sparrows breed locally from the northeastern U.S. and southern Ontario across the Great Lakes region to the eastern edge of the Great Plains, south to Kansas and Oklahoma, and east to central Kentucky and northern Virginia, and North Carolina (Nature Conservancy 1995) (Figure 4). The breeding range of the Henslow's sparrow is contracting in the northwestern and eastern portion of its range (AOU 1983), though it appears to be expanding along the southern and western edge of its range. In 1992, a new, sizable population of breeding Henslow's sparrows was located in Oklahoma (Reinking and Hendricks 1993). More recently, two populations of Henslow's sparrows were discovered in Tennessee during the breeding season – both at military installations [Fort Campbell and Arnold Engineering Development Center (AEDC)]. Also, two new populations have been found on reclaimed strip mines in southwestern Indiana and southeastern Ohio (Bajema and Lima 2001).

Other military installations in the Southeast have documented Henslow's sparrows on their wintering grounds (Mitchell 1998), but not during the breeding season. Fort Stewart (GA), Camp Lejeune (NC), Avon Park Air Force Range and Tyndall Air Force Base (FL), and Fort Polk (LA) all have wintering populations (Mitchell 1998).

Military bases outside of the Southeast contain the most significant populations of breeding Henslow's sparrows. For example, Fort Riley, Kansas had an estimated 3000+ singing males in 1997 (Mitchell 1998). Jefferson Proving Ground, in Indiana, former military base turned National Wildlife Refuge, estimated a breeding population of 600 to 1000 singing males between the years of 1995 and 1997 (Miller et al. 1997). Over 100 singing males occupy the Atterbury Reserve Forces Training Area and adjoining Atterbury State Fish and Wildlife Area, IN (Koford 1997). Fort Drum, New York contains an estimated 40 breeding Henslow's sparrow pairs (Mitchell 1998). Estimates of breeding pairs at Fort Knox, Kentucky range from 12 in 1997 to 20 in 1998 (Mitchell 1998). West Kentucky Army National Guard Training Site also has an expanding breeding population of Henslow's sparrows although population size has not been estimated.

Breeding populations of Henslow's sparrows are rare and local in the Southeast (Hamel 1992), generally limited to northern and central Kentucky, northern Virginia, West Virginia and coastal North Carolina (Lynch and Legrand 1985). Difficulty in locating these sparrows is compounded by their erratic year-to-year movements between sites and regions - fluctuations common for grassland birds (Bent 1968, Wiens 1969, Cody 1985).

Henslow's sparrows are typically found breeding in >30 ha tracts of grass-dominated habitat with relatively tall, dense vegetation (Zimmerman 1988, Herkert 1994b,c). Prior to European settlement, Henslow's sparrows probably bred primarily in native prairie (Ridgway 1889, Cory 1909). Based on the relatively few historical records, the original breeding habitat for these sparrows may have coincided with the native tall-grass prairies (Pruitt 1996). However, Henslow's sparrows in Illinois did not show a preference between native, restored prairie, and non-native grasslands based on census data (Herkert 1994c).

Breeding habitat of the Henslow's sparrow consists of a well-developed litter layer and a relatively high percentage of standing dead vegetation (Hyde 1939, Wiens 1969, Robins 1971, Skinner et al. 1984, Zimmerman 1988, Hanson 1994, Herkert 1994c, Winter 1999). Sparse or no woody vegetation and available song perches also characterize Henslow's sparrow breeding habitat. Researchers have suggested that Henslow's sparrows prefer fields across a broad range of moisture gradients: moist (Hyde

1939, Graber 1968); intermediate (Robins 1971); and dry to wet (Peterson 1983).

Males begin singing and establishing territories in late April to early May. Nesting usually begins in early to mid-May and may continue into August (Hyde 1939, Bent 1968, Robins 1971). Nesting studies indicate that this sparrow is able to raise 2 broods in one nesting season (Hyde 1939, Bent 1968, Robbins 1971, Winter 1998). Wiley and Croft (1964) caught a female in Kentucky on July 14, 1963 with a brood patch indicating late nesting. Fledglings were observed in August in Michigan raising the possibility of triple broods (Robins 1971). Two pairs of adults successfully raised 3 broods in a color-banded population in Kentucky (J. Giocomo, pers. comm.). Henslow's sparrows frequently nest in groups giving them a semi-colonial reputation.

Henslow's sparrow nests are placed on the ground or slightly elevated (to 50 cm high) and usually at the base of a clump of grass (Harrison 1975, Rising and Beadle 1996). Nests are well concealed sometimes with a partial roof constructed over the nest from the surrounding vegetation (Baicich and Harrison 1997). Nests are built in 4-6 days by the female and contain 3-5 eggs (Harrison 1975, Ehrlich et al. 1988, Baicich and Harrison 1997). Nests consist of a deep cup of grasses, dead leaves and occasionally hair.

**Populations in Tennessee**

The Henslow's sparrow was originally listed as an extremely rare migrant in Tennessee by both Ganier (1933) and Robinson (1990), generally arriving between mid-April and mid-May and departing by early October or November. This species was first documented in the state during the breeding season on Aug 2, 1936 at Mud Lake in Shelby County (Coffee 1936). Prior to 1988, only 22 state records existed during migration with the majority sighted in the eastern part of the state. The earliest recorded arrival date in the middle Tennessee area (Davidson County) was April 4, 1957 and no fall late departure date is listed (Robinson 1990). Only two winter records exist for this species: one located in Shelby County on December 26, 1941 and one found in the Great Smoky Mountains National Park on December 22, 1968 (Robinson 1990). In a survey of the breeding birds of Melton Valley in Roane County, Howell (1958) discovered the first observations of a singing male during the summer.

During June and July, 1994 at least 3 Henslow's sparrow males were reported singing near the Cheatham Reservoir dam, Cheatham County by T. J. Witt (Nicholson 1997), which raised the possibility of nesting. In July, 1996, an unconfirmed nest site was located in Stewart County. An agitated and chipping adult Henslow's sparrow carrying food was flushed, but a nest was not located (C. Sloan, pers. comm.).

In the spring of 1997, Henslow's sparrows were found singing on the airfield at AEDC (J. Lamb, pers. comm.). Five Henslow's sparrow territories were located and mapped near the airfield in 1998. Breeding bird surveys conducted at Fort Campbell in 1998 revealed 8 singing males and an adult carrying food (M. Roedel, pers. comm.). Although it was assumed that these populations were breeding, no information existed on the extent of these populations. No confirmed Henslow's sparrow breeding populations existed for Tennessee until these discoveries (Nicholson 1997). Breeding was confirmed on AEDC in 1999 with the capture and banding of a fledgling Henslow's sparrow (Lamb 1999).

**Populations in Kentucky**

Audubon collected the first Henslow's sparrow type specimen in Kentucky, just across from Cincinnati, in 1820 (Audubon 1831). Up until the 1940's, the sparrow was virtually unknown in Kentucky and very few reports have occurred annually since then. No known populations were cited in the USFWS Henslow's sparrow status assessment (Pruitt 1996); however, recent research has documented breeding populations in 4 different sites in Taylor and Muhlenberg counties (M. Monroe, pers. comm.).

Unlike Tennessee, the Henslow's sparrow in Kentucky has recently been considered a locally distributed breeder (Palmer-Ball 1996). Sightings are uncommon and abundance is low, but sporadic across the state, based on atlas survey results. Only 9 of 727 blocks (3.3%) contained confirmed or probable sightings of Henslow's sparrows (Palmer-Ball 1996). Data from BBS routes are insufficient to estimate state population trends. Kentucky has listed the Henslow's sparrow status as Special Concern (Pruitt 1996).

Because so little is known about the reproductive biology of Henslow's sparrows, discovery of a new population on Fort Campbell presented an ideal opportunity to collect baseline data for Fort Campbell biologists and state and federal wildlife agencies to aid in management decisions. Size and distribution of the Henslow's sparrow population, as well as productivity data, is unknown at Fort Campbell. Data from different physiographic regions is needed to better understand the biology of this species.

**Methods**

Point Counts

I sampled avian use in 30 selected native warm season grass fields using 50-m fixed-radius point counts (Hamel et al. 1996) during the 1999 and 2000 breeding seasons. All birds detected either visually or aurally, within 10 minutes, were tallied in 4 categories: 0 to 50 m, 50 m or greater, flyovers, or walk-ins. Flyovers were birds that flew over the point during the 10-minute count. Walk-ins were birds of interest encountered while walking between points. Points were placed systematically at least 200 m apart across a given site. Number of points per field ranged from 2 in the smaller fields to 11 in the larger fields. All points were located at least 50 m from any edge to minimize inclusion of forest bird species.

Counts were started by 15 May each year and completed by 15 June; a second set of counts was conducted between 15 June and 15 July. A technician and I conducted the counts during each field season; the same surveyor sampled the same points consistently within years. Field crews were different between seasons so different technicians were used for the point counts between years, however I sampled the same points both years.

Point counts were conducted, based upon standard protocol, between 5:00 am and 10:00 am CDT (Hamel et al. 1996). Most counts were finished by 9:00 am as the majority of grassland birds stop singing by then. Counts were not conducted during heavy fog, rain, or wind speeds more than 20 km/hr. Each survey point was marked with colored flagging in 1999 and coordinates were recorded with a Global Positioning System (GPS) for relocation the following year. Several points from both years were excluded from analysis because of disturbed vegetation caused by accidental burning, military activity, or wildlife habitat improvement (food plots). Henslow's sparrow playback tapes were used after the counts to illicit male singing if none were heard during the 10-minute time frame to aid in detection (Marion et al. 1981).

Nest Searching

In 1999, I began checking fields for Henslow's sparrows using playback starting April 2 to determine when they arrived on the breeding grounds. Areas where the sparrows were seen in 1998 and random fields on the post were also checked on April 10, 17, 24, and May 13. In 2000, I started searching fields for Henslow's sparrows on April 18.

During the 1999 and 2000 breeding bird seasons, the field technicians and I systematically searched all selected fields for grassland bird species focusing our effort on two primary species: Henslow's sparrow and grasshopper sparrow. Nests of all species found were monitored. Territories of target species located during censusing or by incidental observation were identified and later searched for nests.

Nests were located by walking across grassland plots and paying close attention to behavior and vocalizations of nearby adult birds. Behavioral patterns of adults that were used as clues to nesting behavior were: 1) chipping nearby, 2) flushing close to the observer and flying a short distance, and 3) carrying nest material, food, or fecal sacs. The location of a potential nest site was flagged on nearby vegetation with flagging tape. I then retreated 30 – 50 m and tried to locate the nest with use of binoculars when the bird returned. Sometimes 2 or 3 people observing from different directions were needed to triangulate the position of the nest site.

The rope dragging method (Higgins et al. 1969) was used to flush birds and locate nests in more open fields in 1999. This method involved systematically searching fields by dragging a 20-m rope between two people walking parallel down the field with a third person walking approximately 5 m behind the middle of the rope. Rope dragging did not provide efficient results during the 1999 field season, so this method was abandoned during 2000.

Nests found were marked with a flag placed 5 m north of the nest with date, species, distance to nest, and bearing to nest written on the flag. Nest flags were placed as high as possible on surrounding vegetation. Consistently placing flags at a pre-determined distance and direction helped avoid accidental crushing of the nests during nest monitoring. A detailed map, both micro site and macro site, was drawn on the back of each nest record to aid in relocation of the nest.

Nests were checked every 3-4 days to determine fate until the nest was completed. I did not search for or monitor nests during rain. Nests checked within the 3-4 day time frame and close to fledging on the last visit were considered successful if empty (as long as nest was intact and no signs of predation were evident). Nests which were empty following a 4 day or greater interval between checks (and were close to fledging) were not included as a successful nest in the analysis unless feeding adults or juveniles of that species was seen in the immediate vicinity.

Nest Success

Nest success was calculated using the Mayfield method (Mayfield 1961, 1975). Nests were considered successful if a given nest fledged at least 1 host bird. Nests were considered abandoned if nests containing eggs were inactive for 3 successive visits and eggs were cold. However, abandoned nests were included in our cowbird parasitism calculations. Nests were considered parasitized if at least one cowbird egg or chick was present. Nests were unsuccessful if all eggs were lost before the hatching date or all chicks were lost before the fledging date. Evidence at the unsuccessful nests was used to determine reason for failure. Nests were considered predated if nests disappeared, had holes in them, were tilted, or otherwise had damage prior to the fledging date. Nests were classified as failed due to mowing if a field was mowed between the last check and the nest failure. Also, if eggs, eggshell fragments, or dead chicks were in, below, or close to the nest after a thunderstorm, weather was cited as the cause. If nests failed after military activity had occurred in the field since last nest check (i.e. vehicle tracks, disturbed vegetation), then nests were labeled as failed because of military.

Probability of nest success was defined as the odds a nest would survive both incubation and nestling stages to fledge at least one host young (Mayfield 1975). Based on other studies, daily nest survival was calculated on species for which more than 20 nests were found in a season. Consistent with other studies, it was assumed incubation started the day the last egg was laid (Bent 1968, Winter 1998). Henslow’s sparrows have an average incubation time of 11 days and average fledging time of 9 days, which were used in the nest success calculations (Ehrlich et al. 1988).

Because Henslow's sparrow nests are so difficult to find, very few studies found enough nests to calculate a Mayfield nest success estimate (Winter 1998). In following Winter's (1998) methods, I present the apparent nest success (# of successful nests/total nests) for comparison with earlier studies, along with the Mayfield estimates (Table 2).

<u>Vegetation Sampling</u>

Vegetation surrounding nests, male perch sites, and point count locations was measured to determine the association between habitat characteristics and reproductive success. I characterized Henslow's sparrow habitat by measuring nest site and frequently used male perch site vegetation. Measurements from point count locations were used as random samples. Measurements surrounding nests and perches were taken within one week of nest completion. Point count locations were characterized following the second set of counts in 1999 and in between the first and second set of counts in 2000.

Nest sites and point counts were characterized by placing a 1-$m^2$ frame directly over the nest/point and measuring average herbaceous height, average woody height, average grass height, average litter depth, and percent cover (Table 3). Cover was divided into litter, bare ground, woody, dead woody, forbs, and grass categories. Vertical cover was assessed by placing a density board (15 X 15 cm squares; 2 squares wide and 10 high) at the nest/point and counting the squares covered from the four cardinal directions 15 m from the board (Nudds 1977). An index of total vertical cover was created by averaging the number of squares covered by vegetation divided by the total squares. Distance to edge, permanent water, woody cover, and direction of nest entrance also were recorded. To quantify military disturbance, distance from the nest/point to nearest vehicle track or rut greater than 2.5 cm deep was measured.

Statistical Analysis

Habitat variables were screened by comparing correlation coefficients using PROC CORR (SAS 1999); highly correlated variables ($r > 0.6$) were eliminated. I included 10 uncorrelated variables in logistic regression analysis to identify key habitat characteristics that distinguish occupied from unoccupied sites, nest sites and random sites, territories and random sites, and successful versus unsuccessful nests (PROC LOGISTIC, SAS 1999). In 1999, 20 points with Henslow's sparrows present in either the first or second period were compared with the other 148 sites. In 2000, 24 occupied sites were compared to 146 unoccupied sites. I used 34 and 30 vegetation samples from frequently used male perch sites in 1999 and 2000, respectively, and compared them with 176 and 181 random vegetation samples. Perch site data were also pooled and models were re-run. The number of random points differed between years because of destroyed vegetation from accidental burned sites, disturbed sites from military activity, or points being converted to new food plots.

For the 1999 nests, I compared 6 nests against 176 random vegetation samples. Of the 43 nests found in 2000, 40 were used in vegetation analysis to compare against 181 random locations. Three nests were dropped from the analysis because their fates were not known or they were abandoned. Nests were pooled between years and tested against all random samples. CART (Classification And Regression Trees) models revealed no significant difference in vegetation between years. I also ran logistic regression using the habitat variables at successful nests (n=18) and unsuccessful nests (n=22) for 2000 data. An alpha of < 0.05 was used to determine significance.

Bird Banding

Forty-five Henslow's sparrows were captured and marked in 2000 (Table 4). Mist-nets (6 m) and playback tapes were used to capture juveniles and adult males. One aluminum USFWS band and 3 color bands were placed on adult and juvenile birds while nestlings received only one USFWS band. I took standard measurements recommended for *Ammodramus* sparrows (Pyle 1997) and will report this data to the Bird Banding Lab. These marked birds will be monitored in following years for site fidelity and return rates (survival) in a continuing demographic study.

**Results**

Point Counts

Henslow's sparrows were located within 50 m at 20 out of 176 points in 1999; 17 during the first sampling period (15 May – 15 June) and 7 during the second (16 June – 15 July) (Table 5). Twenty-seven birds were heard or seen at the 20 points with a maximum of 4 individuals heard at one time within the 50-m radius. At 4 of the 20 points, Henslow's sparrows were present during both sampling periods. In 1999, fields on the northern side of the post, including 41-1 and 41-2, were used more by Henslow's sparrows than fields on the southern side, with the exception of Suckchon drop zone (21-1).

In 2000, Henslow's sparrows were documented within 50 m at 24 out of 181 points; 19 during the first sampling period and 9 during the second (Table 5). Twenty-nine individuals were seen or heard at the 24 points during the breeding season. The maximum number of sparrows located within 50 m of any given point was 2, but as many as 4 were heard at one time outside the 50-m radius. Henslow's sparrows were present at 4 of the 24 points for both sets. Only one male was detected in the current year burned class, and 85% of the sparrows were counted in the 1-year burned class (Table 6). Fields heavily occupied by Henslow's sparrows in 2000 included mostly fields burned in 1999: 17-1, 17-2, 35-1, and Suckchon DZ (21-1). In 2000, Henslow's sparrows were located mostly in fields along the south side of the impact zone (Figure 5).

Nesting Chronology

Henslow's sparrows returning from migration in 1999 were first detected April 24 on the Suckchon drop zone (DZ). Three males were singing on territory in broomsedge in a low-lying moist part of the field. The first nest of 1999, which contained 4 nestlings, was discovered on May 19. This nest, which eventually failed, was due to fledge on May 28. The first nest with eggs was located on May 20, containing 4 eggs. The only confirmed nest that fledged occurred on May 29. Based on these two nests, Henslow's sparrow nests were initiated in the first week of May, 1999. There was a large gap in the season, between the first week in June and the last week in July, when no nests were found. Nesting activity appeared to have diminished during this time period. Inexperience and unfamiliarity with the secretive sparrow may have hampered nest-searching efforts during this time. The latest nest of the season was still active on July 30 and was due to fledge in 4-5 days; however, its fate was not determined because of military activity in the area.

In 2000, 15 singing Henslow's sparrow males were detected on April 18. These males were singing in 5 different native grass fields around the base (including Suckchon DZ). A pair of Henslow's sparrows was seen copulating on April 22 in a broomsedge field in Suckchon DZ. The first nest of the season was found on May 4, 2000, containing 4 eggs. A nest with 3 nestlings and one egg was discovered May 8. The first nest to fledge in 2000 occurred on May 20. The average initiation dates for the first clutch was in the last week in April and the first week in May which puts the average fledging dates about 25 May. A lull in nesting activity occurred in 2000 between the first week in June and the last week in June. The last confirmed nest to fledge occurred on July 29. On August 8, a nest was still active with 4 nestlings; however, the fate was not determined.

Nest Success

Apparent nest success rate (# successful nests/total nests) was 20.0% in 1999 (Table 7). Six nests were located in 1999; a small sample size did not allow for a Mayfield nest success calculation. One was successful, 3 were predated, and one was abandoned (Figure 6). The fate of one nest was not determined. None of the 6 nests were parasitized by brown-headed cowbirds. Mean clutch size was 3.8 (± 0.17) and hatching success was 88.9% in 1999. An average of 0.8 young fledged from active nests; 4 young fledged from the one successful nest.

Forty-three nests were found in 2000; 42 were used in data analysis. Apparent nest success was 42.9% and Mayfield nest success was 18.7% (SE ± 0.07) in 2000. The daily survival rate was 93% (SE ± 0.02) for eggs in 2000 and 91% (SE ± 0.02) for nestlings. There was no difference in nest success between incubation and nestling stages. Incubation success was 43.4% (SE ± 0.11) and nestling success was 43.1% (SE ± 0.10). Eighteen nests were successful, 22 predated, and 2 abandoned prior to egg laying (Figure 6). One nest fate remained unknown because it was still active at the time of departure from the study area in August. Only one nest was parasitized by brown-headed cowbirds during 2000. This nest initially contained 3 Henslow's sparrow eggs, one cowbird egg, and one cowbird chick. One of the Henslow's sparrow eggs hatched and another cowbird egg hatched before this nest failed. Predation was the primary cause of nest failure in both years. No nest losses to military activity were documented in either year.

Mean clutch size was 4.3 (± 0.10) in 2000. Hatching success was 85.9% in 2000. An average of 1.6 young fledged from active nests and an average of 3.8 fledged from successful nests in 2000.

## Habitat Analysis

### Point Counts

In 1999, cool-season (P = 0.0377) and warm-season (P = 0.0485) grasses were greater at occupied sites than unoccupied sites (Table 8). Only 7% of the variance was explained by the variables (Max-rescaled R-Square = 0.0694) and the model had 60.2% concordance.

In 2000, field size (P < 0.0001), NWSG (P = 0.0007), and grass height (P = 0.0196) were greater at occupied sites than unoccupied sites (Table 9). Percent legumes, woody vegetation, bare ground, cool season grass, forbs, litter depth and field burn age did not differ between occupied and unoccupied sites. Thirty-seven percent of the variation (Max-rescaled R-Square = 0.3730) was explained by the variables. The model had 83.3% concordance with a 73% correct classification rate.

Pooled data yielded a weaker model explaining 21% of the variance (Max-rescaled R-Square = 0.2114) and 76.0% concordance (Table 10). Field size (P < 0.0001), percent NWSG (P < 0.0001), litter depth (P = 0.0169), and grass height (P = 0.0424) were greater at occupied sites than unoccupied sites.

## Perch Sites

Field size (P < 0.0001) and woody vegetation (P < 0.0001) were greater at perch sites than random sites in 1999 (Table 11). The logistic regression model explained 47% of the variance (Max-rescaled R-Square = 0.4709) and had a concordance of 84.7%.

Woody vegetation (P < 0.0001) and field size (P < 0.0001) were much greater at perch sites in 2000 than random sites whereas percent legumes (P = 0.0193) were much less at perch sites compared to random sites (Table 12). The logistic regression model explained 59% of the variance (Max-rescaled R-Square = 0.5894) and the concordance was 91.9%.

Mean perch height for singing males was 1.6 m (n=28; SE ± 0.10), ranging from 0.6 m to 2.5 m. Distance from male perch to nest ranged from 3.5 to 59.0 m and averaged 21.6 m (n=29; SE ± 2.42). Perches consisted of woody vegetation (52%), forbs (44%), and grass (4%). The most common perch species were goldenrod (*Solidago* spp.), persimmon (*Diospyros virginiana*), sweetgum (*Liquidambar styraciflua*), and sumac (*Rhus* spp).

Nest Sites

Burn class was older (P < 0.0001), percent NWSG was greater (P = 0.0003), and field size was larger (P = 0.0011) at nest sites than random points in 2000. Litter depth was less (P = 0.0012) at nest sites than random sites (Table 13). Forty-two percent of the variance (Max-rescaled R-Square = 0.4162) was explained by the 10 variables and the model had 88.7% concordance. Most nests were in little or big bluestem (65%) or broomsedge (30%). Nests were placed either in the center or at the base of the bunch grasses.

Nest success

NWSG coverage (P = 0.0086) and litter depth (P = 0.0236) were significantly greater at successful nests than unsuccessful nests in 2000 (Table 14). The logistic regression model explained 48% of the variance (Max-rescaled R-Square = 0.4787) and the model was 83.8% concordant.

**Discussion**

Henslow's sparrows on Fort Campbell were detected in consistent numbers at point counts between years even though they shifted field use. These birds were also consistently using the same areas in Suckchon DZ between count periods and years. More sparrows were detected on the first counts (15 May – 15 June) than on the second ones (16 June – 15 July). This has been observed by others as well; Henslow's sparrows were reported singing more intensely and more frequently during courtship with a noticeable decrease in singing after the young hatch (Hyde 1939, Graber 1968, Robins 1971). Henslow's sparrows continue to sing later in the summer, but with less intensity and frequency.

Henslow's sparrows have unstable, year-to-year fluctuations in number and distribution (Bent 1968; Wiens 1969; and Robins 1971). These sparrows appear to shift to different fields between seasons in response to plant succession. All fields occupied by Henslow's sparrows in 1999 were burned a year ago or longer. One exception was field 00-1 which was burned in early 1999 and contained a singing Henslow's sparrow male in July. Fields used by Henslow's sparrows in 2000 were all burned in 1999 except for one field (28-1) that was burned in 1998.

Based on the point count data, Henslow's sparrows appeared to be using the larger, 1-year-old or older burned fields in 2000. This is consistent with what some other studies have shown. Winter (1998) observed an increase in Henslow's sparrow densities between areas burned the same year and areas one year after a burn. Areas at Jefferson Proving Ground had the greatest singing male density in the 1-year since burn fields, greater than the 5 or more years since burn fields (Robb et al. 1998). Herkert (1994b), however, found that densities were greatest in the 2-3 year post-burn age class. Herkert and Glass (1999) also found Henslow's sparrows more abundant on fields burned 2 or more years ago. Although I did sample fields that had been burned greater than 1 year ago, I was limited in the number of larger, older burned fields to sample. Henslow's sparrows would probably use larger, older burned fields given the opportunity, based on other studies. I observed that Henslow's sparrows were occupying fields either very close to or directly bordering the large impact zone (8000 ha). Half of this area is burned on a rotational basis every year to reduce the chance of accidental fires from exploding ordinance. The perimeter of this area may be providing quality-breeding habitat for Henslow's sparrows. Prescribed burns often create a mosaic pattern of burned and unburned patches within one field. Henslow's sparrows, as well as other grassland birds, appear to be using these areas.

Henslow's sparrows have been described as a "semi-colonial" breeding bird (Hyde 1939, Graber 1968, Wiens 1969). This species may have acquired this reputation because of its within-patch selectivity. Individual birds may be selecting patches of unburned or older burned field within a burned or more recently burned field.

Breeding Henslow's sparrows arrived on native grassland fields of Fort Campbell in mid- to late April and began nesting by early May. This is consistent with observations elsewhere at the same latitude. Henslow's sparrows generally return to breeding grounds in Kentucky by mid-April (Mengel 1965, Palmer-Ball 1996) and to southwestern Missouri by early May (Winter 1998). The first male Henslow's sparrows to set up territories appeared to occupy larger fields first. In both years, the first detections of singing Henslow's sparrows were located in Suckchon DZ (largest field), as well as other larger fields, suggesting that large fields may be the preferred habitat.

Mean clutch size, incubation days, nestling days, hatching success, and young fledged per successful nest were consistent with other nesting studies (Table 15). Estimates of nest success (apparent and Mayfield) were lower at Fort Campbell than most other productivity studies.

Winter (1998) reported 39.5% nest success among Henslow's sparrows in Missouri between 1995 and 1997. In Oklahoma, Henslow's sparrows had a Mayfield estimate of 29% between 1992 and 1996 (Reinking et al. In press). Jefferson Proving Ground (JPG) populations, in southeastern Indiana, had a 28.7% nest success rate (n = 14) in 1998 (Robb et al. 1998). Henslow's sparrows in Missouri, in different CRP field landscapes, had an overall Mayfield estimate of 6.5% between 1997 to 1999 (T. McCoy, pers. comm.). Henslow's sparrows currently have stable populations or are expanding their range in Missouri, Oklahoma, and Indiana.

Comparing Henslow's sparrow nest success estimates between studies and regions is difficult because of low numbers of nests to calculate Mayfield estimates. Only one nesting study having > 10 nests had been completed by 1995 (Burhans 2001). Using the apparent nest success rate of 42.9% to compare with other studies, nest success at Fort Campbell was slightly lower. Another study in Kentucky reclaimed strip mines had the highest apparent nest success rate of all studies with 74.2% (n=31) (M. Monroe, pers. comm.). Winter (1998) found relatively high nest success (57.6%) in southwestern

Missouri. McCoy (pers. comm.) calculated an apparent nest success rate of 18.8% in northern Missouri. Robins (1971) in Michigan calculated an apparent nest success estimate of 54.5%. Reinking and Hendricks (1993) found an apparent nest success of 45% in Oklahoma.

Winter's (1998) study was conducted in native tallgrass prairie in southwestern Missouri, which was actively managed with burning and haying. This area in Missouri, within the tallgrass prairie region, appears to provide suitable nesting habitat based on the relatively high nest success rate. However, McCoy's nest success estimate, near the same region, was much lower. The Henslow's sparrow nests in his study were more abundant on the CP1 (cool-season grass) fields as opposed to the CP2 (warm season grass) fields (McCoy et al. 1999). The study in Oklahoma had the highest cowbird parasitism rate (8.0%), which may be affecting nest success there. Avian populations at the edge of their range tend to have lower nest success most likely because of lower quality breeding habitat (Villard and Maurer 1996).

Deep litter depth appears to be associated with higher nest success in Henslow's sparrows. Mean litter depth for the 40 nests in 2000 was 3.85 cm (Table 13). Successful nests had a mean of 5.55 cm compared to 2.45 cm for unsuccessful nests ($P = 0.0309$). All nests found in 2000, except 3, were in the one-year burn class. Burning depletes the litter depth, so the burning cycle may be the driving force in dictating nesting success of Henslow's sparrows at Fort Campbell (Table 16). Older fields may be more productive for these sparrows. A longer (> 2 years) burning rotation in the larger fields may be beneficial to the reproductive output of Henslow's sparrows. Winter (1998) found a positive relationship between litter depth and nesting success. She also discovered that Henslow's sparrow density was largely dependent on a deep litter layer.

While the Mayfield nest success estimate is lower at Fort Campbell than other sites, I would caution that this estimate is based on only one year of data. More productivity data need to be collected. Grassland birds typically have lower nest success rates than other bird groups, ranging from 25–50% (Wiens 1969, Vickery et al. 1992c, Martin 1995). Lower nest success in grassland birds are compensated by a longer breeding season and attempting more broods per season (Wiens 1969, Martin 1995). Although 18.7% may appear to be a low nest success, compared to studies in Missouri and Oklahoma, re-nesting after failure and double brooding aid in sustaining this population. More reproductive data and survival estimates need to be collected before source/sink determinations can be made.

Predation was the main cause of nest mortality of Henslow's sparrows at Fort Campbell (Figure 6). Fifty-five percent of Henslow's sparrow nests were predated in 2000. This predation rate is greater than the 42% predation rate reported from Missouri (Winter 1998), and the 45% predation rate reported from Michigan (Robins 1971). Henslow's sparrows at JPG, in Indiana, experienced a 29% predation rate (Robb 1998). A population in northeast Oklahoma had a predation rate of 55% - very similar to Fort Campbell. Many snakes were observed, such as black rat (*Elaphe obsoleta*), black racer (*Coluber constrictor*), and garter (*Thamnophis* spp.) in the grasslands during the two field seasons and I suspect these were the main nest predators. Direct predation of monitored nests was not witnessed; however, a black racer eating a recently fledged eastern meadowlark was observed, and a black rat snake was seen predating eggs in a gray catbird (*Dumetella carolinensis*) nest next to a study field. Technicians saw snakes very close to two nests that ultimately became depredated.

Others studies have identified snakes as major nest predators of songbirds as well (Best 1978, Wray and Whitmore 1979, Zimmerman 1984). Davison and Bollinger (2000) suspected a high predation rate by snakes on artificial and real grassland bird nests. Winter (1998) believed that snakes were a major predator on Henslow's sparrow nests in southwest Missouri. Research using video cameras to monitor nests in old fields in Missouri has documented black rat snakes and prairie kingsnakes (*Lampropeltis calligaster*) as major predators on passerine nests (Thompson et al. 1999). Sixteen of 23 indigo bunting and field sparrow nests were predated by these 2 species.

Video cameras have also recorded mammalian nest predation events. Pietz and Granfors (1999), monitoring grassland bird nests with video cameras in North Dakota, found skunks (*Mephitis mephitis*), mice (*Peromyscus* spp., *Mus musculus*), red fox (*Vulpes vulpes*), and even white-tailed deer (*Odocoileus virginianus*) depredating nests. Hyde (1939), Robins (1971), and Winter (1998) believed mammals were major predators on Henslow's sparrow nests. Robins (1971) observed a thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) preying upon a nestling Henslow's sparrow. Ground squirrels do not occur at Fort Campbell, but other small mammals, such as field mice or cotton rats (*Sigmodon hispidus*), may be depredating nests (Ettel 1998). Coyotes (*Canis latrans*) were observed on study plots several times, but are probably not major nest predators. Skunks were virtually non-existent on the base in the rear area (A. Leonard, pers. comm.). Avian predators including blue jays (*Cyanocitta cristata*) and American crows (*Corvus brachyrhynchos*) were observed, but rarely in grasslands.

Cowbird parasitism does not appear to be a problem in the productivity of Henslow's sparrows at Fort Campbell. Brown-headed cowbirds were common on point counts for both years, yet the parasitism rate was low (2.1%), consistent with other Henslow's sparrow nesting studies. Robins (1971) and Robb et al. (1998) both had 0% nests parasitized in Michigan and Indiana, respectively. Reinking et al. (in press) found 8% of their nests parasitized in OK and Winter (1998) had a 5% cowbird parasitism rate in Missouri. Bent (1968) did not have any concrete figures, but mentioned the parasitism rate was very low. Schulenberg et al. (1994) documented one Henslow's sparrow nest in Kansas, which contained two cowbird eggs and was abandoned during incubation.

I did not document any direct nest mortality of Henslow's sparrows from military training during either year. However, I did document 3 nests of other species (2 field sparrows and 1 common yellowthroat), in 1999, and 11 nests (7 indigo buntings and 4 field sparrows), in 2000, which failed because of military activities. The eleven nests in 2000 were destroyed during two separate military exercises during June. Most of these nest mortalities occurred from vehicles or tents placed in the fields. I speculate some of these above ground nests (i.e. indigo buntings and field sparrows) may have been damaged from helicopter maneuvers hovering very close to the ground. Considering the large sample of nests found (n=512; Table 17), only a small portion of the nests, 2.8%, were damaged by military training during the two field seasons. Two other nests were destroyed by non-military vehicles (4-wheeler and farm truck) during the course of the research.  Impacts on grassland bird annual productivity is further reduced because most species re-nest when failure occurs.

Henslow's sparrows were typically found occupying similar habitat throughout the base within and between years.  They occurred in native warm season grass fields, typically 1 year or greater since burning, dominated primarily by little bluestem and/or broomsedge consistent with other studies (Robins 1971, Zimmerman 1988, Sample 1989, Herkert 1994b, Winter 1998).  These sparrows also use secondary habitats such as unmowed hayfields (Graber and Graber 1963, Bent 1968, Robins 1971, Peterson 1983, Sample 1989), undisturbed grasslands (Hyde 1939, Wiens 1969, Peterson 1983, Sample 1989, Herkert 1994), and reclaimed surface mines (Peterjohn and Rice 1991, Koford 1997, Bajema et al. 1998).

Deep litter layer and standing dead vegetation are two characteristics cited as most important to Henslow's sparrow nesting habitat (see review in Swanson 1996; Wiens 1969, Robins 1971, Samson 1980, Zimmerman 1988, Verser 1990, Clawson 1991, Herkert 1991, Reinking and Hendricks 1993, Robb et al. 1998, Winter 1998, Lamb 1999).  Other important variables related to Henslow's sparrow breeding habitat include tall, dense herbaceous vegetation and little woody cover; contrary to most studies, I found that litter depth was less ($P = 0.0012$) at nest sites compared to random sites.  However, litter depth was significantly higher at successful nests ($P = 0.0236$) than at unsuccessful nests in 2000.

Native warm season grasses also appear to be an important component of Henslow's sparrow habitat.  NWSG coverage was significantly greater at occupied point count locations and nest sites compared to random points. Productivity appears to be affected by NWSG's too as successful nests contained greater percent of native grasses. Reduction in native grass habitat is most certainly tied to the severe decline in this species.

Height of woody vegetation was higher at male perch sites in both years of the study than at random sites ($P < 0.0001$). Many of the shrubs and small trees used by Henslow's sparrows were re-sprouts of live woody vegetation from dead, burnt trunks. This mix of live and dead woody vegetation seemed to offer structural support, cover, and good visibility for singing males.

Field size was an important habitat parameter to Henslow's sparrows seen at all 3 landscape levels. Presence/absence data revealed field size occupied by Henslow's sparrows was greater ($P < 0.0001$) in 2000, but not significant in 1999 ($P = 0.3679$). Male territories in 1999 ($P < 0.0001$) and 2000 ($P < 0.0001$), and nest sites in 2000 ($P = 0.0011$) were located in larger fields. Most of the Henslow's sparrow nests located were in the largest field on the post – Suckchon DZ – because of the higher density of birds there. Fields occupied by Henslow's sparrows in 1999 were primarily located on the north side of the post next to the impact zone. Field size may have been underestimated for these fields as the impact zone area was not included in the area calculations. Other studies have also documented area sensitivity in Henslow's sparrows (Zimmerman 1988, Herkert 1994a,b,c, Swengel 1996, Winter 1998).

The smallest field (27-3) I documented Henslow's sparrows on was 6.5 ha and 2-years since it was last burned. Three singing males were present on both counts in 1999 in this field; however no breeding activity was observed. This field was burned in the winter of 2000 and the sparrows were not detected during the breeding season of 2000. Henslow's sparrows were also documented nesting in small fragments. The smallest field (30-1) that contained an active nest was 9.3 ha and it had been burned 1-year previously. This nest was located within 5 m of woody vegetation; nest outcome was successful. Henslows's sparrows have avoided nesting near woody vegetation or edges in other studies (Winter 1998, Cully and Michaels 2000).

**Conclusions**

Native grasslands at Fort Campbell appear to offer suitable nesting habitat for Henslows's sparrows created by the regular burning on a 1-3 year rotation. Nest success estimates, while only based on one year of data, are lower than most other studies. This research has provided baseline data on a declining species, which needs further study. Based on nest success analysis, frequency of burning and field size may determine how well this population will do. Deeper litter depth appears to aid in nest success. Burning too frequently (i.e. annually) may negatively affect nesting success by reducing litter depth. Providing older burned fields (3-4 years post-burn) may help Henslow's sparrow productivity.

Burning in a rotational system would allow Henslow's sparrows to access older burned fields. These unburned patches may be important breeding habitat for birds like Henslow's sparrows, which require older fields. Historically, these birds relied on fires to burn in a mosaic pattern creating patches of unburned spots. Letting unburned portions of fields remain may mimic historical conditions. Allowing fields to go longer between burns would allow more litter (fuel) to accumulate, which in turn would produce a hotter fire. More intense burns would be more effective in reducing woody growth. In contrast, frequent fires would reduce fuel loads and may not be as effective in reducing shrubs and trees.

Based on our analysis and other studies, Henslow's sparrows clearly prefer larger fields. These sparrows frequently use the largest fields and fields surrounding the large impact zone more than other fields on the reservation. Because the impact zone is a very large grassland patch maintained by burning, I suspect that Henslow's sparrows are using this area extensively.

# CHAPTER 4

# GRASSHOPPER SPARROW NESTING SUCCESS AND HABITAT CHARACTERISTICS

Grasshopper sparrow populations experienced one of the most significant declines of any grassland bird between 1966-1996 (Peterjohn and Sauer 1999). Based on BBS data, grasshopper sparrow populations declined 66% across North America during the last 30 years (Peterjohn et al. 1994), including a 5.9% decline per year in the eastern U.S. (Askins 1999). Only 3 other eastern grassland species have a greater rate of decrease per year over the same time period – Henslow's sparrow (-9.3%), Lark sparrow (*Chondestes grammacus*) (-6.9%), and western meadowlark (*Sturnella neglecta*) (-7.2%). Because of the population decline, grasshopper sparrow populations have been monitored by federal and state agencies, including Tennessee.

Grasshopper sparrow population declines can mainly be attributed to habitat loss, fragmentation, and degradation (Vickery 1996). Native prairies and grasslands have declined as much as 99% in Wisconsin (Sample 1989), Minnesota (Johnson and Temple 1990), and Illinois (Herkert 1994a) since the beginning of the twentieth century. Although grasshopper sparrows have been able to adapt successfully to hayfields and other less suitable (secondary) grasslands (Graber and Graber 1963, Rodenhouse et al. 1995), conversion of hayfields and pastures to row crops in the last half century have reduced habitat available for grassland birds (Warner 1994, Herkert 1997).

Concern for grasshopper sparrow populations has focused national and regional attention on this species. Grasshopper sparrow was put on the National Audubon Society Blue List in 1974 and remained on it until 1986 (Tate 1986). The eastern subspecies of grasshopper sparrow (*A. s. pratensis*) is considered threatened regionally in the New England states (Vickery 1996). The sparrow is listed as Threatened in New Jersey and Special Concern in New York. In Tennessee, grasshopper sparrow was state listed as threatened in 1975 (Tennessee Wildlife Resources Agency 1975), but was down listed to In Need of Management in 1994 (Tennessee Wildlife Resources Agency 1994). Arkansas and Louisiana Natural Heritage programs are monitoring the species' population in their respective states (Hamel 1992). The Florida grasshopper sparrow (*A. s. floridanus*), a subspecies, was placed on the federal endangered list by the USFWS in 1986 (Federal Register 51 FR 27492-27495). A Canadian subspecies, *A.s. perpallidus*, is considered Endangered in British Columbia (Vickery 1996).

Grasshopper sparrows are fairly widespread across North America ranging from the Atlantic Coast to California and from southern Canada to northern South America (Smith 1968). The breeding range extends from southern British Columbia and Alberta to southern Maine, south to southern California, south-central Texas, and central Georgia, and east to North Carolina, Maryland, and New Hampshire (Dechant et al. 1998) (Figure 7). Based on BBS data, the largest densities of this species occurs in the Great Plains from North Dakota to Oklahoma and northern Texas (Peterjohn et al. 1994). Although this sparrow is found locally distributed throughout the U.S., they are seldom heard or seen because of their weak, inconspicuous song often compared to a grasshopper's voice. This species winters in the southeastern states primarily in broomsedge (*Andropogon virginicus*) fields (Hamel 1992).

Grasshopper sparrows prefer large open grasslands, especially cultivated fields, with patchy bare ground (Smith 1963, Smith 1968, Vickery 1996). Hayfields, savannahs, prairies, and old fields are habitats commonly used by this sparrow. Grasshopper sparrows prefer drier sites with sparser vegetation and more bare ground and tend to avoid fields with a lot of shrubs and woody vegetation. Habitat preference varies between regions, but generally birds occupy areas with more dense, lush vegetation in the West and occupy more sparse vegetation in the East. Eastern populations appear to avoid weedy fields and grain fields (Hamel 1992) and be more numerous on cultivated fields (hayfields) planted in orchardgrass (*Dactylis glomerata*), alfalfa (*Medicago sativa*), red clover (*Trifolium pratense*), and lespedeza (*Lespedeza* spp.) (Smith 1968). These birds occur in other habitats as well such as reclaimed strip mines (Whitmore 1981, Wray et al. 1982), native palmetto (*Serenoa repens*)- wiregrass (*Aristida stricta*) prairie (Delany et al. 1985), pine (*Pinus* spp.)-savannah grassland, and grassy balds in West Virginia and Tennessee (Behrend 1973).

Nests are open cups built in a slight depression in the ground with the rim level with the ground (Harrison 1975, Ehrlich et al. 1988). Nests are typically arched or domed in the back and concealed with overhanging vegetation, built by the female of dried grasses and lined with fine grasses and rootlets. Harrison (1975) noted that birds favored building nests among orchardgrass, clover, and alfalfa. The female builds nests in 2-3 days (Baicich and Harrison 1997); the number of eggs typically ranges from 3-6, but usually 4-5 (Harrison 1975). Grasshopper sparrows have 2 broods per season, possibly 3 in Florida (Ehrlich et al. 1988, Baicich and Harrison 1997). Males establish territories in early April in the southern part of the range to late May or early June in the northern part of the range and nest into mid-August (Hamel 1992). This sparrow is considered semi-colonial, like the Henslow's sparrow, nesting in groups of 3-12 pairs (Ehrlich et al. 1988). Incubation is performed by the female alone and continues for 11-12 days with fledging occurring at 9 days after hatching (Harrison 1975, Ehrlich et al. 1988). Grasshopper sparrows are considered uncommon brown-headed cowbird hosts.

Characteristic of the *Ammodramus* sparrows, grasshopper sparrow nests are very difficult to locate. Adults typically do not fly directly to and from the nest. Instead, they land nearby and walk to the nest on the ground. Females remain very tight on the nest when approached by humans and flush at the last minute. When a female flushes off a nest she runs along the ground, performing a distraction display, before flying.

**Populations in Tennessee and Kentucky**

Grasshopper sparrows are listed as "uncommon to fairly common migrant and summer residents" in Tennessee (Robinson 1990). In Kentucky, they are considered fairly common to common except in the eastern part of the state (Mengel 1965) and were recorded on about 40% of the blocks in the state atlas survey (Palmer-Ball, Jr. 1996). Birds arrive on breeding grounds in Tennessee and Kentucky in mid to late April and continue reproducing until mid-August (Mengel 1965, Nicholson 1997). Birds are generally quiet in the fall until they depart for wintering grounds in October. Based on only 2 over-wintering records and 10 total winter records, grasshopper sparrows appear to be rare winter visitors in Tennessee (Robinson 1990). Although no winter records have been documented for Kentucky, a few may winter there as well (Mengel 1965).

The grasshopper sparrow has habitat requirements much different from that of the Henslow's sparrow. Grasshopper sparrows prefer short-grass conditions and are restricted to large, open grasslands in Tennessee (Nicholson 1997). These sparrows can occupy tall grass prairie if vegetation is sparse and patchy (Sample and Mossman 1997). Hayfields, lightly grazed pastures, clover and alfalfa fields, and airfields are the most commonly used habitats in Tennessee (Alsop 1979, Nicholson 1997). Winter wheat fields and reclaimed surface mines in the Cumberland Mountains have also provided habitat for the grasshopper sparrow.

Ammodramus sparrows, because of their secretive behavior and songs, have not been well documented in the past, especially prior to the 1950's. Despite poor historical documentation, grasshopper sparrow populations probably inhabited the barrens region prior to European settlement where bison grazed and native Americans frequently burned large patches.

Specific habitat information on grasshopper sparrow breeding habitat or nesting success in Tennessee and Kentucky is lacking. Mengel (1965) noted 14 nesting records ranging from May 11 to August 10 with a peak from May 21-31.

## Methods

### Point Counts

I sampled the 30 selected native warm season grass fields using 50-m fixed-radius point counts (Hamel et al. 1996) during the 1999 and 2000 breeding seasons. All birds detected either visually or aurally, within 10 minutes, were tallied in 4 categories: 0 to 50 m, 50 m or greater, flyovers, or walk-ins. Flyovers were any birds that flew over the point during the 10-minute count that did not land. Walk-ins were birds of interest encountered while walking between points. Points were systematically placed at least 200 m apart across a given site. Number of points per field ranged from 2 points in the smaller fields (5 ha) to 11 points in the larger fields (545 ha). All points were located at least 50 m from any edge to minimize counting of forest bird species. Counts were started by 15 May of each year and completed by 15 June; a second set of counts was conducted between 15 June and 15 July. A technician and I conducted the counts during each field season; the same points were sampled consistently by the same surveyor within years. Different technicians were used for the point counts between years; I sampled the same points both years.

Based upon standard protocol, point counts were conducted between 5:00 am and 10:00 am CDT (Hamel et al. 1996). However, most counts were finished by 9:00 am as the majority of grassland birds had stopped singing by then. Counts were not conducted during heavy fog, rain, or wind speeds more than 20 km/hr. Each survey point was marked with colored flagging in 1999 and coordinates were recorded with a Global Positioning System (GPS) for relocation the following year. Several points from both years were excluded from analysis because of disturbed vegetation caused by accidental burning, military activity, or new food plots. Grasshopper sparrow playback tapes were used after the counts to illicit male singing if none were heard during the 10-minute time frame to aid in detection of this focal species (Marion et al. 1981).

Nest Searching

In 1999, I began checking fields for grasshopper sparrows using playback starting April 2 to determine when they arrived back on breeding grounds. Areas where grasshoppers were seen in 1998 and random fields on the post were also checked on April 10, 17, 24, and May 13. In 2000, I started searching fields for grasshopper sparrows on April 18.

During the 1999 and 2000 breeding bird seasons, the field technicians and I systematically searched all selected fields for grassland bird species focusing our effort on two primary species: Henslow's sparrow and grasshopper sparrow. Nests of all species found were monitored. Territories of target species located during censusing or by incidental observation were noted and later searched for nests.

Nests were found by walking across grassland plots and paying close attention to behavior and vocalizations of nearby adult birds. Behavioral patterns of adults that were used as clues to nesting behavior were: 1) chipping nearby, 2) flushing close to the observer and flying a short distance, and 3) carrying nest material, food, or fecal sacs. The location of a potential nest site was flagged on nearby vegetation. Observers then retreated 30 – 50 m and tried to locate the nest with use of binoculars when the bird returned.

Nests found were marked with a flag placed 5 m north of the nest with date, species, distance to nest, and bearing to nest written on flag. Focal species nests had a separate flag color from non-focal species to help with coordination and organization in the field. Nest flags were placed as high as possible on surrounding vegetation as long as it was close to 5 m north. Consistently placing flags at a pre-determined distance and direction helped avoid accidental crushing of the nests during nest monitoring.

Nests were checked every 3-4 days until the nest was completed to determine nest fate. I did not search for or monitor nests during rain. Nests checked within the 3-4 day time frame and close to fledging on the last visit were considered successful if empty (as long as nest was intact and no signs of predation were evident). Nests which were empty following a 4 day or greater interval between checks (and were close to fledging) were not included as a successful nest in the analysis unless feeding adults or juveniles of that species was seen in the immediate vicinity. Nests were categorized as mowing mortalities if nests had crushed eggs or dead chicks after a recent mowing event.

Nest Success

Nest success was calculated for focal species using the Mayfield method (Mayfield 1961, 1975). Nests were considered successful if a given nest fledged at least 1 host bird. Fledglings seen near the nest or adults feeding fledglings near the nest were assumed to be evidence of nest success. Nests were considered abandoned if nests containing eggs were inactive for 3 successive visits and eggs were cold. However, I did include abandoned nests in our cowbird parasitism calculations. A nest was considered parasitized if it contained at least one cowbird chick or egg. Nests were unsuccessful if all eggs were lost before the hatching date or all chicks were lost before the fledging date. Evidence at the unsuccessful nests was used to determine reason for failure. If nests disappeared, had holes in them, were tilted, or otherwise had damage to them prior to the fledging date, they were classified as predated. Nests were classified as failed due to mowing if field was mowed between the last check and the nest failure. Also, if eggs, eggshell fragments, or dead chicks were in, below, or close to the nest after a thunderstorm, I labeled the nest as failed because of weather. If nests failed after signs of military activity had occurred in the field since last nest check (i.e. vehicle tracks running over nest or nest vegetation), then nests were labeled as failed because of military.

Probability of nest success was defined as the odds that a nest would survive both the incubation and nestling stages to fledge at least one host young (Mayfield 1975). Based on other nesting studies, I calculated daily nest survival for each species for which greater than 20 nests in a season were located. Grasshopper sparrow nests were pooled between years to produce a larger sample size for more power in the analysis. Consistent with other studies, I assumed that incubation started the day the last egg was laid (Bent 1968, Winter 1998). Grasshopper sparrows have an average incubation time of 11 days and average fledging time of 9 days, which were used in the nest success calculations (Ehrlich et al. 1988). Only nests which were observed in both the incubation stage and nestling stage were used for hatching success calculations.

## Vegetation Sampling

Vegetation analysis was conducted to determine the association between habitat features of territory and nest-site selection, and reproductive success. I characterized grasshopper sparrow habitat at nest sites and at frequently used male perch sites. Measurements were also conducted on vegetation at all point count locations for use as random samples.  Nest and perch site vegetation measurements were taken within one week of nest completion.  Point count locations were characterized following the second set of counts in 1999 and in between the first and second set of counts in 2000.

Nest sites and point count stations were characterized within a 1-$m^2$ frame directly over the nest/point.  Average herbaceous height, average woody height, average grass height, average litter depth, and percent cover were measured (Table 3).  Horizontal cover was broken down into litter, bare ground, woody, dead woody, forbs, and grass categories.  Vertical cover was assessed by placing a density board (15 X 15 cm squares; 2 squares wide and 10 high) at the nest/point and counting the number of squares covered in the four cardinal directions 15 m from the board (Nudds 1977).  An index of total vertical cover was created by averaging the number of squares covered by vegetation divided by the total squares.  Distance to edge, permanent water, woody cover, and direction of nest entrance also were recorded.  To quantify military disturbance, distance from nest/point to nearest vehicle track or rut greater than 2.5 cm deep was measured.

Statistical Analysis

I conducted logistic regression analysis (SAS 1999) to identify key habitat features associated with grasshopper sparrow territories (nests and perches).  Highly correlated habitat variables ($r > 0.6$) were eliminated using PROC CORR.  Vegetation samples from 23 frequently used male perch sites in 1999 and 2000 were measured and compared with 338 random vegetation samples from both years.  I did not analyze perch data separately for each year because of low sample size.  For the 1999 nests, I compared

18 nests (one nest eliminated because vegetation was mowed) against 168 random vegetation samples. I used 32 of the 35 nests from the 2000 field season for comparison against 170 random sample points. Mowing destroyed two nests, so they were removed from the vegetation analysis. Nests were also pooled between years and tested against all random samples. CART (Classification And Regression Trees) models revealed no difference in random site vegetation between years. Logistic regression was also used to determine if there was a difference in habitat characteristics between successful (n=37) and unsuccessful (n=13) nests. Distance to nearest military vehicle track was categorized as: < 1m, 1-5 m, or > 5m.

## Results

### Point Counts

The 718 point counts during the 2 breeding seasons documented a total of 36 grasshopper sparrows; 10 within 50 m and 26 outside 50 m. In 1999, grasshopper sparrows were detected at 3 points out of 168; one in the early counts (15 May – 15 June) and 2 in the later counts (16 June – 15 July) (Table 18). In 2000, 4 counts out of 170 points detected grasshopper sparrows; 1 in the early counts and 3 in the later set. Detection at points was consistent between years – birds were at the same points in 2000 as in 1999 plus one more point. All 10 birds were detected in the largest plot – Suckchon DZ (545 ha) – and primarily used the areas of the field that had been burned in 1999. Only one other field censused, 27-2 (29.9 ha), contained grasshopper sparrows and they were outside the 50-m radius. Grasshopper sparrows were heard singing in other large DZ's (Corregidor and Bastogne), which were primarily fescue (Figure 8).

Nesting Chronology

Grasshopper sparrows were first heard singing on May 13 in 1999, however the fields were not checked between April 24 and May 12. Our nest searching efforts were delayed until after May 23 in 1999 because of a large military exercise. The first grasshopper sparrow nest of 1999 was found on May 24 and contained 5 chicks. The first grasshopper sparrow nest fledged on 28 May, 1999. The latest nest confirmed fledging occurred on July 16. The last active nest of the season, which ultimately failed due to abandonment, contained 4 eggs on August 9, 1999.

In 2000, grasshopper sparrows were first detected singing in the hayfields in the Suckchon DZ on April 19. At least 3 sparrows were seen in Bastogne DZ on April 22, but none were singing and did not respond to playback. In 2000, the first nest was found May 11 containing 5 eggs. The first nest fledged June 1 in 2000. Based on early nests fledging in the first week in June, the first nests in 2000 were initiated around the first or second week in May. Three nests were still active on August 1. The latest confirmed fledging occurred on August 5 when a nest containing 2 chicks fledged when checked.

Based on back dating of successful nests during both years, peak initiation and fledging, respectively, of nests for the first set of clutches were the second week of May and the first week in June. Another peak of nest initiation and fledging occurred during the third week of June and the third week of July, respectively.

Nest Success

Nineteen grasshopper sparrow nests were located in 1999. Apparent nest success

(# successful nests/total nests) was 72.2% and Mayfield success was 41.8% (SE ± 0.04) (Table 19). Daily survival rate for the incubation stage was 98% (SE ± 0.01) and daily survival rate for the nestling stage was 94% (SE ± 0.01). Overall incubation stage survival was 76% (SE ± 0.06), while nestling stage survival was 55% (SE ± 0.03).

Thirty-five nests were located in 2000. Apparent nest success was 68.6% while Mayfield success was 38.2% (SE ± 0.02). Daily survival rate for the incubation stage was 94% (SE ± 0.004) and daily nestling survival rate was 97% (SE ± 0.002). Overall incubation stage survival was 50% (SE ± 0.03), while nestling stage survival was 77% (SE ± 0.01).

Mean clutch size was 4.4 (SE ± 0.20) for 1999 nests (Table 19). Hatching success was 67.7%. An average of 2.7 young fledged from all grasshopper sparrow nests and an average of 3.8 fledged from successful nests.

In 2000, mean clutch size was 4.5 (SE ± 0.12) and hatching success was 95.5%. An average of 3.0 young fledged per nest and 4.1 fledged from successful nests.

Fates for 1999 nests were 13 successful, 3 predated, one abandoned, and one failed due to weather. No nests in 1999 were parasitized by brown-headed cowbirds. One nest failed due to researcher interference, so I excluded it from all nest success calculations.

In 2000, 24 nests were successful, 7 nests were predated, 2 were abandoned, and 2 were destroyed by mowing. Only one nest in 2000 was parasitized by brown-headed cowbirds; however, this nest failed because of predation.

**Habitat Analysis**

Perch Sites

Grasshopper sparrow perch sites in 1999 and 2000 (pooled) were located in larger fields ($P < 0.0001$) with shorter grass ($P = 0.0024$) than random sites (Table 20). The other habitat variables did not differ between perches and random sites ($P > 0.05$). These 2 variables explained 72% of the variance (Max-rescaled R-square = 0.7150) and had a concordance of 97.5%. The Hosmer and Lemeshow test revealed an excellent fit for the data ($P = 0.9999$). Mean perch height (n=15) for males was 1.09 m (SE ± 0.11) and ranged from 0.5 – 2.2 m. Mean distance from perch to nest was 26.2 m and ranged from 7.0 – 54.0 m. Perches consisted primarily of forbs (76%), woody vegetation (19%), and grass (5%). The most common perch species were goldenrod and sericea (*Lespediza cuneata*).

Nest sites

Field size was larger ($P = 0.0006$), legume coverage was greater ($P = 0.0467$), and percent forbs were less ($P = 0.0233$) at nest sites in 1999 than unoccupied sites (Table 21). The model explained 80% of the variance (Max-rescaled R-square = 0.7957) and concordance was 98.6%. The Hosmer and Lemeshow Goodness-of-Fit Test indicated a good fit of the model ($P = 0.8583$).

Field size was larger ($P < 0.0001$), grass height was shorter ($P = 0.0008$), and forb coverage was lower ($P = 0.0185$) at nest sites in 2000 than random points (Table 22). Ninety percent of the variance (Max-rescaled R-square = 0.8968) was explained by these 3 variables and concordance was 96.8%.

Grass height (P = 0.0004) and forb coverage (P = 0.0019) were lower at nest sites (pooled) than random sites (Table 23). Nests were located in larger fields (P = 0.0310) than random sites as well. Variables in the model accounted for 86% (Max-rescaled R-square = 0.8576) of the variance and had 99.1% concordance with the data. The Hosmer and Lemeshow Goodness-of-Fit Test indicated an excellent fit (P = 0.9895) of the model to the data. Grasshopper sparrow nests were closer to track ruts (P < 0.0001) than random sites. Grasshopper sparrow nests were placed primarily at the base of bluestem grasses (47%), but orchardgrass, fescue, broomsedge, hop clover (*Trifolium* spp.), goldenrod, sunflower (*Helianthus* spp.), and litter were also used as nesting substrates.

<u>Nest success</u>

Logistic regression revealed no differences in habitat characteristics of successful and unsuccessful nests (Table 24).

**Discussion**

Grasshopper sparrows were observed only in large fields at Fort Campbell. The 10 birds documented on counts < 50 m were all in the largest, accessible DZ on the post and did not occur in fields less than 200 ha. Other studies have shown large grassland areas to be an important habitat requirement. In Minnesota, grasshopper sparrows nested more often in large fragments (130-486 ha) and had lower predation rates than in small fields (16-32 ha) (Johnson and Temple 1990). Herkert (1994a) found that habitat area was positively associated with the relative abundance of grasshopper sparrows in Illinois and that 30 ha was the estimated individual area requirement (probability of occurrence equals 50% of its maximum) (Herkert 1994b). Winter (1998) found that field size had only a small effect on grasshopper sparrow abundance in Missouri. However, Samson (1980) estimated the minimum amount of habitat to maintain a viable breeding population of grasshopper sparrows was only 1-10 ha in Missouri.

Grasshopper sparrows were using disturbed areas in these large fields, either recently burned or mowed areas. Point counts were not conducted in hayfields of the large drop zones, but all points where grasshopper sparrows occurred in Suckchon DZ had been burned in 1999. All of the nest sites were in either the mowed areas (≤ 1 year), recently burned areas (≤ 1 year), or areas with military or other soil disturbance (i.e. erosion). Grasshopper sparrows showed a strong tendency to be more abundant in recently burned sites in Illinois (Herkert 1994a). Florida grasshopper sparrows exhibited similar tendencies preferring areas that were less than one year post-burn (Walsh et al. 1995).

In both 1999 and 2000, I noticed that after hayfields were mowed (late May in 1999 and mid-June in 2000), grasshopper sparrows did not abandon fields as Henslow's sparrows have been observed to do and adults from other fields moved in (or used the mowed fields more heavily). Sparrow densities were found to be twice as high on mowed areas as areas that were unmowed in Illinois (Herkert 1991). Swengel (1996) found 59% more grasshopper sparrows on hayed prairies. Winter (1998) found that grasshopper densities significantly increased after haying.

Grasshopper sparrows at Fort Campbell have nest success equal to or greater than other populations in the region. Grasshopper sparrows appear to be doing well reproductively, however more data need to be collected to assess population status. Adequate nest sample sizes for both years provided enough data for Mayfield nest success estimates which were very consistent between 1999 (41.8%) and 2000 (38.2%). These estimates are fairly close in number despite the drought year in 1999, continuous agricultural practices, and military activity. Nesting studies on grasshopper sparrows are generally few, but other nest success rates in the literature include: < 25% in Florida; < 35% in Illinois; 40-50% in Maine; and 52% in southeast Nebraska (Vickery 1996). Grasshopper sparrows nesting in CRP land in Missouri had a 37% Mayfield nest success estimate in CP1 (cool season grass) fields versus a 42% estimate in CP2 (warm season grass) fields (McCoy 1996). Winter (1998) found a 22.0% Mayfield nest success for grasshopper sparrows nesting in southwestern Missouri. In Iowa, 84% of grasshopper sparrow nests failed in grass strips among agricultural fields primarily because of predation (Bryan and Best 1994). Mayfield nest success was 17% and 6% for grasshopper sparrows on undisturbed (unburned and ungrazed) and disturbed (burned and/or grazed each year) plots, respectively, in Oklahoma (Rohrbaugh, Jr. et al. 1999). Grasshopper sparrows at airport grasslands in east-central Illinois had a 41% Mayfield nest success estimate (n=12) where nest success for all other birds at the airfields was only 14% (Kershner and Bollinger 1996).

Grasshopper sparrow nests were found in both cool-season grass hayfields and native warm season grass fields. Separating the two groups for Mayfield estimates reveals a 33.4% success rate for NWSG nests (n=31) and 53.3% for nests in hayfields (n=22). Oddly enough, similar to Kershner and Bollinger's study (1996), grasshopper sparrows appear to have better nest success in mowed fields than other birds. However, good nest success doesn't mean juvenile survival is good. Juvenile survival may be poor in hayfields because juvenile sparrows can't fly when they leave the nest. Some nests may survive direct mowing because their nests are slightly sunken in the ground and partially domed, thereby providing some protection (as long as tires don't roll directly over the nest).

One action which may benefit grassland bird nesting success is to delay mowing of hayfields until after the breeding season (mid-August), or at least until after the first brood is raised (mid-June). Early season mowing and more frequent mowing have had significant negative impacts on nesting success of grassland birds (Rodenhouse et al. 1995). Grasshopper sparrow populations increased from 55 to 168 pairs in 6 years because of deferred mowing until August at Westover Air Reserve Base, MA (Melvin 1994).

Another action that might benefit grasshopper sparrows is converting cool-season grass hayfields to warm-season grass fields. This conversion would help in reducing early season mowing because of the later harvest dates for these grasses. Fescue and orchardgrass fields are typically cut in May and June - the peak of bird nesting. Native warm season grasses can be cut later in the summer, ranging from late June for switchgrass to late July for indiangrass and big bluestem (Capel 1998). Changing from cool-season grasses to warm-season grasses does not ensure that all nests would escape mowing, but it would dramatically improve the chances of a pair raising at least one successful nest. Another benefit of native warm season grasses is that they grow in clumps, which provides a lot of bare ground in between the grass. Grassland birds, especially juveniles not able to fly, are provided with overhead cover and open ground for foraging. Barnes et al. (1995) suggested that the dense structural characteristics of fescue limited northern bobwhites access to arthropods and seeds.

Mean clutch size for grasshopper sparrows at Fort Campbell (4.5 ± 0.10) was similar to the range-wide average of 4.30 ± 0.03 (n=438; McNair 1987). In Missouri, grasshopper sparrows had a mean clutch size of 3.7 ± 0.09 (n=23; Winter 1998). In the Tallgrass Prairie region, Oklahoma sparrow populations had a mean clutch size of 4.2 ± 0.07 (n=92; Vickery 1996). The Florida sub-species has an average clutch size of 3.71± 0.06 (n=51; McNair 1986).

The drought and high daytime temperatures may have caused a low hatching rate of 67.7% in 1999. The hatching rate of 95.5% was much greater in 2000 during more moderate weather conditions. High temperatures in 1999 also may have increased grasshopper sparrow incubation survival (76%) and lowered nestling survival (55%) as nests in 2000 had reversed numbers of overall lower incubation survival (50%) and higher nestling survival (77%). The mean temperature for the Southeast during the three-month period June through August, 1999 was 25.89° C, well above the 1961-1990 historical mean temperature of 25.28° ± 0.06 C (NOAA/National Climatic Data Center 1999).

Judging from the numbers of snakes seen in the fields at Fort Campbell, I believe that snakes were the main nest predators. Snakes leave little if any evidence at predated nests, which complicates estimation of predation rates (Ettel 1998). Research using video cameras documented black rat snakes (*Elaphe obsoleta*) as a major predator of field sparrows and indigo buntings in old fields in Missouri (Thompson et al. 1999). Other research using video cameras to monitor grassland bird nests in North Dakota have documented such predators as skunks, mice, weasels, and even deer on grassland birds (Pietz and Granfors 1999).

Ground-nesting grassland birds suffer greater predation rates than off-ground-nesting species (Martin 1993), ranging from 25-55% (Wiens 1968, Vickery et al. 1992, Martin 1995). Predation rates on grasshopper sparrows are typically greater than 50% (Vickery 1996). Winter (1998) had 8 out of 23 grasshopper sparrow nests depredated (34.8%). However, I found very low nest predation for both years, 16.7% in 1999 and 20.0% in 2000. I suspect several reasons, or a combination of reasons, account for the lower predation rates. Because I suspect snakes are the main predators on grasshopper sparrow nests, I believe the reduced cover characteristic of grasshopper nest sites may deter snakes from using these open areas. Mowing reduces the vegetation height and doesn't leave much cover for protection making snakes more vulnerable to predators. Many snakes were observed in unmowed fields, yet very few were seen in the mowed fields. Increased human activity from military exercises or mowing operations may decrease predators in the hayfields, as well. Large, open fields have been cited as reducing predators and therefore increasing nest success (Winter 1999). Field edges, on the other hand, contain greater species diversity, which attracts predators (Yahner 1988). A positive correlation between fledging success and distance from edge was documented in both field and forest birds in Michigan (Gates and Gysel 1978). Mammalian predators tend to avoid large, open fields for hunting. Training exercises occur frequently at night, and on the larger drop zones, at Fort Campbell. This nighttime activity may also help in reducing predators in the Suckchon DZ. Although number of re-nest attempts at Fort Campbell are unknown, evidence of double brooding, and possibly triple for some birds, may help in compensating for nest predation.

Other major nest predators on the study site included raccoon (*Procyon lotor*), foxes (*Vulpes* spp.), feral cats (*Felis silvestrus*), and coyotes (*Canis latrans*). Coyotes were seen occasionally during the day on the Suckchon DZ, but were not thought to be a major nest predator. Skunks should not have been a problem to these nests, because populations are very low in the rear area of the post (A. Leonard, pers. comm.).

Brown-headed cowbird parasitism rates on grasshopper sparrows were low in this study, 1.9% for both years. This is consistent with other grassland bird studies in the East showing that parasitism does not appear to have a major impact on grasshopper sparrows (Vickery 1996). Grasshopper sparrows are less affected by brood parasitism than other grassland birds and appear to be more affected in the Central Plains than in the East. Most researchers believe the parasitism rate for grasshopper sparrow nests is low because cowbirds are deterred by the well-hidden nest placement. Smith (1968) considered the number of nests parasitised to be low. Only 4% of nests (n=318) in Illinois were parasitized (Peer et al. 2000). No grasshopper sparrow nests in Maine were parasitized by cowbirds during a 3-year study (Vickery et al. 1992c). The Florida sub-species has not been parasitized by brown-headed cowbirds because the Florida sub-species is generally south of the brown-headed cowbird breeding range.

Parasitism rates in the Tallgrass Prairie region were generally higher. Grasshopper sparrows in Oklahoma had a 7.4% parasitism rate out of 121 nests (Vickery 1996). In Kansas, parasitism rates ranged from 22.2% of 18 nests (Hill 1976) to 50% of 14 nests (Elliot 1977). However, Winter (1998) had no nests parasitized out of 24 in Missouri.

Mowing appears to be both beneficial and detrimental to sparrows; preferred short grass habitat is created yet nesting success can be decreased. I documented 4 nests that were mowed during the 2000 field season. Two nests were consumed by the mowing but two nests survived. One of these nests failed soon afterwards as it was abandoned (nest was totally exposed). The other nest fledged only one young from a clutch of 3. Loss of cover appeared to increase stress on the young because of exposure to the elements.

Smith (1963) noted that nests surviving mowing suffered greater predation and parasitism. Alsop (1979) believed that loss of nests mowed between May and July was a contributing factor to the decline of grasshopper sparrows in Tennessee. Alsop's observations were based on sparrows nesting in airfields that are mowed more frequently and at shorter heights than agricultural hay fields. Deferred mowing increased grasshopper sparrow populations at airports in Massachusetts (Melvin 1994).

Grasshopper sparrows need disturbance to maintain quality breeding habitat. Areas occupied in the Suckchon DZ were disturbed. Points burned in 1999 had grasshopper sparrows singing in both 1999 and 2000. Smith (1968) noticed that grasshopper sparrows preferred recently burned-over areas with sparse cover and bare ground. Grasshopper sparrows in Florida preferred fields that were burned less than 1 year ago and avoided areas that were greater than 2 years post burn (Walsh et al. 1995). Mowing, grazing, and burning have all been used as management techniques for this species.

Nests were located in larger fields than random sites. All but 2 of the 54 nests were found in the largest field – Suckchon DZ. The other 2 nests were found in Bastogne DZ (203 ha), another large DZ consisting mostly of fescue.

Nest sites contained a significantly lower percentage of forbs in 1999, 2000, and pooled models. The percent of forbs ranged from almost 12% in 1999 to 20% in 2000. Our mean forbs percentage in 1999 was a lot lower than other studies in similar habitat, but drought conditions were probably responsible for the decreased amount. Wiens (1969) and Whitmore (1981) found 23% and 25% forbs cover, respectively, for grasshopper sparrow nesting territories.

Litter depth has been shown to be significantly lower inside territories in other studies (Wiens 1969, Whitmore 1981), but wasn't significant in our analysis. Winter (1998) also found inconsistent results with litter depth for grasshopper sparrows. Legume cover was significantly greater at nest sites than random sites in 1999. This is in contrast to Johnson and Schwartz (1993) who found a negative correlation between grasshopper sparrow abundance and percent legume cover. In the hayfields, where approximately half our nests were found, a lot of clover (*Trifolium* spp.) was present which probably was the basis for this relationship.

Male grasshopper sparrows at Fort Campbell set up territories in large, short grass fields. Leased hayfields were used extensively by grasshopper sparrows because of their shorter grass height. Some of the leased fields were not cut for hay in 1999 because of cancelled contracts. Effects of the drought on the vegetation may have reduced grass height overall.

A review of the literature found very similar results in other studies. Grasshopper sparrow abundance was found to be negatively correlated with mean grass height and positively correlated with percent grass cover (Herkert 1994a). Johnston and Odum (1956), in Geogia, and McNair (1984), in North Carolina, documented almost no woody vegetation in grasshopper sparrow territories. Grasshopper sparrows were not located in areas with ≥ 35% tree or shrub cover (Johnson and Odum 1956, Bent 1968).

Grasshopper sparrows have generally been found in open, treeless habitats with low, sparse vegetation, especially grass-dominated habitats (Smith 1963, Cody 1968, Wiens 1973, Shugart and James 1973, Whitmore 1979, and Sample 1989). Several researchers have noted a preference for sites with more bare ground (Smith 1963, Wiens 1969, Whitmore 1979, 1981).

In comparing vegetation structure inside and outside of territories, Wiens (1969) found forbs density, forbs height, vegetation density, and litter depth were significantly greater outside of territories. In contrast, I found litter depth to be a little higher within territories, but not significant. Whitmore (1981) reported lower percent grass, forbs, and shrub cover and vegetation height. Our results were consistent with Whitmore's, but our forbs percents were about the same within and outside of territories. A large proportion of males were singing from forb perches in the middle of these hayfields or from forbs or woody perches in the NWSG fields.

Smith (1963) found male song perches usually greater than 50 m from nest. However, the average distance from perch to nest at Fort Campbell was 26.2 m.

## Conclusions

The BBS has documented a severe decline in grasshopper sparrow populations over the last 30 years. Density estimates have been helpful in showing this trend across North America, however, grassland bird densities can shift dramatically between and also within years (Bent 1968). Life history data, especially demographic data, are needed from different geographic areas to document local population trends. Other forces such as fragmentation effects may differ across regions (Villard and Maurer 1996). This research has provided baseline productivity data for Fort Campbell and the barrens region for use in providing information for management of the grasshopper sparrow.

Although this study has provided some baseline information on this species for southeastern grasshopper sparrow populations, more research is needed. Nesting success estimates appear to indicate there is not a problem in that area, however hayfields may still be acting as sinks for these birds if juvenile survival is low. Grasshopper sparrows are not able to fly immediately after fledging, so juvenile survival data is needed to see if they are doing well in hayfields after leaving the nest. Additional demographic data is needed to estimate mortality, juvenile survival, site fidelity, and adult return rates.

Based on our data and the literature, it appears that grasshopper sparrows need some form of regular disturbance on these large fields to provide suitable habitat. However, disturbance during the breeding season, such as mowing or military exercises, should be kept to a minimum to avoid nest destruction.

Grasshopper sparrows prefer shorter grass fields, so hayfields are getting used more than non-hayfields. Depending on mowing cycles (minimum of 25 days to raise brood) use of hayfields may be a prime reason the grasshopper sparrows have been declining at such an alarming rate, especially in the East. Because area appears to be an important feature in their habitat requirements, one step that can be taken in managing these birds is to increase field size. Smaller or medium size fields could be increased around the edges by reducing the woody vegetation and initiating a regular burning rotation for that area. Another management option would be to convert large drop zones to native warm season grasses. NWSG's have a later mowing date than cool season grasses like fescue. Mowing fields later in the summer would likely decrease nest mortality and increase productivity. Providing a regular burning rotation on the larger fields (see Chapter 5) will help to keep vegetation in early succession and provide lower grass height and conditions preferred by grasshopper sparrows. Burning to reduce grass height and woody vegetation is also economically efficient. Increasing field size for grasshopper sparrows is compatible with the military objective of providing large, open fields for airborne and artillery training.

# CHAPTER 5

# DISTRIBUTION OF GRASSLAND BIRD SPECIES BASED ON POINT COUNT ANALYSIS COMPARING FIELD BURN AGE AND FRAGMENT SIZE

Grassland birds have declined dramatically over the last 30 years in North America, based on Breeding Bird Survey (BBS) data (Peterjohn and Sauer 1999). Of all the bird groups, grassland birds exhibited the greatest percentage of species (76%) that were decreasing. Grassland bird populations in the eastern United States have been declining at an even more alarming rate than populations in the mid-West (Askins 1999). Based on BBS data, 14 out of 19 species of eastern grassland birds have declined significantly since 1966 (Askins 1999).

Most researchers have attributed grassland bird population declines to loss and degradation of habitat. Greater than 98% of the tall-grass prairie has been lost east of the Missouri River (Noss et al. 1995). More than 99.9% of native grasslands have been lost in Tennessee and Kentucky (Mengel 1965, Larkin 1997). Loss of this magnitude has reduced the remaining eastern grasslands to an imperiled ecosystem.

Urbanization and agricultural practices have reduced or converted much of the native grasslands to inferior or unsuitable habitat. Non-native, cool-season grasses, such as tall fescue, have replaced most of the native grasses. In North America, native prairie grasslands historically covered approximately 3.6 million $km^2$ (Ryan 1986). Now, between 12-14 million ha of fescue have been planted in the central and south-central United States for livestock forage, erosion control, Conservation Reserve Program (CRP) grasslands, and strip mine reclamation (Barnes et al. 1995). The wildlife benefits of fescue have been questioned by biologists, especially in connection with northern bobwhites (Stoddard 1931, Brennan 1991, Barnes et al. 1995).

Degradation of remaining grasslands has resulted primarily from improper management, suppression of natural disturbance events, and encroachment of woody and exotic vegetation (Johnson and Igl 2001). Fragmentation and isolation of grassland patches have also been cited contributing to poorer quality grasslands and reduced nesting success in grassland birds (Johnson and Temple 1990, Winter and Faaborg 1999).

Some southeastern state wildlife agencies, like Tennessee Wildlife Resources Agency, have promoted restoring native warm season grasses (NWSG) on public and private land to augment habitat for grassland birds. NWSG fields need to be managed to keep them intact. Prescribed burning has been frequently used as a tool for managing NWSG's and controlling succession in grasslands. Regular burning helps reduce woody growth and litter depth, thereby stimulating new growth of grasses and rejuvenating grassland ecosystems.

However, little research has been done on grassland breeding bird response to burning (Skinner 1975, Risser et al. 1981) and even less research on effects of burning within different patch sizes (Herkert 1994b, Swengel 1996, Winter 1998). Avian species response to burning has not been adequately documented in the East. Land managers need data concerning the effects of burning on birds to better manage remaining grassland habitats.

Because of the severe lack of eastern native grasslands, grasslands available for research on declining grassland bird populations are limited. Many military installations, however, contain large blocks of relatively undisturbed land set aside for training purposes. Some of these installations harbor significant amounts of grassland habitat available for wildlife. Fort Campbell Military Reservation, for example, contains one of the largest blocks of native grasslands in the eastern United States.

The grasslands of Fort Campbell provide some of the best habitat in the region for management of grassland birds. These grasslands are burned on a rotational basis every 1-3 years to allow better access and visibility for military training exercises. However, it is unknown what effect these burns have on the distribution or reproductive success of grassland birds. Research is needed to determine the best burning regime that would support and improve training areas and sustain populations of these species.

While demographic data provide important information related to habitat quality (Van Horne 1983), point count data can document distributional trends at a landscape level. Point count data was used to determine grassland bird distribution and to determine whether distributions at Fort Campbell are related to field size and the current burning rotations. Some declining species like indigo bunting, yellow-breasted chat, and field sparrow are still abundant on Fort Campbell and have not been studied in response to different burning rotations and fragment size in the eastern grasslands.

The objective of this chapter is to compare the richness and abundance of grassland bird species in fields of different size and time since last burned at Fort Campbell Military Reservation. Individual species analysis on the more abundant birds will be used to identify key habitat parameters necessary for management.

## Methods

Point Counts

I censused 30 selected fields, during the 1999 and 2000 breeding seasons, between May 15 and June 15 and then again between June 16 and July 15 using 50-m fixed-radius point counts (Hamel et al. 1996). A total of 357 points were censused in 1999, and a total of 362 points were censused in 2000. All birds seen or heard within 10 minutes were recorded into the following 4 categories: 0 to 50 m, 50 m or greater, flyovers, or walk-ins. Counts were conducted between 5:00 and 10:00 am CDT for the 2 count periods (Hamel 1996). Time of detection, during the count, was also tallied in 0-3, 4-5, or 6-10 minute columns. Counts were not conducted during heavy fog, rain, or wind speeds more than 20 km/hr. Several counts during the season were interrupted and postponed because of artillery fire.

Points were systematically placed at least 200 m apart in a given field. The number of points per field depended on size of field; points ranged from 2 in the smaller fields (5 ha) to 11 points in the larger fields (545 ha). All points were located at least 50 m from any edge to minimize counting of forest bird species. A technician and I conducted the counts during each field season; the same surveyor sampled the same points consistently within years. Different technicians were used for the point counts between years; I sampled the same points both years.

Each survey point was marked with flagging in both years and coordinates were recorded with a Global Positioning System (GPS) in 1999 for relocation in 2000. Some points were excluded from analysis, from both years, because of disturbed vegetation within the point count radius caused by accidental burning, military activity, or creation of new food plots.

Fields were selected from 3 size classes: small (5 to 15 ha), medium (25 to 35 ha), and large (> 50 ha). Fields were also categorized into 3 different burn age classes: 0 (burned in the current year), 1 (burned last year), and 2 (burned year before last).

## Vegetation sampling

Point count stations were characterized by placing a 1-$m^2$ PVC frame directly over the point. Average herbaceous height, average woody height, average grass height, average litter depth, and percent cover were measured. Horizontal cover was broken down into litter, bare ground, woody, dead woody, forbs, and grass categories. Vertical cover was assessed by placing a density board (15 X 15 cm squares; 2 squares wide and 10 high) at the point and counting the number of squares covered in the four cardinal directions 15 m from the board (Nudds 1977). An index of total vertical cover was created by averaging the number of squares covered by vegetation divided by the total squares. I also recorded distance to edge, distance to permanent water, and distance to woody cover.

## Richness, Abundance, and Diversity

Richness, abundance, and diversity were calculated at each point for both 1999 and 2000. Species richness was the total number of identified species at each point and avian abundance was the total number of individuals heard or seen at each point. I calculated diversity based on the Shannon-Weaver index (Peet 1975):

$\mathbf{H' = -[\Sigma\, p_i Log(p_i)]}$, where $p_i$ is the proportion of individuals of the *i*th species. Analysis of variance PROC GLM (SAS 1999) was used to determine differences ($\alpha$ = 0.05) in avian richness, abundance, and diversity among fields of different size and burn categories. A repeated measures model was used to test for year effects and differences in richness, abundance, and diversity between the first and second set of point counts. Only point count data from within 50 m were used in the analysis.

Individual Species Analysis

Point count data for individual species were pooled for both years to obtain an adequate sample size for analysis. I analyzed the point count data with logistic regression to determine habitat association ($\alpha$ = 0.05) of individual species based on differences in burn class and field size. Species with greater than 20 total detections, within 50 m of points, including scrub/shrub and forest birds, were used for individual analysis. Analysis was conducted on 20 avian species: American goldfinch, blue-gray gnatcatcher, brown-headed cowbird, blue grosbeak, blue-winged warbler, Carolina wren, common yellowthroat, dickcissel, eastern bluebird, eastern kingbird, eastern towhee, eastern wood-peewee, field sparrow, Henslow's sparrow, indigo bunting, northern bobwhite, northern cardinal, prairie warbler, white-eyed vireo, and yellow-breasted chat. Relationships with habitat variables with $0.05 < P < 0.10$ were deemed marginally significant.

## Results

<u>Point Counts</u>

A total of 714 point counts conducted in 1999 and 2000 resulted in 57 species and 2,986 individuals counted within the 50-m fixed radius plot across all fields. In 1999, 46 bird species were documented at all points and 54 bird species were recorded in 2000. A total of 87 breeding bird species were documented during 1999 and 2000, at unlimited distance from the points (Table 25). Also, a total of 124 avian species were detected over the whole base during the 2 years, including fall, winter, and spring. Non-breeding bird species (n=37) recorded on Fort Campbell (including migrant, wintering, and accidental species) are listed in Table 26.

Indigo bunting, common yellowthroat, field sparrow, and yellow-breasted chat were consistently the most abundant birds on the counts in both years. Other species of interest documented on counts included Bachman's sparrow, Bell's vireo, black-billed cuckoo (> 50 m), bobolink, and lark sparrow. Special concern species which were detected, but not on point counts, included little blue heron (*Egretta caerulea*), Mississippi kite (*Ictinia mississippiensis*), northern harrier (*Circus cyaneus*), scissor-tailed flycatcher (*Tyrannus forficatus*), sedge wren (*Cistothorus platensis*), and upland sandpiper (*Bartramia longicauda*).

Mean richness per point in 1999 was 2.7 species for the first set of counts (15 May – 15 June) and 2.5 species for the second set of counts (16 June – 15 July). The mean abundance per point in 1999 was 3.5 birds on the first counts and 3.3 birds on the second counts. Mean richness in 2000 was 3.4 and 3.7 for the first and second counts, respectively. In 2000, mean abundance per point was 4.8 and 4.9, for the first and second counts, respectively. Shannon-Weaver diversity in 1999 was 0.78 and 0.80 for first and second counts, respectively. In 2000, diversity was 1.02 in the first count and 1.12 in the second count.

Richness, Abundance, and Diversity

Avian richness ($P < 0.0001$), abundance ($P < 0.0001$), and diversity ($P < 0.0001$) differed between years and count periods, therefore years and count periods were not pooled in the results. Mean richness did not differ among burn classes ($P = 0.55$) although richness differed (marginally) among field size classes ($P = 0.088$; Table 27). Richness was greatest in the smallest and largest size-class fields. There was a marginally significant interaction ($P = 0.078$) between burn class and field size class. Richness was greatest in the smallest and largest fields burned one year previously. Richness was lower in 1999 than in 2000 ($P < 0.0001$) and there was a significant interaction between count time period and year ($P = 0.006$; Figure 9). In 1999, richness was less between 16 June and 15 July whereas, in 2000, richness was greater during this time period.

Mean abundance did not differ among burn classes ($P = 0.889$) or field size classes ($P = 0.22$; Table 27). There was a significant interaction, however, between abundance and burn class and field size class ($P = 0.04$). Abundance was greater in the largest fields burned the year before. Abundance was lower in 1999 than in 2000 ($P < 0.0001$). There also was a marginally significant interaction between count time period and year and burn ($P = 0.093$).

Mean Shannon-Weaver diversity did not differ among burn class (P = 0.32) or field size class (P = 0.14; Table 27). Diversity was lower in 1999 than in 2000 (P < 0.0001). There were significant interactions between count period and year (P = 0.004), and between time and field size class (P = 0.04; Figure 10). In 1999, diversity was lower in the second time period, but, in 2000, diversity was greater in the second time period. Diversity was greater in the smaller fields early in the season, yet diversity was greater in the medium and larger fields later in the season.

Individual Species Analysis

Dickcissel (P < 0.0001), Henslow's sparrow (P < 0.0001), and northern bobwhite (P = 0.0286) were all positively associated with larger fields (Table 28). Indigo bunting (P < 0.0001), yellow-breasted chat (P = 0.0029), and prairie warbler (P = 0.0128) were more abundant in smaller fields. The other 14 species analyzed showed no relationship with field size class.

White-eyed vireo (P = 0.0095), prairie warbler (P = 0.0346), blue-gray gnatcatcher (P = 0.0484), and Henslow's sparrow (P = 0.0511) were located in the older burn class fields (Table 29). Field sparrow (P = 0.0008), common yellowthroat (P = 0.0057), American goldfinch (P = 0.0114), eastern kingbird (P = 0.0216), northern cardinal (P = 0.0434), and indigo bunting (P = 0.0660) were more abundant in fields that had been recently burned. The other 10 species analyzed showed no relationship with field burn class.

**Discussion**

Mean richness and abundance per point was similar (3.08 and 4.13, respectively) to other grassland bird studies. Our means were lower than what Larkin (1997) found on point counts at Fort Campbell in 1996 and 1997; richness was 4.67 (n=9) and mean abundance was 3.83 in May, 1997, while richness fell to 4.11 and abundance dropped to 3.67 in June, 1997. Breeding bird species diversity is typically lower in grassland habitats than in forested landscapes. Mean number of non-game breeding birds was 4.1, 4.7, and 4.3 in tall-grass, mixed, and short-grass prairies, respectively (Wiens and Dyer 1975).

Avian diversity and density is generally low in grasslands compared to other habitats (Risser et al. 1981, Cody 1985). Southeastern grasslands have the lowest bird species richness while the Great Plains have the greatest. Cody (1985) reported that 2-6 passerine species was average per census site with homogenous vegetation. Eastern deciduous forests, on the other hand, generally accommodate 10-30 breeding bird species (Kendeigh 1946, Probst 1979). For comparison, point counts conducted in Cherokee National Forest averaged 4 species per point (Buehler 2000).

Avian richness per point was greatest in the smallest and largest fields. Other researchers, however, have reported that avian richness increases directly in relation to area in native grasslands [e.g. Ryan (1986), Herkert (1994a), Winter (1998)]. It is important to note that these studies were reporting the total number of species observed within grasslands of various sizes. My analysis looked at richness per point count station and did not attempt to compile a total species list for each field monitored because intensity of sampling differed among fields of different size classes. Because of this difference in approach, comparison of results among these various studies is difficult.

Point count analysis showed that Henslow's sparrows, dickcissels, and northern bobwhite were more abundant in larger fields. Grasshopper sparrows and eastern meadowlarks did not have enough detections to allow for statistical analysis, but seemed to prefer larger fields too. Herkert (1994a) also found that grasshopper sparrows, Henslow's sparrows, bobolinks, savannah sparrows, and eastern meadowlarks were positively related to field size. Grassland area accounted for 84% of the variation in mean species richness (Herkert 1994a). Winter (1998) also found fragment size to be the most important factor in predicting species richness in Missouri (positive relationship). Winter, however, found that density of the 4 most common species (Henslow's sparrow, dickcissel, grasshopper sparrow, and eastern meadowlark) was explained more by vegetation characteristics than by fragment size.

Indigo buntings, prairie warblers, and yellow-breasted chats were more numerous in smaller fields at Fort Campbell. These scrub/shrub species, which are some of the more common scrub/shrub species on Fort Campbell, probably prefer smaller fields because of the increased amount of edge associated with these fields. Field edges generally provide a transition between grasslands and forest creating habitat for shrub/scrub species. Because the prairies in the Central Plains have less woody vegetation, scrub/shrub species probably do not occur there in the same densities as they do in the Southeast.

Indigo buntings are one of the most abundant breeding birds in Tennessee and

Kentucky (Nicholson 1997, Palmer-Ball 1997). Indigo buntings use a variety of habitats, including small openings in mature forests (Nicholson 1997). Our analyses shows that indigo buntings avoid cool-season grass fields at Fort Campbell, similar to what Cooper (1997) and Larkin (1997) found. These cool-season grass (primarily fescue) fields were larger agricultural fields (> 160 ha) used for hay crops. Indigo buntings also were more abundant in recently burned areas, which is consistent with their proclivity for open areas with dense, low vegetation (Taber and Johnston 1968).

Yellow-breasted chats are also associated with brushy clearings across Tennessee and Kentucky (Mengel 1965, Nicholson 1997). Historically, chats were probably more abundant in the cedar glades and barrens region where burning occurred on a regular basis. Chats used shrub islands, missed by burning, in the middle of these smaller fields, as well as edges of fields.

Some studies have documented a decline in avian abundance from one to several years following a fire, followed by population recovery (Forde et al. 1984, Huber and Steuter 1984, Pylypec 1991), whereas others have shown increases in abundance 2-3 years post-burning (Peterson and Best 1987). In my study, 6 species were more abundant on recently burned fields while 4 species were more abundant on older burned fields. These differences in abundance apparently balanced out such that total abundance across all species was similar among burn classes.

Blue-gray gnatcatcher, Henslow's sparrow, prairie warbler, and white-eyed vireo were associated with older burned fields. Gnatcatchers are habitat generalists and are therefore found in a wide variety of habitats, including field edges, their preferred nesting habitat in Tennessee (Nicholson 1997). Two gnatcatcher nests were documented on field edges of the study plots. Henslow's sparrows were rarely detected in newly burned fields (see Chapter 3), and used older (≥ 1 year old) burned fields with greater frequency. The other two species (prairie warbler and white-eyed vireo) are considered shrub/second-growth species in Tennessee, generally preferring fields with small, scattered shrubs and trees (Nicholson 1997), consistent with older burned fields.

Two other grassland bird species observed at Fort Campbell, which typically have a negative response to burning, were northern bobwhite and sedge wren. Bobwhites were detected across all burn class fields, including newly burned fields. Quail nests in western Tennessee were found primarily in older burned fields, and were built of dead grass and leaves (Dimmick 1972). Stoddard (1939) found that 91% of 581 quail nests were built in areas that had not been burned the spring immediately preceding the nesting season. Sedge wrens were documented using the denser, older-burned fields on Fort Campbell during migration.

American goldfinch, common yellowthroat, eastern kingbird, field sparrow, indigo bunting, and northern cardinal were more abundant on younger burned fields. Goldfinches and kingbirds appeared to be using the newly burned fields primarily for foraging. Goldfinches use early successional fields heavily to forage for seeds, especially asters (Nicholson 1997), while kingbirds "hawk" and glean insects from recently burned areas in Tennessee (Nicholson 1997).

While other studies have found field sparrows (Walkinshaw 1968, Best 1978) and common yellowthroats (Herkert 1994b, Madden et al. 1999) to be more abundant in older fields, I found them to be more abundant in newly burned fields. Vickery et al. (1999) found field sparrow densities increased with time since last burn too. Common yellowthroats, field sparrows, and indigo buntings were using woody patches in the grass fields to nest, which contained taller and thicker forbs. However, I found all of these species nesting in older burned fields, as well, consistent with their typical nesting habitat (Sample and Mossman 1997). Greater detectability in open, burned fields may have increased sightings and influenced the analysis.

Other grassland birds which favor recently burned fields, based on the literature, include grasshopper sparrow and horned lark. These species were not included in the analysis because of insufficient detection during point counts.

Field size showed a much greater influence on grassland bird communities than burning in Illinois (Herkert 1994b). Two of 15 species (Henslow's sparrow and grasshopper sparrow) demonstrated a significant response (negative and positive, respectively) to burning when burning and field size were analyzed together. Ten species were influenced by field size alone. Relative abundance analysis revealed Henslow's sparrow preferred unburned areas and bobolink preferred recently burned areas. Seven of 11 species had their greatest densities on areas in their first growing season after a fire, consistent with our results.

In northwestern North Dakota, Madden et al. (1999) found that total species richness was greatest in grasslands that were burned on a frequent, regular basis and lowest in unburned areas. In the first long-term study of fire effects on birds, Madden et al. (1999) suggested that most grassland bird species were absent from prairies unburned for long periods.  Six of 9 grassland bird species [Baird's sparrow (*Ammodramus bairdii*), bobolink, grasshopper sparrow, Le Conte's sparrow (*Passerherbulus caudacutus*), Sprague's pipit (*Anthus spragueii*), and western meadowlark] were absent from unburned study sites.  Madden et al. (1999) pointed out that most of the other burning studies include "non-prairie" species in their richness, because of woody vegetation in the plots, which inflated richness.  This point applies to Fort Campbell, because the barrens contain a high percentage of woody vegetation, either on the edges or as shrub/tree islands in the grasslands.

I documented differences in avian richness and abundance between time and year, for several possible reasons.  Drought and above average temperatures may have caused richness and abundance to decrease between counts in 1999.  Vegetation was affected by drought conditions and may have changed bird habitat dynamics.  I observed that grasses and forbs decayed early in the summer of 1999 allowing nests to be more exposed.  As the breeding season progressed, some birds may have abandoned the area in search of better nesting habitat.  George et al. (1992) found that severe drought lowered nesting success and densities of breeding grassland birds.

In contrast to 1999, richness and abundance both increased between the first and second counts of 2000.  An increased number of birds in the latter part of the season may reflect the addition of juveniles.  Also, forest birds and their young have been documented moving into grasslands later in the season.

# CHAPTER 6

# MANAGEMENT RECOMMENDATIONS

Past management of Fort Campbell grasslands has provided important habitat for a diverse array of grassland wildlife species while at the same time has met the military requirements for training. Fort Campbell land managers are to be commended for maintaining it as one of the most important grassland areas in the eastern U.S. As with all management strategies, there is room for improvement. With the completion of this research project, several key issues and recommendations have emerged as means to improve lands for wildlife habitat and military training.

**1) Woody encroachment in grasslands.**

Woody encroachment decreases the value of grasslands for wildlife species of management concern (e.g., Henslow's sparrow) and also compromises the value of these areas for military training. Burning effectiveness needs to be increased to get better control of woody vegetation. Fort Campbell should consider experimental late growing season burns (August) or hotter dormant season burns to more effectively control woody vegetation. The frequency of burning (3-year cycle) appears to be adequate but the effectiveness of those burns is not.

**2) Field size.**

Many species of management concern occur in greater abundance in the larger fields (e.g. Suckchon DZ, Bastogne DZ). To meet the needs of these area-sensitive species, management for larger fields (>100 ha) is needed. Because Fort Campbell is an air assault division requiring large spaces to land helicopters and practice parachute drops, large fields benefit the training mission as well. To create more large fields, consolidation of smaller fields is required.

**3) Conversion of cool-season grass hayfields to native warm season grasses.**

Existing hayfields are being mowed in May-June during the peak of the nesting season destroying nests, nestlings, and fledglings. In addition, hayfields in cool season grasses provide poor habitat structure for some species of management concern. Conversion of these hayfields from cool season to warm season grasses would shift the mowing cycle to later in the growing season (July-August) which would allow nesting birds at least one reproductive effort per season without the threat of being destroyed by mowing. These fields could continue to be leased for hay, harvested for seed, and periodically burned as needed for maintenance of the grasslands. Experimental management is needed to determine the most cost-effective means of conversion.

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# Appendix

**Tables**

Table 1. Descriptions of the 30 selected native grassland study sites, Fort Campbell Military Reservation, Kentucky-Tennessee, 1999 and 2000.

| | | Burn Class | | # Pts |
|---|---|---|---|---|
| Field[a] | Size (ha) | 1999 | 2000 | 99/00 |
| 00-1 | 13.9 | 0 | 1 | 3/3 |
| 03-1 | 25.0 | 1 | 2 | 6/5 |
| 05-1 | 26.7 | 2 | 0 | 8/8 |
| 05-2 | 11.9 | 2 | 0 | 5/5 |
| 08-1 | 111.9 | 0 | 1 | 14/9 |
| 17-1 | 47.3 | 0 | 1 | 10/10 |
| 17-2 | 65.2 | 0 | 1 | 10/10 |
| 20-1 | 7.2 | 1 | 2 | 3/3 |
| 20-2[b] | 10.0 | 2 (5 yrs) | 2 (6 yrs) | 4/4 |
| 20-3[b] | 6.9 | 2 (5 yrs) | 2 (6 yrs) | 4/4 |
| 21-1[c] | 565.4 | 0 | 1 | 10/10 |
| 24-1 | 4.8 | 0 | 1 | -/2 |
| 25-1 | 12.0 | 0 | 1 | -/3 |
| 27-1 | 35.9 | 2 | 0 | 10/9 |
| 27-2 | 29.9 | 2 | 0 | 6/6 |
| 27-3 | 6.5 | 2 | 0 | 2/2 |
| 28-1 | 13.5 | 1 | 2 | 5/5 |

Table 1. (Continued)

| Field[a] | Size (ha) | Burn Class 1999 | Burn Class 2000 | # Pts 99/00 |
|---|---|---|---|---|
| 28-2 | 14.7 | 1 | 2 | 4/4 |
| 28-3 | 32.7 | 1 | 2 | 6/6 |
| 30-1 | 9.3 | 0 | 1 | 4/3 |
| 31-1[d] | 34.8 | 0 | 1 | 8/8 |
| 32-1 | 9.5 | 2 | 0 | 4/4 |
| 32-2 | 12.0 | 2 | 0 | 3/3 |
| 32-3 | 11.2 | 2 | 0 | 4/4 |
| 34-1 | 11.3 | 0 | 1 | 4/4 |
| 35-1 | 33.0 | 0 | 1 | 6/6 |
| 41-1 | 61.9 | 1 | 0 | 11/11 |
| 41-2 | 33.9 | 1 | 0 | 10/10 |
| 42-1 | 85.1 | 1 | 0 | 10/10 |
| 43-1 | 105.1 | 1 | 0 | 10/10 |

[a] Field numbers start with Training Area number
[b] Field was excluded from analysis
[c] Points 1, 2, 8, & 10 were burned > 2 years
[d] Points 1-3 burned in 2000

Table 2. Apparent and Mayfield (1961, 1975) nest success estimates of target species in order of abundance on Fort Campbell Military Reservation, Tennessee-Kentucky, May - July, 2000.

| **Species** | **n** | **Apparent** (%) | **Mayfield** (%) |
|---|---|---|---|
| Field sparrow | 87 | 41.4 | 15.4 |
| Henslow's sparrow | 43 | 41.9 | 18.7 |
| Dickcissel | 42 | 45.2 | 26.5 |
| Grasshopper sparrow | 35 | 68.6 | 42.6 |
| Indigo bunting | 32 | 37.5 | 28.3 |
| Prairie warbler | 31 | 58.1 | 36.5 |
| Yellow-breasted chat | 30 | 36.7 | 24.4 |
| Eastern meadowlark | 17 | 29.4 | 12.1 |

Table 3. Description of vegetation measurements used to characterize Henslow's sparrow and grasshopper sparrow male song perches and nest sites, and random points, Fort Campbell Military Reservation, Kentucky-Tennessee, 1999-2000.

| Habitat variable | How Measured | Units |
|---|---|---|
| Average herbaceous height | Average height of the tallest portion of the plants within plot | m |
| Average woody height | Average height of trees, shrubs, or saplings within plot | m |
| Average grass height | Average visual estimate of the height of grass cover excluding seed heads. | m |
| Average litter depth | Average of 4 measurements of litter depth within plot | cm |
| Percent litter cover | Visual estimation of % of plot covered with litter | % cover |
| Percent bare ground | Visual estimation of bare ground within plot | % cover |
| Percent woody | Visual estimation of tree, shrub, and sapling cover within plot | % cover |
| Percent dead woody | Visual estimation of dead woody vegetation within plot | % cover |
| Percent forbs | Visual estimation of forb cover within plot | % cover |
| Percent grasses | Visual estimation of grass cover within plot | % cover |
| Distance to edge | Measured distance from plot to forest, road, or shrub-line using laser range finder | m |

Table 3. (Continued)

| Habitat variable | How Measured | Units |
|---|---|---|
| Distance to woody cover | Measured distance from plot to nearest tree, shrub, or sapling | m |
| Distance to water | Measured distance to nearest water source (intermittent or permanent) | m |
| Distance to military/vehicle disturbance | Measured distance to nearest trackrut ≥ 2.5 cm deep | m |
| Vertical cover | Counted covered squares on density board located 15 m from plot center | % cover |

Table 4. Henslow's sparrows and grasshopper sparrows banded at Fort Campbell Military Reservation, Kentucky-Tennessee, July, 2000.

| | Nestlings | Juveniles | Adults | Male | Female | Total |
|---|---|---|---|---|---|---|
| Henslow's sparrow | 4 | 3 | 38 | 38 | 0 | 45 |
| Grasshopper sparrow | 34 | 0 | 34 | 30 | 4 | 68 |
| Total | | | | | | 113 |

Table 5. Henslow's sparrow detections within 50 m on point counts between 15 May – 15 July, 1999 and 2000 at Fort Campbell Military Reservation, Kentucky-Tennessee.

| | Pts w/ HESP | # HESP | Total Pts | % |
|---|---|---|---|---|
| 1999 | | | | |
| 15 May – 15 June | 17 | 24 | 168 | 10.1 |
| 16 June – 15 July | 7 | 7 | 168 | 4.2 |
| **Total unique** | 20 | | | |
| 2000 | | | | |
| 15 May – 15 June | 19 | 21 | 170 | 11.2 |
| 16 June – 15 July | 9 | 12 | 170 | 5.3 |
| **Total unique** | 24 | | | |
| 1999/2000 | | | | |
| Both periods | 52 | 64 | 338 | 15.4 |
| **Total unique** | 44 | | 338 | 13.0 |

Table 6. Distribution of male Henslow's sparrows by burn class and field size in grasslands on Fort Campbell Military Reservation, Kentucky-Tennessee, based on point count data, May - July, 1999 and 2000.

| **Burn Class** | **Field Size** | | |
|---|---|---|---|
| | Small (10 ha) | Medium (30 ha) | Large (>50 ha) |
| **1999** | | | |
| **0** | 0 | 0 | 0 |
| **1** | 0 | 0 | 25 |
| **2** | 1 | 3 | 2 |
| **2000** | | | |
| **0** | 0 | 0 | 1 |
| **1** | 3 | 10 | 15 |
| **2** | 0 | 0 | 4 |

Table 7. Estimated nest success of Henslow's sparrow in native grassland fields at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 1999 and 2000.

| | 1999 | 2000 | Pooled |
|---|---|---|---|
| Successful nests | 1 | 18 | 19 |
| Unsuccessful nests | 4 | 24 | 28 |
| Unknown fate[1] | 1 | 1 | 2 |
| Total | 6 | 43 | 49 |
| **Nesting success**: | | | |
| Apparent nest success (%) | 20 | 42.9 | 39.6 |
| Mayfield estimate[2] (%) | – | 18.7 ± 0.07 | 16.5 |
| Exposure days | 24.5 | 271.5 | 296.0 |
| Daily survival: | | | |
| Incubation | 1.000 | 0.927 ± 0.02 | 0.932 |
| Nestling | 0.704 | 0.911 ± 0.02 | 0.892 |
| Total | 0.837 | 0.919 | 0.912 |
| Stage survival: | | | |
| Incubation | 1.000 | 0.434 ± 0.11 | 0.463 |
| Nestling | 0.042 | 0.431 ± 0.10 | 0.357 |
| Nesting biology: | | | |
| Clutch size[3] | 3.8 ± 0.17 (6) | 4.3 ± 0.10 (40) | 4.2 ± 0.09 (46) |
| Hatching success (%) | 88.9 (2) | 85.9 (15) | 86.3 (17) |
| Young fledged per nest | 0.8 | 1.6 | 1.5 |
| Young fledged per successful nest | 4.0 | 3.8 | 3.8 |
| Nest parasitized/Total | 0/6 | 1/43 | 1/49 |
| Young fledged per parasitized nest | – | 0 | 0 |

[1] Excluded from analysis
[2] Mayfield (1975); insufficient sample size in 1999 to calculate estimate
[3] Excludes parasitized nests

Table 8. Point count locations where Henslow's sparrow's were present (n=20) and absent (n=148) in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 1999.

| | Occupied | | Unoccupied | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Cool season grass (%) | 5.05 | 4.07 | 1.45 | 0.55 | 0.0455 | 4.3205 | 0.0377 |
| Native warm season grass (%) | 39.55 | 5.96 | 31.49 | 1.88 | 0.0228 | 3.8933 | 0.0485 |
| Burn (yr) | 1.20 | 0.09 | 0.87 | 0.07 | - | 1.9289 | 0.1649 |
| Grass height (m) | 0.45 | 0.03 | 0.39 | 0.02 | - | 0.8575 | 0.3544 |
| Field size (ha) | 97.98 | 35.93 | 72.75 | 10.06 | - | 0.8107 | 0.3679 |
| Litter depth (cm) | 4.95 | 1.36 | 4.33 | 0.60 | - | 0.5252 | 0.4686 |
| Legume (%) | 3.21 | 0.51 | 3.45 | 0.53 | - | 0.1402 | 0.7081 |
| Bare ground (%) | 9.05 | 3.24 | 13.64 | 1.40 | - | 0.0923 | 0.7613 |
| Woody vegetation (%) | 3.95 | 1.52 | 3.62 | 0.63 | - | 0.0644 | 0.7996 |
| Forb (%) | 18.80 | 3.47 | 21.03 | 1.26 | - | 0.0059 | 0.9385 |

Max-rescaled R-Square = 0.0694 Percent Concordant 60.2 Hosmer and Lemeshow goodness-of-fit = 0.7058 correct class. 52% df = 8

Table 9. Point count locations where Henslow's sparrow's were present (n=24) and absent (n=146) in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 2000.

| | Occupied | | Unoccupied | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Field size (ha) | 216.00 | 51.59 | 51.05 | 5.71 | 0.0089 | 23.0053 | <0.0001 |
| Native warm season grass (%) | 27.63 | 4.77 | 19.27 | 1.38 | 0.0546 | 11.5314 | 0.0007 |
| Grass height (m) | 0.52 | 0.03 | 0.46 | 0.01 | 3.9464 | 5.4482 | 0.0196 |
| Bare ground (%) | 8.71 | 1.98 | 13.95 | 1.25 | - | 2.2449 | 0.1341 |
| Woody vegetation (%) | 1.25 | 0.60 | 6.26 | 1.00 | - | 1.5285 | 0.2163 |
| Litter depth (cm) | 6.88 | 1.27 | 4.36 | 0.45 | - | 0.1343 | 0.7140 |
| Forb (%) | 21.17 | 2.15 | 26.15 | 1.25 | - | 0.0768 | 0.7817 |
| Legume (%) | 3.82 | 0.24 | 3.68 | 0.13 | - | 0.0592 | 0.8078 |
| Burn (yr) | 0.92 | 0.12 | 0.58 | 0.06 | - | 0.0492 | 0.8244 |
| Cool season grass (%) | 7.38 | 3.35 | 1.32 | 0.44 | - | 0.0012 | 0.9724 |

Max-rescaled R-Square = 0.3730 Percent Concordant = 83.3 Hosmer and Lemeshow goodness-of-fit = 0.8753 correct class.= 73% df = 8

Table 10. Point count locations (pooled) where Henslow's sparrow's were present (n=44) and absent (n=294) in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 1999 and 2000.

| | Occupied | | Unoccupied | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Field size (ha) | 162.35 | 33.41 | 61.97 | 5.83 | 0.0057 | 25.9200 | <0.0001 |
| Native warm season grass (%) | 33.05 | 3.82 | 25.42 | 1.22 | 0.0350 | 15.4449 | <0.0001 |
| Litter depth (cm) | 3.98 | 0.84 | 2.38 | 0.25 | 1.0197 | 5.7052 | 0.0169 |
| Grass height (m) | 0.49 | 0.02 | 0.43 | 0.01 | 1.8424 | 4.1192 | 0.0424 |
| Burn (yr) | 1.05 | 0.08 | 0.73 | 0.05 | - | 1.8320 | 0.1759 |
| Cool season grass (%) | 6.32 | 2.57 | 1.39 | 0.35 | - | 0.7149 | 0.3978 |
| Woody vegetation (%) | 2.48 | 0.78 | 4.93 | 0.59 | - | 0.5801 | 0.4463 |
| Forb (%) | 20.09 | 1.95 | 23.57 | 0.90 | - | 0.2961 | 0.5863 |
| Bare ground (%) | 8.86 | 1.80 | 13.79 | 0.94 | - | 0.0815 | 0.7753 |
| Legume (%) | 3.53 | 0.13 | 3.64 | 0.07 | - | 0.0028 | 0.9577 |

Max-rescaled R-Square = 0.2114 Percent Concordant = 76.0 Hosmer and Lemeshow goodness-of-fit = 0.7954 correct class.= 65% df 8

Table 11. Habitat measurements of Henslow's sparrow perch sites (n=34) and unoccupied locations (n=168) in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 1999.

| | Perch site | | Unoccupied | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Field size (ha) | 355.61 | 43.67 | 76.00 | 9.87 | 0.0061 | 23.2032 | <0.0001 |
| Woody vegetation (%) | 25.38 | 6.17 | 3.68 | 0.59 | 0.0733 | 18.3665 | <0.0001 |
| Litter depth (cm) | 4.29 | 0.51 | 4.43 | 0.60 | - | 1.7382 | 0.1874 |
| Forb (%) | 32.65 | 3.69 | 27.56 | 1.45 | - | 1.0719 | 0.3005 |
| Cool season grass (%) | 9.47 | 2.93 | 1.89 | 0.69 | - | 1.0009 | 0.3171 |
| Native warm season grass (%) | 20.24 | 3.67 | 34.36 | 1.72 | - | 0.7730 | 0.3793 |
| Legume (%) | 5.12 | 1.90 | 3.44 | 0.53 | - | 0.4646 | 0.4955 |
| Burn (yr) | 1.21 | 0.14 | 0.96 | 0.06 | - | 0.1868 | 0.6656 |
| Grass height (m) | 0.45 | 0.04 | 0.40 | 0.02 | - | 0.1755 | 0.6753 |
| Bare ground (%) | 6.65 | 1.83 | 13.17 | 1.30 | - | 0.0627 | 0.8023 |

Max-rescaled R-Square = 0.4709 Percent Concordant = 84.7 Hosmer and Lemeshow goodness-of-fit = 0.3468 correct class. 81% df = 8

Table 12. Habitat measurements of Henslow's sparrow perch sites (n=30) and unoccupied locations (n=170) in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 2000.

| | Perch site | | Unoccupied | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Woody vegetation (%) | 36.67 | 6.06 | 5.55 | 0.87 | 0.0902 | 24.5651 | <0.0001 |
| Field size (ha) | 197.78 | 44.75 | 74.33 | 9.73 | 0.0057 | 18.6111 | <0.0001 |
| Legume (%) | 0.30 | 0.19 | 2.76 | 0.38 | -0.5347 | 4.9928 | 0.0255 |
| Burn (yr) | 1.07 | 0.05 | 0.67 | 0.06 | - | 3.4100 | 0.0648 |
| Native warm season grass (%) | 11.10 | 2.79 | 21.26 | 1.37 | - | 0.7312 | 0.3925 |
| Grass height (m) | 0.50 | 0.03 | 0.47 | 0.01 | - | 0.4908 | 0.4836 |
| Bare ground (%) | 9.63 | 1.98 | 13.21 | 1.11 | - | 0.3381 | 0.5609 |
| Litter depth (cm) | 8.90 | 1.06 | 4.71 | 0.43 | - | 0.1089 | 0.7414 |
| Cool season grass (%) | 8.90 | 3.64 | 2.18 | 0.62 | - | 0.0772 | 0.7811 |
| Forb (%) | 28.90 | 2.88 | 34.91 | 1.38 | - | 0.0246 | 0.8754 |

Max-rescaled R-Square = 0.5894 Percent Concordant = 91.9 Hosmer and Lemeshow goodness-of-fit = 0.4013 correct class. = 89% df = 8

Table 13. Henslow's sparrow nest sites (n=40) and unoccupied locations (n=170) in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 2000.

| | Occupied | | Unoccupied | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Burn (yr) | 1.18 | 0.06 | 0.69 | 0.06 | 1.6656 | 16.8883 | <0.0001 |
| Native warm season grass (%) | 35.75 | 2.25 | 21.26 | 1.37 | 0.0487 | 13.2189 | 0.0003 |
| Field size (ha) | 225.19 | 40.02 | 74.33 | 9.73 | 0.0040 | 10.6489 | 0.0011 |
| Litter depth (cm) | 3.85 | 0.71 | 4.71 | 0.43 | -0.2035 | 10.4794 | 0.0012 |
| Cool season grass (%) | 1.55 | 0.78 | 2.18 | 0.62 | - | 2.4625 | 0.1166 |
| Bare ground (%) | 15.30 | 1.62 | 13.21 | 1.11 | - | 1.4063 | 0.2357 |
| Legume (%) | 0.78 | 0.32 | 2.76 | 0.38 | - | 0.7773 | 0.3780 |
| Forb (%) | 29.03 | 1.89 | 34.91 | 1.38 | - | 0.4949 | 0.4818 |
| Grass height (m) | 0.45 | 0.02 | 0.47 | 0.01 | - | 0.0920 | 0.7616 |
| Woody vegetation (%) | 2.08 | 0.71 | 5.55 | 0.87 | - | 0.0756 | 0.7833 |

Max-rescaled R-Square = 0.4162 Percent Concordant = 88.7 Hosmer and Lemeshow goodness-of-fit = 0.1568 correct class. = 78% df = 8

Table 14. Henslow's sparrow nest measurements of successful (n=18) and unsuccessful (n=22) nests in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 2000.

| | Successful | | Unsuccessful | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Native warm season grass (%) | 42.39 | 3.20 | 30.32 | 2.69 | 0.1013 | 6.9106 | 0.0086 |
| Litter depth (cm) | 5.55 | 1.46 | 2.45 | 0.31 | 0.5496 | 5.1272 | 0.0236 |
| Field size (ha) | 274.67 | 63.15 | 184.71 | 50.93 | - | 1.1757 | 0.2782 |
| Grass height (m) | 0.45 | 0.04 | 0.45 | 0.02 | - | 0.7064 | 0.4006 |
| Legume (%) | 0.33 | 0.20 | 1.14 | 0.56 | - | 0.6912 | 0.4057 |
| Woody vegetation (%) | 0.67 | 0.46 | 3.23 | 1.18 | - | 0.6717 | 0.4125 |
| Bare ground (%) | 13.06 | 2.52 | 17.14 | 2.07 | - | 0.6703 | 0.4129 |
| Forb (%) | 27.33 | 2.64 | 30.41 | 2.69 | - | 0.0637 | 0.8007 |
| Cool season grass (%) | 1.22 | 1.11 | 1.82 | 1.12 | - | 0.0146 | 0.9038 |
| Burn (yr) | 1.28 | 0.11 | 1.09 | 0.06 | - | 0.0022 | 0.9629 |

Max-rescaled R-Square = 0.4787 Percent Concordant = 83.8 Hosmer and Lemeshow goodness-of-fit = 0.3756 correct class. = 74% df = 8

Table 15. Parameter estimates from other Henslow's sparrow nesting studies.

| Location | n[1] | Clutch[2] | Hatch[3] | Parasitized | Yg/succ[4] | Apparent | Mayfield | Reference |
|---|---|---|---|---|---|---|---|---|
| Michigan | 18(NA) | - | - | - | - | - | - | Hyde (1939) |
| Michigan | 11(6) | 4.2 | - | 0.0% | 2.8 | 54.5% | - | Robins (1971) |
| Missouri | 16(3) | - | - | - | - | 19.0% | 6.5% | McCoy (unpublished) |
| Indiana | 14(10) | 4.5 | - | 0.0% | 4.0 | 71.4% | 28.7% | Robb et al. (1998) |
| Missouri | 59(34) | 3.8 | 93.2% | 5.3% | 3.5 | 57.6% | 39.5% | Winter (1999) |
| Oklahoma | 22(10) | - | - | 8.0% | 3.3 | 45.0% | 29.0% | Reinking et al. (In press) |
| Kentucky | 31(23) | 3.5 | - | 3.2% | - | 74.2% | - | Monroe and Ritchison (unpublished) |
| Tennessee | 43(18) | 4.2 | 86.3% | 2.0% | 3.8 | 39.6% | 18.7%[5] | This study |

[1] n=number of nests (number of successful nests)
[2] North American nest cards = 3.9
[3] Hatching success
[4] Young fledged per successful nest
[5] Based on 40 nests from 2000 field season

Table 16. Mean habitat parameters (pooled) compared by burn class at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 1999 and 2000.

| | Years since prescribed burn | | |
|---|---|---|---|
| | **0** (n=147) | **1** (n=121) | **2** (n=70) |
| Habitat Parameter | Mean (SE) | Mean (SE) | Mean (SE) |
| Grass height (m) | 0.43 ± 0.017 | 0.45 ± 0.018 | 0.45 ± 0.022 |
| Woody cover (%) | 5.88 ± 1.015 | 3.25 ± 0.616 | 4.31 ± 0.876 |
| **Litter depth (cm)*** | **1.21 ± 0.143** | **2.95 ± 0.396** | **4.84 ± 0.867** |
| Bare ground (%) | 18.51 ± 1.407 | 11.26 ± 1.171 | 5.16 ± 1.510 |
| **Native warm season grass (%)** | **24.50 ± 1.497** | **29.82 ± 1.945** | **31.61 ± 3.072** |
| Legume (%) | 4.95 ± 0.655 | 1.83 ± 0.288 | 1.44 ± 0.360 |
| Forb (%) | 33.90 ± 1.535 | 35.26 ± 1.970 | 32.97 ± 2.477 |
| Cool season grass (%) | 1.67 ± 0.538 | 1.01 ± 0.347 | 4.56 ± 1.804 |
| Woody height (m) | 0.23 ± 0.026 | 0.19 ± 0.025 | 0.28 ± 0.044 |
| **Litter cover (%)** | **2.99 ± 0.412** | **7.20 ± 0.727** | **9.77 ± 1.183** |

* Habitat parameters increasing with time since last burn

Table 17. Species and numbers of nests found on Fort Campbell Military Reservation, Tennessee-Kentucky, May - July, 1999 and 2000.

| **Species** | **1999** | **2000** |
|---|---|---|
| Field sparrow | 27 | 87 |
| Dickcissel | 14 | 42 |
| Grasshopper sparrow | 19 | 35 |
| Henslow's sparrow | 6 | 43 |
| Indigo bunting | 6 | 32 |
| Yellow-breasted chat | 4 | 30 |
| Prairie warbler | - | 31 |
| Common yellowthroat | 9 | 21 |
| Eastern meadowlark | 12 | 17 |
| Red-winged blackbird | 15 | 6 |
| Blue grosbeak | 4 | 9 |
| Horned lark | 2 | 3 |
| Brown thrasher | 1 | 2 |
| Eastern towhee | 1 | 2 |
| Northern bobwhite | 2 | 1 |
| Northern cardinal | - | 3 |
| Wild turkey | 1 | 2 |
| Blue-gray gnatcatcher | - | 2 |

Table 17. (Continued)

| Species | 1999 | 2000 |
|---|---|---|
| Brown thrasher | 1 | 1 |
| Eastern kingbird | 1 | 1 |
| Eastern phoebe | 1 | 1 |
| American goldfinch | - | 1 |
| Bachman's sparrow | 1 | - |
| Blue-winged warbler | - | 1 |
| Carolina wren | - | 1 |
| Common nighthawk | - | 1 |
| Killdeer | 1 | - |
| Orchard oriole | 1 | - |
| White-eyed vireo | - | 1 |
| Yellow-billed cuckoo | - | 1 |
| Unknown | 2 | 4 |
| Total | 131 | 381 |
| Overall Total | | 512 |

Table 18. Grasshopper sparrow detections within 50 m on point counts between May 15 - July 15, 1999 and 2000 at Fort Campbell Military Reservation, Kentucky-Tennessee.

| | | Pts w/ GRSP | # GRSP | Total Pts | % |
|---|---|---|---|---|---|
| 1999 | | | | | |
| | 15 May – 15 June | 1 | 1 | 168 | 0.6 |
| | 16 June – 15 July | 2 | 3 | 168 | 1.2 |
| | **Total unique** | 3 | | | |
| 2000 | | | | | |
| | 15 May – 15 June | 1 | 2 | 170 | 0.6 |
| | 16 June – 15 July | 3 | 4 | 170 | 1.8 |
| | **Total unique** | 4 | | | |
| 1999/2000 | | | | | |
| | Both years | 7 | 10 | 338 | 2.0 |
| | **Total unique** | 1 | | 338 | 0.3 |

Table 19. Estimated nest success of grasshopper sparrows in native grasslands and hayfields at Fort Campbell Military Reservation, Kentucky-Tennessee, 1999-2000.

| | 1999 | 2000 | Pooled |
|---|---|---|---|
| Successful nests | 13 | 24 | 37 |
| Unsuccessful nests[1] | 5 | 11 | 16 |
| Unknown fate | 1 | 0 | 1 |
| Total | 19 | 35 | 54 |
| **Nesting success:** | | | |
| Apparent nest success | 72.2% | 68.6% | 71.7% |
| Mayfield estimate[2] | 41.8% | 38.2% | 39.8% |
| Exposure days | 103 | 269.5 | 372.5 |
| Daily survival: | | | |
| Incubation | 0.976 | 0.939 | 0.950 |
| Nestling | 0.935 | 0.971 | 0.961 |
| Total | 0.951 | 0.959 | 0.957 |
| Stage survival: | | | |
| Incubation | 0.762 | 0.499 | 0.566 |
| Nestling | 0.549 | 0.766 | 0.702 |
| Nesting biology: | | | |
| Clutch size[3] | 4.4 ± 0.20 (18) | 4.5 ± 0.12 (31) | 4.5 ± 0.10 (49) |
| Hatching success (%) | 67.7 (7) | 95.5 (25) | 89.4 (32) |
| Young fledged per nest | 2.7 | 3.0 | 2.9 |
| Young fledged per successful nest | 3.8 | 4.1 | 4.0 |
| Parasitism | 0/19 | 1/35 | 1/54 |
| Young fledged per parasitized nest | – | 0 | 0 |

[1] Excludes 1 nest failed due to research interference
[2] Mayfield (1975); includes 2 mowed nests from 2000 & excludes nest accidentally destroyed by researcher in 1999; nests with unknown fates excluded
[3] Excludes parasitized nests

Table 20. Pooled habitat measurements (1999 & 2000) of grasshopper sparrow perch sites (n=23) and unoccupied locations (n=338) in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee.

| | Occupied | | Unoccupied | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Field size (ha) | 562.40 | 0.35 | 74.97 | 6.90 | 0.0122 | 27.5953 | <0.0001 |
| Grass height (m) | 0.27 | 0.02 | 0.43 | 0.01 | -8.9615 | 9.2327 | 0.0024 |
| Legume (%) | 4.52 | 2.57 | 3.10 | 0.32 | - | 0.8756 | 0.3494 |
| Native warm season grass (%) | 11.83 | 3.28 | 27.88 | 1.15 | - | 0.3773 | 0.5391 |
| Cool season grass (%) | 8.70 | 2.65 | 2.03 | 0.46 | - | 0.2078 | 0.6485 |
| Woody vegetation (%) | 6.52 | 3.42 | 4.61 | 0.53 | - | 0.1340 | 0.7143 |
| Forb (%) | 34.70 | 4.85 | 34.20 | 1.10 | - | 0.1014 | 0.7501 |
| Litter depth (cm) | 3.69 | 1.15 | 2.59 | 0.25 | - | 0.0086 | 0.9261 |
| Bare ground (%) | 16.43 | 3.28 | 13.15 | 0.85 | - | 0.0011 | 0.9737 |

Max-rescaled R-Square = 0.7150 Percent Concordant = 97.5 Hosmer and Lemeshow goodness-of-fit = 0.9999 correct class. = 95% df = 7

Table 21. Habitat measurements of grasshopper sparrow nest sites (n=18) and unoccupied locations (n=168) in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 1999.

| | Occupied | | Unoccupied | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Field size (ha) | 545.28 | 20.12 | 75.61 | 9.82 | 0.0096 | 11.7922 | 0.0006 |
| Forb (%) | 11.83 | 2.53 | 29.06 | 1.52 | -0.1211 | 5.1425 | 0.0233 |
| Legume (%) | 37.67 | 7.29 | 3.45 | 0.52 | 0.0640 | 3.9551 | 0.0467 |
| Bare ground (%) | 12.17 | 3.41 | 13.09 | 1.29 | - | 2.4872 | 0.1148 |
| Grass height (m) | 0.28 | 0.04 | 0.40 | 0.02 | - | 0.6757 | 0.4111 |
| Woody vegetation (%) | 0.05 | 0.05 | 3.66 | 0.58 | - | 0.1011 | 0.7505 |
| Cool season grass (%) | 8.22 | 4.35 | 1.88 | 0.69 | - | 0.0703 | 0.7909 |
| Native warm season grass (%) | 19.94 | 5.18 | 34.57 | 1.72 | - | 0.0011 | 0.9730 |
| Litter depth (cm) | 4.33 | 0.84 | 4.40 | 0.55 | - | 0.0003 | 0.9862 |

Max-rescaled R-Square = 0.7957 Percent Concordant = 98.6 Hosmer and Lemeshow goodness-of-fit = 0.8583 correct class. = 94% df = 7

Table 22. Habitat measurements of grasshopper sparrow nest sites (n=32) and unoccupied locations (n=170) in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 2000.

| | Occupied | | Unoccupied | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Field size (ha) | 546.76 | 15.26 | 74.33 | 9.73 | 0.0132 | 19.7766 | <0.0001 |
| Grass height (m) | 0.24 | 0.01 | 0.47 | 0.01 | -4.7453 | 11.1616 | 0.0008 |
| Forb (%) | 20.16 | 2.64 | 39.27 | 1.49 | -0.0755 | 5.5475 | 0.0185 |
| Native warm season grass (%) | 25.47 | 4.02 | 21.26 | 1.37 | - | 1.9844 | 0.1589 |
| Bare ground (%) | 18.53 | 2.49 | 13.21 | 1.11 | - | 1.6835 | 0.1945 |
| Litter depth (cm) | 2.78 | 0.36 | 4.71 | 0.43 | - | 1.6624 | 0.1973 |
| Cool season grass (%) | 8.25 | 3.48 | 2.18 | 0.62 | - | 1.5432 | 0.2141 |
| Legume (%) | 5.19 | 2.39 | 2.76 | 0.38 | - | 0.3883 | 0.5332 |
| Woody vegetation (%) | 0.03 | 0.03 | 5.55 | 0.87 | - | 0.1508 | 0.6978 |

Max-rescaled R-Square = 0.8968 Percent Concordant = 96.8 Hosmer and Lemeshow goodness-of-fit = 0.2461 correct class. = 96% df = 7

Table 23. Pooled habitat measurements (1999 & 2000) of grasshopper sparrow nest sites (n=50) and unoccupied locations (n=338) in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee.

| | Occupied | | Unoccupied | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Grass height (m) | 0.25 | 0.02 | 0.44 | 0.01 | -3.2819 | 12.4746 | 0.0004 |
| Forb (%) | 16.70 | 1.95 | 34.20 | 1.10 | -0.0654 | 9.6219 | 0.0019 |
| Field size (ha) | 562.40 | 0.35 | 74.97 | 6.90 | 0.0194 | 4.6518 | 0.0310 |
| Cool season grass (%) | 8.24 | 2.70 | 2.03 | 0.46 | - | 2.8350 | 0.0922 |
| Bare ground (%) | 16.24 | 2.04 | 13.15 | 0.85 | - | 0.5274 | 0.4677 |
| Woody vegetation (%) | 0.02 | 0.02 | 4.61 | 0.53 | - | 0.2977 | 0.5853 |
| Litter depth (cm) | 1.94 | 0.28 | 2.59 | 0.25 | - | 0.2018 | 0.6533 |
| Legume (%) | 17.04 | 3.72 | 3.10 | 0.32 | - | 0.1405 | 0.7077 |
| Native warm season grass (%) | 23.48 | 3.17 | 27.88 | 1.15 | - | 0.1106 | 0.7395 |

Max-rescaled R-Square = 0.8576   Percent Concordant = 99.1   Hosmer and Lemeshow goodness-of-fit = 0.9895   correct class. = 96%   df = 7

Table 24. Habitat measurements of successful (n=37) versus unsuccessful (n=13) grasshopper sparrow nests in grasslands at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 1999 and 2000.

| | Successful | | Unsuccessful | | | | |
|---|---|---|---|---|---|---|---|
| Habitat Parameter | Mean | SE | Mean | SE | Parameter estimate | $\chi^2$ | ρ |
| Field size (ha) | 565.78 | 0.27 | 565.54 | 0.17 | - | 2.8866 | 0.0893 |
| Grass height (m) | 0.27 | 0.02 | 0.22 | 0.02 | - | 2.0954 | 0.1477 |
| Cool season grass (%) | 9.05 | 3.40 | 5.92 | 3.86 | - | 0.4061 | 0.5240 |
| Bare ground (%) | 14.51 | 2.44 | 21.15 | 3.40 | - | 0.0878 | 0.7670 |
| Legume (%) | 15.70 | 4.20 | 20.23 | 8.17 | - | 0.0973 | 0.7551 |
| Litter depth (cm) | 2.18 | 0.36 | 1.25 | 0.26 | - | 2.4281 | 0.1192 |
| Native warm season grass (%) | 24.57 | 3.86 | 20.38 | 5.44 | - | 0.4142 | 0.5198 |
| Forb (%) | 17.78 | 2.32 | 15.38 | 3.94 | - | 0.0268 | 0.8699 |
| Woody vegetation (%) | 0.08 | 0.06 | 0.08 | 0.08 | - | 0.0012 | 0.9727 |

All effects have been removed from the model.

Table 25. Common and scientific names of breeding birds documented on 50-m radius point counts in native grasslands during May - July, 1999 and 2000, at Fort Campbell Military Reservation, Kentucky-Tennessee. Species are presented in taxonomic order.[1]

| Common Name | Scientific Name | Grassland Obligate[2] | TN/KY Status[3] |
|---|---|---|---|
| Great blue heron | *Ardea herodias* | | |
| Green heron | *Butorides striatus* | | |
| Canada goose | *Branta canadensis* | | |
| Wood duck | *Aix sponsa* | | |
| Mallard | *Anas platyrhynchos* | | |
| Black vulture | *Coragyps atratus* | | |
| Turkey vulture | *Cathartes aura* | | |
| Cooper's hawk | *Accipiter cooperii* | | |
| Red-shouldered hawk | *Buteo lineatus* | | |
| Broad-winged hawk | *Buteo platypterus* | | |
| Red-tailed hawk | *Buteo jamaicensis* | | |
| American kestrel | *Falco sparverius* | | |
| Wild turkey | *Meleagris gallopavo* | | |
| Northern bobwhite | *Colinus virginianus* | | |
| Killdeer | *Charadrius vociferus* | | |
| American woodcock | *Scolopax minor* | | |
| Mourning dove | *Zenaida macroura* | | |
| Yellow-billed cuckoo | *Coccyzus americanus* | | |

Table 25. (Continued)

| **Common Name** | **Scientific Name** | **Grassland Obligate[2]** | **TN/KY Status[3]** |
|---|---|---|---|
| Barred owl | *Strix varia* | | |
| Common nighthawk | *Chordeiles minor* | | |
| Chimney swift | *Chaetura pelagica* | | |
| Ruby-throated hummingbird | *Archilochus colubris* | | |
| Belted kingfisher | *Megaceryle alcyon* | | |
| Red-bellied woodpecker | *Melanerpes carolinus* | | |
| Downy woodpecker | *Picoides pubescens* | | |
| Hairy woodpecker | *Picoides villosus* | | |
| Northern flicker | *Colaptes auratus* | | |
| Pileated woodpecker | *Dryocopus pileatus* | | |
| Eastern wood-pewee | *Contopus virens* | | |
| Acadian flycatcher | *Empidonax virescens* | | |
| Willow flycatcher | *Empidonax traillii* | | |
| Eastern phoebe | *Sayornis phoebe* | | |
| Great-crested flycatcher | *Myiarchus crinitus* | | |
| Eastern kingbird | *Tyrannus tyrannus* | | |
| Horned lark | *Eremophila alpestris* | x | |
| Purple martin | *Progne subis* | | |
| Tree swallow | *Tachycineta bicolor* | | |

Table 25. (Continued)

| Common Name | Scientific Name | Grassland Obligate[2] | TN/KY Status[3] |
|---|---|---|---|
| Cliff swallow | *Hirundo pyrrhonota* | | |
| Barn swallow | *Hirundo rustica* | | |
| Blue jay | *Cyanocitta cristata* | | |
| American crow | *Corvus brachyrhynchos* | | |
| Carolina chickadee | *Parus bicolor* | | |
| Eastern tufted titmouse | *Parus carolinensis* | | |
| White-breasted nuthatch | *Sitta carolinensis* | | |
| Carolina wren | *Thryothorus ludovicianus* | | |
| Blue-gray gnatcatcher | *Polioptila caerulea* | | |
| Eastern bluebird | *Sialia sialis* | | |
| Wood thrush | *Hylocichla mustelina* | | |
| American robin | *Turdus migratorius* | | |
| Gray catbird | *Dumetella carolinensis* | | |
| Northern mockingbird | *Mimus polyglottos* | | |
| Brown thrasher | *Toxostoma rufum* | | |
| Cedar waxwing | *Bombycilla cedrorum* | | |
| European starling | *Sturnus vulgaris* | | |
| White-eyed vireo | *Vireo griseus* | | |
| Bell's vireo | *Vireo bellii* | | SC(KY) |

Table 25. (Continued)

| **Common Name** | **Scientific Name** | **Grassland Obligate**[2] | **TN/KY Status**[3] |
|---|---|---|---|
| Yellow-throated vireo | *Vireo flavifrons* | | |
| Red-eyed vireo | *Vireo olivaceus* | | |
| Blue-winged warbler | *Vermivora pinus* | | |
| Northern parula | *Parula americana* | | |
| Yellow-throated warbler | *Dendroica dominica* | | |
| Pine warbler | *Dendroica pinus* | | |
| Prairie warbler | *Dendroica discolor* | | |
| Black-and-white warbler | *Mniotilta varia* | | |
| American redstart | *Setophaga ruticilla* | | |
| Louisiana waterthrush | *Seiurus motacilla* | | |
| Kentucky warbler | *Oporornis formosus* | | |
| Common yellowthroat | *Geothlypis trichas* | | |
| Yellow-breasted chat | *Icteria virens* | | |
| Summer tanager | *Piranga rubra* | | |
| Northern cardinal | *Cardinalis cardinalis* | | |
| Blue grosbeak | *Guiraca caerulea* | | |
| Indigo bunting | *Passerina cyanea* | | |
| Dickcissel | *Spiza americana* | x | |
| Eastern towhee | *Pipilo erythrophthalmus* | | |

Table 25. (Continued)

| **Common Name** | **Scientific Name** | **Grassland Obligate**[2] | **TN/KY Status**[3] |
| --- | --- | --- | --- |
| Bachman's sparrow | *Aimophila aestivalis* | | E(TN&KY) |
| Chipping sparrow | *Spizella passerina* | | |
| Field sparrow | *Spizella pusilla* | | |
| Lark sparrow | *Chondestes grammacus* | | T(TN&KY) |
| Grasshopper sparrow | *Ammodramus savannarum* | x | SC(TN) |
| Henslow's sparrow | *Ammodramus henslowii* | x | SC(TN&KY) |
| Red-winged blackbird | *Agelaius phoeniceus* | | |
| Eastern meadowlark | *Sturnella magna* | x | |
| Common grackle | *Quiscalus quiscula* | | |
| Brown-headed cowbird | *Molothrus ater* | | |
| Orchard oriole | *Icterus spurius* | | |
| American goldfinch | *Carduelis tristis* | | |

[1] Based on the check-list of North American birds (AOU 1983).
[2] Obligate grassland birds are species that require grasslands for most or all of their breeding cycle, but may use other non-grassland habitats (Sample and Mossman 1997).
[3] Based on the Tennessee Department of Environment and Conservation's Division of Natural Heritage rare vertebrates list and the KSNPC (Kentucky State Nature Preserve Commission)
E = Endangered
T = Threatened
SC = Special Concern

Table 26. Other non-breeding birds documented at Fort Campbell Military Reservation, Kentucky-Tennessee, 1999 and 2000. Species are presented in taxonomic order.[1]

| Common Name | Scientific Name | Grassland Obligate[2] | TN/KY Status[3] |
|---|---|---|---|
| Pied-billed grebe | *Podilymbus podiceps* | | E(KY) |
| Little blue heron | *Egretta caerulea* | | SC(TN),E(KY) |
| Blue-winged teal | *Anas discor* | | E(KY) |
| Red-breasted merganser | *Mergus serrator* | | |
| Mississippi kite | *Ictinia mississippiensis* | | SC |
| Northern harrier | *Circus cyaneus* | x | SC(TN), T(KY) |
| Sora | *Porzana carolina* | | |
| Sandhill crane | *Grus canadensis* | | SC(TN) |
| Solitary sandpiper | *Tringa solitaria* | | |
| Upland sandpiper | *Bartramia longicauda* | x | E(KY) |
| Common snipe | *Gallinago gallinago* | | |
| Black-billed cuckoo | *Coccyzus erythropthalmus* | | |
| Yellow-bellied sapsucker | *Sphyrapicus varius* | | |
| Scissor-tailed flycatcher | *Tyrannus forficatus* | | |
| Red-breasted nuthatch | *Sitta canadensis* | | |
| Sedge wren | *Cistothorus platensis* | x | SC(KY) |
| Golden-crowned kinglet | *Regulus satrapa* | | |
| Ruby-crowned kinglet | *Regulus calendula* | | |
| Hermit thrush | Catharus guttatus | | |

Table 26. (Continued)

| **Common Name** | **Scientific Name** | **Grassland Obligate**[2] | **TN/KY Status**[3] |
|---|---|---|---|
| American pipit | *Anthus rubescens* | | |
| Solitary vireo | *Vireo solitarius* | | |
| Nashville warbler | *Vermivora ruficapilla* | | |
| Yellow warbler | *Dendroica petechia* | | |
| Chestnut-sided warbler | *Dendroica pensylvanica* | | |
| Magnolia warbler | *Dendroica magnolia* | | |
| Black-throated green warbler | *Dendroica virens* | | |
| Palm warbler | *Dendroica palmarum* | | |
| Bay-breasted warbler | *Dendroica castanea* | | |
| Savannah sparrow | *Passerculus sandwichensis* | x | |
| Fox sparrow | *Passerella iliaca* | | |
| Song sparrow | *Melospiza melodia* | | |
| Swamp sparrow | *Melospiza georgiana* | | |
| White-throated sparrow | *Zonotrichia albicollis* | | |
| White-crowned sparrow | *Zonotrichia leucophrys* | | |
| Dark-eyed junco | *Junco hyemalis* | | |
| Bobolink | *Dolichonyx oryzivorus* | x | SC |
| Baltimore oriole | *Icterus galbula* | | |

[1] Based on the check-list of North American birds (AOU 1983).
[2] Obligate grassland birds are species that require grasslands for most or all of their breeding cycle, but may use other non-grassland habitats (Sample and Mossman 1997).
[3] Based on the Tennessee Department of Environment and Conservation's Division of Natural Heritage rare vertebrates list and the KSNPC (Kentucky State Nature Preserve Commission)
E = Endangered T = Threatened SC = Special Concern

Table 27. Results of 4-way analysis of variance of avian richness and abundance for burn class and field size on Fort Campbell Military Reservation, May - July, 1999 and 2000.

| Parameter | df | Mean Square | F Value | P value |
|---|---|---|---|---|
| **Richness** | | | | |
| Burn | 2 | 2.96 | 0.59 | 0.5542 |
| Area | 2 | 12.24 | 2.45 | 0.0882 |
| Burn*Area | 4 | 10.62 | 2.12 | 0.0777 |
| Year | 1 | 131.10 | 26.21 | <0.0001 |
| Year*Burn | 2 | 5.69 | 1.14 | 0.3221 |
| Year*Area | 2 | 2.10 | 0.42 | 0.6572 |
| Year*Burn*Area | 4 | 11.44 | 2.29 | 0.0598 |
| Time | 1 | 6.79 | 3.24 | 0.0727 |
| Time*Burn | 2 | 3.55 | 1.70 | 0.1848 |
| Time*Area | 2 | 0.74 | 0.35 | 0.7021 |
| Time*Burn*Area | 4 | 1.57 | 0.75 | 0.5600 |
| Time*Year | 1 | 15.74 | 7.52 | 0.0064 |
| Time*Year*Burn | 2 | 0.55 | 0.26 | 0.7683 |
| Time*Year*Area | 2 | 3.77 | 1.80 | 0.1670 |
| Time*Year*Burn*Area | 4 | 3.01 | 1.44 | 0.2204 |

Table 27.  (Con't)

| Parameter | df | Mean Square | F Value | P value |
|---|---|---|---|---|
| **Abundance** | | | | |
| Burn | 2 | 1.11 | 0.12 | 0.8887 |
| Area | 2 | 14.25 | 1.52 | 0.2206 |
| Burn*Area | 4 | 23.71 | 2.53 | 0.0407 |
| Year | 1 | 296.12 | 31.56 | <0.0001 |
| Year*Burn | 2 | 17.53 | 1.87 | 0.1561 |
| Year*Area | 2 | 5.41 | 0.58 | 0.5622 |
| Year*Burn*Area | 4 | 18.81 | 2.00 | 0.0936 |
| Time | 1 | 0.78 | 0.16 | 0.6910 |
| Time*Burn | 2 | 8.70 | 1.76 | 0.1735 |
| Time*Area | 2 | 2.84 | 0.57 | 0.5635 |
| Time*Burn*Area | 4 | 5.96 | 1.21 | 0.3081 |
| Time*Year | 1 | 2.03 | 0.41 | 0.5221 |
| Time*Year*Burn | 2 | 11.82 | 2.39 | 0.0930 |
| Time*Year*Area | 2 | 1.28 | 0.26 | 0.7725 |
| Time*Year*Burn*Area | 4 | 12.10 | 2.45 | 0.0462 |

Table 27. (Con't)

| Parameter | df | Mean Square | F Value | P value |
|---|---|---|---|---|
| **Diversity** | | | | |
| Burn | 2 | 0.57 | 1.14 | 0.3209 |
| Area | 2 | 0.98 | 1.97 | 0.1405 |
| Burn*Area | 4 | 0.16 | 0.32 | 0.8632 |
| Year | 1 | 15.60 | 31.43 | <0.0001 |
| Burn*Year | 2 | 0.78 | 1.56 | 0.2109 |
| Area*Year | 2 | 0.19 | 0.39 | 0.6761 |
| Burn*Area*Year | 4 | 1.43 | 2.87 | 0.0232 |
| Time | 1 | <0.01 | 0.00 | 0.9896 |
| Time*Burn | 2 | 0.21 | 1.00 | 0.3707 |
| Time*Area | 2 | 0.68 | 3.24 | 0.0403 |
| Time*Burn*Area | 4 | 0.38 | 1.79 | 0.1297 |
| Time*Year | 1 | 1.72 | 8.17 | 0.0045 |
| Time*Year*Burn | 2 | 0.04 | 0.17 | 0.8447 |
| Time*Year*Area | 2 | 0.41 | 1.93 | 0.1462 |
| Time*Year*Burn*Area | 4 | 0.42 | 2.01 | 0.0934 |

Table 28. Results of logistic regression using avian presence/absence data[1] with field size (small, medium, large) in the model for Fort Campbell Military Reservation, 1999 and 2000.

| **Species** | **Parameter estimate** | $c^2$ | r |
|---|---|---|---|
| Dickcissel | 0.00640 | 62.0554 | <0.0001 |
| Henslow's sparrow | 0.00329 | 20.0430 | <0.0001 |
| Indigo bunting | -0.00355 | 18.0903 | <0.0001 |
| Yellow-breasted chat | -0.00283 | 8.8738 | 0.0029 |
| Prairie warbler | -0.00620 | 6.2011 | 0.0128 |
| Northern bobwhite | 0.00243 | 4.7921 | 0.0286 |
| Eastern bluebird | -0.01120 | 1.5529 | 0.2127 |
| Blue-winged warbler | -0.00338 | 1.2291 | 0.2676 |
| Brown-headed cowbird | -0.00320 | 1.1866 | 0.2760 |
| Blue-gray gnatcatcher | -0.00144 | 1.0119 | 0.3145 |
| Field sparrow | -0.00059 | 0.8706 | 0.3508 |
| Eastern wood-peewee | -0.00368 | 0.8697 | 0.3510 |
| Eastern kingbird | 0.00149 | 0.8461 | 0.3577 |
| White-eyed vireo | -0.00111 | 0.7831 | 0.3762 |
| Eastern towhee | -0.00069 | 0.4575 | 0.4988 |
| Common yellowthroat | -0.00019 | 0.0950 | 0.7580 |
| American goldfinch | 0.00004 | 0.0010 | 0.9747 |
| Blue grosbeak | 0.00004 | 0.0005 | 0.9822 |
| Northern cardinal | -0.00004 | 0.0005 | 0.9831 |
| Carolina wren | 0.00003 | 0.0002 | 0.9890 |

[1] Based on ≥ 20 detections

Table 29. Results of logistic regression using avian presence/absence data[1] with burn class (0 – current year, 1- burned 1 year ago, 2+ - burned 2 or more years ago) in the model for Fort Campbell Military Reservation, 1999 and 2000.

| **Species** | **Parameter estimate** | $c^2$ | r |
|---|---|---|---|
| Field sparrow | -0.2727 | 11.2414 | 0.0008 |
| Common yellowthroat | -0.2226 | 7.6298 | 0.0057 |
| White-eyed vireo | 0.2996 | 6.7302 | 0.0095 |
| American goldfinch | -0.4178 | 6.4031 | 0.0114 |
| Eastern kingbird | -0.6942 | 5.2802 | 0.0216 |
| Prairie warbler | 0.2047 | 4.4669 | 0.0346 |
| Northern cardinal | -0.4613 | 4.0814 | 0.0434 |
| Blue-gray gnatcatcher | 0.2440 | 3.8966 | 0.0484 |
| Henslow's sparrow | 0.2592 | 3.8035 | 0.0511 |
| Indigo bunting | -0.1427 | 3.3786 | 0.0660 |
| Blue grosbeak | -0.4130 | 2.3722 | 0.1235 |
| Carolina wren | -0.3448 | 1.7725 | 0.1831 |
| Blue-winged warbler | 0.2195 | 1.7466 | 0.1863 |
| Northern bobwhite | -0.2843 | 1.5887 | 0.2075 |
| Eastern bluebird | 0.1958 | 1.0429 | 0.3071 |
| Brown-headed cowbird | -0.1661 | 0.6913 | 0.4057 |
| Dickcissel | -0.1407 | 0.4615 | 0.4969 |
| Eastern wood-peewee | -0.1311 | 0.3010 | 0.5832 |
| Eastern towhee | -0.0206 | 0.0326 | 0.8567 |
| Yellow-breasted chat | 0.0013 | 0.0002 | 0.9877 |

[1] Based on ≥ 20 detections

Table 30. Relative abundance of avian species at point counts (n=357) < 50 m in different size classes at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 1999 and 2000.

| | Size Class[1] | | |
|---|---|---|---|
| **Species** | **S** | **M** | **L** |
| American goldfinch | 13 | 21 | 31 |
| American robin | 0 | 0 | 2 |
| Bachman's sparrow | 0 | 0 | 3 |
| Baltimore oriole | 0 | 0 | 1 |
| Blue-gray gnatcatcher | 23 | 10 | 18 |
| Brown-headed cowbird | 11 | 12 | 13 |
| Blue grosbeak | 2 | 14 | 8 |
| Blue jay | 0 | 1 | 4 |
| Blue-winged warbler | 8 | 6 | 14 |
| Bobolink | 0 | 0 | 1 |
| Brown thrasher | 1 | 1 | 5 |
| Carolina chickadee | 2 | 5 | 6 |
| Carolina wren | 7 | 6 | 12 |
| Cedar waxwing | 1 | 0 | 1 |
| Common yellow-throat | 96 | 100 | 126 |
| Dickcissel ***(+) | 1 | 14 | 30 |
| Downy woodpecker | 0 | 3 | 4 |
| Eastern bluebird | 4 | 11 | 3 |

Table 30. (Continued)

| | Size Class[1] | | |
|---|---|---|---|
| **Species** | **S** | **M** | **L** |
| Eastern kingbird | 2 | 7 | 15 |
| Eastern meadowlark | 0 | 0 | 9 |
| Eastern phoebe | 1 | 8 | 3 |
| Eastern towhee | 31 | 22 | 42 |
| Eastern tufted titmouse | 0 | 0 | 6 |
| Eastern wood-peewee | 2 | 6 | 8 |
| Field sparrow | 69 | 116 | 148 |
| Great-crested flycatcher | 1 | 0 | 0 |
| Green heron | 1 | 1 | 0 |
| Gray catbird | 6 | 1 | 7 |
| Grasshopper sparrow | 0 | 0 | 9 |
| Hairy woodpecker | 0 | 1 | 0 |
| Henslow's sparrow *******(+) | 4 | 16 | 32 |
| Horned lark | 0 | 0 | 1 |
| Indigo bunting ***(-) | 92 | 141 | 129 |
| Kentucky warbler | 0 | 1 | 1 |
| Lark sparrow | 0 | 1 | 0 |
| Lincoln sparrow | 0 | 0 | 1 |
| Mourning dove | 0 | 1 | 3 |

Table 30. (Continued)

| | Size Class[1] | | |
|---|---|---|---|
| **Species** | **S** | **M** | **L** |
| Northern bobwhite *****(+) | 4 | 12 | 17 |
| Northern cardinal | 4 | 12 | 22 |
| Northern flicker | 0 | 1 | 0 |
| Orchard oriole | 2 | 8 | 9 |
| Prairie warbler *****(-) | 60 | 18 | 35 |
| Red-bellied woodpecker | 1 | 0 | 3 |
| Red-eyed vireo | 2 | 1 | 3 |
| Red-winged blackbird | 1 | 6 | 10 |
| Ruby-throated hummingbird | 2 | 2 | 3 |
| Summer tanager | 4 | 4 | 8 |
| White-eyed vireo | 20 | 13 | 23 |
| Wild turkey | 1 | 0 | 2 |
| Yellow-breasted chat ******(-) | 64 | 62 | 97 |
| Yellow-billed cuckoo | 3 | 3 | 3 |
| Yellow-throated vireo | 1 | 0 | 0 |
| Yellow-throated warbler | 1 | 0 | 0 |

[1] S = 5–15 ha; M = 25-35 ha; L = > 50 ha
* P < 0.100
** P < 0.010
*** P < 0.001
(-) Indicates significant negative response to field size
(+) Indicates significant positive response to field size

Table 31. Relative abundance of avian species at point counts (n=357) < 50 m in different burn classes (year since last burned) at Fort Campbell Military Reservation, Kentucky-Tennessee, May - July, 1999 and 2000.

| | Burn Class[1] | | |
|---|---|---|---|
| **Species** | **0** | **1** | **2** |
| American goldfinch *(-) | 22 | 26 | 7 |
| American robin | 0 | 1 | 0 |
| Bachman’s sparrow | 3 | 0 | 0 |
| Baltimore oriole | 0 | 1 | 0 |
| Blue-gray gnatcatcher *(+) | 19 | 19 | 11 |
| Brown-headed cowbird | 16 | 7 | 9 |
| Blue grosbeak | 13 | 7 | 4 |
| Blue jay | 4 | 1 | 0 |
| Blue-winged warbler | 5 | 16 | 5 |
| Bobolink | 0 | 1 | 0 |
| Brown thrasher | 4 | 2 | 1 |
| Carolina chickadee | 8 | 4 | 2 |
| Carolina wren | 12 | 12 | 1 |
| Cedar waxwing | 1 | 0 | 0 |
| Common yellow-throat **(-) | 156 | 112 | 49 |
| Dickcissel | 15 | 25 | 5 |
| Downy woodpecker | 5 | 2 | 0 |

Table 31. (Continued)

| | Burn Class[1] | | |
|---|---|---|---|
| **Species** | **0** | **1** | **2** |
| Eastern bluebird | 10 | 1 | 7 |
| Eastern kingbird *****(-) | 14 | 9 | 1 |
| Eastern meadowlark | 6 | 3 | 0 |
| Eastern phoebe | 7 | 4 | 1 |
| Eastern towhee | 41 | 32 | 16 |
| Eastern tufted titmouse | 2 | 4 | 0 |
| Eastern wood-peewee | 11 | 5 | 5 |
| Field sparrow *******(-) | 158 | 120 | 54 |
| Green heron | 0 | 1 | 0 |
| Gray catbird | 4 | 7 | 3 |
| Grasshopper sparrow | 5 | 4 | 0 |
| Hairy woodpecker | 1 | 0 | 0 |
| Henslow's sparrow *(+) | 5 | 39 | 8 |
| Horned lark | 1 | 0 | 0 |
| Indigo bunting *(-) | 169 | 118 | 66 |
| Kentucky warbler | 2 | 0 | 0 |
| Lark sparrow | 1 | 0 | 0 |
| Lincoln sparrow | 0 | 1 | 0 |
| Mourning dove | 2 | 2 | 0 |

Table 31. (Continued)

| | Burn Class[1] | | |
|---|---|---|---|
| **Species** | **0** | **1** | **2** |
| Northern bobwhite | 17 | 12 | 4 |
| Northern cardinal *(-) | 18 | 16 | 3 |
| Northern flicker | 1 | 0 | 0 |
| Orchard oriole | 12 | 4 | 2 |
| Prairie warbler *****(+) | 33 | 46 | 24 |
| Red-bellied woodpecker | 1 | 2 | 1 |
| Red-eyed vireo | 3 | 2 | 1 |
| Red-winged blackbird | 4 | 9 | 4 |
| Ruby-throated hummingbird | 1 | 5 | 0 |
| Summer tanager | 8 | 6 | 1 |
| White-eyed vireo **(+) | 17 | 24 | 12 |
| Wild turkey | 1 | 2 | 0 |
| Yellow-breasted chat | 88 | 90 | 37 |
| Yellow-billed cuckoo | 3 | 2 | 3 |

[1] 0 = burned in current year; 1 = 1 year post-burn; 2 = 2 year post-burn
* P < 0.100
** P < 0.010
*** P < 0.001
(-) Indicates significant negative response to burn
(+) Indicates significant positive response to burn

**Figures**

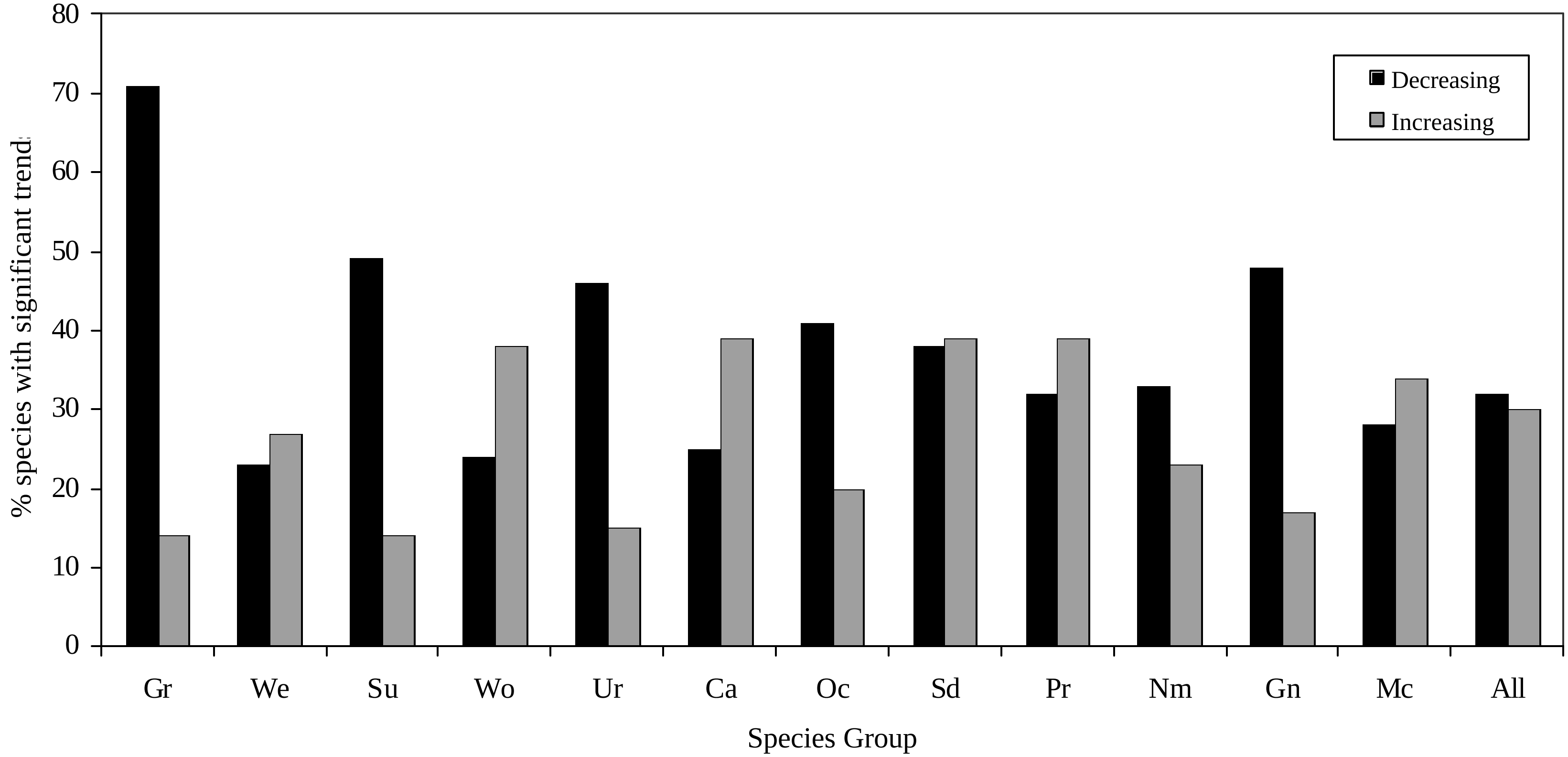


Figure 1. Percentage of eastern bird species, by bird groups, with significantly increasing or decreasing trends between 1966 and 1998 based upon BBS (Breeding Bird Survey) data. Gr = Grassland, We = Wetland, Su = Shrub/early successional, Wo = Woodland, Ur = Urban, Ca = Cavity nesters, Oc = Open-cup nesters, Sd = Short-distance migrants, Pr = Permanent residents, Nm = Neotropical migrants, Gn = Ground and low-nesting, Mc = Mid-story and canopy nesting, All = All species. (Sauer et al. 2000).

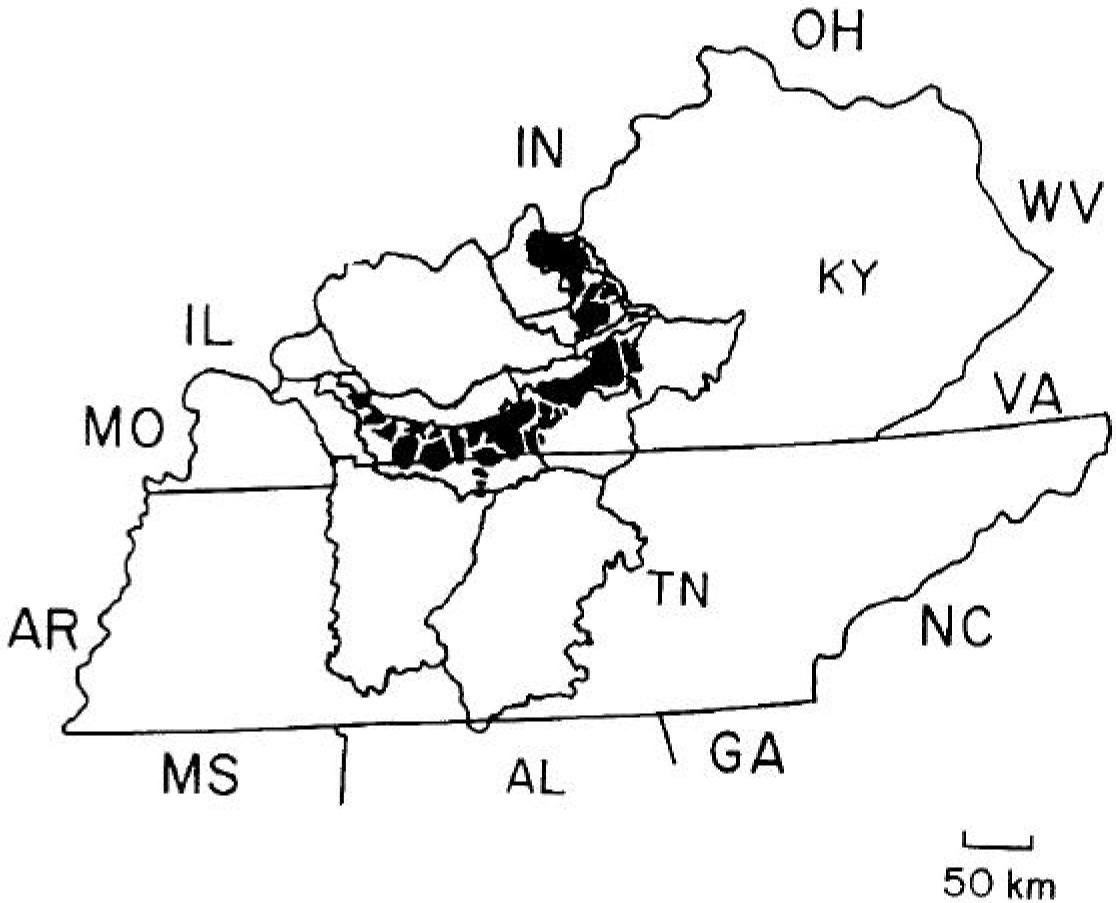


Figure 2. Historical native grasslands (black) of the Big Barrens region in Kentucky and Tennessee. Included are the outlines of the subsections of the Interior Low Plateau Physiographic Province (Baskin et al. 1994).

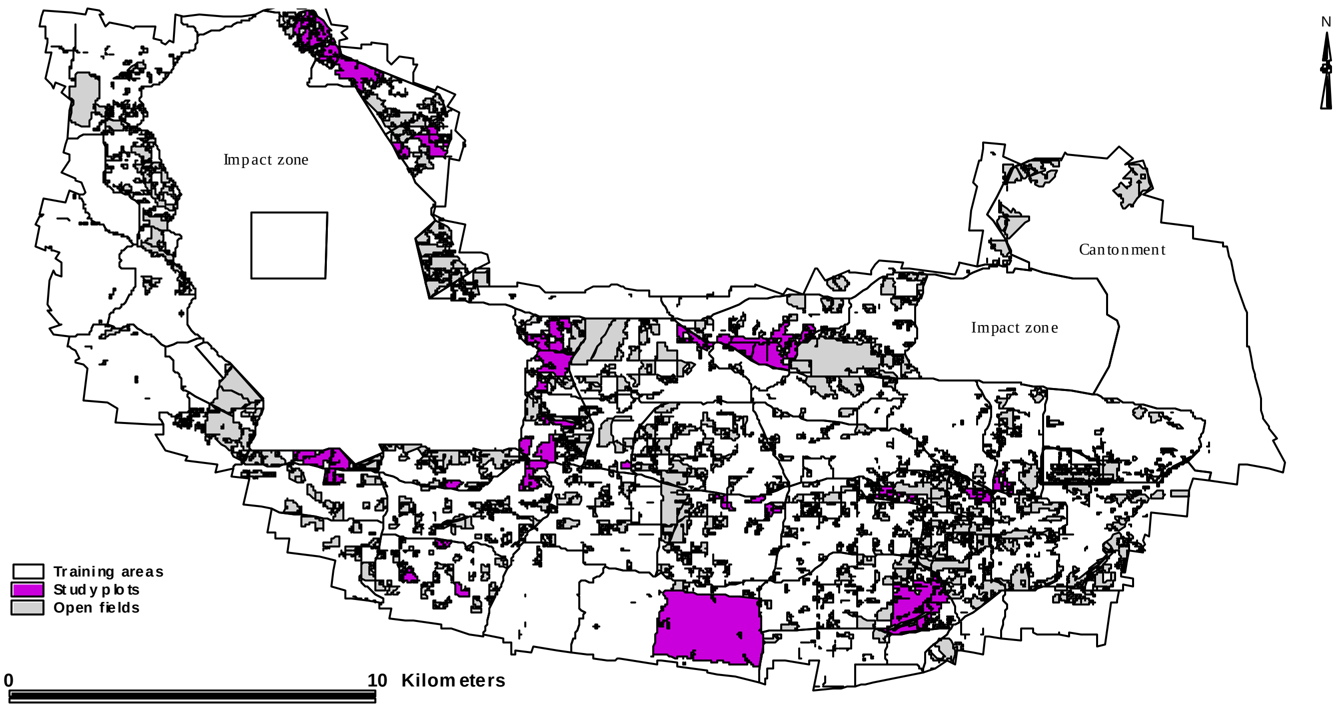


Figure 3. Native warm season grass fields selected for conducting point counts and nest searching on Fort Campbell Military Reservation, Tennessee-Kentucky, May-July, 1999 and 2000.

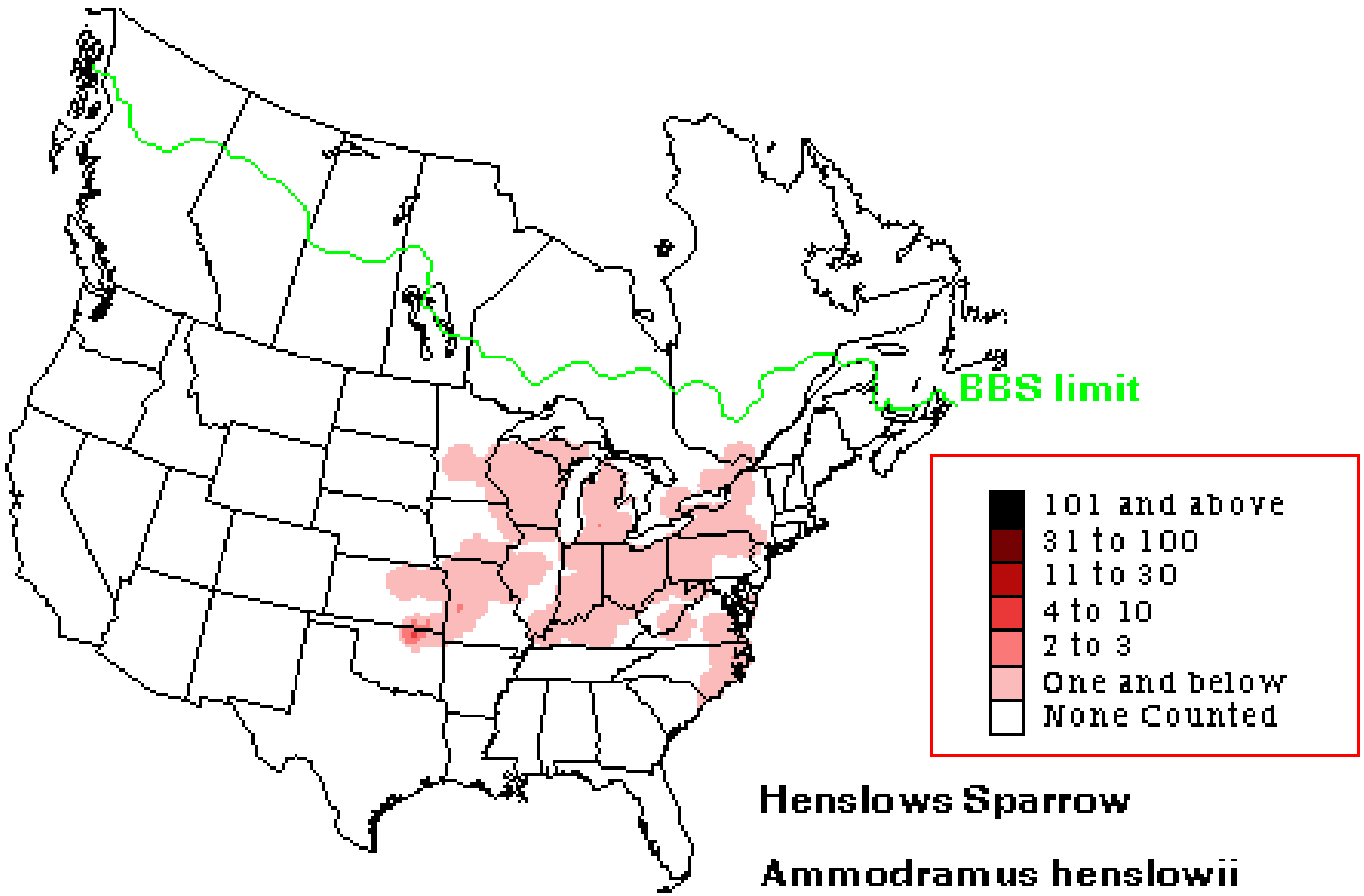


Figure 4. Breeding distribution of the Henslow's sparrow in North America, based on Breeding Bird Survey data, 1966-1996. Scale represents average number of individuals detected per route per year (Sauer et al. 2000).

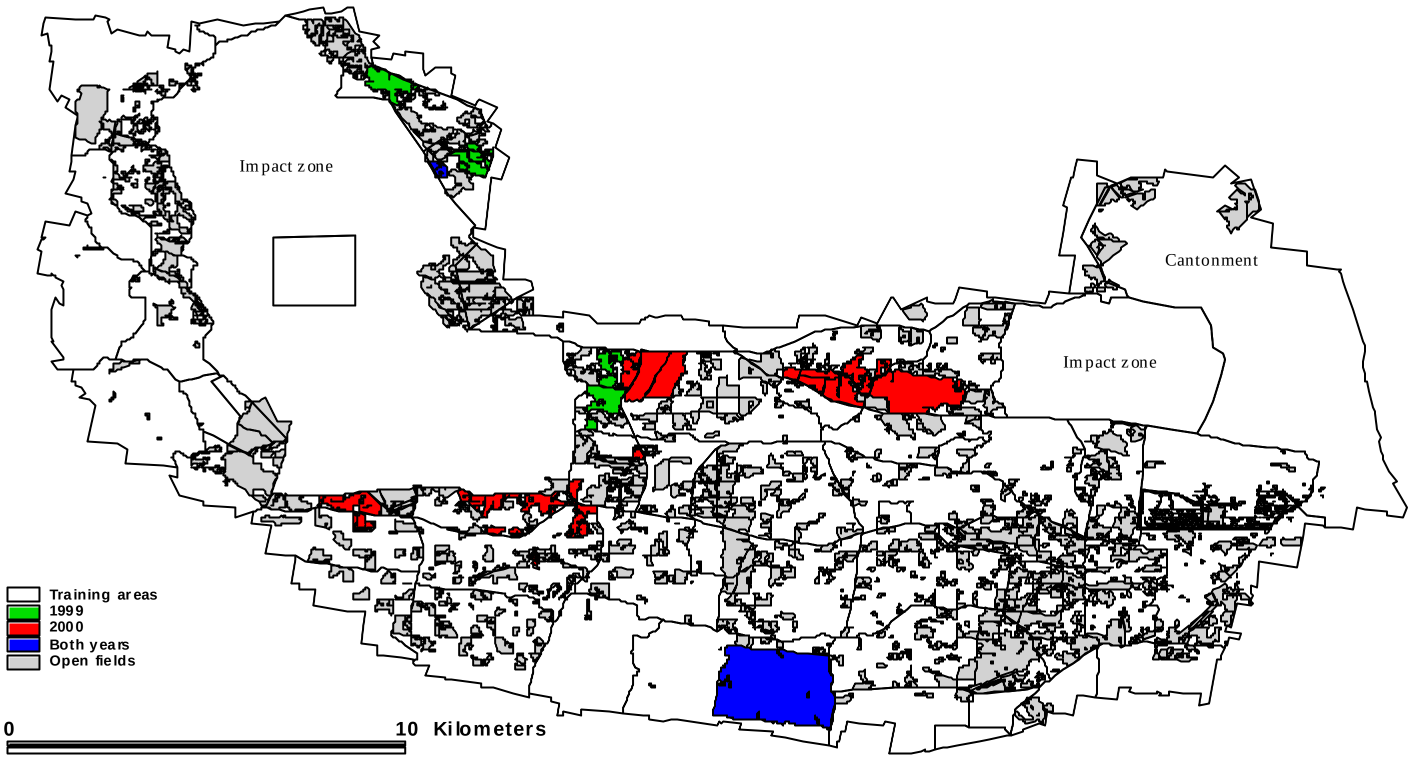


Figure 5. Native warm season grass fields where Henslow's sparrow territories were located on Fort Campbell Military Reservation, Tennessee-Kentucky, May-July, 1999 and 2000.

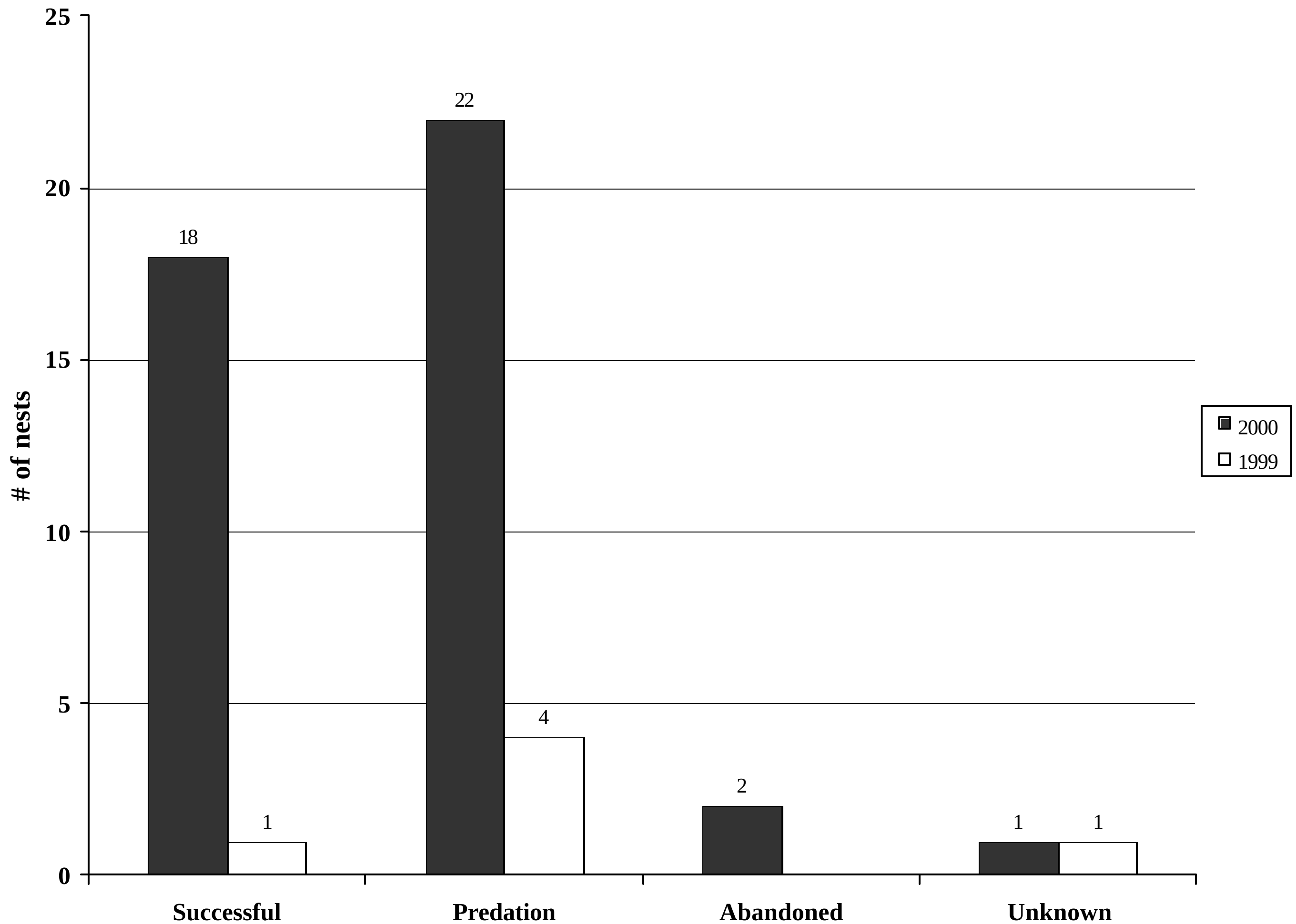


Figure 6. Henslow's sparrow nest failure categories at Fort Campbell Military Reservation, Kentucky-Tennessee, May-July, 1999 and 2000.

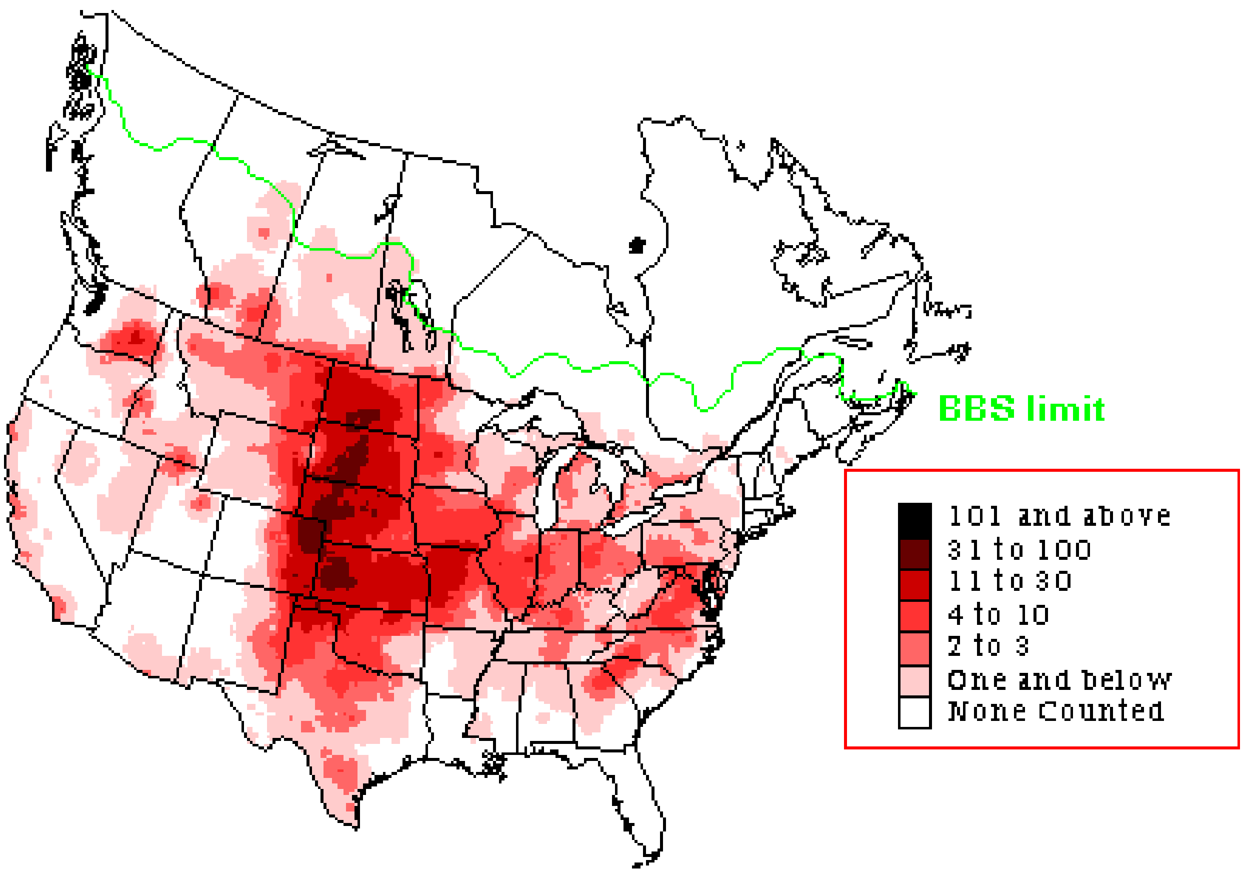


Figure 7. Breeding distribution of the grasshopper sparrow in North America, based on Breeding Bird Survey data, 1985-1991. Scale represents average number of individuals detected per route per year (Price et al. 1995).

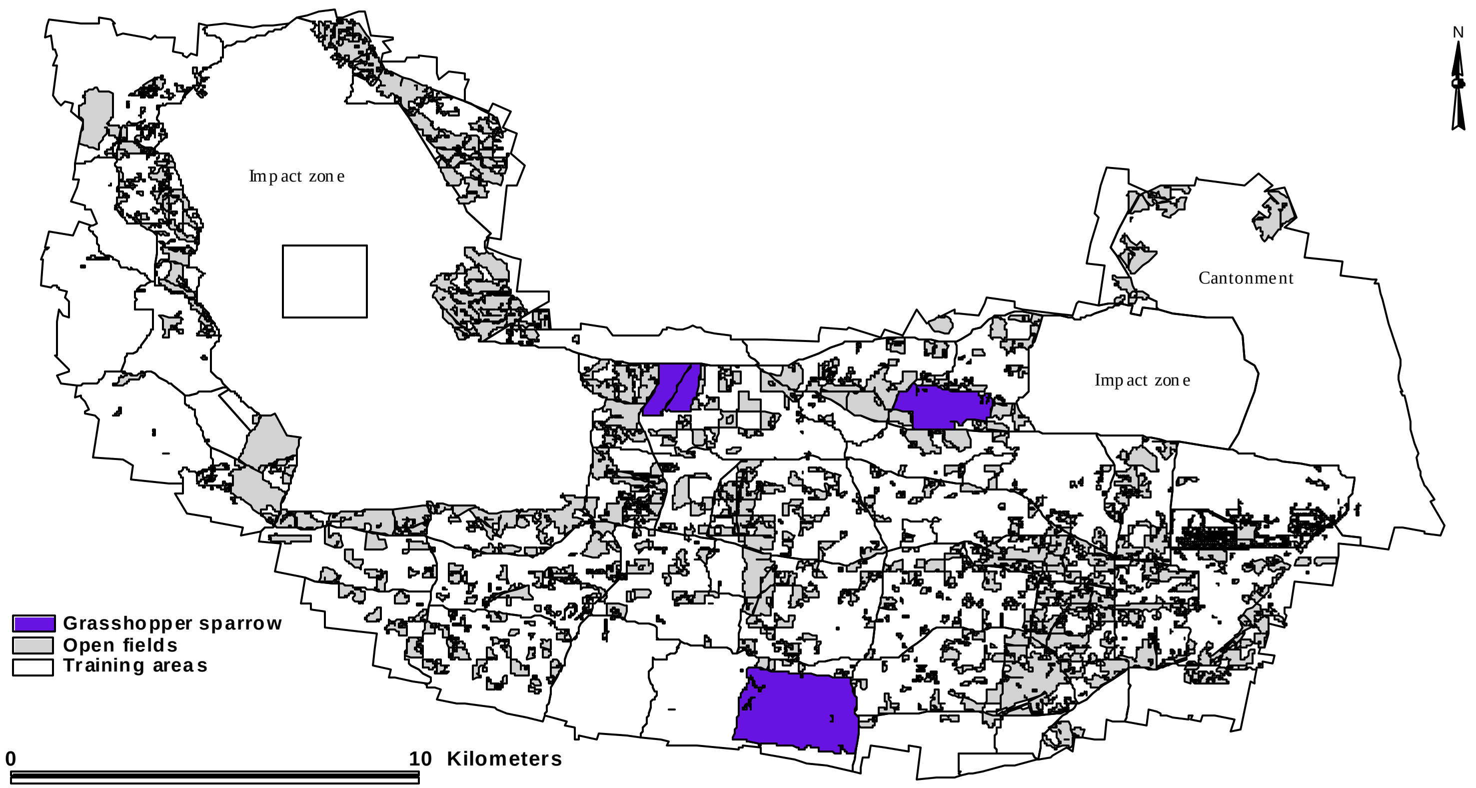


Figure 8. Native warm season grass fields where grasshopper sparrow territories were located on Fort Campbell Military Reservation, Tennessee-Kentucky, May-July, 1999 and 2000.

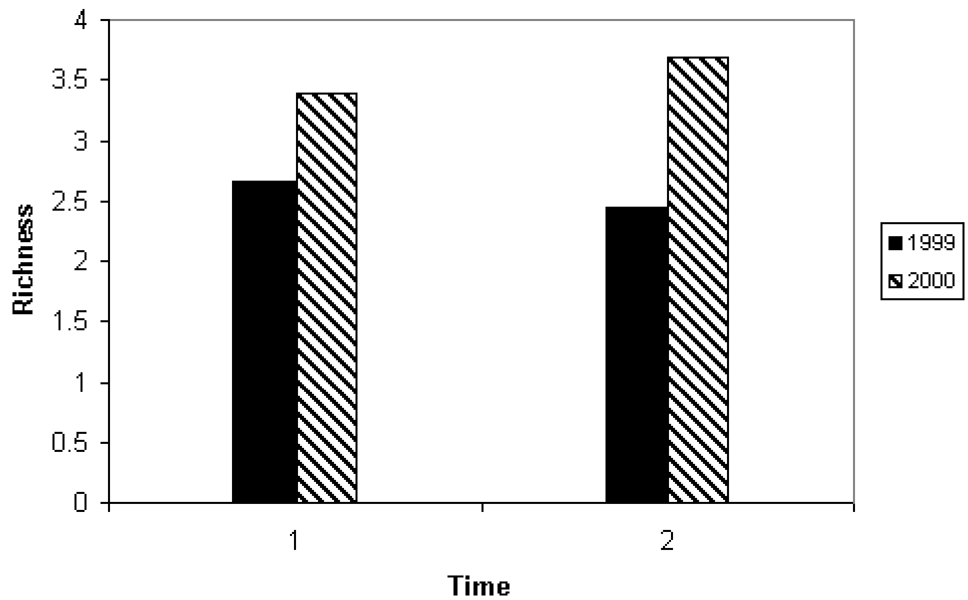


Figure 9. Richness of avian species compared between year and count time, Fort Campbell Military Reservation, Kentucky-Tennessee, 1999 and 2000.

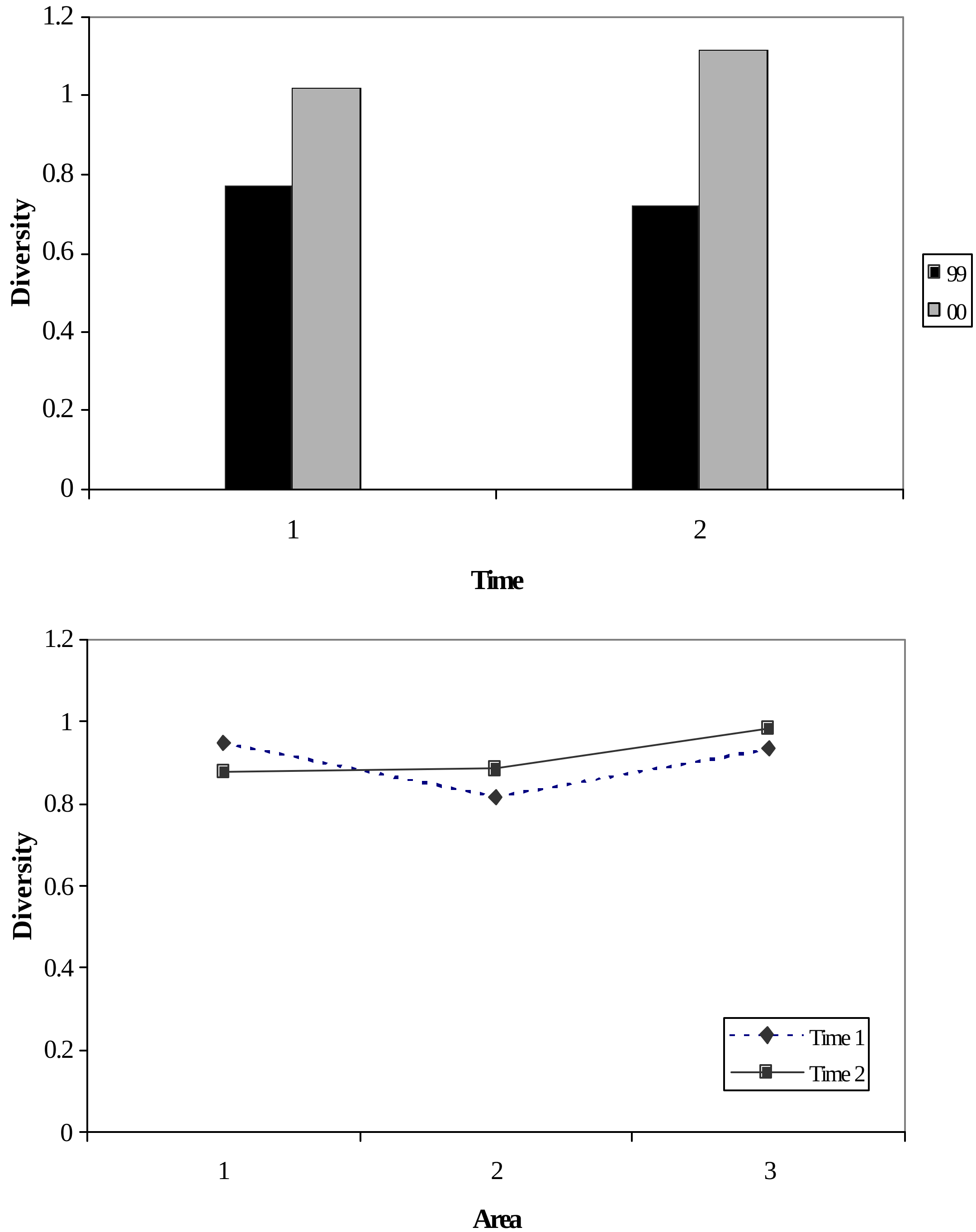


Figure 10. Shannon-Weiner Diversity Index between a) year and count time and b) count time and area (1=5-15 ha, 2=25-35 ha, 3=>50 ha), Fort Campbell Military Reservation, Kentucky-Tennessee, 1999 and 2000.

# VITA

Daniel Moss was born and raised in Nashville, TN in 1961. He graduated from University School of Nashville in 1979. He attended the University of Tennessee, Knoxville and graduated with a Bachelor of Arts in Psychology in June 1984. Daniel returned to Nashville to pursue several jobs unrelated to his degree. During this time he spent much time outdoors enjoying wildlife at Radnor Lake, Warner parks, and on the family farm in Chapel Hill, TN. After much soul searching Daniel decided to return to Murray State University in 1994 to follow his passion for ornithological research. He graduated in 1996 with a Bachelor of Science degree in Biology after focusing his curriculum on Wildlife Science.

Daniel worked as a field technician on several avian research projects in Missouri, South Carolina, Tennessee, Alaska, and Costa Rica between 1995 and 1998. During this time he decided to pursue a graduate project in ornithology to enhance his scientific skills and aid in the research of declining migratory birds. Daniel returned to the University of Tennessee, Knoxville to complete his Master of Science degree in Wildlife and Fisheries Science in May 2001. Daniel would like to apply his knowledge to the field of avian conservation with an emphasis on declining birds, both game and non-game.