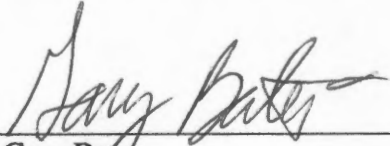


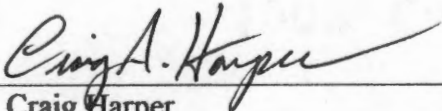
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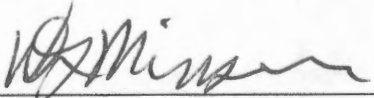
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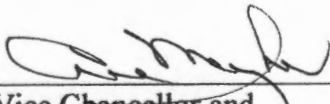
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EFFECTIVENESS OF NATIVE GRASSLAND RESTORATION IN RESTORING GRASSLAND BIRD COMMUNITIES IN TENNESSEE

**A Thesis
Presented for the
Master of Science
Degree
University of Tennessee, Knoxville**

Scott Allen Dykes

May 2005

ACKNOWLEDGEMENTS

There are many people who contributed to the success of my research who I would like to thank. I would especially like to thank my major professor, Dr. David Buehler for all of his guidance and support in this research. I appreciate his confidence and providing me with the opportunity to work on this project. I would also like to thank Billy Minser for his tireless efforts in helping start this project and for his friendship during my time at the University of Tennessee. I truly appreciate his advice and words of encouragement. I would also like to thank my other committee members, Dr. Gary Bates and Dr. Craig Harper for their valuable advice, constructive comments and suggestions. I would like to thank the many individuals from the Tennessee Wildlife Resources Agency, U.S. Department of Agriculture Natural Resources Conservation Service, and the many private landowners for their assistance in this research. I am grateful to the Tennessee Wildlife Resources Agency for funding this research through a North American Bird Conservation Initiative grant. I would also like to thank Quail Unlimited and the private donors who also provided funding for this project.

This project would not have been successful without the efforts of the dedicated field technicians who spent countless hours shedding blood, sweat and tears helping me collect data: Jason Burke, Josh Cooper, and Jason Scott.

I am deeply thankful to my friends in the FWF department for their support and contributions, especially Lesley Bulluck, Vijack Chimchome, Jenny Fieldler, Carrie Hedio, Aaron Keller, Dan Kim, Benny Thatcher, and Shelton Whittington. I would

especially like to thank Jim Giocomo for his assistance and encouragement throughout this process.

I would like to thank my family and personal friends who always supported me and encouraged me to follow my dreams. My parents, Jack and Carlotta Dykes have supported me with unwavering devotion, for which I am truly grateful. I am grateful to them for always being there throughout my educational career. I am forever thankful to my loving wife, April Dykes, for her enduring love and patience through the duration of this effort. This endeavor was as difficult for her as it was for me and I appreciate her support. I would also like to thank my son, Caleb Dykes, who waited patiently for his father to come home each night even though it was usually late and sometimes not at all. Most importantly, I thank God for His love and guidance throughout my life.

ABSTRACT

Grassland bird populations have declined more than any other group of birds over the last 37 years, based on Breeding Bird Survey (BBS) data (Hunter et al. 2001, Sauer et al. 2003). In Tennessee, significant effort is underway to restore native grasslands through partnerships between Tennessee Wildlife Resources Agency (TWRA), U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) and private landowners. This partnership has put thousands of hectares of native grasslands back on the Tennessee landscape. It is unknown, however, whether there has been a positive response by grassland birds to this restored habitat. Furthermore, the restoration has proceeded on an opportunistic basis, with emphasis placed on willing landowners, rather than conducting the restoration where wildlife benefits might be maximized.

Forty-five and forty-three restored native warm season grass (NWSG) fields were evaluated in 2002 and 2003, respectively. Three native grassland fields at Fort Campbell Military Reservation (FCMR) where viable populations of grassland birds are regularly found breeding were also evaluated each year for comparison. All fields were evaluated for vegetative species composition and structure and avian use. Effects of management practices for each field (mowing and burning) were also evaluated.

Restored program and FCMR fields were predominantly NWSG and forbs. Vegetative height in FCMR fields did not exceed 50 cm in either year while restored program fields exceeded 90 cm in both years. In restored program fields, bare ground cover was reduced from 16.7% in 2002 to 7.47% in 2003 ($P < 0.05$). Burned fields had

significantly less litter cover ($\bar{x}$ = 7%) than fields being mowed ($\bar{x}$ = 17.24 %) or not being managed ($\bar{x}$ = 13.7%) ($P < 0.05$). Litter depths were also greater in fields being mowed ($\bar{x}$ = 1.06 cm) and not being managed ($\bar{x}$ = 0.90 cm) than litter depths in fields being burned ($\bar{x}$ = 0.45 cm), ($P = 0.0004$). Forb cover was greater in burned fields ($\bar{x}$ = 33.75 %), than forb cover in fields being mowed ($\bar{x}$ = 19.86 %) or fields not being managed ($\bar{x}$ = 22.95%) ($P = 0.0006$).

Eighty-eight species of birds were noted in and around restored NWSG fields in Tennessee. Field size was the best explanatory variable for observed species richness of grassland species in restored NWSG fields in both years ($P < 0.005$). Nearly all of the grassland species in this study were positively associated with larger (> 30 ha) field sizes. Many species showed a negative relationship with increased vegetative heights and increased cover by NWSG. Many species also showed a positive relationship to increased levels of bare ground in both years. Henslow's sparrow (*Ammodramus henslowii*) showed a positive relationship with increased litter depths. Grasshopper sparrows (*Ammodramus savannarum*), Henslow's sparrows, eastern meadowlarks (*Sturnella magna*), dickcissels (*Spiza Americana*), and northern bobwhites (*Colinus virginianus*) were found in fields where average vegetative height was ≤ 52 cm. Northern bobwhites were found in restored fields where average litter depths were < 1 cm. Northern bobwhites were found in restored NWSG fields in all size classes; Grasshopper sparrows, Henslow's sparrows, eastern meadowlarks, and dickcissels occurred more often in larger patches when available.

Observed vegetative composition and structure were a result of management within the restored NWSG fields. Fields at FCMR are burned on a 1-3 year rotation,

whereas 70% of the fields evaluated in this study were being managed by mowing or were not being managed. If the managing organizations in Tennessee do not coordinate their management efforts, then grassland management in Tennessee will probably never reach its full potential. Restored NWSG fields in Tennessee need to be managed using rotational (every three to four years) burning. In areas where burning is not an option, moderate disking could be used instead of mowing. With appropriate management, NWSG restoration in Tennessee could ultimately be more successful than previously thought possible.

TABLE OF CONTENTS

<u>Chapter</u>	<u>Page</u>
1. INTRODUCTION.....	1
Tall Fescue.....	7
Grassland Establishment and Management	8
Tennessee Grassland Management	11
2. STUDY AREA	13
3. AN EVALUATION OF RESTORED NATIVE GRASS FIELDS IN TENNESSEE	17
Methods	19
Statistical Analysis	21
Results.....	22
Discussion	24
FCMR vs. Program Fields	24
Management Effects	25
4. BIRD RESPONSE TO RESTORED NATIVE GRASS FIELDS IN TENNESSEE	30
Methods	35
Point Counts	36
Timed-Area Search	36
Statistical Analysis	37
Results.....	38
Grassland Species	39
Species of Concern	39
Northern Bobwhites.....	40
Grasshopper Sparrows	41
Henslow's Sparrows	41
Dickcissels.....	42
Eastern Meadowlarks.....	43
Discussion	44
Grassland Species	44
Species of Concern	45
Northern Bobwhites.....	47
Grasshopper Sparrows	49
Henslow's Sparrows	50
Dickcissels.....	51
Eastern Meadowlarks.....	51
5. MANAGEMENT IMPLICATIONS.....	53

<u>Chapter</u>	<u>Page</u>
LITERATURE CITED.....	57
APPENDIX.....	70
Tables.....	71
Figures.....	89
VITA.....	121

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Planting information of restored native warm season grass program fields evaluated in Tennessee, 2002 and 2003	72
2. History and current management of restored native warm season grass fields evaluated in Tennessee, 2002 and 2003	73
3. Dominant vegetation in Fort Campbell Military Reservation and restored native warm season grass fields, summer 2002 and 2003	74
4. Native warm season grass dominance by species in Fort Campbell Military Reservation and restored native warm season grass fields, summer 2002 and 2003	75
5. Field structure and composition in Fort Campbell Military Reservation and restored program fields, summer 2002 and 2003. Habitat measurements from Moss (2001) are included	76
6. Habitat measurements of restored native warm season grass fields (n = 41) by management practice, summer 2002 and 2003	77
7. Habitat measurements of restored native warm season grass fields (n = 41) by year, summer 2002 and 2003	77
8. Common and scientific names of grassland bird species documented in and around evaluated grassland fields in Tennessee, summer 2002 and 2003. Species are in taxonomic order	78
9. Presence of grassland species in restored native warm season grass fields, summer 2002 and 2003	79
10. Presence of grassland species in all fields evaluated, summer 2002 and 2003	80
11. Common and scientific names of all bird species documented in and around grassland fields evaluated in Tennessee, summer 2002 and 2003. Species are in taxonomic order	81
12. Results of multiple linear regression models to predict grassland bird species occurrences in Tennessee, summer 2002 and 2003	86

13. Results from AIC model selection and stepwise linear regression of vegetation variables to explain bird presence by species, summer 2002	87
14. Results from AIC model selection and stepwise linear regression of vegetation variables to explain bird presence by species, summer 2003	88

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Historic grassland habitat in Tennessee (Packard and Mutel 1997)	90
2. Fields within Tennessee counties evaluated for native warm season grass restoration and breeding bird use, May-July, 2002 and 2003	91
3. Number of restored native warm season grass fields evaluated by percent of the landscape in grass and pasture cover (landscape) and field size	92
4. Plot array used to evaluate vegetation around point counts, summer 2002 and 2003	93
5. Average field composition of Fort Campbell Military Reservation fields, summer 2002 and 2003	94
6. Average field composition of restored native warm season grass fields (n = 41), summer 2002 and 2003	94
7. Field composition by management practice in program fields (n = 41), summer 2002 and 2003 (pooled)	95
8. Average net change in litter depth by management type in restored native warm season grass fields (n = 41), summer 2002 and 2003	96
9. Average net change of cover types in restored native warm season grass fields (n = 41), summer 2002 and 2003	96
10. Mean vegetative density across management types in restored native warm season grass fields (n = 41), summer 2002 and 2003 (pooled)	97
11. Mean vegetative height across management types in program fields (n = 41) evaluated, summer 2002 and 2003 (pooled)	97
12. Average percent cover by litter and bare ground in Fort Campbell Military Reservation and restored native warm season grass fields, summer 2002 and 2003. *Habitat measurements from Moss (2001) are included	98

13. Average percent cover by native warm season grass and forbs in Fort Campbell Military Reservation and restored native warm season grass fields, summer 2002 and 2003. *Habitat measurements from Moss (2001) are included	99
14. Log-linear relationship for observed grassland species richness and field size, summer 2002	100
15. Log-linear relationship for observed species of concern richness and field size, summer 2002	101
16. Log-linear relationship for observed grassland species richness and field size, summer 2003	102
17. Log-linear relationship for observed species of concern richness and field size, summer 2003	103
18. Average landscape cover by grass/pasture and field size where northern bobwhites occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003	104
19. Average vegetative height and forb cover where northern bobwhites occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003	105
20. Average native warm season grass and bare ground cover where northern bobwhites occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003	106
21. Average density and litter depths where northern bobwhites occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003	107
22. Average landscape cover by grass/pasture and field size where grasshopper sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003	108
23. Average litter depths and bare ground cover where grasshopper sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003	109

24. Average vegetative height and forb cover where grasshopper sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.....	110
25. Average NWSG and litter cover where grasshopper sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.....	111
26. Average landscape cover by grass/pasture and field size where Henslow's sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.....	112
27. Average vegetative height and forb cover where Henslow's sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.....	113
28. Average litter depths and NWSG cover where Henslow's sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.....	114
29. Average landscape cover by grass/pasture and field size where dickcissels occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.....	115
30. Average vegetative height and forb cover where dickcissels occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.....	116
31. Average NWSG and litter cover where dickcissels occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.....	117
32. Average CSG and bare ground cover where dickcissels occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.....	118
33. Average landscape cover by grass/pasture and field size where eastern meadowlarks occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.....	119

34. Average vegetative height and forb cover where eastern meadowlarks occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003 120

CHAPTER 1

Introduction

Native grasslands support a diversity of wildlife (Risser 1988). Grasslands once covered more than 162 million ha of the central United States and were divided into three regions: the short-grass prairie, mixed-grass prairie, and the eastern tall-grass prairie. The tall-grass prairie extended from Canada and Minnesota and south to Texas and is classified as a temperate, mesic grassland that is highly productive. The mixed-grass prairie extended from Canada and eastern North Dakota south to Texas, whereas the short-grass prairie extended from eastern Montana to western Texas and New Mexico (Sampson and Knopf 1994). Outside of these areas were blocks of smaller prairie habitat and transition zones of pine (*Pinus spp.*) and oak (*Quercus spp.*) savannah as is found in Tennessee. Mature trees were present in the pine and oak savannah ecosystems, however their occurrence was sporadic allowing grasses to comprise the understory (Kilburn 1959).

Landscape influences movement of wildlife (Crist et al. 1992). The size of grassland patches and composition of the landscape in grass are important for many grassland wildlife species (Herkert 1994a). Today, there are no intact grasslands large enough to support presettlement wildlife populations (Steinauer and Collins 1996). In addition, smaller fields with more edge are more susceptible to being invaded by exotic plants (Solecki 1997). Johnson and Igl (2001) listed encroachment of woody and exotic vegetation as one of the top three concerns involving grassland breeding grounds. Field edges have also been reported as being avoided by grassland birds (Wiens 1969, Helzer

1996, Delisle and Savidge 1997) and have shown increased levels of brood parasitism and nest predation (Johnson and Temple 1990, Burger et al. 1994, Helzer 1996).

However, no effects have been found when comparing agricultural edges and grassland nest predation rates (Mankin and Warner 1992, Winter et al. 2000, Howard et al. 2001).

Habitat fragmentation is another concern with grasslands (Johnson and Igl 2001). The effects of patch size on grassland birds are noticeably different in highly fragmented and less fragmented landscapes (Donovan et al. 1997). Johnson and Igl (2001) concluded that locating grassland fields near other grassland fields or establishing one large field compared to several smaller fields would benefit more grassland bird species. Many studies where patch sizes were less than 31 ha have shown negative relationships between the size of the patch and nest predation (Johnson and Temple 1990, Burger et al. 1994, Clawson and Rotella 1998, Winter et al. 2000). A minimum patch size of 50 ha may be required before there is no effect of patch size on nest predation (Howard et al. 2001).

Historically, biologists and ecologists thought that native grasslands were not a priority for conservation and management because grasslands were considered less diverse than other ecosystems (Knapp et al. 1998). They believed there were ample native grasslands that would always be intact. Over the last century, however, much of the native grasslands have been converted to row crops, pasture, and developed areas. As a result, less than one half of 1% of original tall grass prairie remains and as much as 80% of the mixed grass prairie has been lost (Samson and Knopf 1994). Native grasslands are now our nation's most threatened ecosystem (Sampson and Knopf 1994, Noss et al. 1995).

With the loss of grassland habitat came the decline of many grassland species of wildlife, especially grassland birds. In fact, grassland bird populations have experienced declines greater than any other group of birds in the last 37 years based on the Breeding Bird Survey (BBS) (Hunter et al. 2001, Sauer et al. 2003). These declines can primarily be attributed to loss of native grassland habitat. Most native grasslands were converted to croplands and hay fields and are of little value to most grassland wildlife species (Johnson and Schwartz 1993, Johnson and Igl 1995, Best et al. 1997).

Today, federal, state, and private conservationists are working to restore native grasslands. The primary contributor to grassland restoration across the United States has been the U. S. Department of Agriculture (USDA) through the Conservation Reserve Program (CRP). CRP was established in 1985 to reduce soil erosion and curb overproduction of agriculture by converting highly erodible farmland to perennial habitat (U.S. Department of Agriculture 2000, McIntyre and Thompson 2003). Under provisions of the 1985 Food Security Act (Farm Bill), more than 14 million ha of crop fields were converted to permanent cover (Osborn and Heimlich 1994). As a byproduct, ephemeral grassland habitat was created. Amendments in 1990 and 1996 changed the Farm Bill by creating state technical committees, ranking applications based on environmental benefits, incorporating wildlife needs, and the creation of new programs such as the Wetlands Reserve Program (WRP), Wildlife Habitat Incentives Program (WHIP) and Environmental Quality Incentives Program (EQIP) (Heard et al. 2000). In 2002, Congress reauthorized 1.6 billion dollars for these programs.

A voluntary program, CRP offers annual rental payments for up to 10 to 15 years and cost share assistance (up to 50%) to establish long-term ground covers on eligible

land. The program is overseen by the USDA Natural Resources Conservation Service (NRCS). In the program, landowners can convert existing fields to native warm-season grasses (NWSG) and receive assistance for establishment plus an annual payment (~\$58/acre in Tennessee). Additional funding is available for maintenance of these fields (e.g., follow-up spraying). To be eligible, lands must meet criteria for being agricultural lands, able to plant in a legal and normal manner, have a high soil erosion index, or be located in a national or state conservation priority area (U.S. Department of Agriculture 2000).

The initial species selected to accomplish erosion control goals were mostly non-native cool-season grasses (CSG). Starting in the 1980s, tall fescue (*Festuca arundinacea*) was used in 90% of the CRP grass plantings in Tennessee and Kentucky (Carmichael 1997). In the Southeast, 62% of initial CRP acres were enrolled in pine plantings, primarily loblolly pine (*Pinus taeda*) (Heard et al. 2000). Of all tree plantings under CRP, >90% were planted in the Southeast (Osborn et al. 1992) which already had a landscape comprised of 48% forest cover (Heard et al. 2000). Pine plantations are reported to have lower diversity of understory plants than stands naturally regenerated or regenerated by clearcutting (Carmichael 1997). As a result, the CRP in the Southeast has not had the same positive effects as those reported for CRP fields in the Great Plains (Carmichael 1997, Heard et al. 2000). In fact, CRP was suggested to have had a negative impact on some species in the Southeast, such as northern bobwhite (*Colinus virginianus*) (Capel 1995, Carmichael 1997).

Ryan et al. (1998) conducted a literature review to assess grassland CRP impacts on grassland birds in the central United States. Relative abundance of grassland species

in CRP fields was reported to range from 1.4 to 10.5 times greater than abundance in row crop fields (the habitat replaced by CRP). They reported that more than 90 species of birds (from 10 orders) were using CRP fields; 42 species were identified as nesting within CRP habitat. Best et al. (1997) found 33 species of birds nesting in CRP fields in Iowa compared to only 10 species found breeding in row crops.

As of January 2004, 110,290 ha of agricultural land have been enrolled in the CRP in Tennessee. In program year 2004, 9,709 ha of NWSG will be established, 2,092 ha will be established in non-native cool-season grasses and legumes, and 1,279 ha of trees will be planted (U.S. Department of Agriculture 2004).

The Farm Security and Rural Investment Act of 2002 reauthorized WHIP to improve wildlife habitat. A voluntary program, WHIP aids individuals interested in developing and maintaining wildlife habitat on private land. In the program, NRCS provides technical assistance and up to 75% cost-share assistance to create more suitable fish and wildlife habitat. Because the program was designed to benefit wildlife, WHIP often is available to landowners who may not be eligible for other conservation programs such as CRP (Heard et al. 2000).

WHIP provides cost-share assistance to landowners who want to provide more suitable wildlife habitat on their properties with practices such as NWSG establishment. The program can also be implemented with other programs to achieve more comprehensive wildlife objectives. Agreements generally last for 5 to 10 years and can be renewed if the property is qualified (U.S. Department of Agriculture 2003a).

The Grassland Reserve Program (GRP) was established as part of the 2002 Farm Bill amendment to restore and protect grassland habitat. To be qualified, lands must be at

least 16 ha in size and meet eligibility standards as to field type (hay field, pasture, or forb-dominated fields). Landowners with uncultivated lands may receive up to 90% cost share assistance to establish grassland habitat. Annual payments do not exceed 75% of the grazing value of the land covered by the contract for the life of the contract. In the program, landowners can still hay or graze their fields. However, the program requires that 20% of the field be undisturbed between April 15th and August 15th to provide nesting habitat for grassland species. In 2003, Tennessee received \$898,000 to be allocated for this program (U.S. Department of Agriculture 2003b).

Tennessee grasslands are being restored through state landowner assistance programs such as the Tennessee Wildlife Resources Agency (TWRA) Farm Wildlife Habitat Program (FWHP). Native grass fields were planted beginning in the late 1980's under the Upland Game Bird Habitat Program (now called the FWHP). Since 1988, approximately 2,090 ha of NWSG have been planted in Tennessee under this program. The FWHP offers technical assistance and up to 75% cost share of practice costs for willing landowners who wish to improve wildlife habitat on their property. The program assists landowners in non-native grass eradication, establishment of NWSG, controlled burning, and other wildlife practices as needed. Applicants are considered on a first-come first-serve basis, and contracts are in place for five years. Haying is permitted on 75% of NWSG fields established specifically for forage but only during years 3, 4, and 5 after establishment. Grazing is not permitted in the program. Landowners are not reimbursed until the practice is in place and has been inspected (T. White, TWRA, pers. comm.)

Tall Fescue

In 1931, a strain of fescue was discovered growing on a farm in Kentucky. Because of its ease of establishment and persistence, tall fescue was widely accepted by landowners throughout the state of Tennessee and planted as the main forage for their livestock. Millions of hectares of native grasses were converted to non-native cool-season forages; most fields were converted to tall fescue. Tall fescue gained a reputation for unpalatability, as many livestock exhibited poor weight gains and symptoms of toxicosis. It was initially thought that the structure of the plant was responsible. In the late 1970's, however, it was discovered that most of the tall fescue in Tennessee was infected by the fungal endophyte, *Neotyphodium coenophialum* (Bates 1995). Infected plants are asymptomatic, and the fungus provides fescue with enhanced tolerance to drought, disease, and herbivory (Bates 1995).

Tall fescue tends to grow in a thick sod that provides unsuitable structure for wintering, nesting and brooding grassland wildlife (Barnes et al. 1995, Sole and Keyser 1998). Many grassland birds are granivorous, yet seeds of tall fescue are not preferred (Ellis 1961) and do not meet nutritional requirements for most species (Barnes et al. 1995, Madison et al. 1995). Tall fescue seeds have also been linked to reduced fertility and hatching in Japanese quail (*Coturnix japonica*) (Zavos et al. 1993). Grassland bird species change from a diet of seeds to insects during the breeding season to ensure their young are provided a diet high in protein for development (McIntyre and Thompson 2003). The quality of their habitat depends greatly on the abundance and availability of invertebrates (Jackson et al. 1987). Abundant invertebrate availability results from a diversity of plant species, a large amount of forbs, and areas of open ground (Hurst 1972,

McIntyre and Thompson 2003). Because infected fescue is persistent and grows in a thick sod with extensive thatch build-up, forb growth is greatly reduced.

Tall fescue has been linked to northern bobwhite decline in some areas (Brennen 1991). Even before 1950, researchers hypothesized that tall fescue may not be good quail escape, nesting, or brooding habitat because of the minimal bare ground and inadequate structure provided (Davison 1949). Burger et al. (1990) found NWSG fields allowed for earlier nest initiation and provided better nest concealment than did cool-season grass fields. Barnes et al. (1995) found that while invertebrate populations appeared diverse in tall fescue, their availability to quail chicks was minimal. Larkin (1997) found greater avian abundances in NWSG fields compared to tall fescue fields and attributed these results to the appropriate mixture of NWSG, forbs and bare ground.

Grassland Establishment and Management

Converting tall fescue fields to NWSG is an accepted method for improving grassland habitat for wildlife (Madison et al. 1995, Washburn et al. 1999). As grasslands age and go through succession, the vegetative structure and composition change (Burger et al. 1990). Characteristic, young NWSG fields (≤ 2 growing seasons) tend to be comprised of annual weeds, legumes, and abundant bare ground. Once a NWSG field is established (> 2 yrs), it tends to have taller vegetation with more bare ground, compared to CSG fields (McCoy et al 2001a). Mature (> 4 years) NWSG fields that have not been disturbed are characteristically dominated by perennial grasses with significant amounts of litter accumulation, reduced forbs and reduced bare ground (Millenbah et al. 1996, McCoy et al. 2001a). These older fields with extremely dense vegetation and large

amounts of litter accumulation restrict use by some grassland wildlife (King and Savidge 1995, McCoy et al. 2001a).

Peak growth of NWSG occurs when soil temperatures are $> 15.5^{\circ}\text{C}$. The extensive and well-developed root system of NWSG is adapted to low rainfall allowing it to flourish during the hottest months which correlate with many wildlife breeding seasons (Langer 1972). Native warm-season grasses are bunch grasses that grow in clumps with stiff, erect stems which allow for covered travel corridors between the clumps for wildlife. The structure provided by NWSG results in excellent brood/young rearing habitat for many grassland birds and mammals. Howard et al. (2001) found the structure in CRP grasslands in Colorado more important in controlling nest predation than landscape context. Appropriate structure alters sensory cues, impedes mobility, and increases the overall energetic cost for predators searching for nests to depredate (Martin 1993, Dion et al. 2000). In addition, nests initiated later in the growing season when there is more vegetation have greater success than nests initiated earlier (Clawson and Rotella 1998). Cool-season grasses provide less vertical density and vertical structure during the breeding season (Deslisle and Savidge 1997), so from a structural point of view, NWSG fields provide superior breeding habitat for most grassland wildlife.

Once NWSG is established, it is common for NWSG to dominate forb growth in a field (Millenbah et al. 1996, Patterson and Best 1996). To maintain proper structure and the correct proportions of bare ground, forbs and NWSG, grassland fields must be managed if they are to continue providing optimal habitat for grassland birds. As grasslands go through succession, vegetative structure and composition change (Burger et al. 1990). Managers and policy makers need to understand what changes are occurring in

NWSG fields to promote policies and practices for management (McCoy et al. 2001b). Kline (1997) suggested that managers take an entire growing season to evaluate grassland species composition and growth dynamics before implementing any management. Learning appropriate methods for restoring and managing native grasslands will reduce the likelihood of choosing improper solutions to existing problems. For example, mowing NWSG fields is often chosen as a “quick fix” for setting back succession. This approach may actually lead to accelerated grass succession and increased litter depths (McCoy et al. 2001a). Native grassland fields managed by mowing are often mowed during the grassland bird nesting season. Several studies have noted the detrimental impacts of mowing on grassland wildlife (Patterson and Best 1996, Ryan et al. 1998, McCoy et al. 2001a). If birds place all of their efforts into nesting and then lose their nests because of mowing, then no reproductive output will come from that field.

When managing native grasslands, costs associated with equipment and man-hours to do the work should be considered. Burning is the simplest and most cost effective method for controlling succession and maintaining native grasslands (Shriver and Vickery 2001). In fact, prescribed burning is still used to routinely enhance grazing in some areas (Pons et al. 2003), just as Native Americans did centuries ago. Burning in a mosaic pattern on large landscapes provides the diversity of structure required by a suite of grassland bird species. Askins (2000) noted that a wide array of vegetative structure must be in place to maximize wildlife species richness in grassland habitats. For grassland wildlife species, habitat preferences differ from sparse and open to dense areas with taller vegetation (Wiens 1969). Fire is part of a “positive feed-back” system where the old growth from previous growing seasons provides excellent fuel for the fire,

and the fire stimulates lush green growth and returns nutrients to the soil the following growing season (Kline 1997). Fire is also important in the removal of litter. Delisle and Savidge (1997) found a linear increase in litter depth in grass fields over a 3-year period. Cool-season grasses such as tall fescue may also be decreased if burned at the right time of year (Packard and Mutel 1997).

Tennessee Grassland Management

TWRA and NRCS are contributing greatly to restoring native grasslands back to the Tennessee landscape. In the past, Tennessee contained blocks of native grasslands maintained by regular burning by Native Americans (Baskin et al. 1994, Packard and Mutel 1997) (Figure 1)*. These fires affected the landscape significantly (Delcourt and Delcourt 1997). These native grassland areas, however, have been reduced to the minimal amounts found today.

Millions of dollars and thousands of man hours have been and continue to be invested into NWSG restoration in Tennessee. Though NWSG are generally considered beneficial to grassland wildlife, only a few studies have been conducted to compare and contrast the effects of exotic grasses versus NWSG in these fields (Best et al. 1997, Delisle and Savidge 1997, Best et al. 1998, Clawson and Rotella 1998, Howard et al. 2001, McCoy et al. 2001b, McIntyre and Thompson 2003). In the Great Plains, native grassland restoration had an enormous, positive influence on the landscape and markedly improved the bird communities associated with those areas (Johnson and Swartz 1993, Johnson and Igl 1995, King and Savidge 1995, Clawson and Rotella 1998). It is

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

uncertain, however, what the response by grassland birds has been in restored areas in Tennessee. Because of landscape differences between western states and Tennessee, results from western studies may not apply.

Given the regional declines in grassland birds, it is crucial to focus on grasslands across Tennessee and document the potential for restoration. For these reasons, this research assessed the TWRA/NRCS NWSG restoration program on selected fields throughout Tennessee. The goal of this study was to further assist TWRA/NRCS in management of this habitat type such that wildlife benefits might be maximized. The objectives of this study were to:

- 1) evaluate the success of the restoration of native grasslands in terms of composition and structure of established vegetation,
- 2) evaluate the success of the restoration in terms of avian use of these NWSG fields and correlate that use with composition, structure, field size, and landscape context,
- 3) identify management needs in maintaining restored grasslands in Tennessee.

CHAPTER 2

Study Area

Tennessee covers 106,759 square kilometers (10,675,931 ha) comprised of wetland, woodland, row crop, pasture, and urbanized areas stretching across 95 counties. The Tennessee River runs obliquely across the state and divides Tennessee into three distinct regions: eastern, middle, and western. Average annual rainfall is 104, 122, and 137 cm in eastern, middle, and western Tennessee, respectively (Vickers and Cunningham 2003). Average temperatures in Tennessee for the months data were collected (May-July) were 22.5, 23, and 24 °C in eastern, middle, and western Tennessee, respectively (Vickers and Cunningham 2003). Eastern Tennessee extends from the southern Blue Ridge to the eastern side of the Cumberland Plateau. Middle Tennessee includes the Cumberland Plateau across to the northward-flowing Tennessee River. Areas of higher elevation in this area are known as the Eastern and Western Highland Rim and an area of low elevation in this area is known as the Central Basin. Western Tennessee extends from the Tennessee River to the Mississippi River and contains highly fertile farmland. This portion of the state also contains the lowest elevations (57 m above sea level).

Tennessee contains nearly 2,700 species of plants (University of Tennessee Herbarium 2004). Many of the native grasses found in Tennessee are similar to those found in the tallgrass prairie region of the United States (DeSelm 1994). Historically, farms in Tennessee were small in size and fragmented to produce multiple crops which sustained the families that lived there (Tennessee Wildlife Resources Agency 1980).

Settlers began moving across northeastern Tennessee during the late 1700's (Folmsbee et al. 1960). Both the cleared forests and existing open grasslands were primarily used for pasture. These open areas were normally burned in the spring to promote lush growth for livestock (DeSelm 1994). As more and more of the landscape was turned into farms, burning regimes changed throughout the landscape. In the 1920's, Herbert L. Stoddard documented the need for the return of fire to the landscape to manage for early successional wildlife. It wasn't until the 1970's, though, when private landowners as well as state agencies began to think about fire as a management tool once again (Johnson and Hale 2000). Past managers, having little knowledge of grasslands and minimal research on which to rely, did little to manage native grassland habitats. Today, however, as more research and resources are accumulated, focus must be placed on managing grasslands and the wildlife that rely on them for survival.

Restored native grassland habitats were evaluated in 24 of the 95 counties across Tennessee (Figure 2). Fields were selected by contacting state (TWRA) and federal (NRCS) natural resources personnel and compiling a list of participating landowners that owned NWSG fields. Fields were categorized into 3 size classes (2-9.7, 10-16, and ≥ 16.5 ha) and into 3 grassland landscape settings (0-25%, 26-40%, and $> 40\%$ of the total landscape in grass cover) (Figure 3). Percent landcover was calculated using Arc View by drawing a 10 km circle around each field and calculating the percent cover in grass cover types (hay fields and pastures). After compiling a list of selected sites, landowners were contacted by telephone and asked for permission to evaluate their fields.

Data were collected over two years on a total of 47 fields undergoing NWSG restoration across the state. Approximately 2.7 kg/ha (6 lbs/acre) Pure Live Seed (PLS)

of NWSG had been planted in each field (Table 1). A native grass mix [big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*)] had been planted on forty-one of the fields (Table 1). Some restored fields also were planted with eastern gammagrass (*Tripsacum dactyloides*). Four fields were monocultures of switchgrass, one was a monoculture of eastern gammagrass, and one a monoculture of indiangrass (Table 1). Most fields (n = 29) were historically row crop fields. Nine fields were historically hayed, six were pasture, and three were fallow (Table 2). All fields were established using no-till drills with two fields being disced before drilling (Table 1). Twenty fields were sprayed with a Roundup/Plateau mix before planting, seventeen were sprayed with only Roundup, three were sprayed with only Plateau, and seven were not sprayed before planting (Table 1). Data were also collected from three fields at Fort Campbell Military Reservation (FCMR) to use as a standard by which I compared restored NWSG fields.

The goal of most grassland restoration efforts is to mimic habitat conditions found in native prairie ecosystems. The term “prairie” is a French term meaning “meadow.” Prairie implies a landscape that is treeless, open, and grass-dominated intermixed with forbs (Risser et al. 1981). FCMR contains remnant prairie with fields as large as 600 ha. However, some fields at FCMR were historically planted in tall fescue, orchardgrass (*Dactylis glomerata*), smooth brome (*Bromus inermis*), and timothy (*Phleum pratense*) for hay production. One of the three fields (the largest) used in this study at FCMR historically had portions planted in tall fescue. As a result, fescue invasion had occurred throughout the portion of the field used in my research. The other two fields were remnant prairie habitat lacking tall fescue. Because we know FCMR provides suitable

habitat for the full compliment of grassland birds [except greater prairie chicken (*Tympanuchus cupido*)], FCMR should serve as a standard for comparison with restored program fields in Tennessee.

CHAPTER 3

An Evaluation of Restored Native Grass Fields in Tennessee

Grassland wildlife are dependant upon grassland vegetative composition and structure to successfully reproduce. Grassland composition and structure is dependant on many abiotic factors such as annual rainfall, slope, temperature, and soil characteristics (Kline 1997). Grasses, legumes, and forbs respond differently to each factor and result in the diversity of habitat conditions found within grasslands. Warm-season grasses, cool-season grasses, forbs, and woody vegetation contribute to the vegetative diversity found in grasslands (Zimmerman 1997). Because many of these plant species are competing for resources at the same time, peak growing seasons for many grassland plants are offset.

Grassland plants evolved with early herbivores over thousands of years and developed resistance mechanisms to high temperatures, strong winds, grazing, fire, and drought (Packard and Mutel 1997, Manske 2000). The structure of grasses is important in providing individual species the ability to survive the diverse conditions. Native grassland plants commonly have thin, vertical leaves which provide for less wind resistance and less heating by the sun that is common in the open habitat where they normally occur (Kline 1997). The extensive, well-developed root systems of native grasses can make up as much as 65% of the plant's biomass (Miller 1997). This allows for sufficient growth even during times of drought and regrowth after disturbances such as fire, mowing, or grazing.

Historically, Tennessee contained large areas of native grasslands (DeSelm 1994), which were once home to many now extirpated species of wildlife, including the greater prairie-chicken, elk (*Cervus elaphus*), and American bison (*Bison bison*) (Gainer 1933, Kellogg 1939). Because of land clearing for agriculture, development, and the lack of fire, most Tennessee grasslands have been lost.

Fort Campbell Military Reservation, located in Stewart and Montgomery counties in Tennessee, maintains more than 10,000 ha of grass-dominated habitat (Moss 2001). One of the largest grasslands east of the Mississippi River can be found at FCMR (Moss 2001). Recent (1999-2004) research on grassland birds at FCMR in Tennessee-Kentucky has documented the potential for maintaining viable populations of grassland bird species in need of management in the region [e.g., Henslow's sparrow (*Ammodramus henslowii*), grasshopper sparrow (*Ammodramus savannarum*), and Bachman's sparrow (*Aimophila aestivalis*)] (Moss 2001, Giocomo et al. 2002). Known as barrens, the areas where these species were studied are treeless, grass-dominated fields located on hilly, karst topography (Chester et al. 1997). DeSelm (1994) studied and inventoried Tennessee barrens most of his career and found that barrens are associated with glade openings on shallow soil over limestone in middle Tennessee. He found barrens associated with open sandstone on the Cumberland Plateau, and in deeper soils in the Ridge and Valley. DeSelm (1994) further noted that these barrens were very similar to western tallgrass prairies in that they shared similar dominant plant compositions. Remnant and restored grassland fields in Tennessee contain one or more native warm-season grasses, such as big bluestem, little bluestem, indiagrass, switchgrass, or broomsedge (*Andropogon virginicus*).

In Tennessee, the USDA NRCS, and TWRA are putting significant effort and resources into restoring native grasslands to the state through programs such as the FWHP, CRP, WHIP, and GRP. Management of these fields, however, varies between TWRA and NRCS and by Tennessee region (eastern, middle, and western). Success of the restoration effort has not been documented.

The objective of this chapter is to compare restored NWSG fields in Tennessee with the remnant prairie habitat found at FCMR. Further, this chapter will compare and contrast three management effects (burn, mow, and no management) on restored NWSG fields in Tennessee.

Methods

Data collection for this study was conducted from 15 May through 15 July, 2002 and 2003. Forty-five fields undergoing NWSG restoration were evaluated in 2002 and 43 fields were evaluated in 2003; 41 fields were evaluated both years. Three fields at FCMR (one in each size class) were evaluated to use as a comparison to restored NWSG fields for vegetative composition and structure.

A program field was defined as any field that had been planted and restoration attempted in converting that field to native grasses under TWRA or NRCS assistance. Evaluated fields were at least two growing seasons old except for a few fields that were only one growing season but met my criteria as an established NWSG field (Table 1). Fields were classified into three management categories based on their management history (mowing, burning, or no management) (Table 2). All fields were either newly established or had been managed within the last 3 years. On average, fields managed by

burning in 2002 ($n = 15$) had been established 5 growing seasons. Fields managed by mowing ($n = 18$) or not being managed ($n = 12$), had been established for at least 2 growing seasons (Table 2). In 2003, fields being managed by burning ($n = 13$) had been established, on average, for 6 growing seasons. Fields managed by mowing ($n = 17$) or not being managed ($n = 13$) had been established for 3 growing seasons (Table 2). Fields not re-evaluated in both years were flooded or had been altered since the previous year and no longer met my criteria as an established NWSG field. Each field was evaluated for NWSG restoration success and other plant composition. Successful fields were defined as those fields where NWSG was the dominant vegetative species found in the field.

Vegetation was measured at avian point-count centers (Chapter 4) and 9 other plots (radiating at 40 degree angles, 20 m out from point center and 28 m apart) for a total of 10 vegetation plots at each point-count location (Figure 4). Points were distributed systematically across each field at least 200 m apart. One point was evaluated per every 10 ha, with a maximum of 4 points on the largest fields. At each plot, litter depth (cm) and percent cover by bare ground, NWSG, CSG, forbs, woody vegetation and residual stems (stems from the previous growing season) were measured within a 1-m² frame. Vertical density was also measured using a density board (15 X 15 cm squares; 2 squares wide X 10 squares high). Density board measurements were taken by walking 15 m from the board (located at plot center) and reading the number of covered squares in the four cardinal directions (Nudds 1977). Average vertical structure by height was then calculated by averaging the total number of covered squares and dividing that number by the total number of squares.

Litter depth was measured by placing a ruler in the ground until it struck a hard surface. The distance from the hard surface to the top of the litter was measured and recorded to the nearest centimeter. This was done in the four corners and in the center of the 1-m² frame, resulting in five litter depth measurements. The measurements were averaged at each plot.

All percent cover measurements were accomplished by visually estimating what was seen inside of the 1-m² frame. An overall average height (cm) for all vegetative species present was estimated. Percent bare ground was estimated as the amount of ground within the 1-m² frame that was not covered by any of the previously mentioned vegetation. All measurements inside the 1-m² frame added to 100 percent. The same observer estimated all measurements during 2002 and 2003 for consistency.

Statistical Analysis

Descriptive statistics were used to compare FCMR and program fields. Data were averaged by point within each field. Average field composition was calculated from program fields and FCMR fields and plotted against each other on graphs.

Vegetation characteristics for program fields (n = 41) were compared and tested for differences in, and interactions between, year and management type. When comparing fields across years and management practices, the assumptions of normality and equal variances were tested. When tested, Univariate ANOVA with normally distributed variables was used to test for differences between years and among management types. Two of the variables (litter depth and percent cover by CSG) were normalized after changing them to ranks and were also tested using ANOVA. The final

three variables (percent cover by NWSG, woody vegetation, and residual stems) would not normalize and continued to show unequal variance, so Friedman's Analysis of Variance by ranks was used.

Results

Fort Campbell fields were predominantly NWSG, CSG, and forbs (Figure 5). Program fields evaluated across both years were predominately NWSG and forbs (Figure 6). In FCMR fields, the most common vegetation besides NWSG and forbs was predominantly tall fescue (Table 3). The most common vegetation found in program fields besides NWSG and forbs was smooth brome, johnsongrass (*Sorghum halepense*), tall fescue, and little barley (*Hordeum pusillum*) in both years (Table 3). Little bluestem and broomsedge were the dominant NWSG found in fields at FCMR (Table 4). Big bluestem and switchgrass were the dominant NWSG observed in program fields in both years (Table 4). Fort Campbell fields had a maximum litter cover less than 27% in both years (Table 5). Mean litter cover at FCMR did not exceed 14% (Table 5). Program fields had a maximum litter cover of almost 40% in both years (Table 5). Mean litter cover in program fields was 10.8% and 15.2% in 2002 and 2003, respectively (Table 5). Average cover by bare ground in FCMR fields was 15.6% and 13.1% in 2002 and 2003, respectively (Table 5). Average cover by bare ground decreased in program fields from 16.7% in 2002 to 7.47% in 2003 (Table 5). Forb cover did not exceed 30% in FCMR fields in 2002 or 2003 (Table 5). In program fields, maximum forb cover was 45% and 63% in 2002 and 2003, respectively (Table 5). Vegetative height in FCMR fields did not exceed 50 cm in either year (Table 5). Maximum vegetative height in program fields was

almost 92 cm in both years (Table 5). Fort Campbell fields averaged 1.8% and 3.3% woody cover in 2002 and 2003, respectively. Program fields averaged 2% and 1.8% woody cover in 2002 and 2003, respectively (Table 5). Residual stems were only detected at FCMR in 2003 and did not exceed 3% at any of the evaluated points. In program fields, maximum residual stem cover was 14.2% and 4.4% in 2002 and 2003, respectively (Table 5).

In program fields, percent cover by litter was greater in mowed fields ($\bar{x} = 17.24\%$) and fields not being managed ($\bar{x} = 13.7\%$) than fields being burned ($\bar{x} = 7\%$) ($P < 0.05$) (Table 6, Figure 7). Average litter depths were greater in 2003 program fields than in 2002 with an average net gain of 0.865 cm ($P < 0.05$) (Table 7). Litter depth gains were greater in fields being mowed ($\bar{x} = 1.06$ cm) and not being managed ($\bar{x} = 0.91$ cm) than litter depth gains in fields managed by burning across the two years ($\bar{x} = 0.46$ cm), ($P = 0.0004$) (Table 6, Figure 8). The amount of bare ground was reduced from 2002 to 2003 with an average loss of 9.27% ($P < 0.05$) (Table 7, Figure 9). Vegetative density was greater in fields that were managed by burning ($\bar{x} = 75\%$) than fields that were being mowed ($\bar{x} = 58\%$), ($P = 0.0005$), but density did not differ between fields being burned and fields not being managed ($\bar{x} = 71\%$) (Table 6, Figure 10). Forb cover was greater in burned fields ($\bar{x} = 33.75\%$), ($P = 0.0006$) than fields being mowed ($\bar{x} = 19.86\%$) or fields not being managed ($\bar{x} = 22.95\%$) (Table 6, Figure 7). Vegetative height was greater in burned fields ($\bar{x} = 59.53$ cm) than fields being mowed ($\bar{x} = 46.33$ cm) ($P = 0.0048$), but vegetative height did not differ between burned fields and fields not being managed ($\bar{x} = 52.36$ cm) (Table 6, Figure 11). Woody

vegetation was greater in burned fields ($\bar{x} = 3.8 \%$) than fields not being managed ($\bar{x} = 0.18\%$) ($P < .05$) (Table 6, Figure 7). All other variables showed no significant differences across management practices or years ($P > 0.05$, Tables 6 and 7).

Discussion

FCMR vs. Program Fields

Restoration efforts in Tennessee have been successful in reproducing some of the grassland conditions found at FCMR, with some notable exceptions. Similar to program fields, NWSG and forbs were two dominant vegetative species found in FCMR fields across both years. However, in my limited sampling, tall fescue was the most common species found at FCMR fields besides NWSG and forbs. More extensive sampling by Moss (2001) suggests my samples were not representative of all FCMR fields (Table 5). Before the 1940's, FCMR was primarily planted in row crops (D. Moss, pers. comm.) After the property became FCMR, agricultural leases were still part of the land management and tall fescue was planted for hay production in some fields resulting in the presence of fescue in these fields today. Tall fescue was also present in restored program fields with about 10% cover, much greater than CSG cover reported by Moss (2001) at FCMR.

Fort Campbell fields and program fields also differed in vegetative height. FCMR fields were dominated by little bluestem, broomsedge, and exotic CSG. Maximum heights of little bluestem and broomsedge normally do not exceed 1.5 m (Brown 1979). Program fields were seeded with a NWSG mix; however, the most prevalent species in the mix were big bluestem and indiangrass which can reach heights

of 2.5 m. Sporadic occurrences of exotic grasses such as johnsongrass in restored program fields also added to the average vegetative height, as johnsongrass can reach heights of 3 m (Miller and Miller 1999).

The 338 fields studied by Moss (2001) at Fort Campbell did not exceed 10% cover by litter unlike the shift toward more litter cover and less bare ground observed in program fields in my study (Figure 12). Fields at FCMR showed an increase in litter cover and a decrease in bare ground over three growing seasons after burning. Forb cover did not exceed 35% at FCMR (Figure 13). The consistency in habitat conditions can be attributed to the management regime in place at FCMR where fields are burned on a 1-3 year rotation (Moss 2001).

Management Effects

The seeding rates and planting methods prescribed by TWRA and NRCS were successful in establishment of NWSG in program fields. Composition in all fields, however, varied by year and by management practice. Restored CRP fields were primarily established for the purpose of erosion control and follow-up management of these fields was limited. Management of CRP fields is ultimately decided by a particular county Farm Service Agency (FSA) technical committee. These 3-5 member committees are elected by local landowners. For this reason, management practices in one county may differ or not be acceptable in another. Restored fields under TWRA contracts were primarily established for the purpose of wildlife habitat and were being managed by burning in most cases. However, some managers (in both agencies) and landowners preferred mowing as a management practice because they were uncomfortable (or lacked

appropriate knowledge) using fire. Mixed feelings toward the use of fire and inconsistent management strategies can be detrimental to grassland habitat. In Wisconsin, Allen (1994) identified untimely management practices and indecisive management strategies as problems that were detrimental to grassland wildlife.

Mowing is often chosen as an alternative to fire. This management strategy actually leads to short-term accelerated grass succession and increased litter depths (McCoy et al. 2001a). When defoliation occurs, the photosynthetic rate of replacement leaves is greatly enhanced, but only for a few weeks (Manske 2000). The new leaves grow longer than those on a non-defoliated plant of the same age (Langer 1972). In the short term, mowing can be beneficial to grassland wildlife (McCoy et al. 2001a) and may be necessary during the first summer of establishment to aid in controlling broadleaf weeds which cause competition and reduce NWSG composition (Rasnake et al. 1998). By removing the above ground biomass during the growing season, however, NWSG must use stored energy to replenish ample foliage above the ground to survive. When large amounts of leaves are lost, the means for photosynthesis are lost as well. Only healthy plants can withstand the stress placed on them by repeated defoliation within the same growing season. If defoliated too late in the growing season, the plant may not have enough time to rejuvenate their stored energy resulting in reduced growth and possibly death of the plant.

There are also problems associated with using fire, including human issues, health, accidents (from smoke), and air quality issues. These issues have resulted in restriction on prescribed burning in some areas (Johnson and Hale 2000). For these and other reasons, many managers and landowners choose to leave their fields unmanaged.

Unmanaged fields, however, are subject to invasion by woody and exotic species that occur with natural succession and reduce grassland wildlife habitat quality.

Johnsongrass, smooth brome, tall fescue, and little barley were the most common non-native grasses found in restored NWSG fields other than NWSG and forbs. If left unchecked, johnsongrass can dominate a NWSG field and quickly become a management problem.

The reduction in bare ground appeared to be the result of a lack of management. As the fields aged, dead vegetative debris from the previous growing seasons filled in bare ground spaces. In mowed fields, litter filled in the bare ground spaces at a much faster rate. Also, forbs and NWSG filled in bare space over time.

As litter filled in bare ground areas, litter depths accumulated. Delisle and Savidge (1997) found a linear increase in litter depth in grass fields over a 3-year period. Though mowed fields accumulate litter at faster rates than unmanaged fields, unmanaged fields do produce sufficient litter to change the composition of the stand over time. This study found no difference in litter depth in mowed and unmanaged fields, indicating a management practice which removes litter would be beneficial for both. Disturbances such as fire or disking are necessary to manage these problems (Burger et al. 1990).

Vegetative density and height are important in nest-site selection for grassland species. Burger et al. (1990) suggested taller growing NWSG fields produced nesting cover earlier than CSG fields that had shorter vegetative heights. When grassland species arrive on the breeding grounds to reproduce, appropriate structure must be in place if they are to benefit from that field. A variety of grass species will ensure diverse structure is in place at different times during the breeding season. And, if species are using these fields

as wintering grounds, composition and structure of the field are key in providing appropriate thermal and escape cover.

Changes in forb cover can be attributed to forbs being lost over time in mowed and unmanaged fields as NWSG became more established and litter cover accumulated. Burned fields, which were more than twice as old as mowed or unmanaged fields, contained less litter with more bare ground space allowing increased forb growth. The increased diversity of forbs, vegetative height, and density in burned program fields can primarily be attributed to the use of fire. Burning reduces ground litter and allows sunlight to penetrate the soil's surface. The use of fire stimulates plant growth and returns nutrients to the soil (Kline 1997).

Woody cover was greater in burned fields than fields not being managed, probably because the average age of the burned stands was 2 times that of the unmanaged stands. Even in burned fields, woody encroachment can be a problem if burning isn't effective. The timing of burns to control woody cover is critical. If fields are burned while the woody vegetation is dormant, then woody vegetation may resprout the following growing season.

Small portions of low shrub vegetation can be beneficial in a grassland, providing nesting cover and singing perches for some grassland bird species, such as field sparrows (*Spizella pusilla*), dickcissels (*Spiza Americana*), and Henslow's sparrow. Woody vegetation, such as sweetgum (*Liquidambar styraciflua*), will dominate a field in a few growing seasons, however, if left unchecked.

Based on plant species composition within restored NWSG fields, the restoration effort in Tennessee has been successful. However, results also showed follow-up

management of these fields was an issue. Burning is the best and most cost-effective management practice for controlling succession and maintaining restored NWSG fields (Shriver and Vickery 2001). Results from this study showed burned fields matched the NWSG habitat conditions at FCMR better than mowed fields or fields not being managed. If restored NWSG fields are not properly managed, then the grassland restoration effort will not achieve its full value for grassland wildlife in Tennessee. Fields at FCMR are burned on 1-3 year rotations and provide optimal structure for many species of wildlife, especially grassland birds. Restored NWSG fields in Tennessee should be managed in a similar fashion. If left unmanaged, restored fields will succeed to mostly shrub/scrub habitat in the next 3-5 years.

CHAPTER 4

Bird Response to Restored Native Grass Fields in Tennessee

As early as the 1970's, concern was rising for grassland birds (Hine 1973). Breeding Bird Survey (BBS) results solidified these concerns showing grassland birds were declining at a faster rate than any other group (Hunter et al. 2001, Sauer et al. 2003). The causes for these declines are generally unknown. Inadequate research has been conducted on grassland species compared to other groups of birds (Askins 1993, 1999, Peterjohn and Sauer 1999). Past work has concentrated on the breeding grounds and little is known about migration and wintering ground effects. Furthermore, most research has been done west of the Mississippi River in areas containing large quantities of grassland. Little is known about avian populations in eastern grasslands and restored grassland habitat in areas such as Tennessee.

Though the specific causes for grassland bird declines have not been identified, several factors have been suggested. Temple (1988) hypothesized excessive over-winter mortality could be a limiting factor because of an increase in alteration of migration and wintering habitats. Changes and loss of appropriate breeding habitat, however, is thought to be most limiting for grassland birds (Askins 1993, Peterjohn and Sauer 1999, Vickery et al. 1999). Suitable breeding habitat must be of adequate size, in the appropriate landscape context, and contain adequate nesting substrate and food resources for different bird species to carry out successful reproduction (Sample and Mossman 1997). Grasslands are normally low in species richness; however, food is not a limiting factor on

the breeding grounds for grassland birds (Wiens 1973). The maximum energy need for grassland birds during an entire breeding season was estimated to be less than 3 kcal/m² (Wiens 1973) and is low considering total annual energy flow through a grassland was estimated to be 75.6 kcal/m² (Van Hook 1971).

Patch size is extremely important to some grassland species (Herkert 1994a). Recent studies conducted in grasslands at Fort Campbell Military Reservation on the Tennessee/Kentucky state line have shown the potential for maintaining viable grassland bird populations within the state (Moss 2001, Giocomo et al. 2002). What is unknown, however, is the response of grassland species in Tennessee to grasslands that have been restored through state and federal programs.

Landscape-scale factors, including field size are important to many grassland bird species. Some species will use small tracts of grassland; however, proper structure must be in place. Landscape influences movement of wildlife (Crist et al. 1992). Samson (1980) applied the theory of island biogeography to grassland birds in an attempt to understand their use of patchy habitats. Wiens (1995) however, suggested studying grasslands based on the amount of grass cover in a given landscape was more appropriate. The amount of grassland found in a landscape is a primary parameter if that is what determines bird use of a field (Ribic and Sample 2001). This brings up the question: Can the same management principles and goals for Tennessee grassland birds be applied if landscape proves not to be a factor? Nearly all of the existing research on grassland birds has taken place in areas where the landscape matrix is largely a grassland setting; however, this is not the case for most of Tennessee. For grassland habitats in Tennessee, patch size may be the most important factor dictating species occurrence, as

the state may never have a grass-dominated landscape. Herkert (1994a) found a significant relationship between field size and species diversity. Large (600 ha) established tracts are known to attract breeding populations of grassland-dependent species to Tennessee to breed (Moss 2001). Bird species in need of management that occur in Tennessee grasslands include northern bobwhites, grasshopper sparrows, Henslow's sparrows, dickcissels, eastern meadowlarks (*Sturnella magna*), and field sparrows. All these species show decreasing population trends based on BBS data (Sauer et al. 2003).

According to the Northern Bobwhite Conservation Initiative (NBCI), northern bobwhite numbers experienced dramatic, rangewide declines (65.8%) from 1980 to 1999 (Dimmick et al. 2002). The BBS displayed similar declines in northern bobwhite breeding numbers averaging 5.5% per year from 1980 to 2003 in Tennessee (Sauer et al. 2003). Northern bobwhites are not as sensitive to area as many grassland species and will use small tracts of grassland habitat.

Grasshopper sparrows have declined 3.8% per year from 1966 to 2003 in the U.S. (Sauer et al. 2003). Prime habitat for grasshopper sparrows is a dry, open upland mixed with prairie (Smith 1963). Grasshopper sparrows prefer grasslands with short to medium vegetation heights and increased areas of bare ground (Vickery 1996, Delisle and Savidge 1997). Grasshopper sparrows may prefer areas where bare ground cover is $\geq 24\%$ (Whitmore 1979a). Grasshopper sparrows are sensitive to area and prefer large tracts of grassland for breeding (Herkert 1994 a,b, Vickery et al. 1994, Bollinger 1995, Helzer and Jelenski 1999). Herkert (1994b) suggested areas > 30 ha may be needed to support a breeding population.

Henslow's sparrows has declined 8.6% per year over the last 37 years in the U.S. according to BBS data (Sauer et al. 2003). Ground-nesting species, such as Henslow's sparrows, require grassland undisturbed by frequent mowing or burning (Wiens 1969, Herkert 1994c). Grasslands 1-2 years post-burn with some shrub cover were typical Henslow's sparrow habitat at FCMR (Moss 2001, Giocomo et al. 2002). Appropriate litter cover and litter depths along with vertical cover are very important in their nesting success. Preferred habitat contains areas with well-developed litter structure (Wiens 1969, Herkert 1994c, Bollinger 1995, Winter and Faaborg 1999) and a large component of grass intermixed with forbs (Wiens 1969). Similar structure is also preferred on the wintering grounds (Plentovich et al. 1999). In the U.S., Henslow's sparrows winter south of Tennessee from South Carolina west to Texas. Henslow's sparrows prefer large tracts of grassland for breeding (Herkert 1994 *a,b*, Bollinger 1995) and upon arrival to the breeding grounds in the spring will select large areas first to set up territories (Mazur 1996). Optimal size for a Henslow's breeding ground was > 30 ha in Kansas (Zimmerman 1988) and New York (Mazur 1996). Henslow's sparrows will, however, use smaller patches if they are in the appropriate landscape context. In Missouri, Henslow's sparrows were absent from a 28-ha isolated prairie fragment but was present in a 16-ha fragment less than 2 km from a larger patch that contained Henslow's sparrow (Hayden 1985). An increase in Henslow's sparrows' density was also observed as the percent of the landscape in grassland surrounding a field increased (Winter 1998).

Dickcissel populations have declined by 1.2% per year in the U.S. since 1966 (Sauer et al. 2003). Dickcissels prefer complex field structure for singing, and where forbs or shrubs are lacking, NWSG provides suitable structure (Deslisle and Savidge

1997). Deslisle and Savidge (1997) found thick areas of forbs within CSG fields determined dickcissel abundance because of the absence of suitable song perches. Hull et al. (1996) found greater dickcissel abundances in CRP fields where more forbs intermixed with NWSG. Winter and Faaborg (1999) reported that patch size had an affect on dickcissel productivity. Dickcissels tolerated fragmented patches, however, survival probabilities were greater in larger patches (Winter 1998). Dickcissels have been reported using patches < 10 ha in size (Herkert 1991, Helzer and Jelenski 1999), however, dickcissel abundance has been positively correlated with larger patch sizes (Swengel 1996).

Eastern meadowlarks have declined by 2.9% per year in the U.S. since 1966 (Sauer et al. 2003). Eastern meadowlarks prefer moderately tall vegetation (25-50 cm) for nesting areas (Schroeder and Sousa 1982). Eastern meadowlarks prefer grass-dominated habitat and abundant litter cover (Wiens 1969, Rotenberry and Wiens 1980, Bollinger 1995, Hull et al. 1996). Eastern meadowlarks are found in restored grasslands (King and Savidge 1995), pastures (Wiens 1969), hayfields (Bollinger 1995), and agricultural fields (Best et al. 1997). Eastern meadowlarks prefer large grassland areas over small areas for breeding (Herkert 1991, Herkert 1994a, 1994b, Vickery et al. 1994). Eastern meadowlarks were reported as not being affected by surrounding landscape variables in Missouri (Winter 1998) and Nebraska (King and Savidge 1995). However, in Illinois, Herkert et al. (1993) found eastern meadowlarks were sensitive to habitat fragmentation. Required area for eastern meadowlarks was estimated to be > 5 ha (Herkert 1994b).

The objective of this chapter is to evaluate the success of restored native grasslands in terms of avian use. This chapter will correlate avian use of restored NWSG fields with vegetative composition, structure, and landscape characteristics. Furthermore, this chapter will compare and contrast the effects of landscape and microhabitat variables for 4 grassland-nesting bird species (grasshopper sparrow, Henslow's sparrow, dickcissel, and eastern meadowlark) and one early successional breeder (northern bobwhite) from my list of species of special management concern (Table 8). Field sparrow results were not used in my research because field sparrows have a wide array of suitable nesting habitat (Sample and Mossman 1997). Field sparrows were found in 90% of evaluated fields and in all field size classes.

Methods

Field work was conducted 15 May through 15 July, 2002 and 2003. Sixty-six fields were evaluated across both years. Forty-seven of the evaluated fields were "program fields" established through TWRA or NRCS programs. Sixteen fields were nonprogram NWSG fields established by other methods. These fields were primarily comprised of forbs and shrubs with less than 20% of the ground covered in NWSG. The NWSG species in these fields originated from a natural seedbank and contained mostly little bluestem and broomsedge. Three fields (one in each size class) at FCMR were also evaluated. All fields were evaluated for NWSG restoration success and other plant composition (Chapter 3). Management history for each field was also documented (mow, burn, or no management). Fields not evaluated in both years were either flooded or had

been altered since the previous year and no longer met the criteria of an established NWSG field.

Point Counts

Ten-minute point-counts (Hamel et al. 1996) were used to document the presence of breeding birds. Species seen or heard within 50 m, beyond 50 m, and flying over the site were recorded. The time frame in which the species was seen or heard (0-3, 3-5 and 5-10 min) was also recorded. Each field was monitored once each year between sunrise and 10:00 am Eastern Daylight Time (EDT). Counts were not conducted on days of heavy fog, wind, or rain. Each survey point was flagged and coordinates recorded with a Global Positioning System (GPS) in 2002 so researchers could return to the same location for the following season's point counts. The number of survey points placed in each field was determined by field size. Points were distributed systematically across each field at least 200 m apart. One point was evaluated per every 10 ha, with a maximum of 4 points in the largest fields.

Timed-Area Search

After each point-count, a 30 minute timed-area search for birds was conducted. The purpose of the timed search was to supplement point counts with bird species not detected during the point counts. This was accomplished by walking 200 m² areas around the point-count center. All species flushed were recorded. Additional species seen or heard outside the area searched but inside the field boundaries were also noted. I

compiled a complete list of species for each field based on point-count and area-search data.

Statistical Analysis

I used linear regression to identify significant ($P < 0.05$) landscape and microhabitat characteristics that best explained observed patterns of grassland species richness. One point was randomly chosen in each field containing multiple point counts to use in linear regression analysis to balance sampling across all fields. For preliminary analysis, NCSS (2001) statistical software was used to test the assumption of normality for the data and perform correlation analysis. Data not normally distributed were transformed using their square roots (except the natural log transformation was used for field size). Correlated values ($r > 0.5$) were removed from the model based on what made the most biological sense for the bird species being researched.

I created two bird lists for analysis of program fields. The first list included five species which were grassland obligate and facultative species with decreasing population trends and are of management concern (Table 8). The second list included 13 grassland obligate and facultative species (Table 8). Litter depth, average vegetative height, percent bare ground, percent forb cover, native warm-season grass cover, cool-season grass cover, presence of woody vegetation, presence of residual weed stems, field size, and percent of the surrounding landscape covered in grass were used in the model selection as variables that biologically best explained why the species occurred where they did. Each list from 2002 and 2003 was analyzed with and without the landscape and field size variables to better identify which micro-habitat variables were most related to

species richness. All program fields evaluated in 2002 ($n = 45$) and 2003 ($n = 43$) were used to describe field characteristics where northern bobwhites were found (Table 9). Because of low sample sizes, all fields evaluated in 2002 ($n = 58$) and 2003 ($n = 59$) were used to describe field characteristics where Henslow's sparrows, grasshopper sparrows, eastern meadowlarks, and dickcissels were found (Table 10). Scatter-plot graphs were created to illustrate species richness relationships for program and FCMR fields based on microhabitat variables.

Logistic regression models were created for grasshopper sparrows, Henslow's sparrows, eastern meadowlarks, dickcissels, and northern bobwhites. To create the models, a stepwise selection (SAS V8.0) procedure was used followed by a best subset model selection. The smallest Akaike's Information Criterion (AIC) value was then used to reflect the best models (Burnham and Anderson 1998). The lowest AIC values from those models were then used to create tables that reflected the variables that best explained observed species richness. The relationship to the variable (positive or negative) and the level of significance were also recorded.

Results

Eighty-eight bird species were noted in or within seeing/hearing distance of NWSG fields in Tennessee (Table 11). Thirty-six species were noted immediately within the fields. Field sparrows and common yellowthroats (*Geothlypis trichas*) were the most common species recorded in all evaluated fields (Table 10).

Grassland Species

In 2002, field size was not a significant predictor of observed species richness for the 13 grassland bird species (Figure 14). Grassland bird species richness was positively associated with the amount of bare ground ($F = 6.43$, $P = 0.015$) and negatively associated with the presence of residual stems ($F = 5.47$, $P = 0.024$) and cool-season grass ($F = 4.21$, $P = 0.046$), in 2002 (Table 12). In 2003, field size ($F = 15.00$, $P = 0.0004$; Figure 15) and the presence of woody vegetation ($F = 10.26$, $P = 0.0027$) were significant predictors of grassland bird species richness. When landscape variables were removed from the model, a negative relationship between bird species richness and NWSG was detected ($F = 4.66$, $P = 0.036$) (Table 12).

Species of Concern

For bird species of concern, field size ($F = 8.5$, $P = 0.005$; Figure 16) and the amount of bare ground ($F = 6.7$, $P = 0.013$) were positively associated with observed species richness in 2002 (Table 12). After removing landscape variables from the model, a positive relationship with the amount of bare ground ($F = 13.55$, $P = 0.0006$) was observed (Table 12). In 2003, field size ($F = 20.2$, $P < 0.0001$; Figure 17) and presence of woody vegetation ($F = 4.73$, $P = 0.035$) showed a positive relationship with observed species richness for species of concern (Table 12). When landscape variables were removed from the model, no significant variables were found.

Northern Bobwhites

Northern bobwhites used 39 of 45 (87%) program fields in 2002 and 31 of the 43 (72%) program fields in 2003 (Table 9). Northern bobwhites were found in all fields evaluated at FCMR (Figure 18). Northern bobwhites were found in all size classes and all landscape settings in restored NWSG fields (Figure 18). The relationship between northern bobwhite occurrence and the measured habitat variables, in both 2002 and 2003, was weak [$P = .121$, $R^2 = .201$ (2002) and $P = .198$, $R^2 = .190$ (2003)]. As a result, no definitive patterns were shown in the AIC models selected (Tables 13 and 14). Northern bobwhites were detected in restored NWSG fields with average vegetative heights between 20 and 70 cm in both years (Figure 19). Average vegetative height did not exceed 50 cm in fields at FCMR (Figure 19). Forb cover in program fields where northern bobwhites were detected ranged from 2-66% in both years (Figure 19). In FCMR fields, forb cover where northern bobwhites occurred ranged from 3-30% in both years (Figure 19). Northern bobwhites were detected in restored NWSG fields that ranged from 1-89% cover by NWSG (Figure 20). Fields at FCMR where northern bobwhites were detected did not exceed 50% cover by NWSG (Figure 20). Percent cover by bare ground varied across years, and ranged from 0-41% in program fields and 1-34% in FCMR fields (Figure 20). Litter depths in fields used by northern bobwhites also varied between years, and ranged from 0 cm to 4 cm in program fields and 0.25 cm to 4.5 cm in FCMR fields (Figure 21).

Grasshopper Sparrows

Grasshopper sparrows used 1 of the three fields (the largest-600 ha) at FCMR in each year (Figure 22). They were also found in 5 (11%) and 3 (7%) restored fields in 2002 and 2003, respectively (Table 9). Field sizes used ranged from 6-65 ha (Figure 22). Grasshopper sparrows only occurred in fields that were ≥ 40 ha or smaller fields that had a landscape comprised of $> 30\%$ grass/pasture (Figure 22). Optimal models found by AIC for grasshopper sparrows showed a significant negative response to vegetative height in both years and a positive response to bare ground and litter depth in several models in 2002 (Tables 13 and 14). Percent cover by bare ground where grasshopper sparrows occurred varied across years, and ranged from 1.5-40% in program fields and 1.5-30% in FCMR fields (Figure 23). In program fields, average litter depths where grasshopper sparrows occurred was < 1 cm in 2002 and < 2 cm in 2003 (Figure 23). At FCMR, litter depths where grasshopper sparrows occurred ranged from 3.5 cm to 4.5 cm in 2002 and were < 1.2 cm in 2003 (Figure 23). Grasshopper sparrow fields did not exceed average vegetative heights of 50 cm or forb cover exceeding 40% (Figure 24). Fields where grasshopper sparrows occurred did not exceed 50% cover in NWSG or 25% cover in litter (Figure 25).

Henslow's Sparrows

Henslow's sparrows were detected in all 3 fields at FCMR in 2002 and were not detected in any other fields visited (Figure 26). In 2003, Henslow's sparrows were only detected in the medium and large FCMR fields and 5 other fields evaluated throughout the state (Table 10, Figure 26). Three of the five fields where Henslow's sparrows

occurred in 2003 were program fields established in Benton County, Tennessee. The other two fields were at the U.S. Forest Service Land Between the Lakes (LBL) National Recreation Area and the Department of Defense Arnold Engineering and Development Center (AEDC). In restored NWSG fields, field size where Henslow's sparrows occurred ranged from 10-120 ha (Figure 26). Henslow's sparrows were found in program fields where the percent of the landscape in grass/pasture ranged from 5-46% (Figure 26). On average, Henslow's sparrows occurred in fields where forb cover was less than 35% in both years (Figure 27). Henslow's sparrows occurred in fields where vegetative heights were < 60 cm in both years (Figure 27). When litter depth occurred in the optimal AIC model selection, there was always a positive relationship (Tables 13 and 14). In 2002, litter depths where Henslow's sparrows occurred at FCMR ranged from 0.2-4.4 cm (Figure 28). In 2003, litter depths where Henslow's sparrows occurred ranged from 0.37-3.0 cm in program fields and ranged from 0.71-2.5 cm in FCMR fields (Figure 28). In 2002, there was a significant positive response to vegetative height; no consistent relationship with vegetation height was apparent in 2003 (Tables 13 and 14). There also was a significant, negative relationship to increased levels of NWSG in 2003 (Table 14). Cover by NWSG did not exceed 51% at FCMR in either year or 42% cover in program fields in 2003 (Figure 28).

Dickcissels

Dickcissels were detected only in the largest field at FCMR in both years (Figure 29). Dickcissels were detected in 11 and 6 other fields in 2002 and 2003, respectively (Table 10, Figure 29). They were found in 6 of the 7 largest fields evaluated in 2002 and

3 of the 4 largest fields evaluated in 2003 (Figure 29). Field size in restored fields with dickcissels ranged from 5-120 ha (Figure 29). Dickcissels were found in fields where the percent of the landscape in grass/pasture ranged from 19-75% (Figure 19). Dickcissels generally occurred in fields where vegetative height was < 50 cm and forb cover was $\leq 40\%$ (Figure 30). They also occurred in fields where average NWSG was $\leq 50\%$ cover (Figure 31). There was a positive relationship between dickcissel occurrence and bare ground in both years (Tables 13 and 14). Average cover by bare ground where dickcissels occurred ranged from 0-40% in program fields and 1.5-30% in FCMR fields (Figure 32). There was a positive relationship with CSG in 2002 but not in 2003 (Tables 13 and 14). Overall, CSG cover in program fields where dickcissels occurred was $< 35\%$ in both years (Figure 32). In FCMR fields, CSG cover where dickcissels occurred ranged from 10-58% (Figure 32). A negative relationship with vegetative height was also detected in some AIC models in 2002 but generally not in 2003 (Tables 13 and 14).

Eastern Meadowlarks

Eastern meadowlarks were observed in 16 (28%) and 15 (25%) fields in 2002 and 2003 respectively (Table 10). They were found in the same two fields (large and medium-sized fields) at FCMR in both years. Program fields where eastern meadowlarks were observed ranged from 4-120 ha (Figure 33). Eastern meadowlarks were found in program fields where the percent of the landscape in grass/pasture ranged from 5-72% (Figure 33). The relationship between eastern meadowlark occurrence and the measured habitat variables was significant in 2002 ($P = 0.018$, $R^2 = .307$) but not in 2003 ($P = .193$, $R^2 = .116$, Tables 13 and 14). Eastern meadowlarks had a negative relationship with

vegetative height in 2002 (Table 13). Eastern meadowlarks generally did not occur in fields where vegetative height was > 60 cm or forb cover > 50% (Figure 34).

Discussion

Grassland Species

Assessing grassland bird habitat needs can be complicated because grassland species inhabit micro-sites within large, less suitable areas of grassland habitat (Sample and Mossman 1997). Results from this research indicate managing for grassland bird diversity requires diverse habitat. Because grassland species require diverse habitat conditions for nesting, regression analysis did not find consistent variables that best explained why the 13 species in question occurred where they did. These findings can be attributed to the species list in question including a variety of bird species. The positive association found in AIC models to bare ground in 2002 reflects the need for more open ground within the fields. In 2003, fields with more woody cover and less NWSG cover had the greatest species richness further reflecting that optimal habitat includes diverse vegetative structure and composition with ample bare ground.

Though many grassland species are sensitive to field size (Herkert 1994a), many are even more sensitive to the micro-habitat characteristics found within the field (Johnson and Igl 2001). Field size was not a good predictor in 2002 of avian diversity, perhaps because of a lack of suitable structure in some fields. By 2003, fields were better established and field size was a better predictor than structural components of the fields.

Habitat structure explained some of the variation in species richness, but adding landscape variables improved models for many grassland bird species in my study,

similar to the results of Fletcher and Koford (2002). Thus, local habitat and landscape factors can be important in managing grassland birds (Fletcher and Koford 2002, Herkert 1994 *a,b*). Johnson and Igl (2001) also concluded that establishing grassland habitat close to existing grasslands or establishing one large field instead of multiple small fields would increase species richness in that particular field.

Species of Concern

After narrowing the bird list to five species of management concern, field size was consistently the best explanatory variable for observed patterns of species richness. Field size has been directly linked to nest success in restored NWSG fields (Burger et al. 1994, Clawson and Rotella 1998). Small fields contain more predation pressure because of decreased area to search and increased “edge.” Small fields also attract nest parasites, such as the brown-headed cowbird (*Molothrus ater*) (Johnson and Temple 1990, Burger et al. 1994). Small fields, though established with the best of intentions and with perfect structural design, could be a sink for many grassland species.

“Area sensitivity” is described as a species being found more often in larger patches than smaller ones and vice versa (Robbins et al. 1989, Herkert 1994a). Some species, such as the Henslow’s sparrow, may not be area sensitive, contrary to previous findings (Horn et al. 2000). One alternative explanation for finding Henslow’s sparrows in larger fields may be that Henslow’s sparrows are an uncommon bird and the chances of finding them are greater on larger areas where the habitat is more diverse (Connor and McCoy 1979). Donovan et al. (1997) also suggested patch size effects may be different depending on how great the level of fragmentation is in that particular landscape.

Another possible explanation often overlooked is sampling bias (Askins et al. 1990). Samson (1980), Helzer and Jelinski (1999) and Walk and Warner (1999) sampled fields proportionately with the size of the field. Horn et al. (2000) questioned this approach by suggesting large fields sampled in this manner were “oversampled” in comparison to smaller fields. In addition to using proportional sampling, they suggested using Hinsley et al.’s (1996) approach, using a null model in determining sensitivity of a species. Hinsley et al. (1996) compared the expected number of pairs of birds in a patch $[(\text{population size observed in all patches} / \text{total area of all patches}) * \text{size of a given patch}]$ to the observed number of pairs in a patch. Linear regression was then used to determine if there was a residual relationship between the numbers of observed and expected pairs of birds in a patch and patch size. Significant differences indicated occurrence and patch size was more than just a function of sampling (Horn et al. 2000). Horn et al. (2000) also found from model simulations that when birds settle randomly in a field and that field is sampled with equal effort (regardless of field size), an accurate assessment of area sensitivity also can be attained (e.g., Askins et al. 1990 and Vickery et al. 1994). It is also possible that different species may be area sensitive in some regions of their range, but not area sensitive in other regions of their range (Johnson and Igl 2001). Landscape, study design, analysis, and location of the study within the species’ range could greatly affect the outcome in determining area sensitivity of grassland birds (Johnson and Igl 2001).

This study sampled fields proportionately to the size of the field; however, one random point was selected from fields containing multiple points for species richness analysis. Results showed fields > 10 ha had the greatest species richness for the species.

of concern used in this study (Figure 16 and 17). Ten ha is probably the minimum size at which NWSG fields in Tennessee should be established if maximizing grassland bird diversity is the goal. The significant ($P < 0.05$) increase observed in species richness as field size increased indicates larger fields may provide more opportunity to manage for grassland bird diversity. Fields > 30 ha may be optimal for grassland birds in Tennessee if their preferences are similar to other findings (Herkert 1994 *a,b*, Zimmerman 1988, Mazur 1996). Many studies where patch sizes were > 30 ha have shown negative relationships between patch size and increased nest predation (Johnson and Temple 1990, Burger et al. 1994, Clawson and Rotella 1998, Winter et al. 2000).

Northern Bobwhites

In this study, northern bobwhites were found in fields as small as 2 ha, reflecting their tolerance for small patches. However, it has been suggested that field size has an impact on predation rates for many bird species associated with grasslands (Johnson and Temple 1990, Renfrew and Ribic 2003). Thus, habitat quality could still differ for northern bobwhites by field size.

Northern bobwhites were most commonly observed in fields where litter depths averaged < 1 cm. Native warm-season grass provided favorable nesting habitat for northern bobwhites and they preferred one year post-disturbance conditions (Dimmick 1971). Deep litter depths are not beneficial to species with precocial young, such as the northern bobwhite, because deep litter impedes chick mobility. Litter depth changes of 20% (increasing or decreasing) affect grassland bird (McCoy et al. 2001*a*) and northern bobwhite use (Burger et al. 1994) of CRP fields.

This study found a 31% increase in litter depth across the two years in program fields. These results can be attributed to nearly 70% of the fields evaluated being managed by mowing or not being managed. If this ratio of management holds true across the state, then ample nesting structure may be in place for many grassland species, but brooding habitat may be limited. Open, bare ground under a vegetative canopy is extremely important foraging habitat for these species. Litter buildup impedes chick mobility, decreasing foraging opportunities and increasing energy expended. Management of this cover type is most beneficial for bobwhites if segments of the field are rotationally burned, leaving a range of litter characteristics in place for use at different times of their life cycle. Burger et al. (1990) found warm-season grass fields provided more concealment than CSG CRP fields for bobwhite nesting structure. In a cooperative study between TWRA and NRCS on NWSG block and buffer strips over a three-year period, quail cock counts increased 213% in NWSG and decreased 31% in the control (agricultural land lacking NWSG) (M.J. Gudlin, pers. comm.).

In this study, northern bobwhites were associated with restored grassland fields that had average vegetative heights of 52 cm. Vegetative height is important for northern bobwhites with respect to their nesting habitat (Stoddard 1931, Klimstra and Roseberry 1975). Northern bobwhites preferred winter roosting cover at least 30 cm tall and most commonly used vegetation 30-90 cm tall to nest (Klimstra and Ziccardi 1963). In Tennessee, northern bobwhites preferred broomsedge or similar grasses (such as little bluestem) 30 to 60 cm tall for nesting (Dimmick 1968).

This study showed program fields averaged 18% and 7% bare ground in 2002 and 2003, respectively. Nesting attempts and nesting success in the fields evaluated in this

study was unknown; however, it is likely that if nesting was attempted and these fields were the only suitable areas for brood rearing, the minimal levels of bare ground found within the fields may have reduced quail chick survival.

Grasshopper Sparrows

Most program fields had vegetative heights much taller than that preferred by grasshopper sparrows; thus, suitable nesting areas were limited in program fields. Herkert (1994a) found grasshopper sparrow abundance negatively correlated with mean grass height and positively related to percent grass cover. Results from this study were similar, as grasshopper sparrows were found in fields with average vegetative height less than 50 cm.

Other grasshopper sparrow habitat requirements include moderately deep litter and sparse coverage of woody vegetation (Wiens 1969). Though woody vegetation was not present in most program fields, increased litter depth was. Results showed a positive response by grasshopper sparrows to increased litter depths in 2002. These findings are probably a result of field age and management taking place in the fields. Litter depths in 2002 did not exceed 1.5 cm in program fields.

Grasshopper sparrows breed in NWSG fields as well as pasture and hay fields (Whitmore 1979b, Johnson and Schwartz 1993, Delisle and Savidge 1997, Horn et al. 2000). Although average territory size for grasshopper sparrows is small (< 2 ha) (Wiens 1969), grasshopper sparrows are area sensitive and prefer large grasslands over small grasslands (Herkert 1994a, Vickery et al. 1994; Bollinger 1995). In fact, the minimum area needed to support a breeding population may be > 30 ha (Herkert 1994b).

Vegetative structure, however, has proven more important than patch size for greater grasshopper sparrow densities in some studies (Winter 1998, Winter and Faaborg 1999). Results from this study showed similar findings, but grasshopper sparrows did use smaller fields (< 30 ha) when the landscape surrounding the field was > 40% grass/pasture (Figure 22).

Henslow's Sparrows

Henslow's sparrow occurrence was positively correlated with litter depth, which is consistent with other studies (Wiens 1969, Bollinger 1995, Winter and Faaborg 1999). The negative relationship to increased cover by NWSG in 2003 may be a result of NWSG fields becoming too dense. Because Henslow's sparrows prefer areas with a mixture of grass and forbs (Wiens 1969), the possibility of having too much NWSG does exist as suggested by my results.

Results in this study were similar to Moss (2001), as Henslow's sparrows were found in all field sizes evaluated at FCMR. Field size is important for Henslow's sparrow habitat (Bollinger 1995, Herkert 1994a). Henslow's sparrows are more often found in large grassland areas than in small areas (Herkert 1994a, Bollinger 1995, Winter and Faaborg 1999), but will nest in grasslands less than 50 ha in size (Robins 1971, Winter 1998). Moss (2001) reported nesting Henslow's sparrows in one field that was 6.5 ha in size; however, most fields used by Henslow's sparrows in his study were much larger.

Dickcissels

I documented dickcissels in fields with little bare ground, similar to other studies (Wiens 1973, Rotenberry and Wiens 1980, Hughes 1996). However, AIC models found a significant, positive relationship with bare ground in both years for dickcissels. These results possibly reflect that dickcissels may have a minimum amount of bare ground that is preferred. More open areas may be better foraging areas for dickcissels than areas lacking bare ground.

Dickcissels have been found in other studies to prefer dense vegetation of moderate height (Rotenberry and Wiens 1980, Delisle and Savidge 1997, Winter 1998). In this study, dickcissels displayed a negative relationship with vegetation height, indicating the structure in program fields may be too tall.

Dickcissels may be tolerant of habitat fragmentation (Herkert 1991, Winter 1998), but seem to prefer larger patches when available. In this study, Dickcissels were found in fields as small as 5 hectares; however, percent of the landscape in grass/pasture was not < 19%.

Eastern Meadowlarks

Eastern meadowlarks used fields with vegetative heights < 50 cm. Eastern meadowlarks preferred grass-dominated habitat and abundant litter cover (Wiens 1969, Rotenberry and Wiens 1980, Bollinger 1995, Hull et al. 1996). The preference for lesser amounts of forbs reflects their desire for more grass-dominated habitats. The range of field sizes where meadowlarks were found in this study reflects their tolerance of a range

of patch sizes. However, eastern meadowlarks elsewhere have been shown to prefer larger patches (Herkert et al. 1993, Vickery et al. 1994).

Many small fields (< 10 ha) restored to NWSG in TN may not be used by area-sensitive species such as eastern meadowlarks. Other species, such as northern bobwhites, that do not require larger acreages will respond to restoration efforts in small fields. Larger fields (> 30 ha) or smaller fields in landscapes with large portions (> 40%) of grass should be restored when possible because nesting success should be higher.

Based on observations in the field and talking with many landowners, there are opportunities to establish additional tracts of NWSG close to restored fields. This would increase suitability as breeding habitat significantly. Where small fields have been established sparsely across the landscape, TWRA/NRCS should make a conscious effort to enroll additional acreage in the state/federal programs where possible. In fact, numerous fields evaluated in this study could have been planted side-by-side to increase effective field size. In the future, TWRA/NRCS should coordinate future contracts to establish fields close to existing fields. Using existing restored acreage data, "focal areas" could be identified where significant acreage has been restored and improvements on a landscape scale may be possible.

CHAPTER 5

Management Implications

Non-native grass such as tall fescue, in general, is detrimental to most wildlife species (Brennen 1991, Barnes et al. 1995, Sole and Keyser 1998). However, the structure provided by tall fescue in limited cases was positively related with Henslow's sparrow, eastern meadowlark, and dickcissel occurrence. Historically, native CSG was part of the diversity found in the true prairie ecosystem (Risser et al. 1981). FCMR fields contained non-native CSG but still supported the full compliment of grassland birds. Thus, total eradication of fescue may not be necessary to promote conservation of grassland birds.

A certain amount of woody vegetation also adds diversity to NWSG fields and allows ground nesting species to coexist with species that nest in shrubs (Vinton and Collins 1997). If left unmanaged, however, woody vegetation may increase in coverage and become problematic. In fact, grasslands invaded by woody species generally contain greater avian diversity because of an increase in edge and generalist species (Arnold and Higgins 1986), though many of these species may not be priorities for conservation.

The primary differences between FCMR and program fields were vegetative species composition, overall vegetative height, and bare ground cover. Decreased vegetative height, reduced NWSG and forb cover, and increased bare ground seemed to be favored by most grassland birds. Fields at FCMR were dominated by little bluestem and broomsedge, whereas program fields were dominated by big bluestem that can reach

heights of 2.5 m. Most of the program fields were seeded to taller NWSG, such as big bluestem, indiangrass, and switchgrass. Many grassland bird species may benefit from an increased emphasis in seed mixtures on little bluestem. It is good however, to have a diversity of structure, some fields with taller species and some fields with a shorter mix. An advantage to taller species is better cover in winter, providing roosting habitat for many birds and escape and thermal cover for many mammals.

Grass cover can be reduced initially by using a lighter seeding rate. Most models reflected a negative response to NWSG by grassland species, indicating too much grass cover. Planting 3- 4.5 lbs/acre of NWSG with 1.0 lb/acre of native forbs would provide more bare ground and increase time until management was necessary. When a NWSG field has the appropriate mixture of NWSG, forbs and bare ground, greater avian abundances can be expected (Larkin 1997).

Over time, NWSG can completely dominate a field if not properly managed (Millenbah et al. 1996, Patterson and Best 1996, Harper et al. 2002). As grasslands go through succession, the vegetative structure and composition change (Burger et al. 1990). Diversity is important in optimal grassland breeding habitat. Furthermore, fields planted to monotypic stands of NWSG are not preferred by many grassland bird species. Six restored fields were planted to monotypic stands and were of limited value to breeding birds, just as monotypic CSG fields were of little value (McCoy et al 2001b). McCoy et al. (2001b) reported switchgrass fields had the same species richness, abundance, and nesting success as CSG fields. They further stated single-species plantings should be avoided to improve grassland benefits for wildlife during the breeding season. Based on personal observation, monotypic stands of NWSG in Tennessee appeared to have the

least species diversity, abundance, and richness of all evaluated fields during the breeding season. These fields, however, may be important as wintering habitat for many species of wildlife.

Time since disturbance greatly affects the habitat value of a field (Burger et al. 1990). Different needs for grassland bird species are met with a variety in structural diversity (Klimstra and Roseberry 1975, Burger et al. 1990). Newly established fields provide roosting, foraging, and brood-rearing habitat whereas “older” fields provide more suitable nesting structure (Burger et al. 1990). Millenbah et al. (1996) looked at the effects of field age on the relative abundance, diversity, and productivity of grassland birds in CRP fields. They found younger (1-2 years old) stands had greater diversity and relative abundance because of the combination of forbs and bare ground. They found older fields (3-6 years old) had the greatest bird productivity because of more litter cover, and vegetative structure. Structural complexity is associated with bird use of a field (MacArthur and MacArthur 1961, Cody 1968). As fields age, suitability for specific grassland species changes (Winter and Faaborg 1999). Eventually, however, grasslands require disturbance to set back succession.

Disturbance reduces biomass and changes resource availability (Pickett and White 1985). Suitable habitat structure is influenced by management history (Sample and Mossman 1997). Data from this study suggest management has an impact on plant species composition and structure and that burning provided optimal conditions for grassland birds.

Management agencies in Tennessee need to coordinate efforts to maximize habitat diversity and promote effective seeding and management strategies to ensure

Tennessee restored grasslands reach their full potential. Many restored NWSG fields in Tennessee are managed by mowing. Some fields are not being managed at all and are being invaded by non-native and woody vegetative species. These fields would be enhanced significantly if rotational burning was used. In areas where burning is not an option, light disking could be implemented as a preferred alternative to mowing (J. Gruchy, unpublished data).

Changes in the occurrences of native plants and animals are reflections of our land stewardship. So far, evidence from grassland habitats suggests we have fallen short (Heard et al. 2000). The breeding grounds are very important for grassland species survival, but restoring a fully functional prairie habitat may only be possible on large scales. In Tennessee, there are areas where optimal breeding habitat could be established where reproductive effort would be maximized. Efforts must be oriented toward proper structure and landscape factors for given grassland species. Grassland management should be focused cooperatively within counties and regions, resulting in state-wide impacts. The best way to achieve this would be planting large fields (at least 30 ha) that will allow for a mosaic of management and provide multiple habitat types within an area. Large areas of grassland habitat could be achieved by restoring grasslands where neighboring properties in the restoration program could be managed together as one large unit instead of scattered smaller units. These fields should then be managed using rotational burning (at least every three years). With appropriate management, based on knowledge from sound grassland research, NWSG restoration in Tennessee could ultimately be more successful than previously thought possible.

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Serotype	Number of isolates	Percentage of total isolates	Number of isolates	Percentage of total isolates
1	1	0.01	1	0.01
2	1	0.01	1	0.01
3	1	0.01	1	0.01
4	1	0.01	1	0.01
5	1	0.01	1	0.01
6	1	0.01	1	0.01
7	1	0.01	1	0.01
8	1	0.01	1	0.01
9	1	0.01	1	0.01
10	1	0.01	1	0.01
11	1	0.01	1	0.01
12	1	0.01	1	0.01
13	1	0.01	1	0.01
14	1	0.01	1	0.01
15	1	0.01	1	0.01
16	1	0.01	1	0.01
17	1	0.01	1	0.01
18	1	0.01	1	0.01
19	1	0.01	1	0.01
20	1	0.01	1	0.01
21	1	0.01	1	0.01
22	1	0.01	1	0.01
23	1	0.01	1	0.01
24	1	0.01	1	0.01
25	1	0.01	1	0.01
26	1	0.01	1	0.01
27	1	0.01	1	0.01
28	1	0.01	1	0.01
29	1	0.01	1	0.01
30	1	0.01	1	0.01
31	1	0.01	1	0.01
32	1	0.01	1	0.01
33	1	0.01	1	0.01
34	1	0.01	1	0.01
35	1	0.01	1	0.01
36	1	0.01	1	0.01
37	1	0.01	1	0.01
38	1	0.01	1	0.01
39	1	0.01	1	0.01
40	1	0.01	1	0.01
41	1	0.01	1	0.01
42	1	0.01	1	0.01
43	1	0.01	1	0.01
44	1	0.01	1	0.01
45	1	0.01	1	0.01
46	1	0.01	1	0.01
47	1	0.01	1	0.01
48	1	0.01	1	0.01
49	1	0.01	1	0.01
50	1	0.01	1	0.01
51	1	0.01	1	0.01
52	1	0.01	1	0.01
53	1	0.01	1	0.01
54	1	0.01	1	0.01
55	1	0.01	1	0.01
56	1	0.01	1	0.01
57	1	0.01	1	0.01
58	1	0.01	1	0.01
59	1	0.01	1	0.01
60	1	0.01	1	0.01
61	1	0.01	1	0.01
62	1	0.01	1	0.01
63	1	0.01	1	0.01
64	1	0.01	1	0.01
65	1	0.01	1	0.01
66	1	0.01	1	0.01
67	1	0.01	1	0.01
68	1	0.01	1	0.01
69	1	0.01	1	0.01
70	1	0.01	1	0.01
71	1	0.01	1	0.01
72	1	0.01	1	0.01
73	1	0.01	1	0.01
74	1	0.01	1	0.01
75	1	0.01	1	0.01
76	1	0.01	1	0.01
77	1	0.01	1	0.01
78	1	0.01	1	0.01
79	1	0.01	1	0.01
80	1	0.01	1	0.01
81	1	0.01	1	0.01
82	1	0.01	1	0.01
83	1	0.01	1	0.01
84	1	0.01	1	0.01
85	1	0.01	1	0.01
86	1	0.01	1	0.01
87	1	0.01	1	0.01
88	1	0.01	1	0.01
89	1	0.01	1	0.01
90	1	0.01	1	0.01
91	1	0.01	1	0.01
92	1	0.01	1	0.01
93	1	0.01	1	0.01
94	1	0.01	1	0.01
95	1	0.01	1	0.01
96	1	0.01	1	0.01
97	1	0.01	1	0.01
98	1	0.01	1	0.01
99	1	0.01	1	0.01
100	1	0.01	1	0.01

Tables

Table 1. Planting information of restored native warm season grass program fields evaluated in Tennessee, 2002 and 2003.

Field #	Responsible Organization	Year Planted	Herbicide Used	Planting Method	Species Planted	Seeding Rate (lbs/acre) (PLS ³)
4	NRCS	1998	Plateau/Roundup	No-Till Drill	Mix 1 ¹	6
5	NRCS	1999	Plateau/Roundup	No-Till Drill	Mix 1	6
6	NRCS	1999	None	Disc, No-Till Drill	Mix 1	6
7	NRCS	2000	Plateau/Roundup	No-Till Drill	Mix 1	6
8	NRCS	2000	Plateau/Roundup	No-Till Drill	Mix 1	6
9	NRCS	2000	Plateau/Roundup	No-Till Drill	Mix 1	6
10	NRCS	2000	Plateau/Roundup	No-Till Drill	Mix 1	6
11	NRCS	2000	Plateau/Roundup	No-Till Drill	Mix 1	6
12	NRCS	2000	Plateau/Roundup	No-Till Drill	Mix 1	6
13	NRCS	2000	Plateau/Roundup	No-Till Drill	Mix 1	6
14	NRCS	2000	Plateau/Roundup	No-Till Drill	Mix 1	6
15	NRCS	2001	Plateau/Roundup	No-Till Drill	Mix 1	6
16	NRCS	2000	Plateau/Roundup	No-Till Drill	Mix 1	6
17	NRCS	2000	Plateau	No-Till Drill	Mix 1	6
18	NRCS	2000	Plateau	No-Till Drill	Mix 1	6
19	NRCS	2000	Plateau	No-Till Drill	Mix 1	6
20	NRCS	2001	Plateau/Roundup	No-Till Drill	Mix 1	6
21	NRCS	2001	Plateau/Roundup	No-Till Drill	Mix 1	6
22	NRCS	2001	Plateau/Roundup	No-Till Drill	Mix 1	6
24	TWRA	1999	None	No-Till Drill	Mix 2 ²	6
25	TWRA	1999	None	No-Till Drill	Mix 2	6
27	TWRA	1999	None	No-Till Drill	Mix 2	6
28	TWRA	1999	None	No-Till Drill	Mix 2	6
29	NRCS	2001	Plateau/Roundup	No-Till Drill	Mix 1	6
30	NRCS	2001	Plateau/Roundup	No-Till Drill	Mix 1	6
31	NRCS	2001	Plateau/Roundup	No-Till Drill	Mix 1	6
32	TWRA	1998	Roundup	No-Till Drill	Mix 2	6
33	TWRA	1997	Roundup	Disc, No-Till Drill	Switchgrass *	6
34	TWRA	2000	Plateau/Roundup	No-Till Drill	Switchgrass*	6
35	TWRA	1999	Roundup	No-Till Drill	Indiangrass*	6
36	TWRA	1995	Roundup	No-Till Drill	Mix 1	6
37	TWRA	1995	Roundup	No-Till Drill	Mix 1	6
38	TWRA	2000	Roundup	No-Till Drill	Switchgrass*	6
40	TWRA	1995	Roundup	No-Till Drill	Mix 1	8
41	TWRA	1992	Roundup	No-Till Drill	Switchgrass*	9
42	TWRA	1993	Roundup	No-Till Drill	Mix 1	6
43	TWRA	1993	Roundup	No-Till Drill	Mix 2	6
44	TWRA	1998	Roundup	No-Till Drill	Mix 2	6
52	TWRA	1995	None	No-Till Drill	Mix 2	6
53	TWRA	1999	None	No-Till Drill	Mix 2	6
54	TWRA	2000	Roundup	No-Till Drill	Mix 2	6
55	TWRA	1994	Roundup	No-Till Drill	Mix 2	6
60	TWRA	1999	Roundup	No-Till Drill	Mix 2	6
61	TWRA	2000	Roundup	No-Till Drill	Mix 2	6
62	TWRA	2000	Roundup	No-Till Drill	Mix 2	6
N5	TWRA	2001	Plateau/Roundup	No-Till Drill	Mix 1	6
N7	TWRA	2000	Roundup	No-Till Drill	Gammagrass*	6

¹ Mix 1 is Big Bluestem, Little Bluestem, Indiangrass, Switchgrass, and Eastern Gammagrass.

² Mix 2 is Big Bluestem, Little Bluestem, Indiangrass, and Switchgrass.

³ Pure live seed (% purity x % germination)

* Indicates a single species planting.

Table 2. History and current management of restored native warm season grass fields evaluated in Tennessee, 2002 and 2003.

Field #	Responsible Organization	Year Planted	Current Management	How Often	Field History
*4	NRCS	1998	Mow	Every other year	Row Crops
*5	NRCS	1999	Mow	Every other year	Row Crops
6	NRCS	1999	Mow	Every other year	Row Crops
*7	NRCS	2000	Mow	Annually	Row Crops
*8	NRCS	2000	Mow	Annually	Row Crops
*9	NRCS	2000	Mow	Annually	Row Crops
*10	NRCS	2000	Mow	Every other year	Hay
*11	NRCS	2000	Mow	Every other year	Hay
*12	NRCS	2000	Mow	Annually	Row Crops
*13	NRCS	2000	Mow	50% Annually	Row Crops
*14	NRCS	2000	Mow	50% Annually	Row Crops
*15	NRCS	2001	None	N/A	Row Crops
*16	NRCS	2000	Mow	Annually	Row Crops
*17	NRCS	2000	Mow	Annually	Row Crops
*18	NRCS	2000	Mow	Annually	Row Crops
*19	NRCS	2000	Mow	Annually	Row Crops
*20	NRCS	2001	Mow	50% Annually	Row Crops
*21	NRCS	2001	None	Annually	Row Crops
*22	NRCS	2001	None	N/A	Row Crops
*24	TWRA	1999	Mow	Annually	Row Crops
*25	TWRA	1999	None	N/A	Row Crops
*27	TWRA	1999	Mow	Annually	Row Crops
*28	TWRA	1999	None	N/A	Row Crops
*29	NRCS	2001	None	N/A	Row Crops
*30	NRCS	2001	None	N/A	Row Crops
*31	NRCS	2001	None	N/A	Row Crops
*32	TWRA	1998	Burned	Every other year	Hay
33	TWRA	1997	Burned	Every other year	Hay
34	TWRA	2000	Burned	Every other year	Fallow
*35	TWRA	1999	Burned	Every other year	Row Crops
*36	TWRA	1995	Burned	Every other year	Hay
37	TWRA	1995	Burned	Every other year	Hay
*38	TWRA	2000	None	N/A	Pasture
*40	TWRA	1995	Burned	Every other year	Pasture
*41	TWRA	1992	Burned	Every other year	Row Crops
*42	TWRA	1993	Burned	Every other year	Row Crops
*43	TWRA	1993	Burned	Every other year	Row Crops
*44	TWRA	1998	Burned	Every other year	Fallow
*52	TWRA	1995	Burned	Every other year	Row crops
*53	TWRA	1999	Burned	Every other year	Fallow
*54	TWRA	2000	None	N/A	Pasture
*55	TWRA	1994	Burned	Every three years	Pasture
*60	TWRA	1999	Burned	Every three years	Hay
*61	TWRA	2000	None	N/A	Pasture
*62	TWRA	2000	Burned	Every three years	Pasture
N5	TWRA	2001	Burned	Every three years	Hay
N7	TWRA	2000	None	N/A	Hay

* Indicates the 41 fields evaluated in both years

Table 3. Dominant vegetation in Fort Campbell Military Reservation and restored native warm season grass fields, summer 2002 and 2003.

2002				
Program fields			Fort Campbell	
Vegetation class	Number of fields where species occurred	Percent (n = 45)	Number of fields where species occurred	Percent (n = 3)
NWSG	45	100	3	100
Forbs	45	100	3	100
Johnsongrass	22	49	0	0
Smooth Brome	20	44	1	33
Tall Fescue	18	40	2	67
Little Barley	13	29	0	0

2003				
Program fields			Fort Campbell	
Vegetation class	Number of fields where species occurred	Percent (n = 43)	Number of fields where species occurred	Percent (n = 3)
NWSG	43	100	3	100
Forbs	43	100	3	100
Smooth Brome	20	47	1	33
Little Barley	18	42	0	0
Johnsongrass	16	37	0	0
Tall Fescue	12	28	2	67

Table 4. Native warm season grass dominance by species in Fort Campbell Military Reservation and restored native warm season grass fields, summer 2002 and 2003.

Grass species	2002			
	Program fields		Fort Campbell	
	Number of fields where species occurred	Percent (n = 45)	Number of fields where species occurred	Percent (n = 3)
Big Bluestem	37	82	0	0
Switchgrass	31	69	0	0
Indiangrass	30	67	0	0
Broomsedge	30	67	2	67
Little Bluestem	22	49	2	67
Eastern Gammagrass	1	2	0	0

Grass species	2003			
	Program fields		Fort Campbell	
	Number of fields where species occurred	Percent (n = 43)	Number of fields where species occurred	Percent (n = 3)
Big Bluestem	39	90	0	0
Switchgrass	32	74	0	0
Indiangrass	29	67	1	33
Broomsedge	24	56	2	67
Little Bluestem	23	53	2	67
Eastern Gammagrass	1	2	0	0

Table 5. Field structure and composition in Fort Campbell Military Reservation and restored program fields, summer 2002 and 2003. Habitat measurements from Moss (2001) are included.

FCMR fields									
	2002			2003			Moss (2001)		
	Mean	Min	Max	Mean	Min	Max	n = 147 Mean0*	n = 121 Mean1*	n = 70 Mean2*
Litter Cover	11.70	3.60	26.50	14.00	4.80	25.00	2.99	7.20	9.77
Bare ground	15.60	7.10	33.70	13.10	1.50	30.00	18.51	11.26	5.16
Litter Depth	1.50	0.26	4.43	1.31	0.71	2.48	1.21	2.95	4.84
Density	62.50	52.00	84.00	53.20	30.00	80.50	-	-	-
Vegetative Height	15.80	1.60	31.50	34.00	14.30	49.88	43.00	45.00	45.00
%NWSG	35.20	8.80	51.10	16.40	1.00	44.10	24.50	29.82	31.61
%CSG	18.60	2.60	32.70	26.40	3.00	64.00	1.67	1.01	4.56
%Forbs	16.80	3.30	29.50	20.50	13.50	24.20	33.90	35.26	32.97
%Woody	1.80	0.00	10.20	3.32	0.00	8.60	5.88	3.25	4.31
%Residual stems	0.00	0.00	0.00	0.56	0.00	3.30	-	-	-

* Indicates years since prescribed burn

Program fields						
	2002			2003		
	Mean	Min	Max	Mean	Min	Max
Litter Cover	10.80	0.00	38.30	15.20	0.00	39.80
Bare ground	16.70	0.70	33.20	7.47	0.00	27.00
Litter Depth	0.39	0.00	1.50	1.26	0.00	4.90
Density	65.00	32.00	96.00	69.00	33.00	98.00
Vegetative Height	52.30	27.00	92.30	51.97	21.70	91.30
%NWSG	30.50	2.75	63.00	36.50	7.70	70.80
%CSG	10.80	0.00	35.10	10.40	0.00	51.50
%Forbs	25.40	5.40	45.40	24.70	1.00	62.60
%Woody	2.00	0.00	17.80	1.86	0.00	16.10
%Residual stems	0.75	0.00	14.20	0.23	0.00	4.40

Table 6. Habitat measurements of restored native warm season grass fields (n = 41) by management practice, summer 2002 and 2003.

Variable	Mow (A)		Burn (B)		None (C)		Differences	F value	P
	$\bar{X}$	STDERR	$\bar{X}$	STDERR	$\bar{X}$	STDERR			
Litter Cover (%)	17.24	1.76	7.00	1.32	13.70	2.04	AB and B,C	10.48	<.001
Litter Depth (cm)	1.06	0.15	0.46	0.12	0.91	0.23	AB and B,C	8.63	0.0004
Density (%)	0.59	0.03	0.76	0.03	0.72	0.04	AB	8.51	0.0005
Bare ground (%)	11.69	1.63	12.44	1.35	12.36	2.11	none	0.09	0.911
NWSG (%)	35.08	2.40	32.17	2.96	32.82	5.16	none	*	0.065
CSG (%)	11.25	1.75	7.62	1.31	13.27	2.97	none	1.02	0.364
Forb (%)	19.86	1.72	33.75	3.06	22.95	3.35	AB and B,C	8.25	0.0006
Woody (%)	1.55	0.53	3.88	1.03	0.18	0.10	A,C	*	0.042
Vegetative Height (cm)	46.33	2.32	59.53	3.18	52.36	3.20	B,A	0.20	0.0048
Residual stems (%)	0.16	0.11	0.29	0.13	1.25	0.67	none	*	0.082
Two-factor Anova		* Friedman's Analysis of Variance by Ranks						df = 2	

Table 7. Habitat measurements of restored native warm season grass fields (n = 41) by year, summer 2002 and 2003.

	2002		2003				
Habitat Parameter	$\bar{X}$	STDERR	$\bar{X}$	STDERR	Net change	F value	P
Litter Cover (%)	10.83	1.34	15.26	1.69	4.43	3.74	0.056
Litter Depth (cm)	0.40	0.06	1.26	0.16	0.87	25.14	<.001
Density (%)	0.66	0.03	0.69	0.03	0.04	1.51	0.223
Bare ground (%)	16.74	1.37	7.47	0.89	-9.27	31.56	<.001
NWSG (%)	30.59	2.26	36.52	3.05	5.93	*	0.611
CSG (%)	10.80	1.45	10.48	1.83	-0.32	0.72	0.398
Forb (%)	25.40	1.64	24.79	2.81	-0.61	0.11	0.746
Woody (%)	2.00	0.62	1.86	0.56	-0.14	*	0.529
Vegetative Height (cm)	52.30	2.19	51.97	2.68	-0.33	0.00	0.984
Residual stems (%)	0.75	0.36	0.24	0.13	-0.52	*	0.073
Two-factor ANOVA		* Friedman's Analysis of Variance by Ranks					df = 2

Table 8. Common and scientific names of grassland bird species documented in and around evaluated grassland fields in Tennessee, summer 2002 and 2003. Species are in taxonomic order.

Common Name	Scientific Name	Species of Concern ¹	Obligate/Facultative ²
Northern Bobwhite	<i>Colinus virginianus</i>	X	F
Eastern Kingbird	<i>Tyrannus tyrannus</i>		F
Eastern Bluebird	<i>Sialia sialis</i>		F
Prairie Warbler	<i>Dendroica discolor</i>		F
Common Yellowthroat	<i>Geothlypis trichas</i>		F
Yellow-breasted Chat	<i>Icteria virens</i>		F
Dickcissel	<i>Spiza americana</i>	X	O
Field Sparrow	<i>Spizella pusilla</i>	X	F
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	X	O
Henslow's Sparrow	<i>Ammodramus henslowii</i>	X	O
Red-winged Blackbird	<i>Agelaius phoeniceus</i>		F
Eastern Meadowlark	<i>Sturnella magna</i>	X	O
Brown-headed cowbird	<i>Molothrus ater</i>		F

¹ grassland nesting species with decreasing population trends (Sauer et al. 2003).

² grassland obligate species (O) that require grassland habitat for most or all of their breeding cycle or facultative species (F) that are commonly seen in grasslands but do not require grassland habitat for nesting (Sample and Mossman 1997).

Table 9. Presence of grassland species in restored native warm season grass fields, summer 2002 and 2003.

Species	Number of fields where bird species was observed (2002)		Number of fields where bird species was observed (2003)	
	Percent of fields (n = 45)		Percent of fields (n = 43)	
Henslow's Sparrow	0	0	3	7
Grasshopper Sparrow	5	11	3	7
Dickcissel	10	22	5	12
Eastern Meadowlark	13	29	9	21
Field Sparrow	41	91	40	93
Northern Bobwhite	39	86	31	72
Prairie Warbler	8	18	7	16
Eastern Kingbird	13	29	10	23
Eastern Bluebird	8	18	10	23
Common Yellowthroat	41	91	37	86
Brown-headed Cowbird	10	22	16	37
Yellow-breasted Chat	29	64	33	77
Red-winged Blackbird	21	47	19	44

Table 10. Presence of grassland species in all fields evaluated, summer 2002 and 2003.

Species	Number of fields where bird species was observed		Number of fields where bird species was observed	
	(2002)	Percent of fields (n = 58)	(2003)	Percent of fields (n = 59)
Henslow's Sparrow	3	5	7	12
Grasshopper Sparrow	7	12	5	8
Dickcissel	12	21	7	12
Eastern Meadowlark	16	28	15	25
Field Sparrow	53	91	53	90
Northern Bobwhite	49	84	38	64
Prairie Warbler	13	22	17	29
Eastern Kingbird	19	33	14	24
Eastern Bluebird	9	16	15	25
Common Yellowthroat	54	93	49	83
Brown-headed Cowbird	11	19	18	31
Yellow-breasted Chat	39	67	44	75
Red-winged Blackbird	26	45	23	39

Table 11. Common and scientific names of all bird species documented in and around grassland fields evaluated in Tennessee, summer 2002 and 2003. Species are in taxonomic order.

Common Name	Scientific Name	Species Within Fields ¹
Double-crested Cormorant	<i>Phalacrocorax auritus</i>	
Great Egret	<i>Ardea albus</i>	
Great Blue Heron	<i>Ardea herodias</i>	X
Green Heron	<i>Butorides striatus</i>	X
Black-crowned Night-heron	<i>Nycticorax nycticorax</i>	
Canada Goose	<i>Branta canadensis</i>	
Wood Duck	<i>Aix spinosa</i>	X
Mallard	<i>Anas platyrhynchos</i>	X
Black Vulture	<i>Coragyps atratus</i>	
Turkey Vulture	<i>Cathartes aura</i>	
Osprey	<i>Pandion haliaetus</i>	
Cooper's Hawk	<i>Accipiter cooperii</i>	X
Red-shouldered Hawk	<i>Buteo lineatus</i>	
Sharp-shinned Hawk	<i>Accipiter striatus</i>	X
Broad-winged Hawk	<i>Buteo platypterus</i>	
Red-tailed Hawk	<i>Buteo jamaicensis</i>	X
American Kestrel	<i>Falco sparverius</i>	X
Wild Turkey	<i>Meleagris gallopavo</i>	X

Table 11. Continued

Common Name	Scientific Name	Species Within Fields ¹
Northern Bobwhite	<i>Colinus virginianus</i>	X
Killdeer	<i>Charadrius vociferous</i>	X
American Woodcock	<i>Scolopax minor</i>	X
Mourning Dove	<i>Zenaida macroura</i>	X
Yellow-Billed Cuckoo	<i>Coccyzus americanus</i>	
Barred Owl	<i>Strix varia</i>	
Chimney Swift	<i>Chaetura pelagica</i>	
Ruby-throated Hummingbird	<i>Archilochus colubris</i>	
Belted Kingfisher	<i>Megaceryle alcyon</i>	
Red-bellied Woodpecker	<i>Melanerpes carolinus</i>	
Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>	
Downy Woodpecker	<i>Picoides pubescens</i>	
Northern Flicker	<i>Colaptes auratus</i>	
Pileated Woodpecker	<i>Dryocopus pileatus</i>	
Yellow-bellied Sapsucker	<i>Sphyrapicus varius</i>	
Eastern Wood-Pewee	<i>Contopus virens</i>	
Acadian Flycatcher	<i>Empidonax virescens</i>	
Eastern Phoebe	<i>Sayornis phoebe</i>	
Great-crested Flycatcher	<i>Myiarchus crinitus</i>	

Table 11. Continued

Common Name	Scientific Name	Species Within Fields ¹
Eastern Kingbird	<i>Tyrannus tyrannus</i>	X
Purple Martin	<i>Progne subis</i>	
Tree Swallow	<i>Tachycineta bicolor</i>	X
Cliff Swallow	<i>Hirundo pyrrhonota</i>	X
Barn Swallow	<i>Hirundo rustica</i>	X
Blue Jay	<i>Cyanocitta cristata</i>	
American Crow	<i>Corvus brachyrhynchos</i>	
Carolina Chickadee	<i>Parus bicolor</i>	
Tufted Titmouse	<i>Parus carolinensis</i>	
White-breasted Nuthatch	<i>Sitta carolinensis</i>	
Carolina Wren	<i>Thryothorus ludovicianus</i>	
Blue-gray gnat catcher	<i>Poliophtila caerulea</i>	
Eastern Bluebird	<i>Sialia sialis</i>	X
Wood Thrush	<i>Hylocichla mustelina</i>	
American Robin	<i>Turdus migratorius</i>	X
Northern Mockingbird	<i>Mimus polyglottos</i>	X
Brown Thrasher	<i>Toxostoma rufum</i>	
Cedar Waxwing	<i>Bombycilla cedrorum</i>	
European Starling	<i>Sturnus vulgaris</i>	

Table 11. Continued

Common Name	Scientific Name	Species Within Fields ¹
Red-eyed Vireo	<i>Vireo olivaceus</i>	
White-eyed Vireo	<i>Vireo griseus</i>	
Yellow-throated Vireo	<i>Vireo flavifrons</i>	
Northern Parula	<i>Parula americana</i>	
Ovenbird	<i>Seiurus aurocapillus</i>	
Black-throated Green Warbler	<i>Dendroica virens</i>	
Blue-winged Warbler	<i>Vermivora pinus</i>	
Chestnut-sided Warbler	<i>Dendroica pensylvanica</i>	
Pine Warbler	<i>Dendroica pinus</i>	
Prairie Warbler	<i>Dendroica discolor</i>	X
Common Yellowthroat	<i>Geothlypis trichas</i>	X
Yellow-breasted Chat	<i>Icteria virens</i>	X
Scarlet Tanager	<i>Piranga olivacea</i>	
Summer Tanager	<i>Piranga rubra</i>	
Northern Cardinal	<i>Cardinalis cardinalis</i>	
Blue Grosbeak	<i>Guiraca caerulea</i>	X
Indigo Bunting	<i>Passerina cyanea</i>	X
Dickcissel	<i>Spiza Americana</i>	X
Eastern Towhee	<i>Pipilo erythrophthalmus</i>	X

Table 11. Continued

Common Name	Scientific Name	Species Within Fields ¹
Chipping Sparrow	<i>Spizella pusilla</i>	
Field Sparrow	<i>Spizella pusilla</i>	X
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	X
Henslow's Sparrow	<i>Ammodramus henslowii</i>	X
Song Sparrow	<i>Melospiza melodia</i>	
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	X
Bobolink	<i>Dolichonyx oryzivorus</i>	X
Eastern Meadowlark	<i>Sturnella magna</i>	X
Common Grackle	<i>Quiscalus quiscula</i>	X
Brown-headed Cowbird	<i>Molothrus ater</i>	
Orchard Oriole	<i>Icterus spurius</i>	X
American Goldfinch	<i>Carduelis tristis</i>	X
House Finch	<i>Carpodacus mexicanus</i>	

¹ Species noted within the boundaries of the native grass fields. Other species were observed outside the fields or as flyovers.

Table 12. Results of multiple linear regression models to predict grassland bird species occurrences in Tennessee, summer 2002 and 2003.

<u>2002 fields (n = 45) (Grassland species)</u>									
Variable	Parameter Estimate			Without LNDSCP/FLDSZ			Model		
	Estimate	STD ERR	F value	Estimate	STD ERR	F value	R ²	P	R ²
Bare ground	0.06	0.02	6.43	0.06	0.02	6.43	0.29	0.015	0.29
Cool season grass	-0.05	0.02	4.21	-0.05	0.02	4.21		0.046	
Residual stems	-1.09	0.47	5.47	-1.09	0.47	5.47		0.024	
<u>2002 fields (n = 45) (Species of concern)</u>									
Variable	Parameter Estimate			Without LNDSCP/FLDSZ			Model		
	Estimate	STD ERR	F value	Estimate	STD ERR	F value	R ²	P	R ²
Field size	0.96	0.33	8.50	0.06	0.02	13.55	0.37	0.001	0.24
Bare ground	0.04	0.02	6.70						
<u>2003 fields (n = 43) (Grassland species)</u>									
Variable	Parameter Estimate			Without LNDSCP/FLDSZ			Model		
	Estimate	STD ERR	F value	Estimate	STD ERR	F value	R ²	P	R ²
Field size	2.80	0.72	15.00				0.33	0.036	0.10
Woody	1.92	0.60	10.26	Warm season grass	-0.03	4.66			
<u>2003 fields (n = 43) (Species of concern)</u>									
Variable	Parameter Estimate			Without LNDSCP/FLDSZ			Model		
	Estimate	STD ERR	F value	Estimate	STD ERR	F value	R ²	P	R ²
Field size	1.77	0.40	20.20	Nothing significant	N/A	N/A		N/A	N/A
Woody	0.71	0.33	4.73						

Table 13. Results from AIC model selection and stepwise linear regression of vegetation variables to explain bird presence by species, summer 2002.

2002											
Species	# of var	Chi-squared	AIC	delta AIC	Mod	warm	veght	bare	cool	wood	resid
Grasshopper Sparrow	1	3.60	41.42	0.00			- *				
	2	5.42	41.49	0.07		-	- *				
	2	4.09	42.58	1.16			- **			+	
	2	5.15	42.66	1.24	+		- *				
	2	4.54	42.74	1.32			- *	+			
	2	6.68	42.80	1.38	+ *			+ *			
	3	7.80	43.07	1.65	+		-	+			
	3	7.94	43.17	1.75	+ *	-		+ *			
Species	# of var	Chi-squared	AIC	delta AIC	Mod	warm	veght	bare	cool	wood	resid
Henslow's Sparrow	2	8.76	18.54	0.00			- *		+		
	2	12.34	19.69	1.15	+		-				
	1	4.91	19.75	1.21			- *				
	3	13.84	20.12	1.58	+		- *		+		
Species	# of var	Chi-squared	AIC	delta AIC	Mod	warm	veght	bare	cool	wood	resid
Dickcissel	2	10.03	49.31	0.00	+			+ **			
	3	10.38	49.42	0.11			-	+ *	+ *		
	3	11.63	49.67	0.36	+			+ ***	+		
	2	8.45	49.96	0.65				+ **	+ *		
	3	10.98	50.22	0.91	+			+ *			
	2	7.64	50.39	1.08			-	+			
	1	4.61	50.53	1.22			- **				
	2	6.37	50.59	1.28			- **		+		
	3	10.62	50.60	1.29	+			+ **			-
	3	10.14	51.12	1.81	+			+ **		-	
Species	# of var	Chi-squared	AIC	delta AIC	Mod	warm	veght	bare	cool	wood	resid
Eastern Meadowlark	1	7.10	47.58	0.00			- **				
	2	8.20	48.15	0.57			- **		+		
	2	8.33	48.59	1.01			- **	+			
	3	9.67	49.01	1.43			- **	+	+		
	2	7.25	49.39	1.81	-		- **				
	2	7.26	49.46	1.88			- **				-
	2	7.12	49.51	1.93		-	- **				
Species	# of var	Chi-squared	AIC	delta AIC	Mod	warm	veght	bare	cool	wood	resid
Northern Bobwhite	1	0.36	52.21	0.00			-				
	1	0.23	53.61	1.40	-						
	1	0.18	53.84	1.63				-			
	1	0.0006	53.88	1.67		-					
	2	0.86	54.06	1.85	-			-			

(* P < 0.1 ** P < 0.05 *** P < 0.01)

Table 14. Results from AIC model selection and stepwise linear regression of vegetation variables to explain bird presence by species, summer 2003.

2003										
Species	# of var	Chi-squared	AIC	delta AIC	ltd	warm	veght	bare	wood	resid
Grasshopper Sparrow	1	4.21	33.05	0.00			- *			
	2	4.28	34.05	1.00		-	- *			
	2	5.25	34.38	1.33	-		- *			
	2	4.60	34.73	1.68			- *			-
	2	4.61	34.86	1.81			- *		-	
	2	4.61	35.02	1.97			- *	+		
Species	# of var	Chi-squared	AIC	delta AIC	ltd	warm	veght	bare	wood	resid
Henslow's Sparrow	2	6.68	40.19	0.00	+ *	- **				
	1	4.17	41.63	1.44		- *				
	3	6.76	42.00	1.81	+ *	- **		+		
	3	6.90	42.13	1.94	+ *	- **	+			
	3	6.69	42.18	1.99	+ *	- **			-	
	3	6.74	42.19	2.00	+ *	- **				+
Species	# of var	Chi-squared	AIC	delta AIC	ltd	warm	veght	bare	wood	resid
Dickcissel	1	4.29	43.15	0.00				+ *		
	2	6.13	43.51	0.36				+ *		+
	2	4.96	44.20	1.05		+		+ **		
	2	4.85	44.23	1.08				+ *	-	
	2	5.43	44.29	1.14	+			+ **		
	3	7.54	44.29	1.14	+			+ **		+
	3	6.94	44.49	1.34		+		+ **		+
	3	6.53	44.74	1.59				+ *	-	+
	2	4.44	45.07	1.92			-	+		
Species	# of var	Chi-squared	AIC	delta AIC	ltd	warm	veght	bare	wood	resid
Eastern Meadowlark	1	1.09	58.74	0.00						-
	1	0.85	59.54	0.80				+		
	1	0.73	59.65	0.91	+					
	1	0.48	59.85	1.11			-			
	2	2.67	59.88	1.14	+			+		
	2	1.84	59.95	1.21	+					-
	2	1.80	60.10	1.36			-			-
	1	0.23	60.12	1.38					+	
	2	1.85	60.16	1.42				+		-
	3	3.63	60.50	1.76	+			+		-
	2	1.28	60.58	1.84					+	-
Species	# of var	Chi-squared	AIC	delta AIC	ltd	warm	veght	bare	wood	resid
Northern Bobwhite	1	0.73	78.77	0.00					+	
	1	0.72	78.86	0.09	-					
	1	0.24	79.32	0.55			+			
	1	0.21	79.35	0.58				-		
	1	0.20	79.36	0.59						-
	2	1.59	80.06	1.29	-			-		
	2	1.31	80.19	1.42	-				+	
	2	0.93	80.64	1.87	-					-
	2	0.91	80.59	1.82			+		+	
	2	0.91	80.59	1.82				-	+	

(* P < 0.1 ** P < 0.05)

Figures

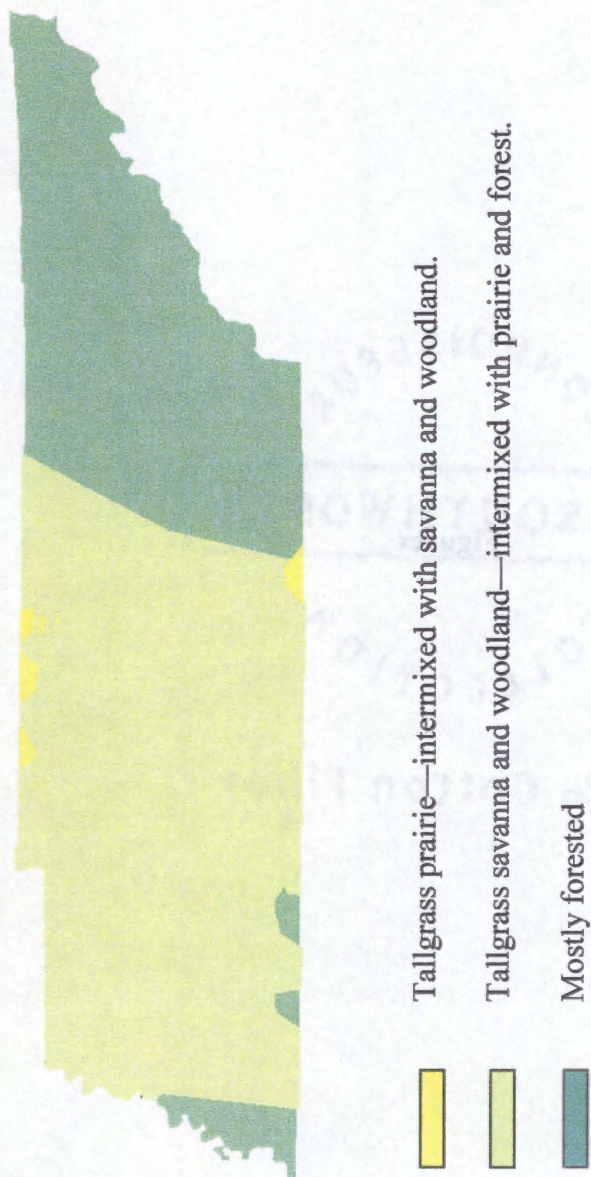


Figure 1. Historic grassland habitat in Tennessee (Packard and Mutel 1997).

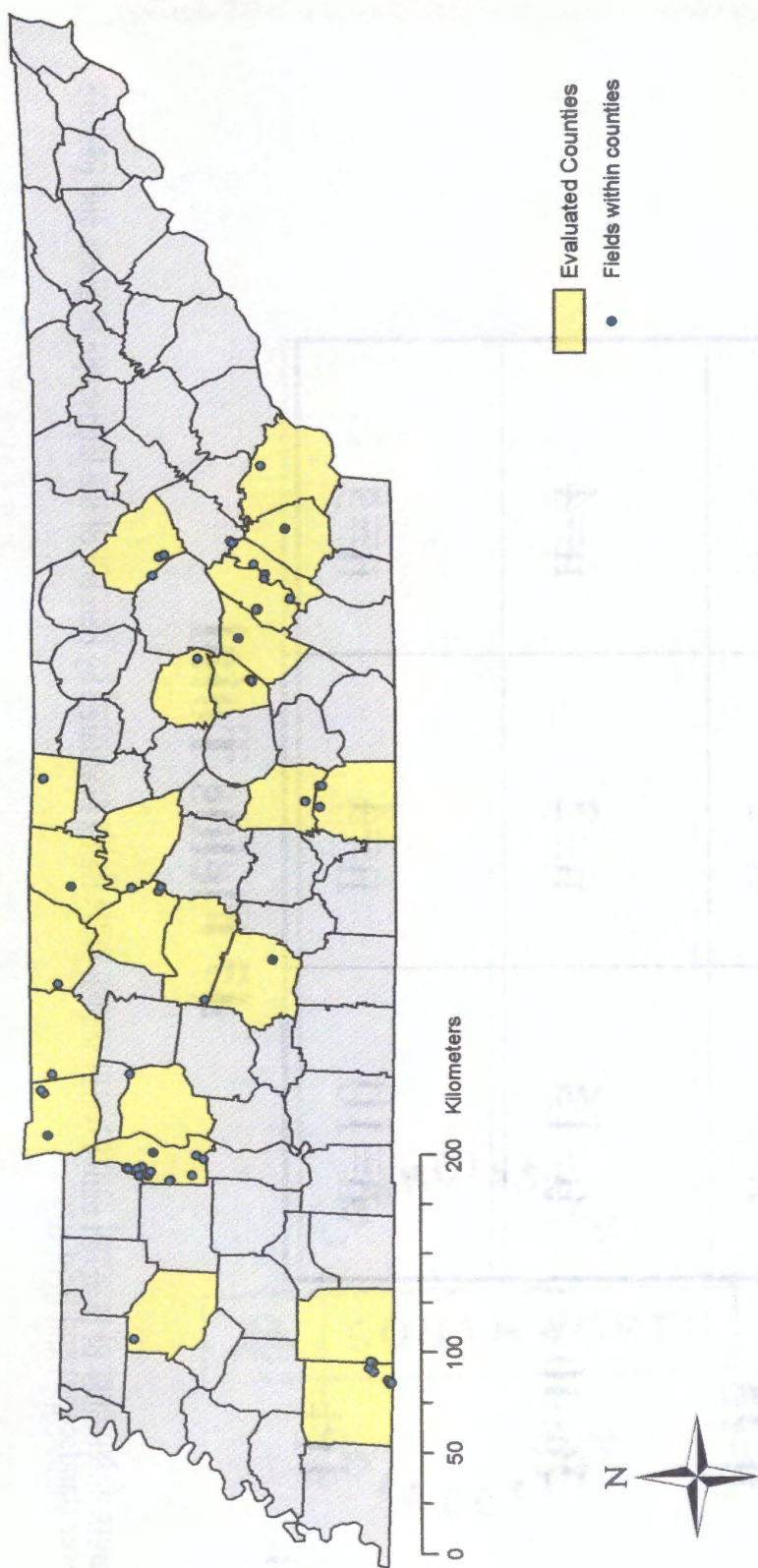


Figure 2. Fields within Tennessee counties evaluated for native warm season grass restoration and breeding bird use, May-July, 2002 and 2003.

L a n d s c a p e (%)		Field Size (ha)		
		2-9.7	10-16	16.5-120
0-25		n=3	n=2	n=2
	26-40	n=15	n=2	n=4
	41+	n=10	n=4	n=5
		47 Fields Total		

Figure 3. Number of restored native warm season grass fields evaluated by percent of the landscape in grass and pasture cover (landscape) and field size.

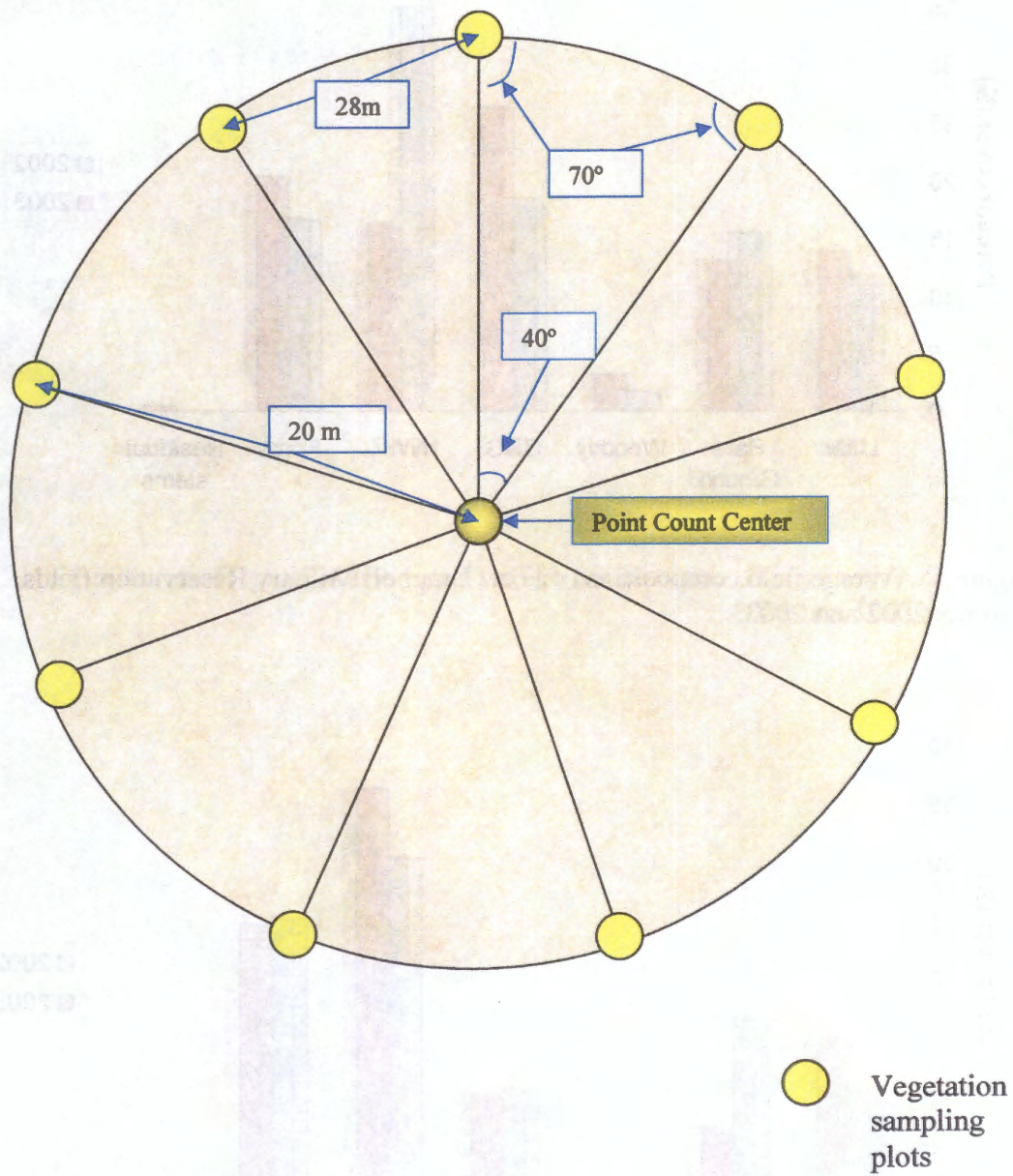


Figure 4: Plot array used to evaluate vegetation around point counts, summer 2002 and 2003.

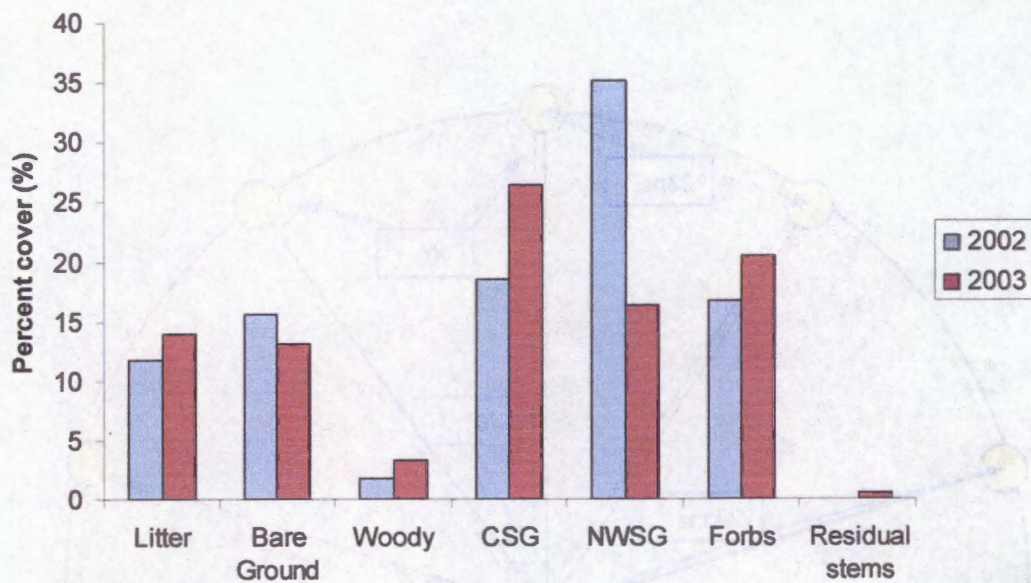


Figure 5. Average field composition of Fort Campbell Military Reservation fields, summer 2002 and 2003.

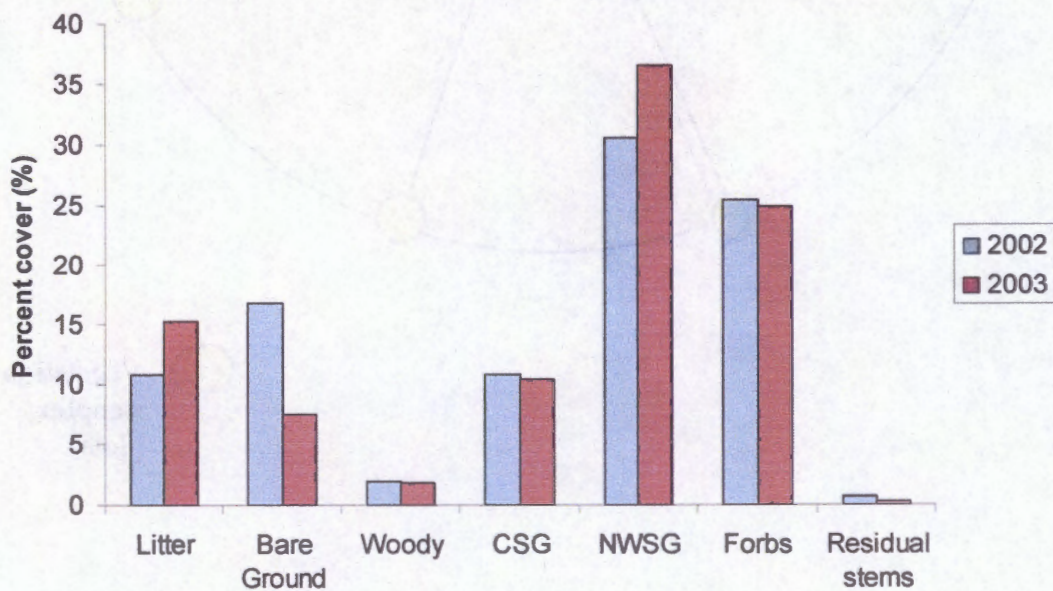


Figure 6. Average field composition of restored native warm season grass fields (n = 41), summer 2002 and 2003.

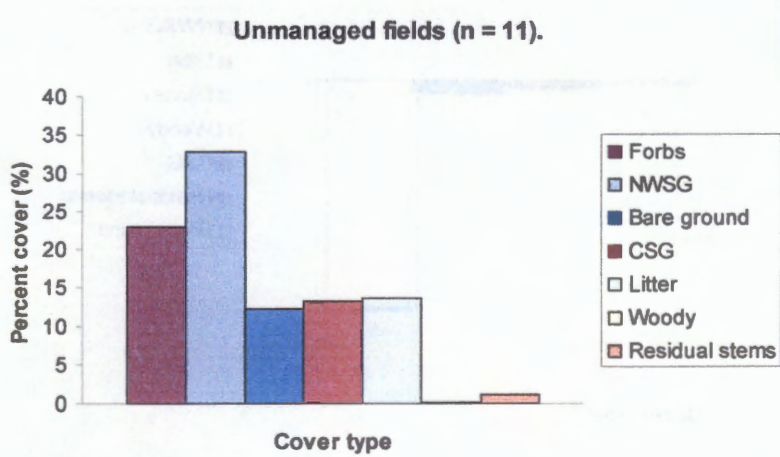
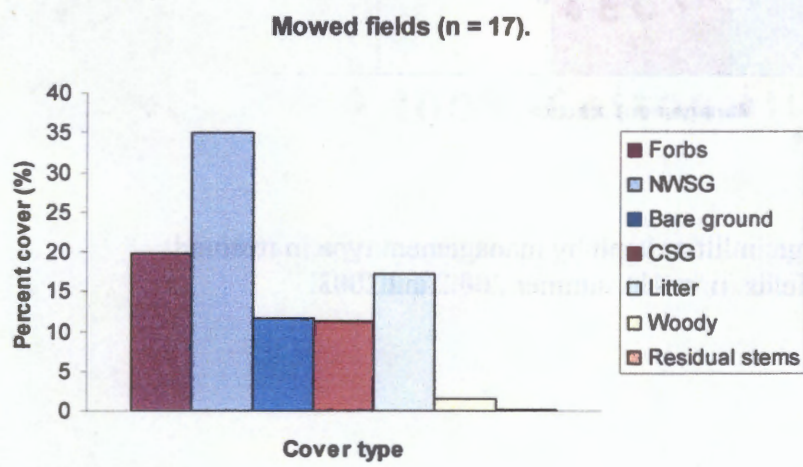
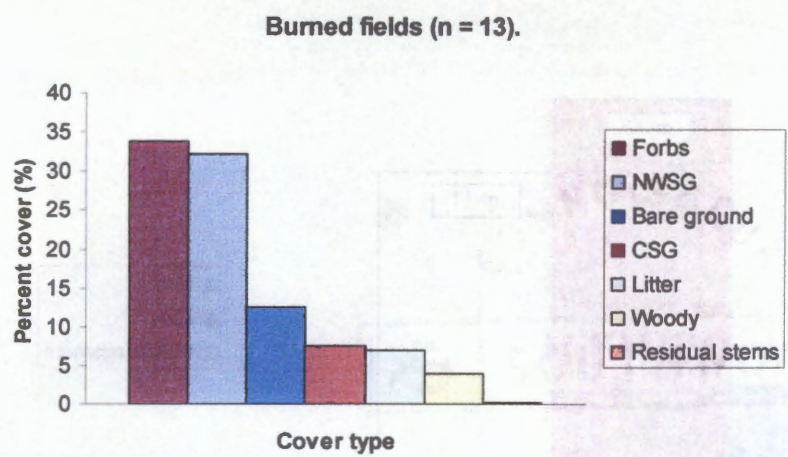


Figure 7. Field composition by management practice in program fields (n = 41), summer 2002 and 2003 (pooled).

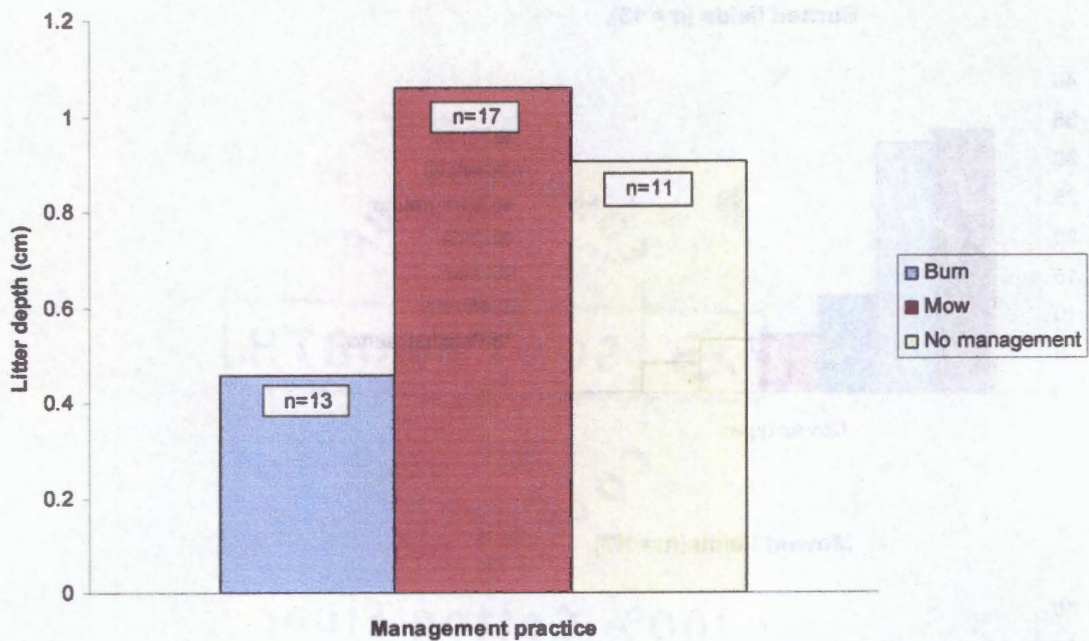


Figure 8. Average net change in litter depth by management type in restored native warm season grass fields (n = 41), summer 2002 and 2003.

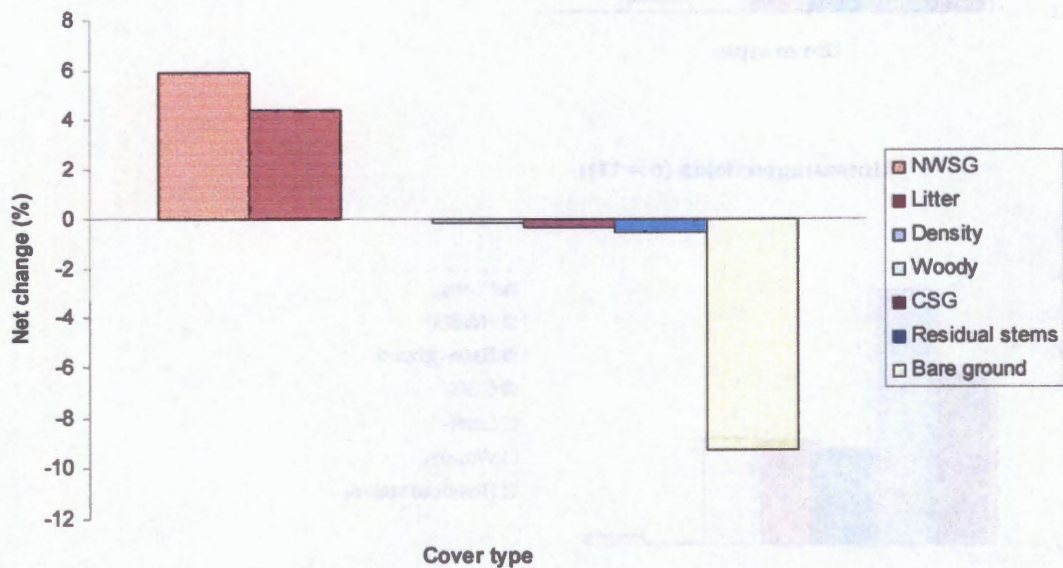


Figure 9. Average net change of cover types in restored native warm season grass fields (n = 41), summer 2002 and 2003.

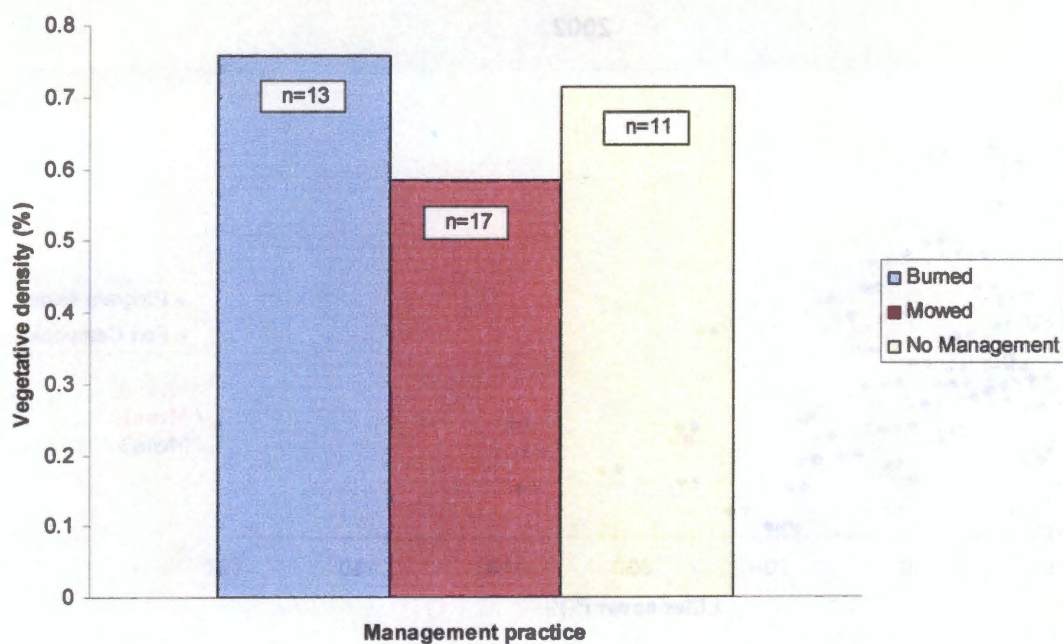


Figure 10. Mean vegetative density across management types in restored native warm season grass fields (n = 41), summer 2002 and 2003 (pooled).

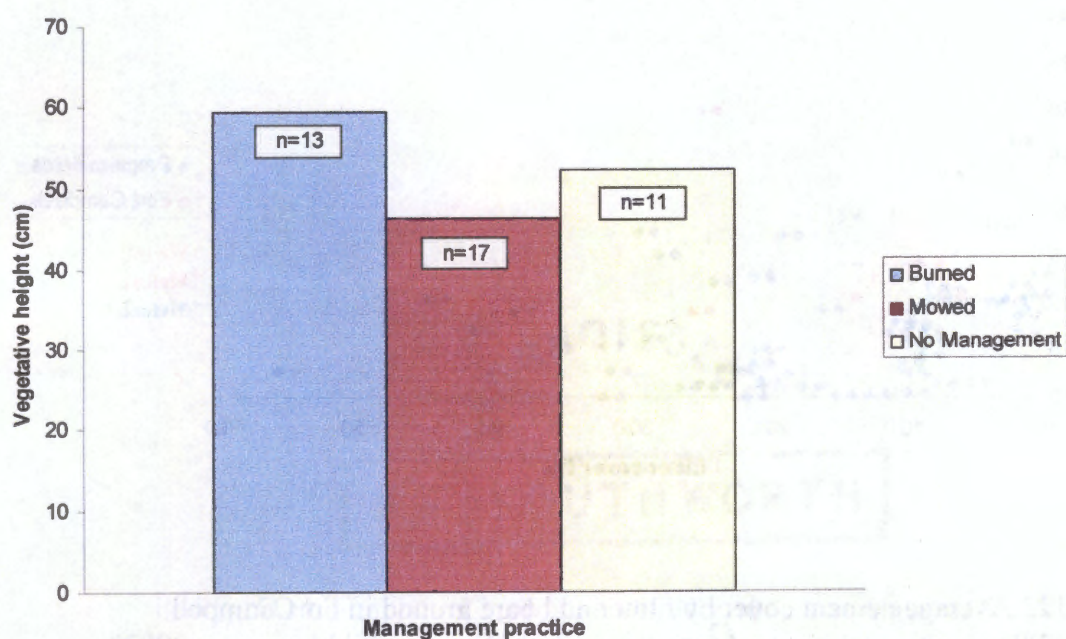


Figure 11. Mean vegetative height across management types in program fields (n = 41) evaluated, summer 2002 and 2003 (pooled).

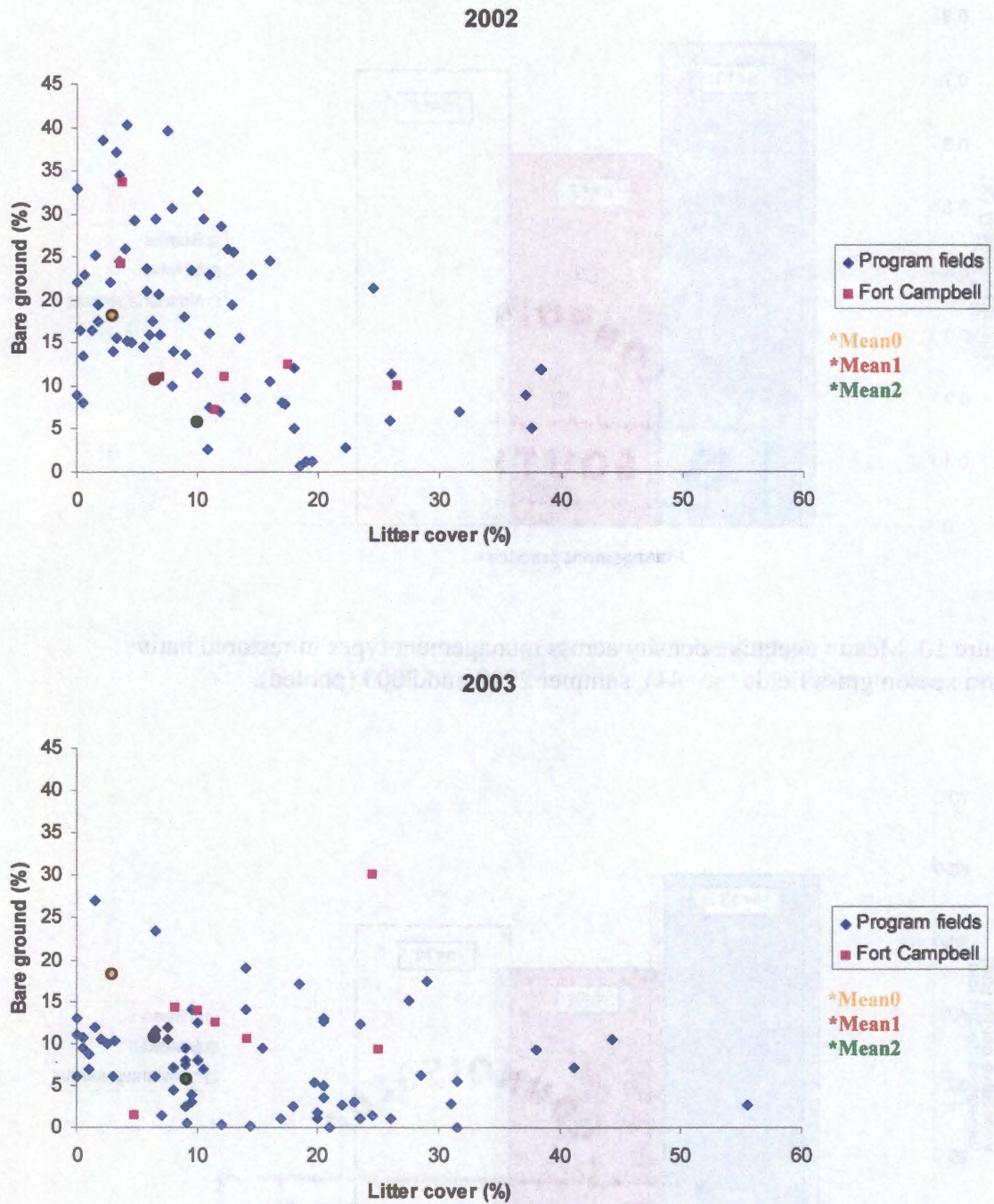


Figure 12. Average percent cover by litter and bare ground in Fort Campbell Military Reservation and restored native warm season grass fields, summer 2002 and 2003. *Habitat measurements from Moss (2001) are included.

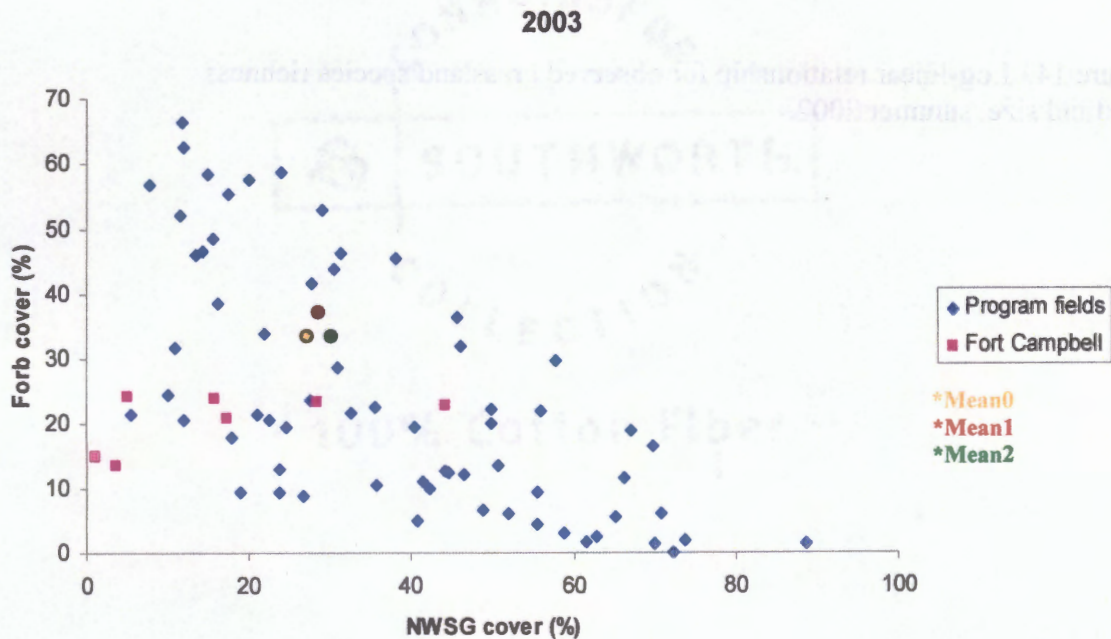
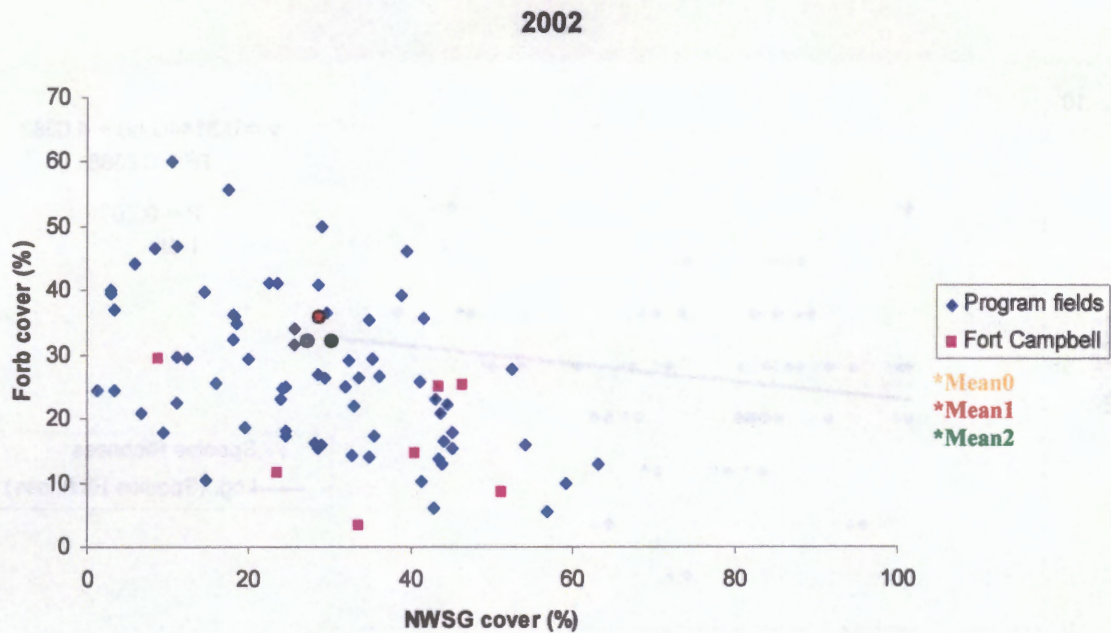


Figure 13. Average percent cover by native warm season grass and forbs in Fort Campbell Military Reservation and restored native warm season grass fields, summer 2002 and 2003. *Habitat measurements from Moss (2001) are included.

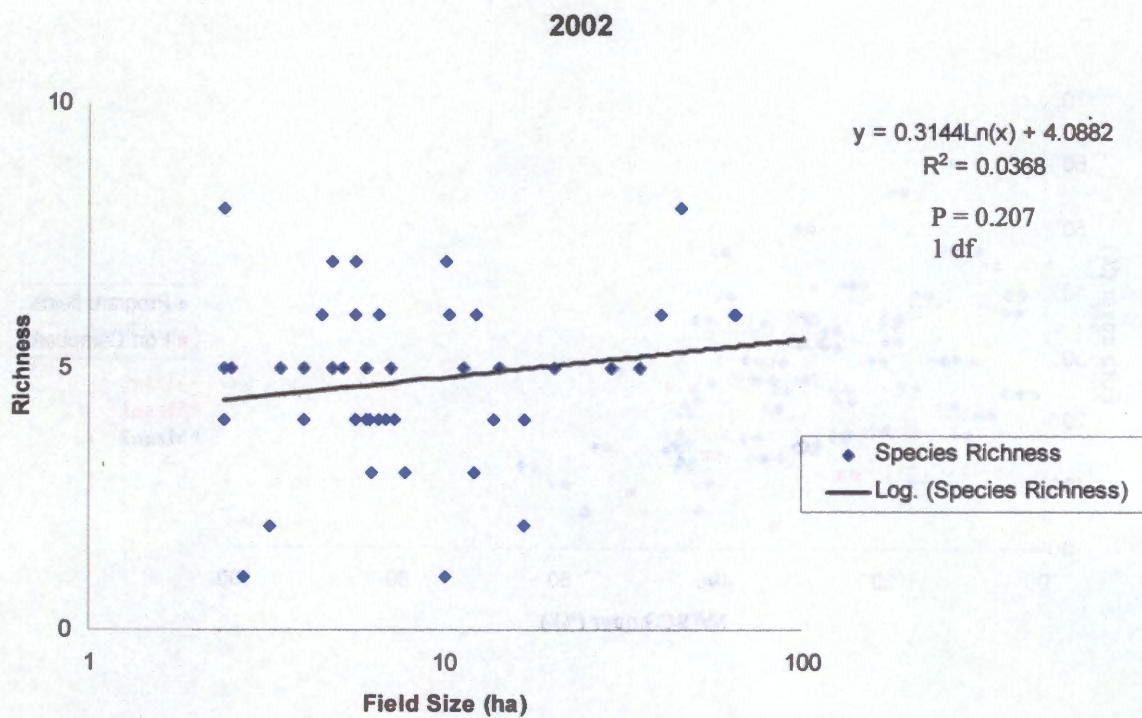


Figure 14. Log-linear relationship for observed grassland species richness and field size, summer 2002.

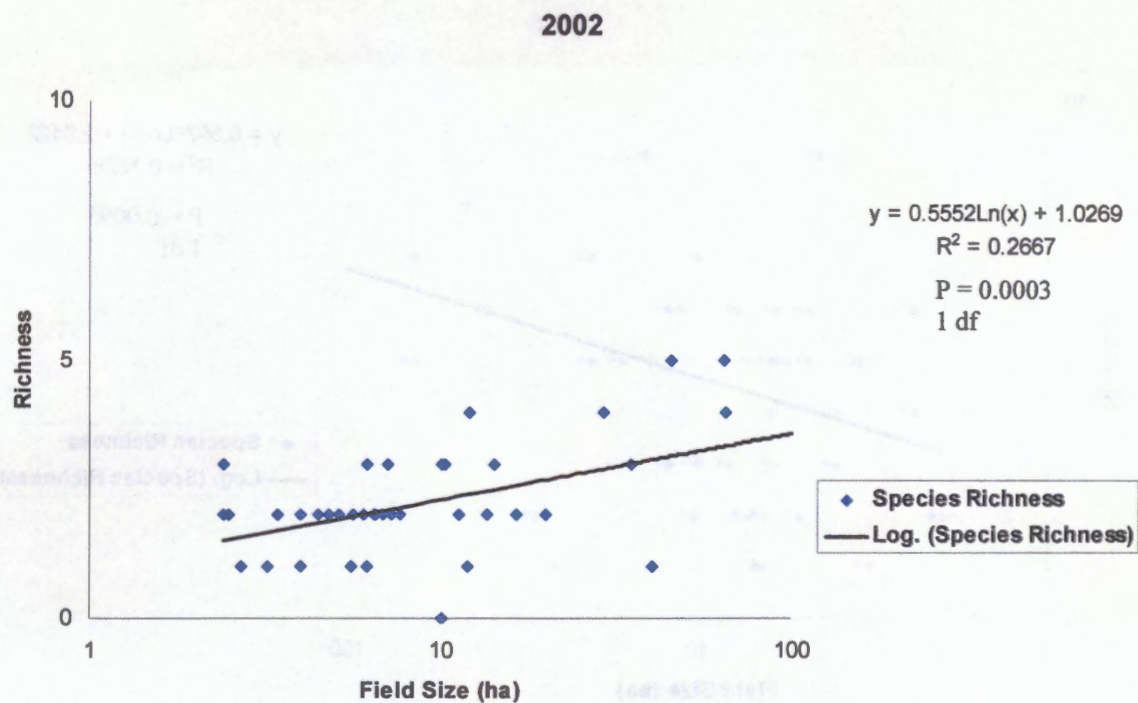


Figure 15. Log-linear relationship for observed species of concern richness and field size, summer 2002.

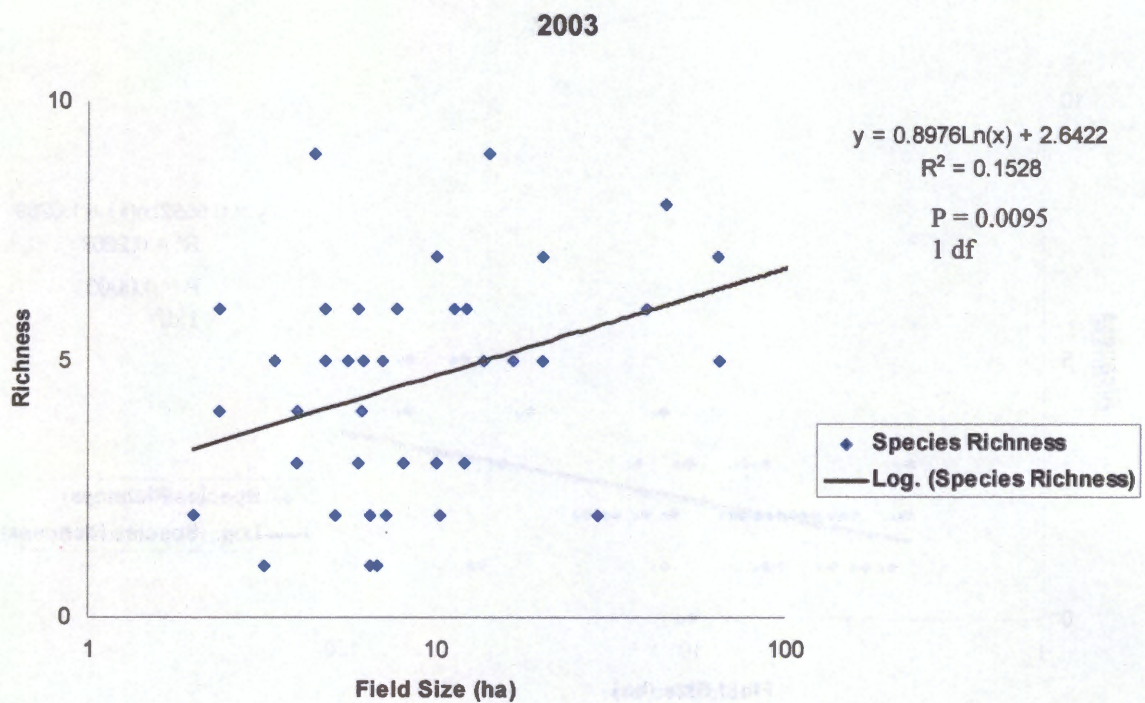


Figure 16. Log-linear relationship for observed grassland species richness and field size, summer 2003.

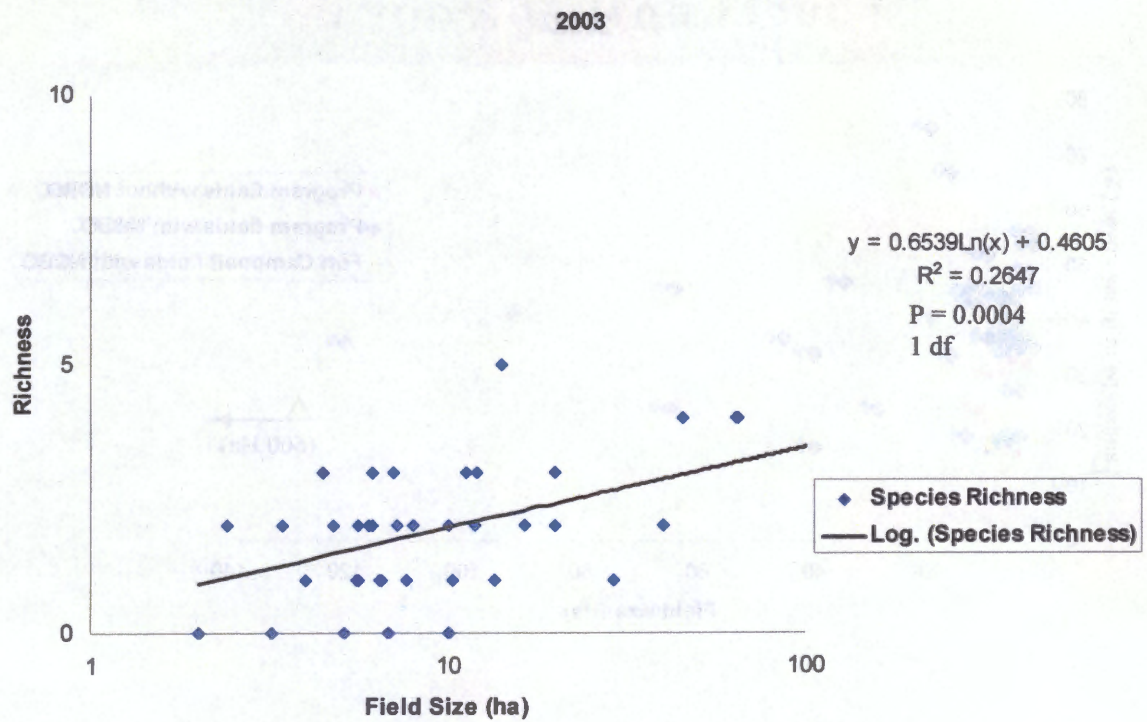


Figure 17. Log linear relationship for observed species of concern richness and field size, summer 2003.

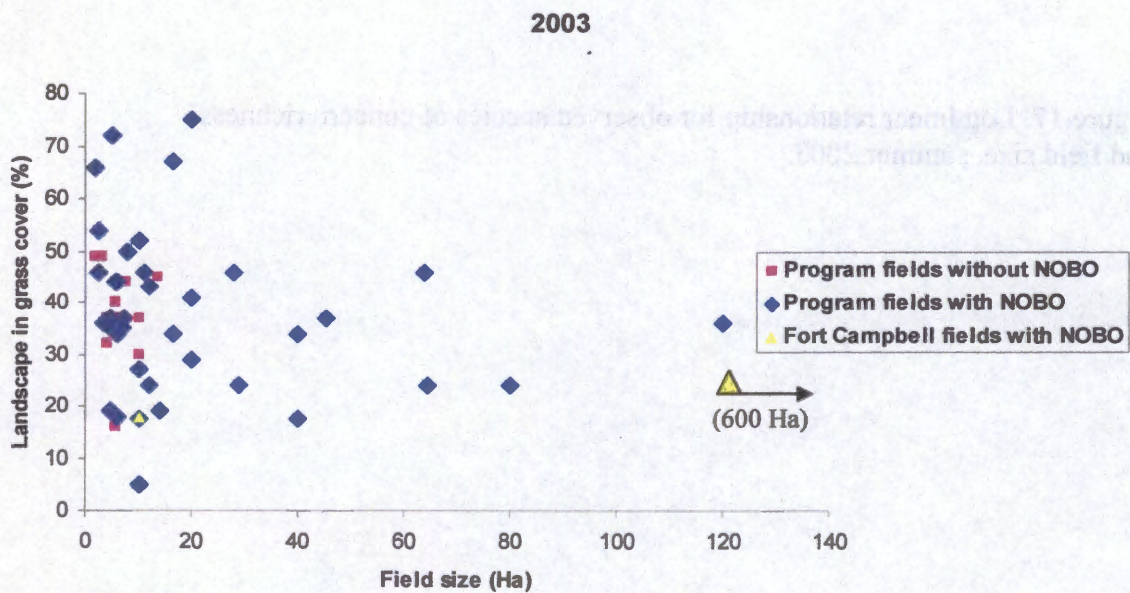
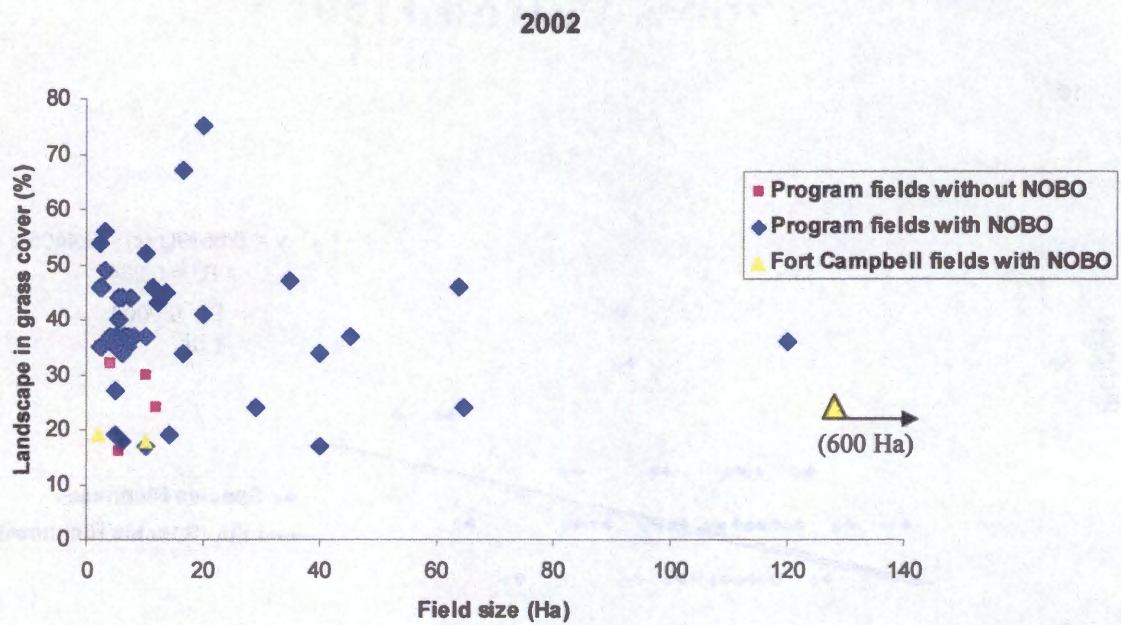


Figure 18. Average landscape cover by grass/pasture and field size where northern bobwhites occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

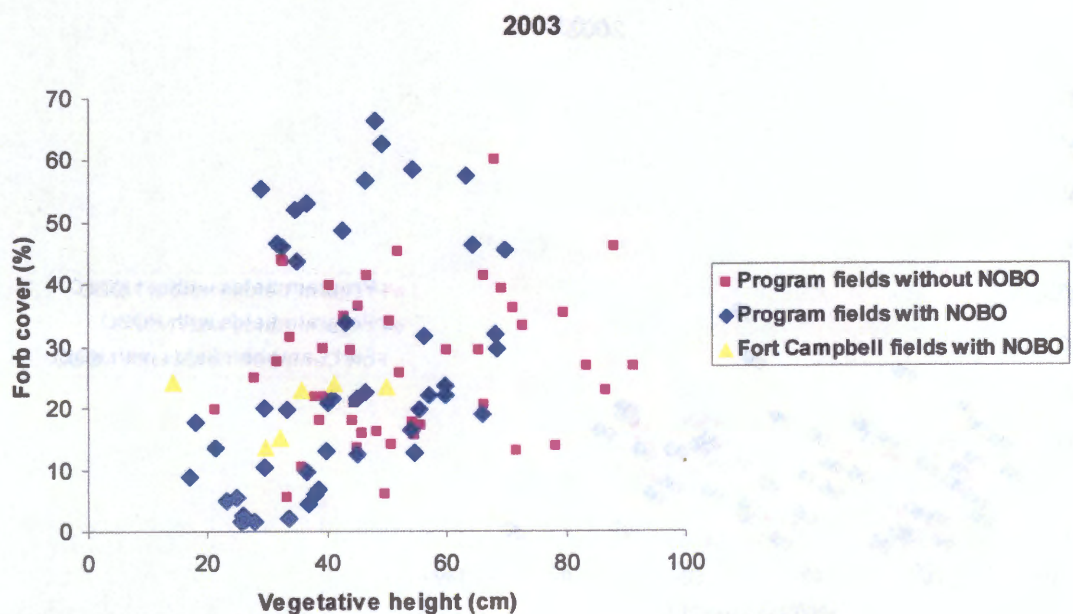
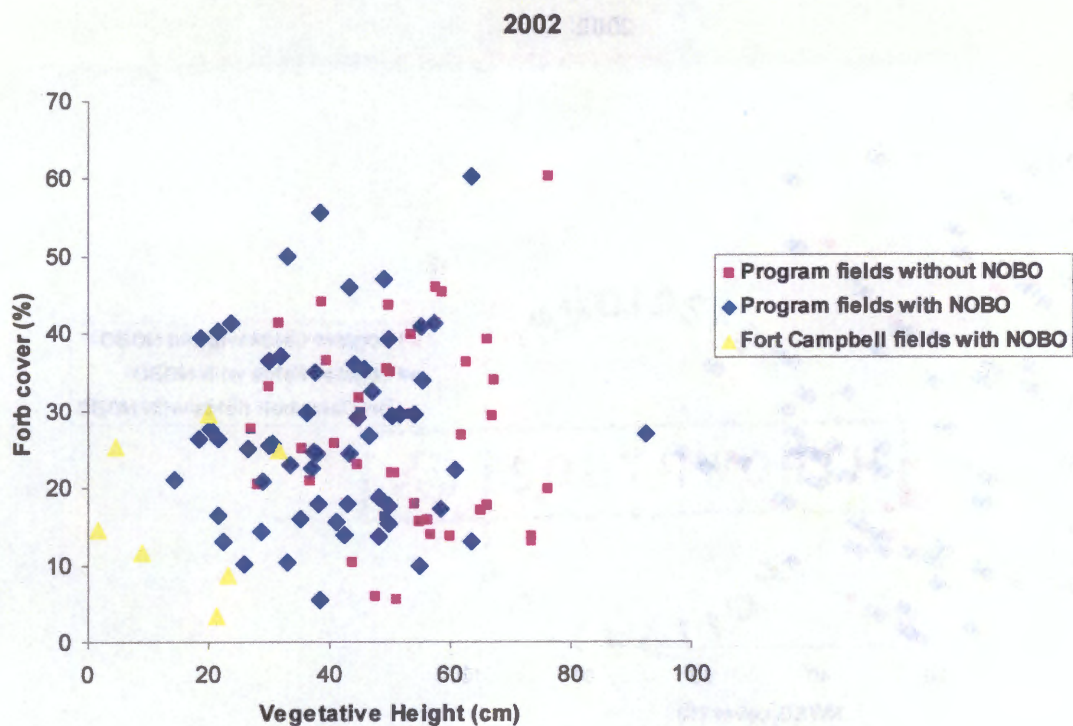


Figure 19. Average vegetative height and forb cover where northern bobwhites occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

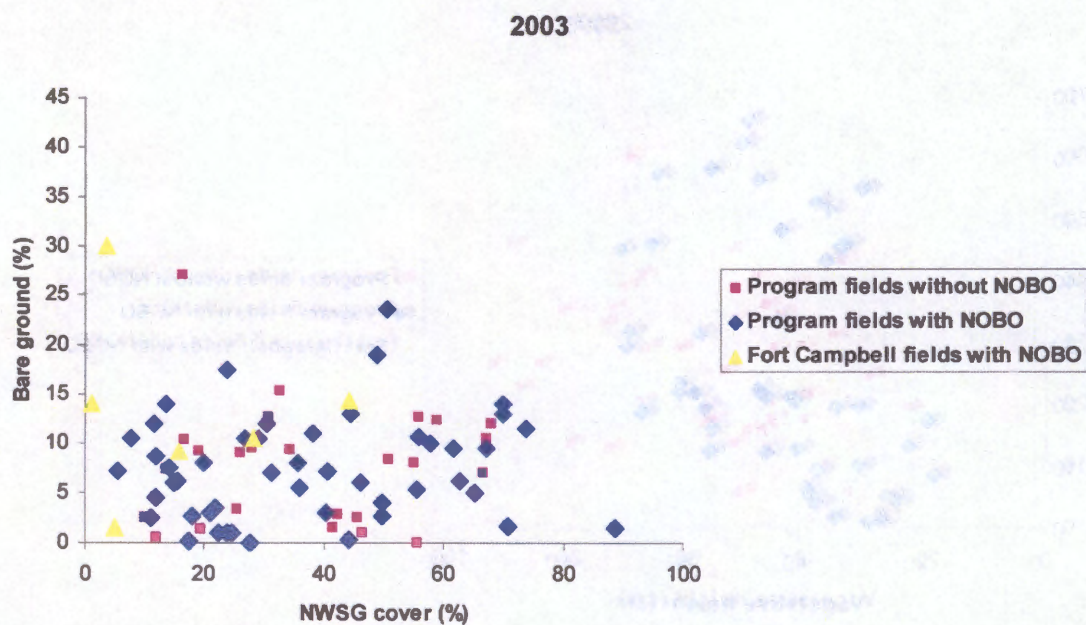
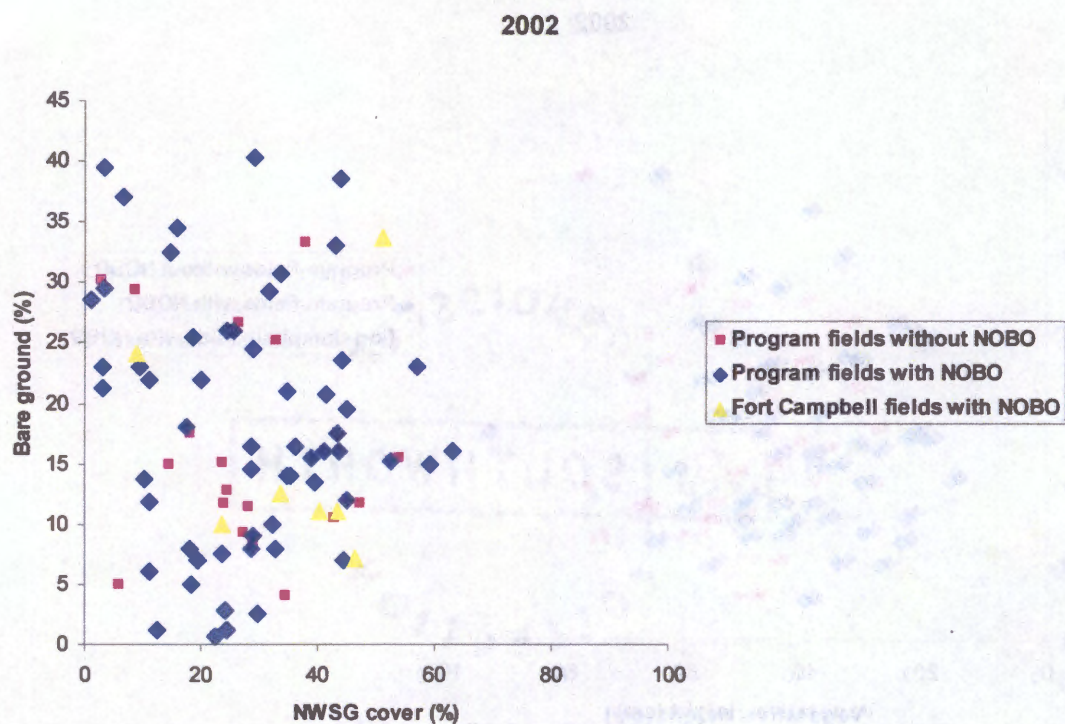


Figure 20. Average native warm season grass and bare ground cover where northern bobwhites occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

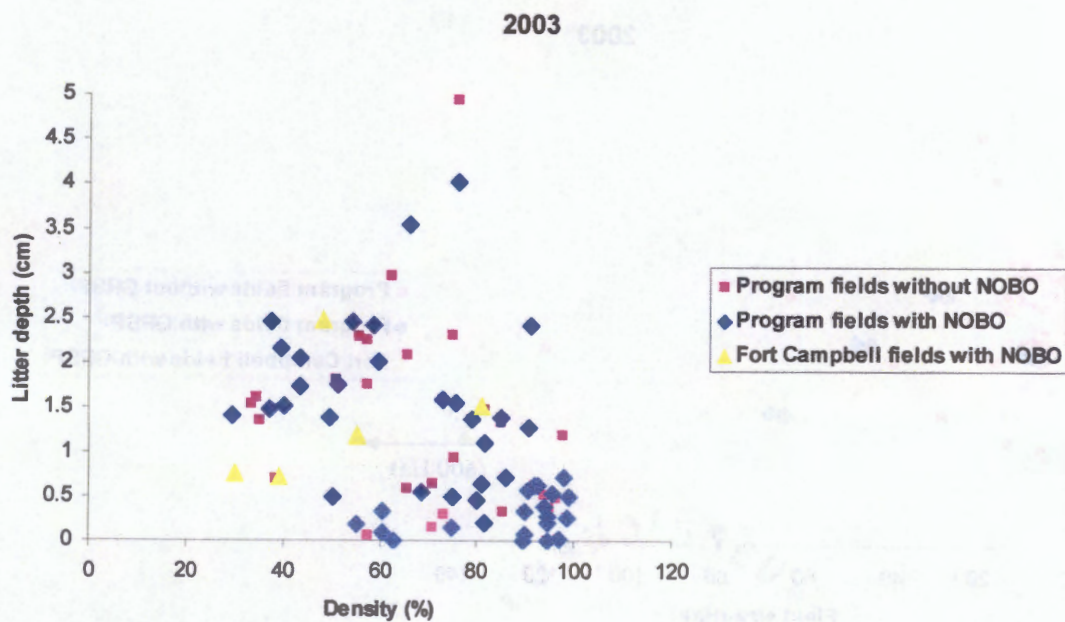
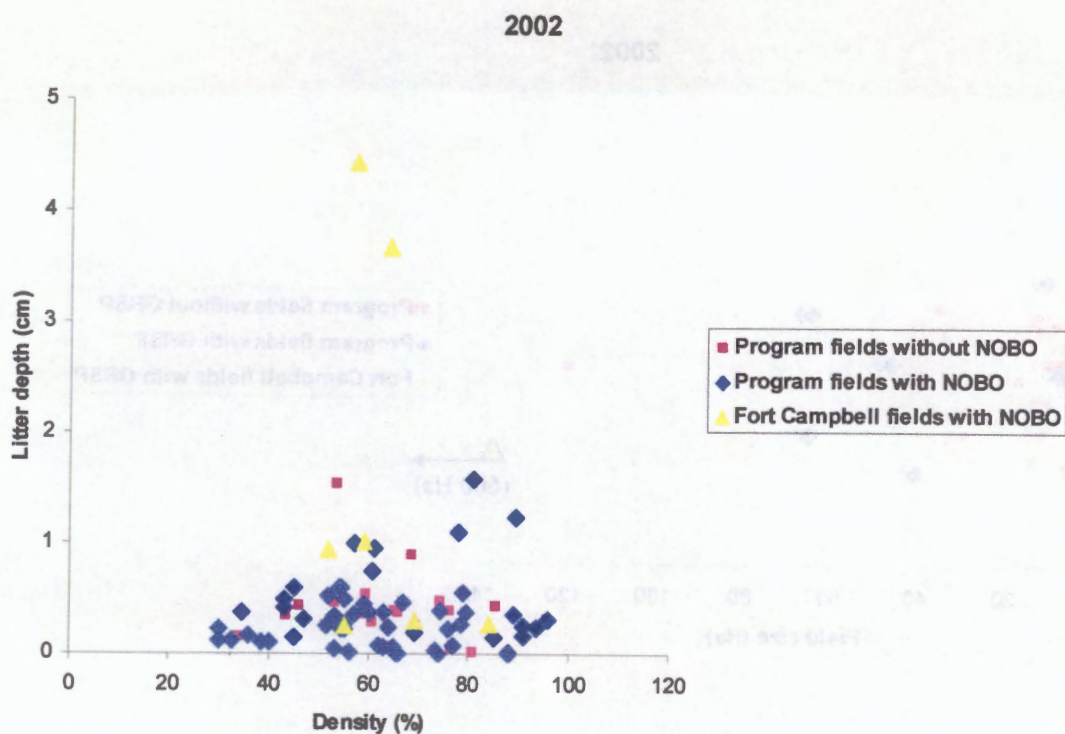
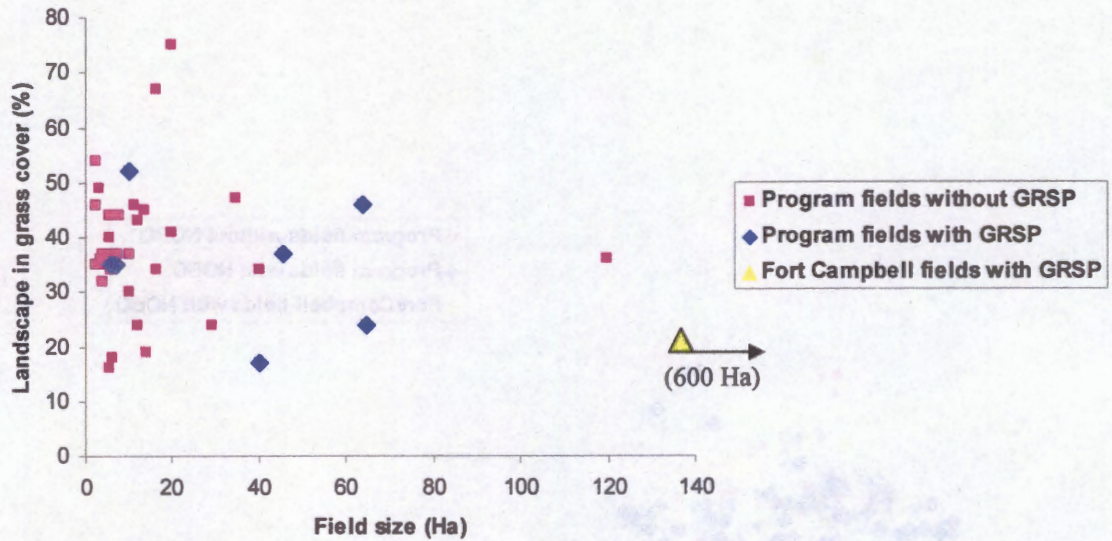


Figure 21. Average density and litter depths where northern bobwhites occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

2002



2003

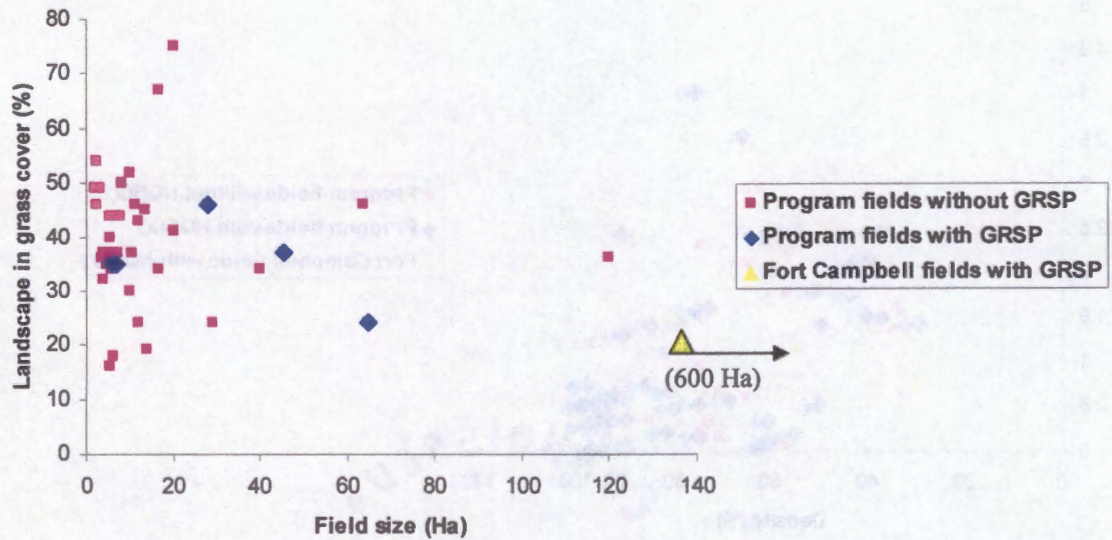
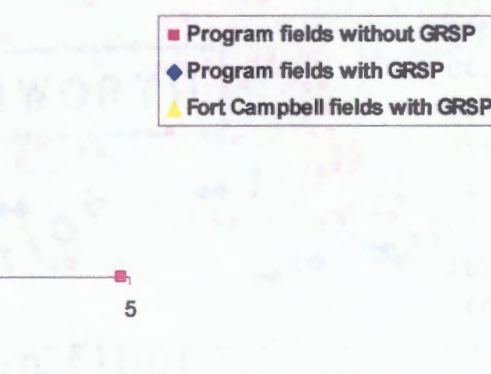
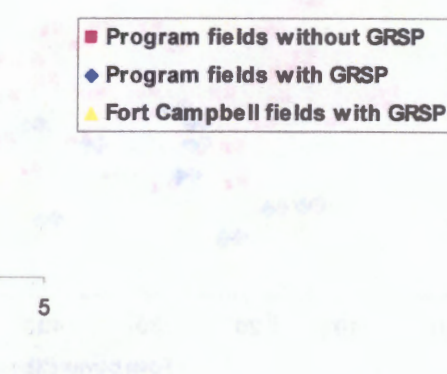


Figure 22. Average landscape cover by grass/pasture and field size where grasshopper sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.



hopper on fields,

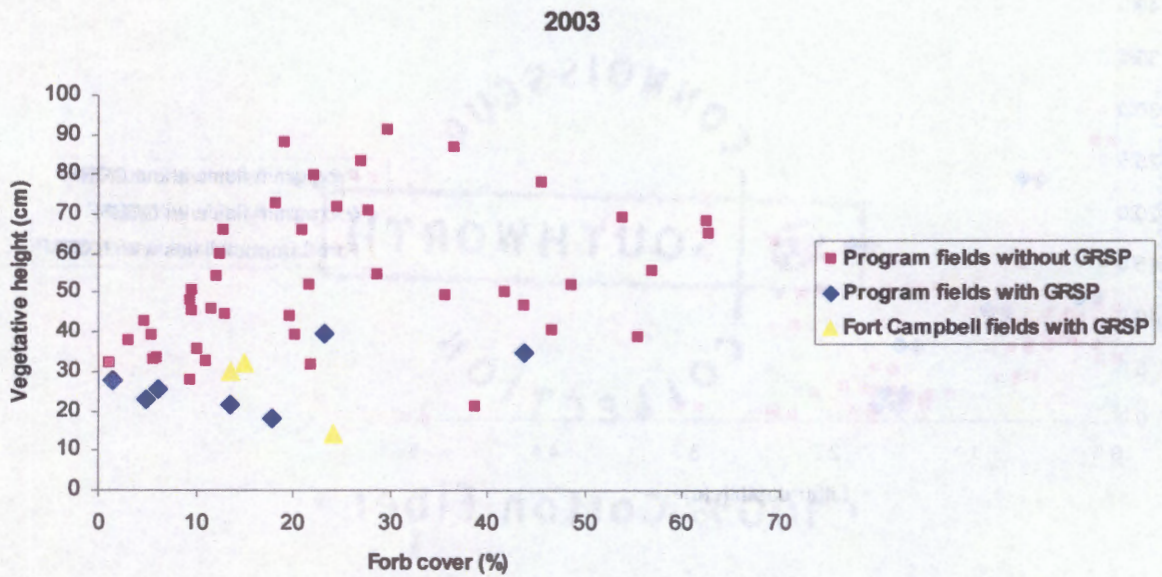
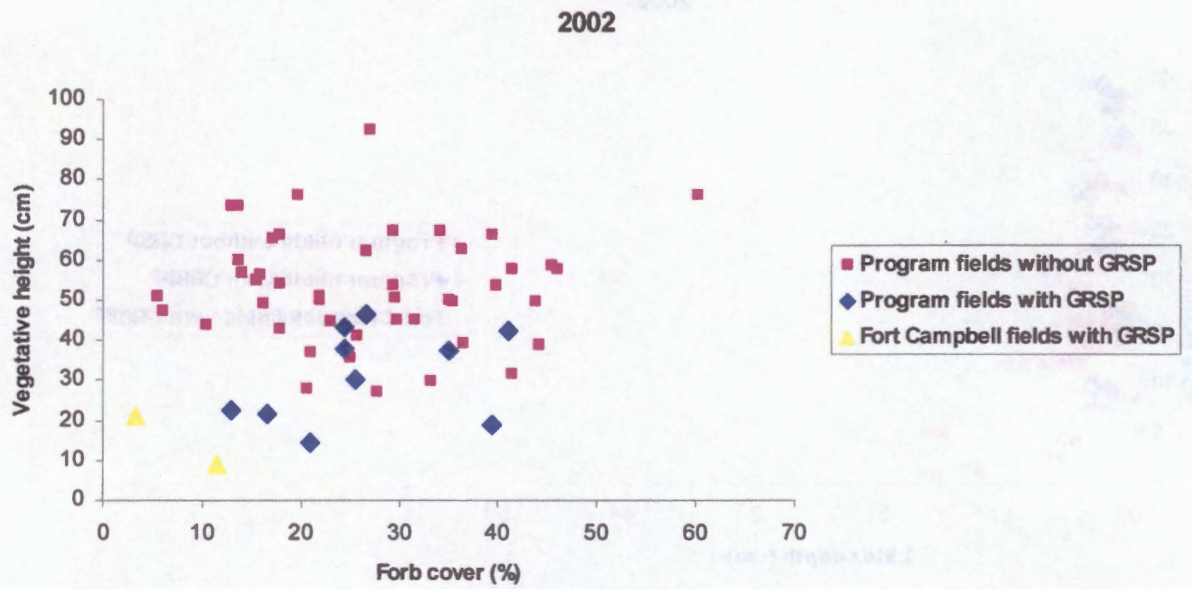


Figure 24. Average vegetative height and forb cover where grasshopper sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

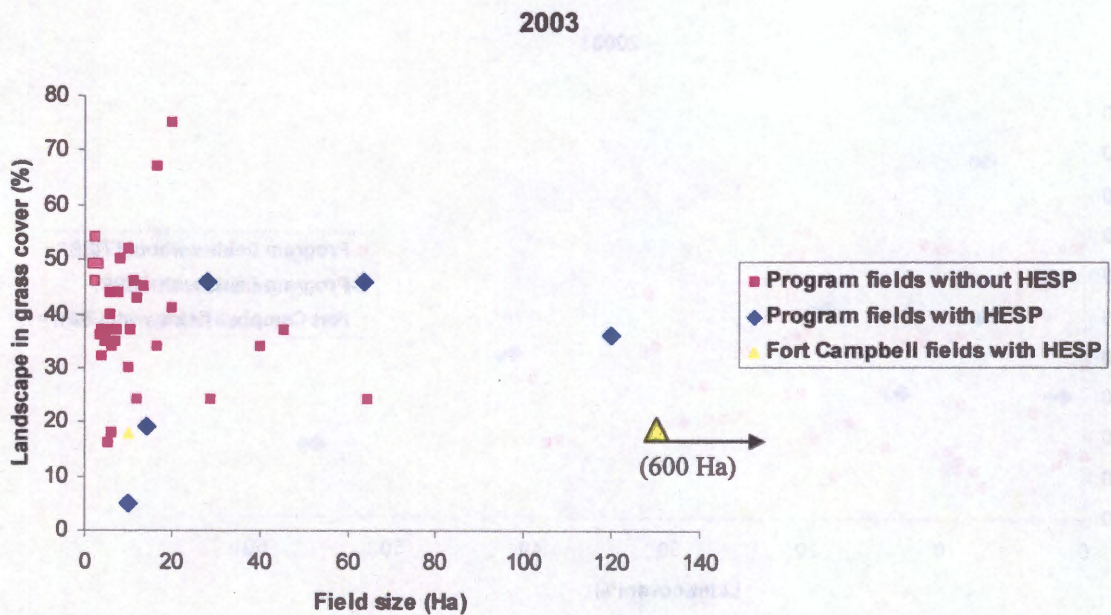
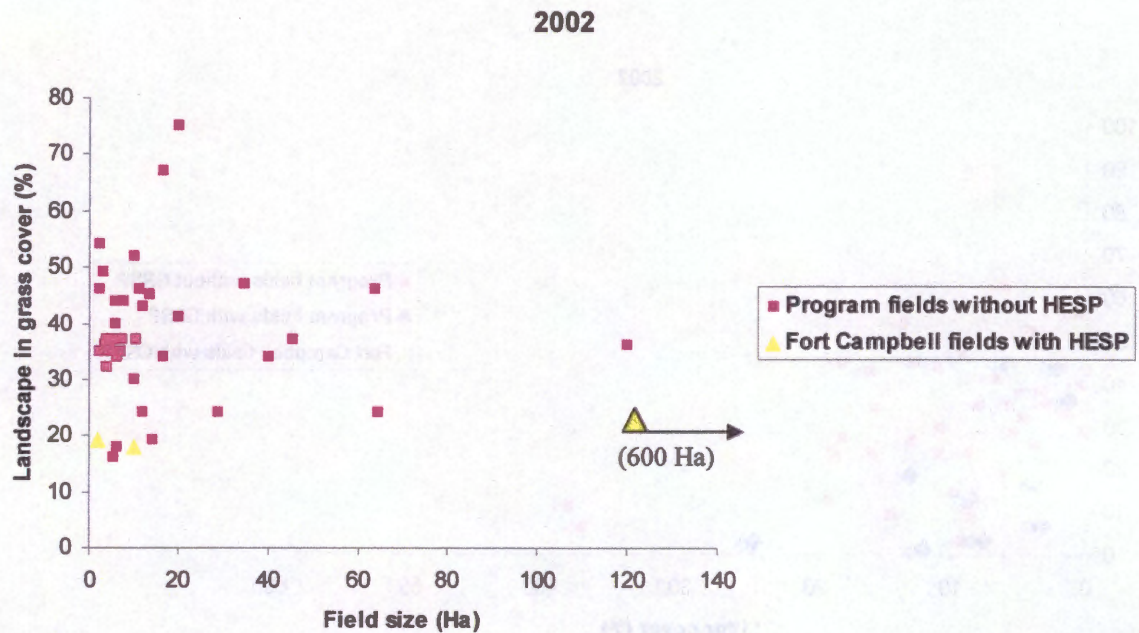
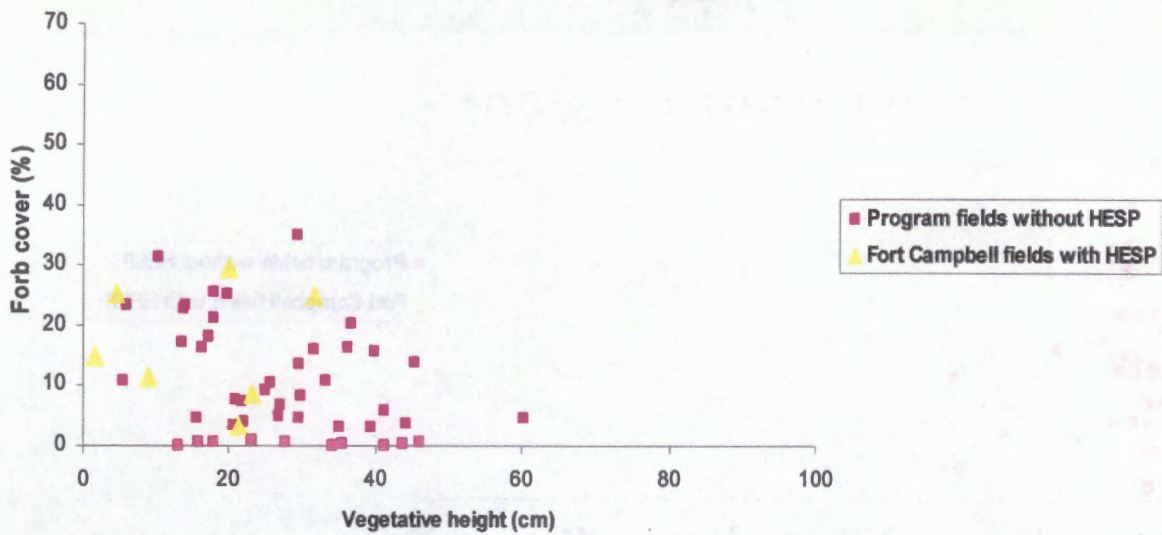


Figure 26. Average landscape cover by grass/pasture and field size where Henslow's sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

2002



2003

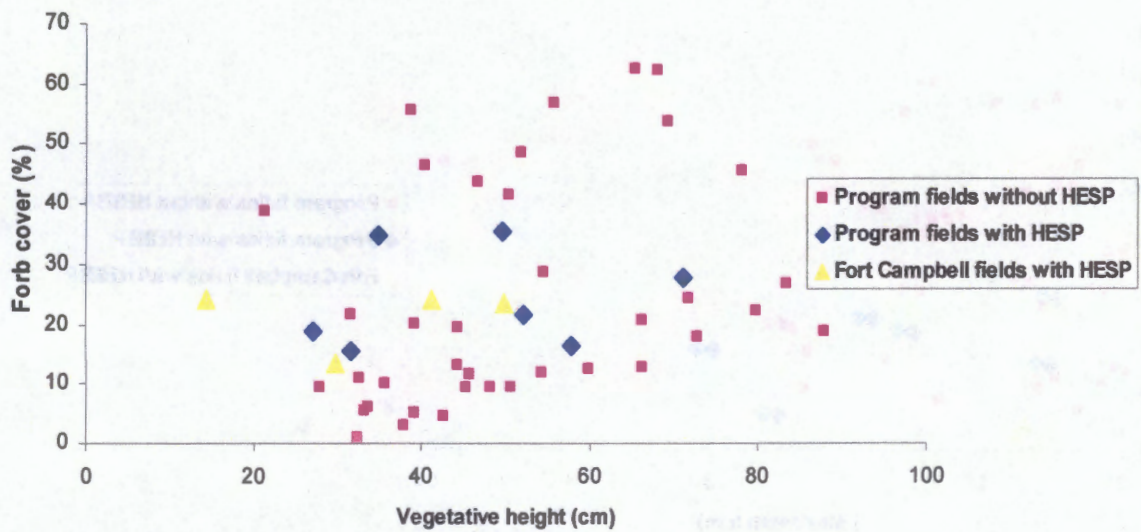
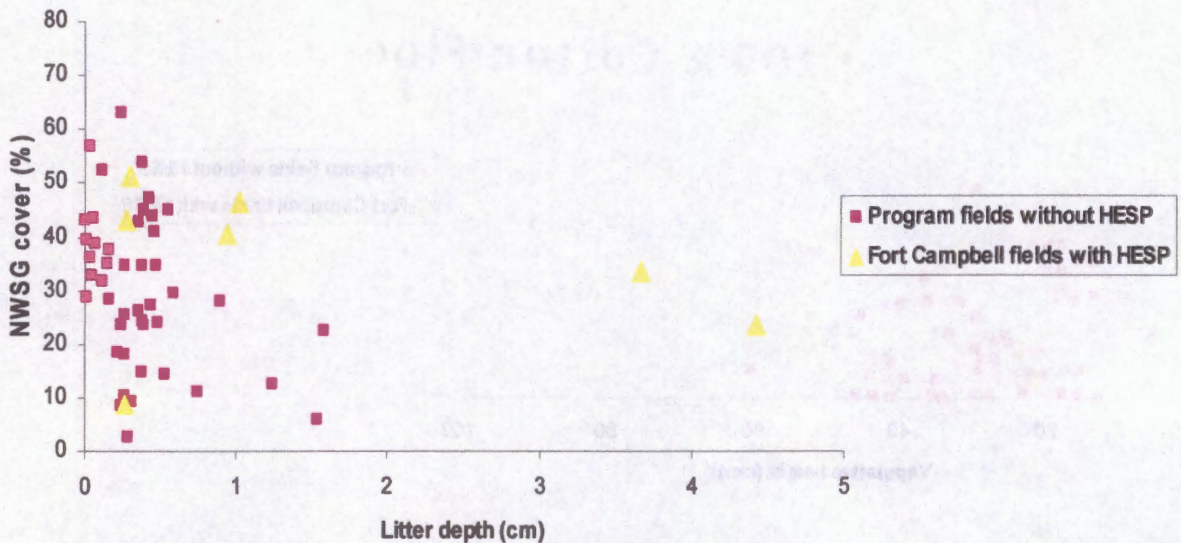


Figure 27. Average vegetative height and forb cover where Henslow's sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

2002



2003

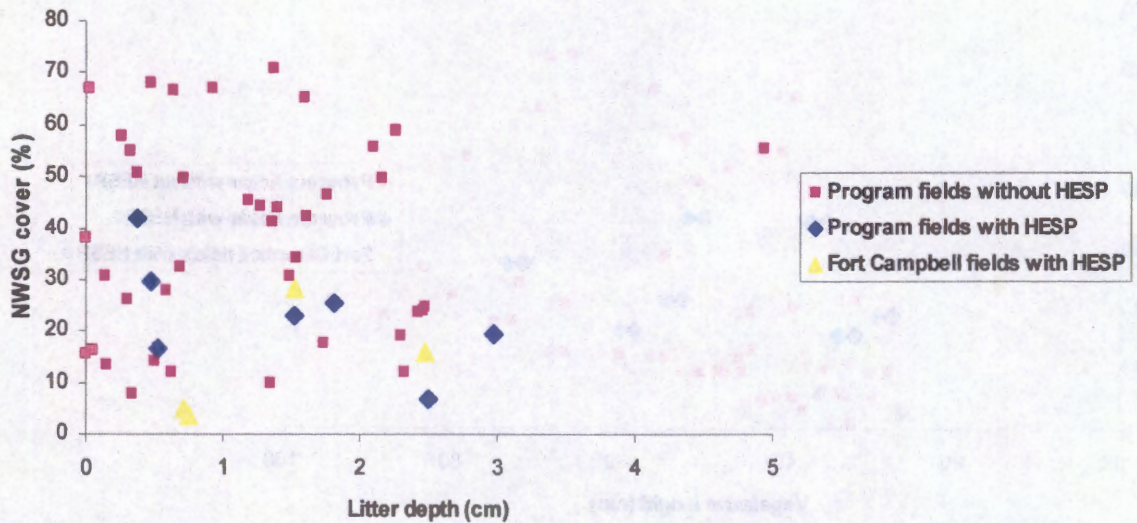


Figure 28. Average litter depths and NWSG cover where Henslow's sparrows occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

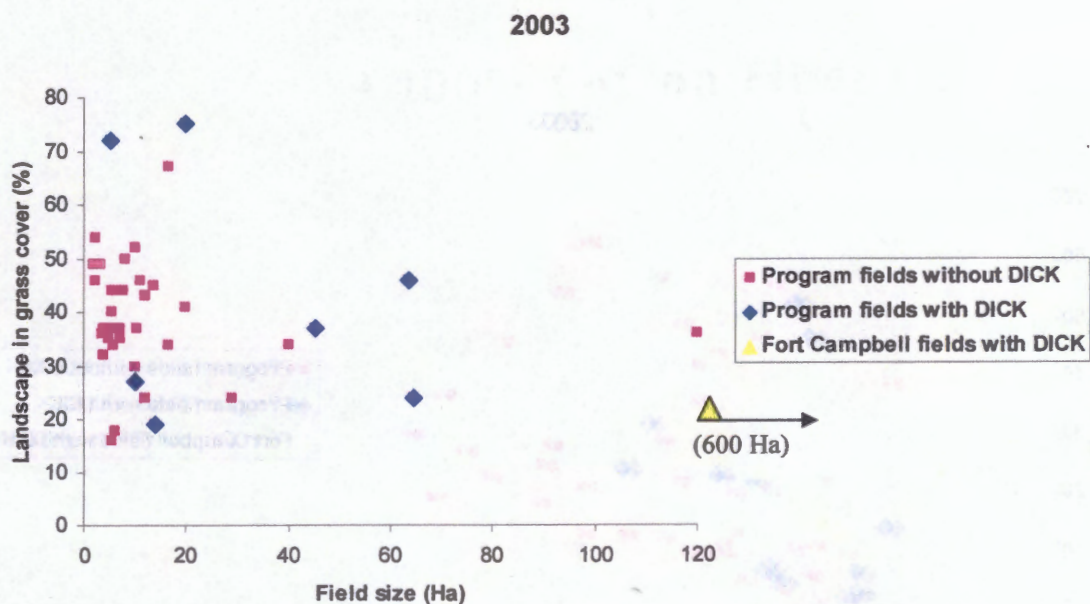
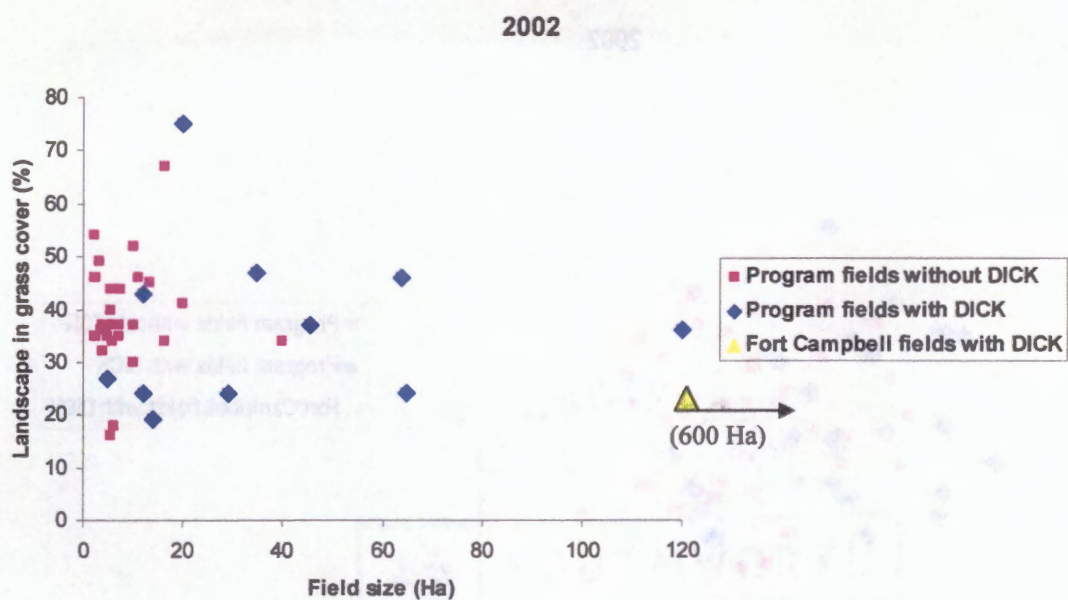


Figure 29. Average landscape cover by grass/pasture and field size where dickcissels occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

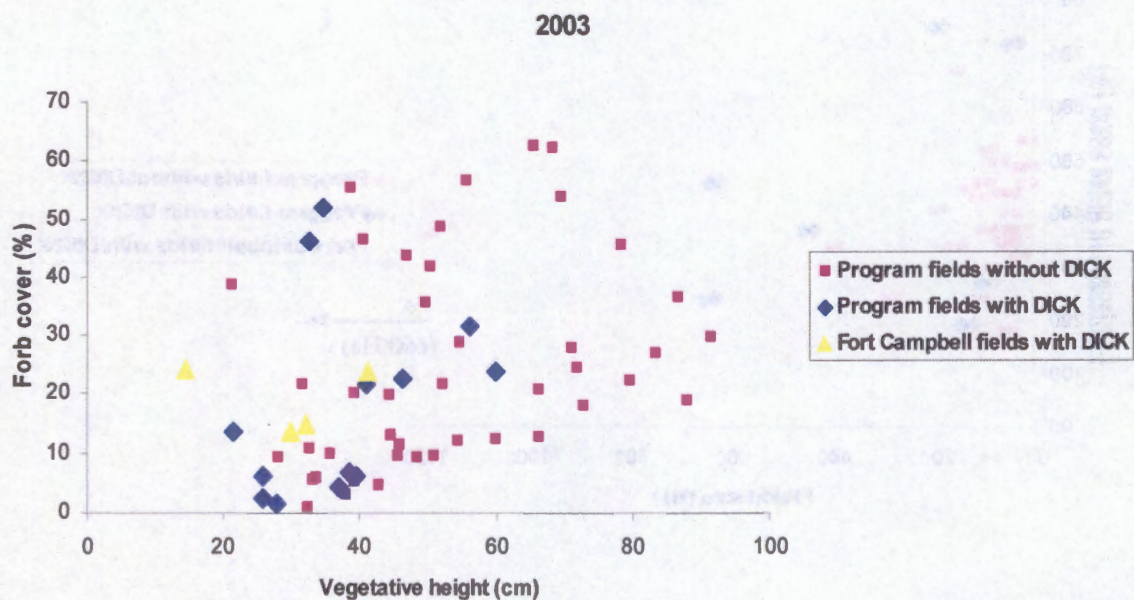
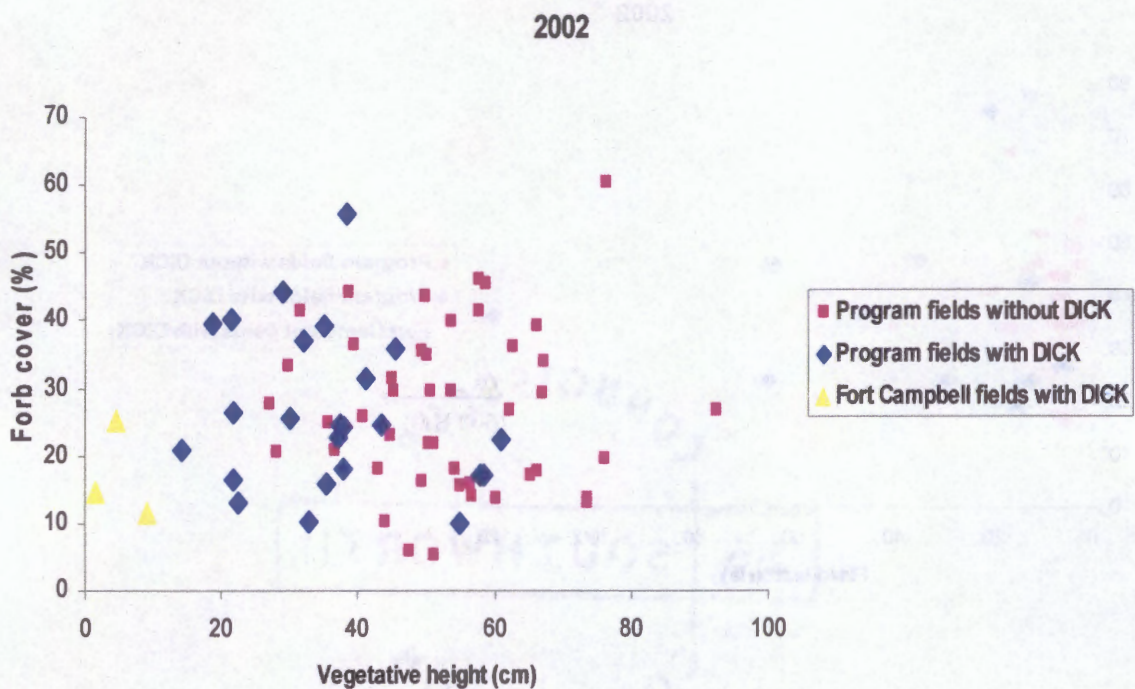
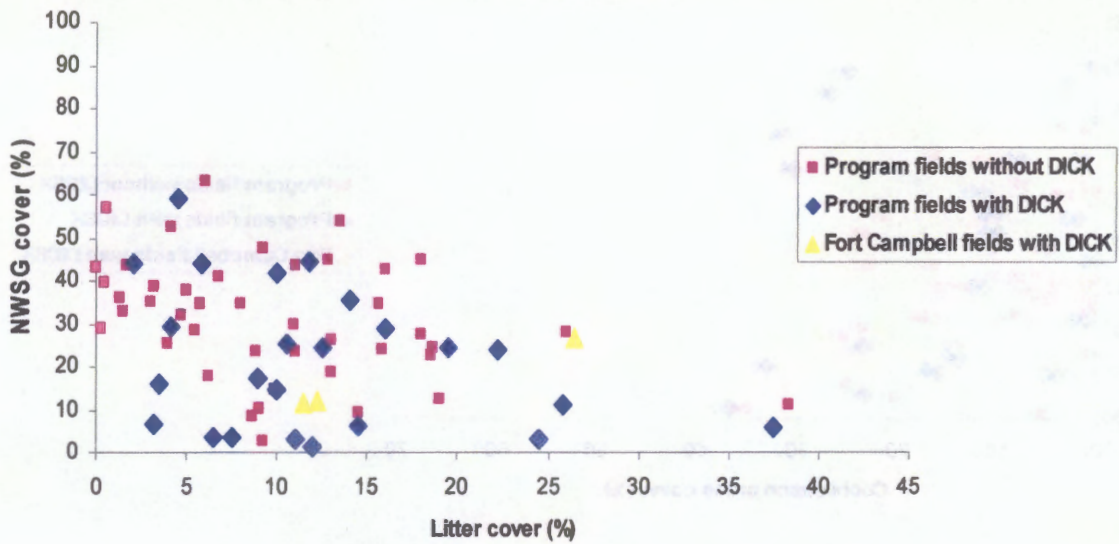


Figure 30. Average vegetative height and forb cover where dickcissels occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

2002



2003

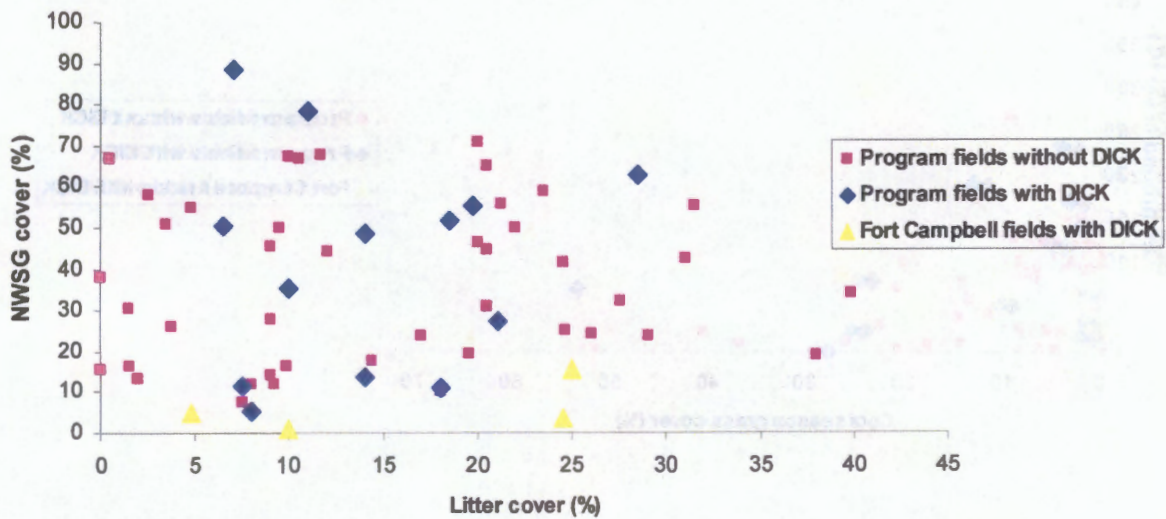
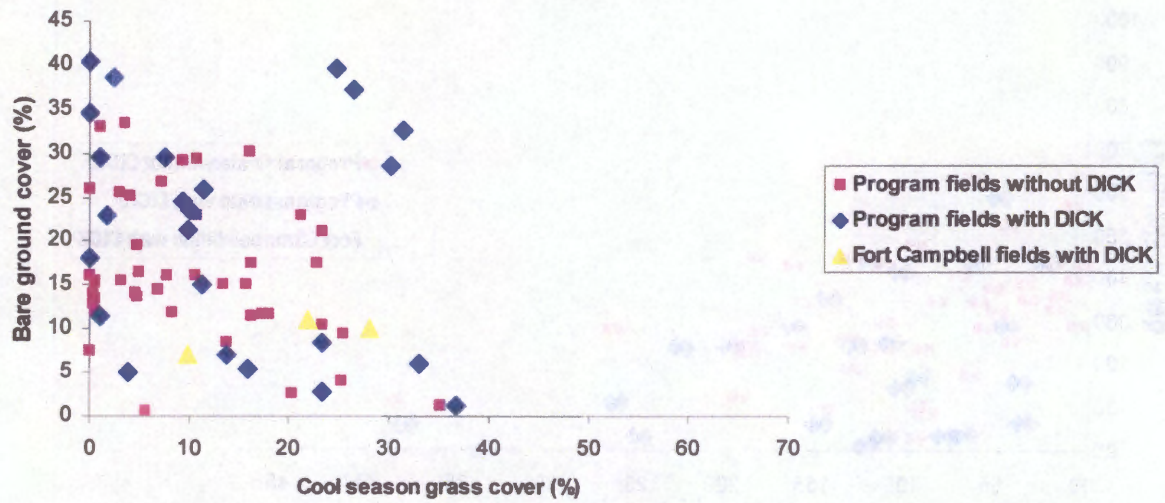


Figure 31. Average NWSG and litter cover where dickcissels occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

2002



2003

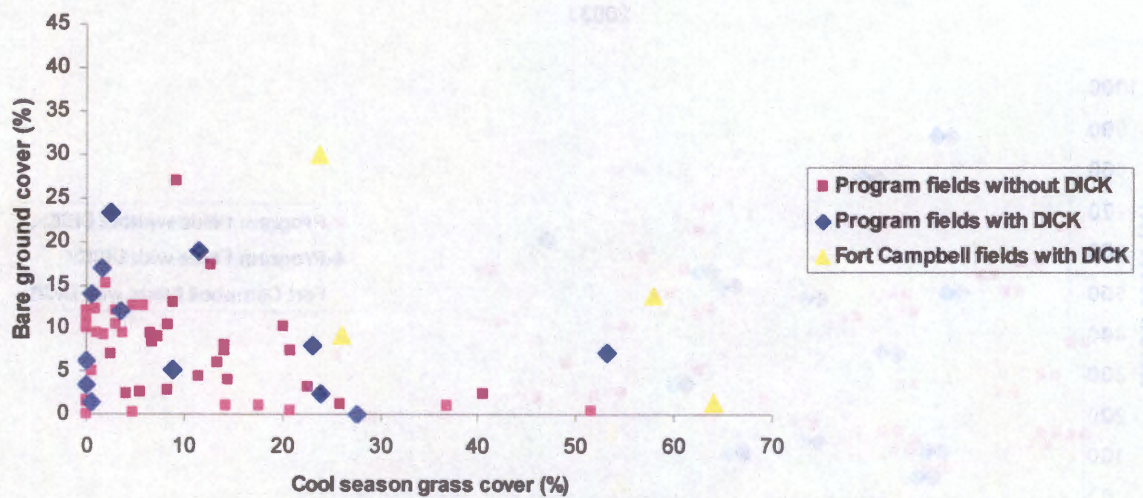


Figure 32. Average CSG and bare ground cover where dickcissels occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

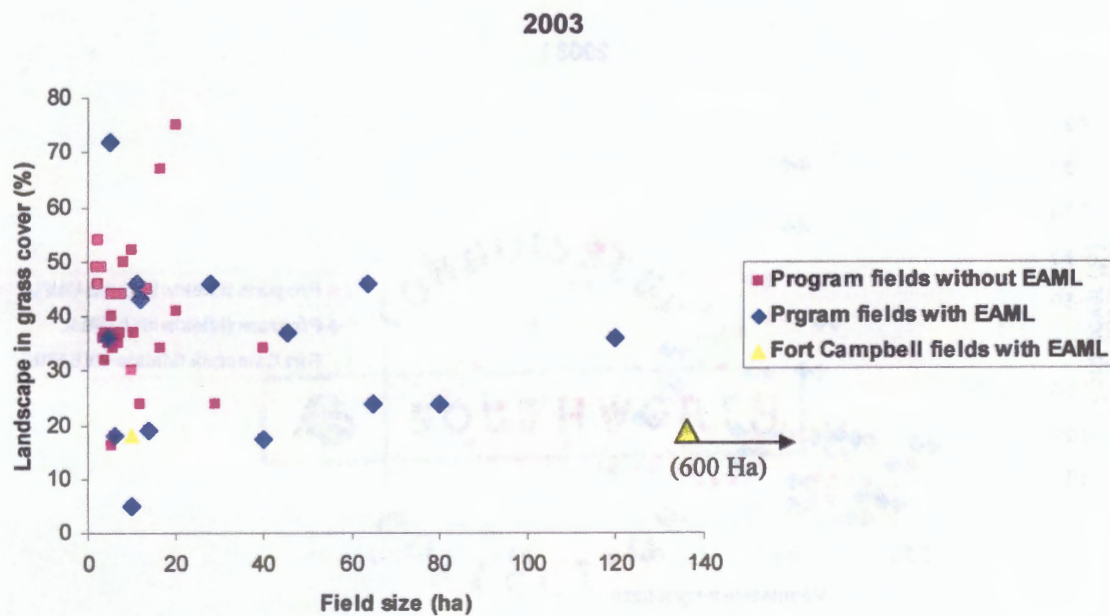
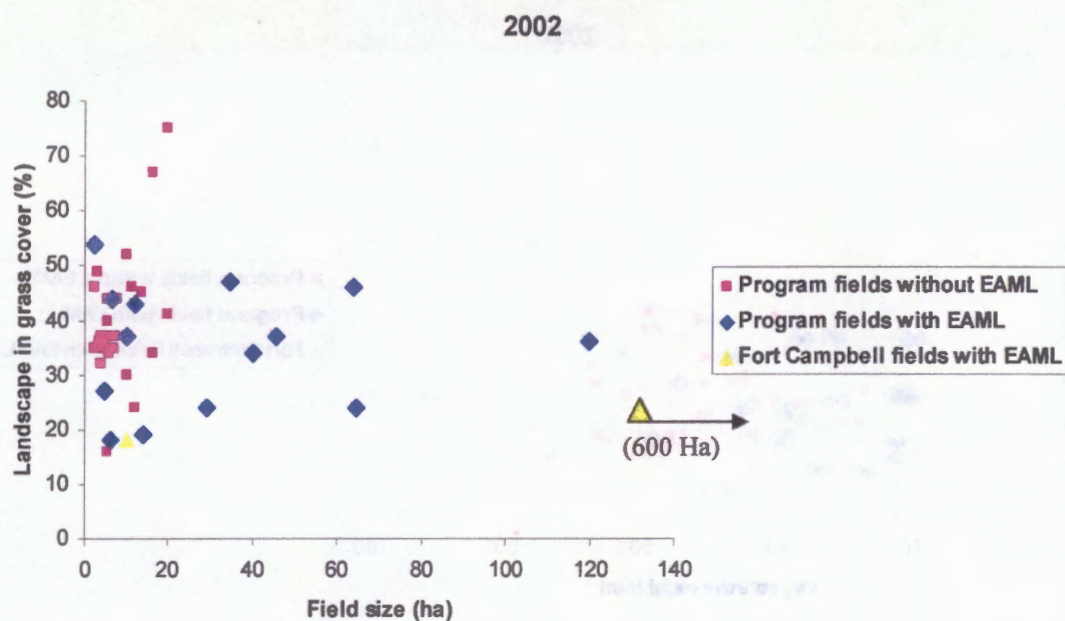


Figure 33. Average landscape cover by grass/pasture and field size where eastern meadowlarks occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

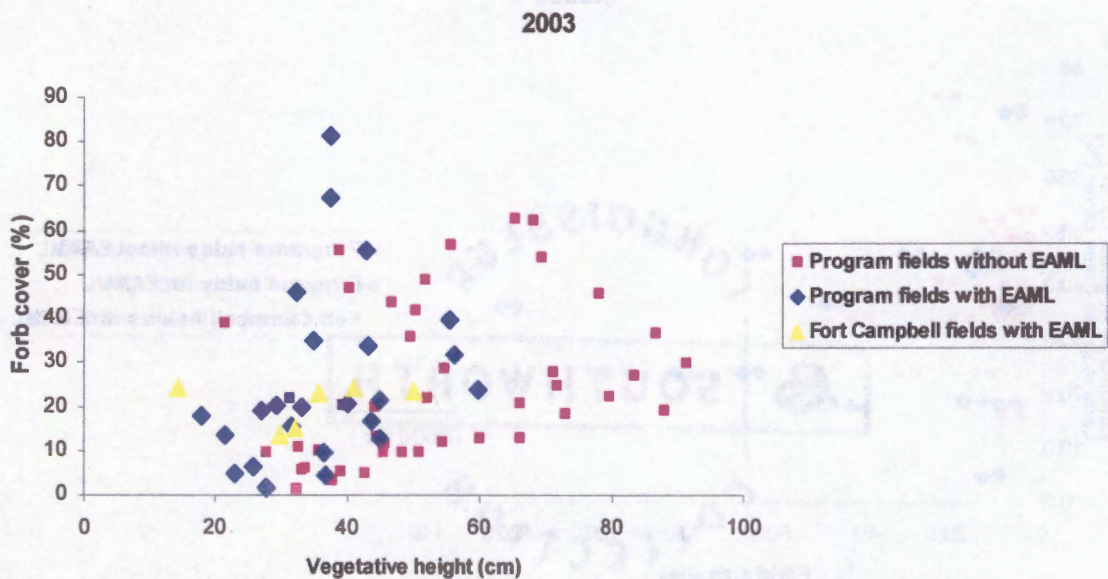
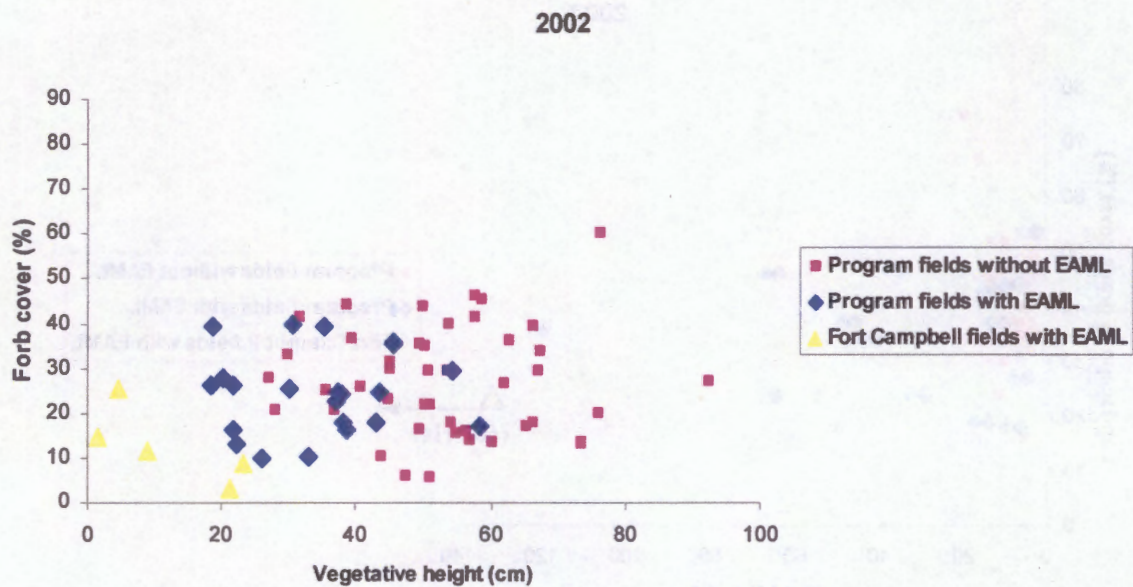


Figure 34. Average vegetative height and forb cover where eastern meadowlarks occurred in restored and Fort Campbell Military Reservation fields, summer 2002 and 2003.

VITA

Scott Dykes was born in Jonesborough, TN in 1972. He is the son of Jack and Carlotta Dykes and has one brother, Randall, and one sister, Lori. As a youth, Scott developed an appreciation for natural resources through outdoor recreational activities including hunting, fishing, and camping. Scott graduated from Davy Crockett High School in 1990. He served four years active duty in the United States Marine Corps. After being honorably discharged in 1996, Scott began his educational career at Northeast State Technical Community College where he received an Associate of Science degree. After transferring to the University of Tennessee in 1999, Scott earned a Bachelor of Science degree in Forestry, Wildlife and Fisheries.

Scott worked as a summer intern for the Tennessee Wildlife Resources Agency at Yuchi Refuge at Smith Bend. During his internship, Scott assisted in native grassland restoration. This experience fostered in him an awareness of the importance of native grasslands. Scott returned to the University of Tennessee to complete his Master of Science degree with focus on native grasslands in Tennessee. Scott has committed himself professionally to wildlife conservation, both game and non-game.

VITA

Scott Byers was born in Henderson, TN in 1972. He is the son of Jack and
Cathie Byers and has one brother, Patrick, and one sister, Lori. As a young person,
he developed an appreciation for natural resources through outdoor recreational activities
including hunting, fishing, and camping. Scott graduated from Perry County High
School in 1990. He served four years active duty in the United States Marine Corps
after being drafted in 1990. Scott began his educational career in
Henderson State Technical Community College where he earned an Associate
Science degree. After graduation he was the University of Tennessee in 1994. Scott earned a
Bachelor of Science degree from the University of Tennessee in 1997.
Scott worked as a research technician for the Tennessee Wildlife Resources Agency in
Henderson County, Tennessee. During his employment, Scott assisted in native grassland
restoration. This experience allowed him to gain an appreciation of the importance of native
ecosystems. Scott returned to the University of Tennessee to pursue his Master's
degree with focus on native grasslands in Tennessee. Scott has continued
to work professionally in wildlife conservation and grassland management.