A NATURAL FEATURES INVENTORY OF THE SMOKY HILL ANG RANGE, KANSAS

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Kansas Biological Survey
2101 Constant Ave.
Lawrence, KS 66047

A NATURAL FEATURES INVENTORY OF THE SMOKY HILL ANG RANGE, KANSAS

PREPARED FOR

AIR NATIONAL GUARD READINESS CENTER
3500 FETCHET AVENUE
ANDREWS AFB, MD 20762-5157

AND

SMOKY HILL AIR NATIONAL GUARD RANGE
8429 WEST FARRELLY ROAD
SALINA, KS 67401-9407

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Cover Photo: Smoky Hill ANG Range Landscape. Hillary Loring.

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EXECUTIVE SUMMARY

A five-year study of the biological resources on the Smoky Hill Air National Guard Range was conducted from 2003—2007 by the Kansas Biological Survey. The three primary objectives of the project were to conduct biological inventories for animals, plants, and natural communities; document the land use history and past management of the installation; and prepare recommendations and an action plan for the control and abatement of invasive and non-native species.

Surveys for rare and endangered species revealed no evidence of federal or state listed threatened or endangered species inhabiting the installation. Several federal endangered bird species migrate through central Kansas and occasionally may visit Smoky Hill ANGR for short periods of time, including Whooping Crane, Bald Eagle, Piping Plover, and Least Tern. The installation (or private land immediately adjacent to it) does support populations of six species of state-rare plants and eight species of state-rare animals.

General floristic and faunistic studies documented many new species for the installation. Terrestrial elements of the flora are generally what one would predict for a tallgrass-dominated site in the eastern Smoky Hills physiographic province. A dearth of riverine and aquatic habitats on the site probably limits mesophytic and aquatic elements of the flora. Roughly 700 specimens representing 412 species of vascular plants were collected on or near the installation. Voucher specimens for all plant species documented on the installation have been deposited in the R. L. McGregor Herbarium at the University of Kansas. Vertebrate surveys documented seven species of amphibians, 27 species of reptiles, 28 species of mammals, and 150 species of birds. As expected from the habitats available, the diversity of grassland species was high, and species affiliated with aquatic and forested habitats were relatively few.

Plant community studies confirmed three major types of natural communities. The dominant plant community on the installation is Dakota Hill Tallgrass Prairie. The size and generally good condition of this largely unfragmented tallgrass prairie makes it a valuable reservoir of biological diversity for the Great Plains. Vegetation condition was assessed to be highest in the Impact Area and in the hay leases. Plant surveys conducted on Smoky Hill ANGR provided a quantitative assessment of the effects of current management practices on plant diversity and plant community quality. Permanent plots provide valuable baseline data on the condition of the vegetation and can be used to track changes over time.

Sound management of Smoky Hill ANGR has resulted in a generally good quality of grassland communities throughout the property. The absence of any major weed infestation attests to the quality of the range, its management, and good grazing practices. The Impact Area is unique. It contains a low component of weedy species and the highest percent cover of conservative plant species. Hay meadows exhibit the greatest species richness, the highest average cover of vegetation, the least bare ground, and the highest floristic quality index of the three management types. Grasslands on Smoky Hill ANGR support large populations of breeding birds. The relative abundances of species varied among the four habitats studied: grazed, hayed, unburned/ungrazed, and burned/ungrazed. Burned sites attracted the fewest species and lowest overall relative abundances; the three other habitats were similar to one another. Unburned/ungrazed sites were important to Henslow's Sparrow and Bell's Vireo, two species of conservation concern.

A review of range practices by a team of range and wildlife experts was conducted in 2004. The team generally made favorable comments about current range practices. Many suggestions for ways to improve management were offered, although the practicality of any alterations in light of the military mission and lease system needs to be evaluated by ANG staff. The majority of the suggestions dealt with incorporating mixed management--that is varying management type and intensity over time.

Information on invasive and non-native species was collected in conjunction with other biological studies. Many non-native species have become established at Smoky Hill ANGR. For example, 16% of the vascular plant documented on the installation are non-native. However, few of these are considered highly invasive species that pose management concerns. Musk-thistle, a Kansas noxious weed, is widely distributed in grazing leases, but population densities are generally extremely low. Management recommendations for control of musk-thistle and other invasive species are provided. Invasion of prairies by native and non-native tree species is a problem that is being addressed under current management. However, more attention to this issue is recommended.

A report on the environmental history of the area (Appendix F) discusses the changing land use practices from the time of European-American arrival and settlement to the present. Agricultural development of the prairie, transition to military ownership, and recent history are presented. Aerial photography from 1938, shortly before military training operations were initiated in the area, was obtained from the National Archives and digitally analyzed for land use practices. Results are discussed in Chapter 2 and provided as GIS shape files.

A invasive and non-native species plan is contained in Appendix G. The plan reviews regulations covering invasive species; discusses the status, threat level, and control methods for 17 invasive species of plants and vertebrates and one vegetation type (woody plants) present on Smoky Hill ANGR; and present a 5-year implementation plan for invasive species.

CHAPTER 1. INTRODUCTION

1.1. PROJECT BACKGROUND

In 2002, the Kansas Natural Heritage Inventory (KSNHI), a program of the Kansas Biological Survey (KBS) at the University of Kansas, initiated a five-year project examining the biological resources of the Smoky Hill Air National Guard Range (Smoky Hill ANGR), located in Saline and McPherson counties, Kansas (Figure 1.1). The impetus for this project was a desire to obtain baseline information on rare, threatened, and endangered species and on the flora, fauna, and natural communities occurring on the installation. Working with the Air National Guard, a scope of services addressing these topics was developed for what would be the first phase of a three-phase project. In 2003, the project was amended to include a second phase with a scope of services for three additional activities at the installation that included research on the land use history of the area, a study of the effects of land management practices on vegetation and breeding birds, and a review of range management practices. Finally, in 2005, a third phase was added that included development of an action plan on invasive and non-native species at Smoky Hill ANGR. This report describes each project objective, summarizes the methods used to attain those objectives, and presents the results of each phase of the study. Digital files containing data collected during the course of this project including species distributions, past and present land cover and land use, and the distribution of other natural features, have been provided to Smoky Hill ANGR to facilitate management of the installation's natural resources.

1.2. STUDY OBJECTIVES

Below, each of the study objectives is described in greater detail, organized by project phase and category (animal, plant, natural community, and data management). Table 1.1 shows where in the report each objective is addressed. Chapters 2—6 are organized by biological topic (natural communities, plants, and animals) and by the primary study objectives. Each chapter is devoted to one or more objective and describes research methods, results and discussion, and conclusions or recommendations. Supporting documentation is provided in the appendices at the end of the report.

Phase I. Biological Inventory

Objective I.a. Animal Studies: Conduct targeted surveys for rare animal species tracked by KSNHI. Little previous work on rare, threatened, and endangered animal species at Smoky Hill ANGR had been done prior to this study. To meet this objective, studies were conducted of rare, threatened, or endangered animal species classified by the U.S. Fish and Wildlife Service, Kansas Department of Wildlife and Parks, and KSNHI, that have the potential to occur on Smoky Hill ANGR. Busby and Guarisco (2000) had previously conducted a survey for two federal endangered species, Topeka Shiner (*Notropis topeka*), and American Burying Beetle (*Nicrophorus americanus*).

Objective I.b. Animal Studies: Conduct general surveys for native vertebrate species. To provide baseline information on the fauna of the installation, information on the status of all terrestrial vertebrate species was obtained through field investigations. A previous biological inventory on the Army National Guard portion of Smoky Hill ANGR by Charlton et al. (2000) provided some baseline information.

Objective I.c. Plant Studies: Conduct targeted surveys for rare plant species tracked by KSNHI. We are aware of no previous work on rare, threatened, and endangered plant species at Smoky Hill ANGR. This study concentrated on rare species tracked by KSNHI; no federal threatened or endangered plant species occur in the vicinity of Smoky Hill ANGR.

Objective I.d. Plant Studies: Conduct general floristic surveys of all native and naturalized species on the installation. Previous floristic studies on the Army National Guard portion of Smoky Hill ANGR were conducted by Charlton et al. (2000). To meet this objective, vascular plants were collected in all habitats on the installation throughout the growing season.

Objective I.e. Plant Studies: Conduct targeted surveys for state-listed noxious weeds, especially sericea lespedeza, musk-thistle, and Canada thistle. Data concerning infestations of noxious weeds was gathered in the course of general floristic surveys and targeted weed surveys.

Objective I.f. Natural Communities: Identify specific locations of outstanding natural areas (plant communities) and provide a digital data layer of these areas. To meet this objective, plant ecologists visited sites in all management units of the installation and classified vegetation composition and quality.

Objective I.g. Natural Communities: Provide an assessment of the effects of current management practices on plant diversity and plant community quality. Smoky Hill ANGR manages land with a variety of practices, such as fire, grazing, haying, and rest. Vegetation data stratified by recent management practices were collected and used to evaluate the effects of management practices on vegetation parameters.

Objective I.h. Data Management: Manage species and natural community data from field work. This objective provides information management for all survey data collected for this project and supports report preparation.

Objective I.i. Data Management: Create digital files of survey data and a GIS coverage of high quality plant communities. Work under this objective facilitates transfer of data in the format of spreadsheets and GIS products to Smoky Hill ANGR to support future land management decisions.

Objective I.j. Data Management: Compile field survey data and related geospatial data into a GIS project and create hardcopy graphical displays. Work under this objective provides for the development of GIS products and facilitates report preparation to support future land management decisions.

Phase II. Land Use History and Management

Objective II.a. Research on land use history of Smoky Hill ANGR. The archeology and historic cultural resources of the installation have received study (see, for example, Saint Onge et al. 2005). However, the land use history of the property prior to U.S. government ownership had not been investigated prior to this study. This research focuses on the agricultural land use from Euro-American settlement to the World War II period.

Objective II.b. Conduct a study of managing prairie by burning and its affects on the vegetation and grassland birds. One unusual aspect of land management history at Smoky Hill ANGR is the use of annual fire within the Impact Area. Research to meet this objective was designed to answer the question of how annual burning influences 1) plant species composition, diversity, and conservatism, and 2) the abundance of breeding grassland birds.

Objective II.c. Provide an assessment of range management practices. Smoky Hill ANGR strives to maintain and restore the ecological condition of the native mixed-grass and tallgrass prairie through grazing and other management practices that also allow agricultural income. A review of range management practices by range and wildlife management experts was undertaken to meet this objective.

Phase III. Preparation of Recommendations and Action Plan for Control and Abatement of Invasive and Non-native Species.

As prescribed by DOD policy, the Integrated Natural Resource Management Plan (INRMP) (Engineering-environmental Management, Inc. 2007) implements ecosystem management consistent with military mission requirements. At Smoky Hill ANGR, the INRMP supports the military mission as well as the agricultural lease program. Control and abatement of invasive and non-native species is integral to achievement of INRMP goals, and the action plan will provide guidance on this topic. Tasks associated with plan development are as follows:

Task 1. Conduct background research.

Task 2. Analyze and evaluate database.

Task 3. Identify data gaps.

Task 4. Develop methodology.

Task 5. Classify vegetative community types.

Task 6. Verify plant community mapping units in the field.

Task 7. Delineate boundaries of critical habitat and stands of non-native plants.

Task 8. Conduct qualitative surveys for non-native and invasive species.

Task 9. Integrate updated plant community mapping into the installation's GIS databases.

Task 10. Prepare report of recommendations and action plan for control and abatement of invasive and non-native species.

1.3. STUDY AREA

The INRMP for Smoky Hill ANGR provides a detailed description of the physical setting, history, environment, and biota of the installation and surrounding areas. The installation is 33,873 acres (nearly 53 square miles) in size, of which approximately 90% is used by Kansas Air National Guard (KSANG). The remaining 10% of the range is used by the Kansas Army National Guard (KSARNG). The KSANG area contains a 10,109-acre Impact Area where air-ground training is conducted. Surrounding the Impact Area is a buffer area, most of which is in an agricultural lease program. Most of the agricultural leases are for cattle grazing; a few are for crop production or hay (Figure 2.1). Management units (fire units) have been assigned to all sections (640 acres) or portions thereof within Smoky Hill ANGR (Figure 1.2).

TABLE 1.1. Cross reference of study objectives and where objectives are addressed in the report.

Objective	Chapter
I.a. Rare animal surveys	4
I.b. General vertebrate surveys	4
I.c. Rare plant surveys	3
I.d. General floristic surveys	3
I.e. Noxious and invasive plant surveys	3
I.f. Natural areas and digital data layer of these areas	2
I.g. Effects of management practices on vegetation	2
I.h. Manage species and natural community data	2, 3, 4
I.i. Digital files with species data and plant communities	2, 3, 4
I.j. Digital data layers	See Appendix E
II.a. Land use history	Appendix F
II.b. Annual burning effects on vegetation and grassland birds	2, 4
II.c. Range management assessment	5
III. Action plan for invasive and non-native species	3, 6

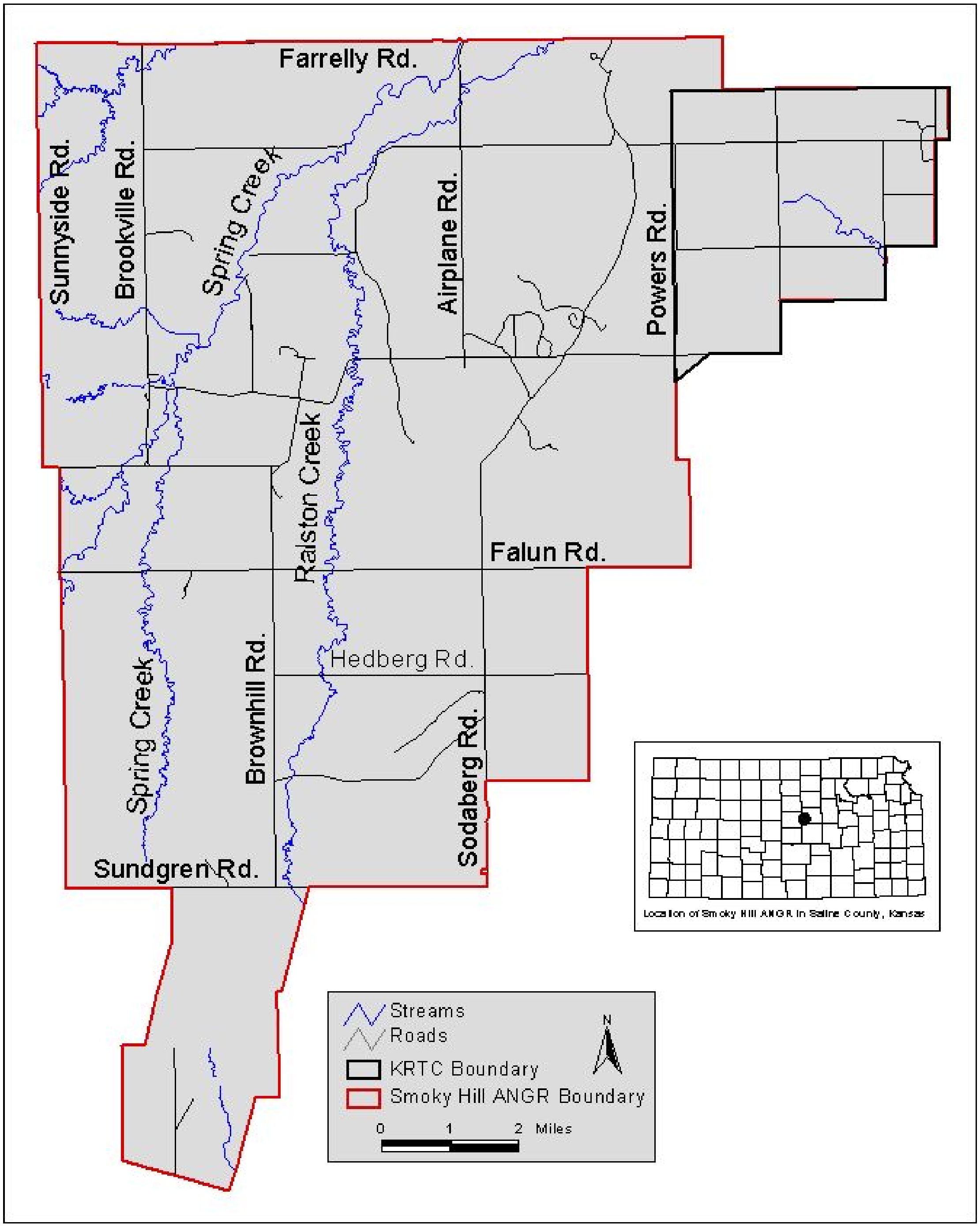


FIGURE 1.1. Map of Smoky Hill ANGR showing major roads and streams.

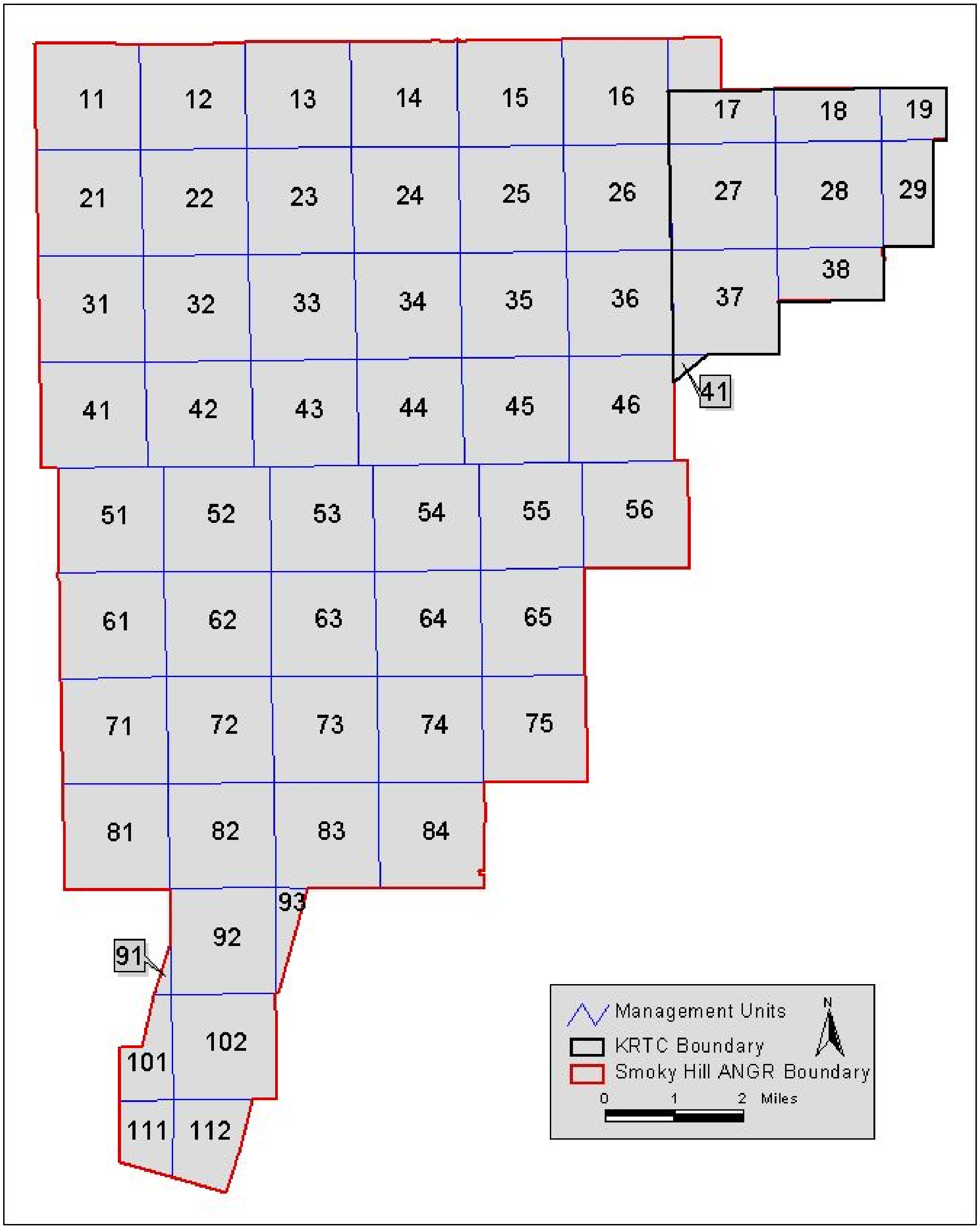


FIGURE 1.2. Management units at Smoky Hill ANGR. Unit boundaries conform to those of section grids.

1.4. OVERVIEW OF ECOLOGICAL HISTORY, CURRENT CONDITIONS AND LAND MANAGEMENT RECOMMENDATIONS

1.4.1. Management goals and philosophy

Natural resources management goals at Smoky Hill AGNR are "to enhance and maintain biological diversity within Range boundaries," while assuring the successful accomplishment of the military mission. Management practices should minimize habitat fragmentation and promote the natural pattern and connectivity of habitats; protect rare and ecologically important species; maintain and mimic natural processes; and restore species, communities, and ecosystems (INRMP 2007).

1.4.2. Historical ecological conditions

A Saline County land survey from 1860 indicates that the original vegetation on Smoky Hill ANGR was more than 99% tallgrass prairie (see Chapter 2). The installation lies near the transition zone between tallgrass and mixed-grass prairie. No well-developed forests were present; small areas of woodlands along streams totaled only 91 acres. The prairie was maintained by fire and grazing. Fires were of natural and human origin, with lightning-caused fires occurring during the growing season, and human-set fires occurring mostly in spring and fall in association with hunting excursions (Earls 2006). Large herds of bison and elk grazed the prairie periodically, and deer and pronghorn were also present.

Land use changed dramatically after 1850 with the arrival of Euro-American settlers who homesteaded in the area (see Appendix F.1). Rowcrop agriculture was practiced in riparian zones and other areas with richer soils. Slopes and uplands with shallower soils were used mostly for livestock grazing. Use of fire as a management tool ceased, and large grazing animals were eliminated by hunting. By 1938, a few years prior to military acquisition, an estimated 8—15% of the land currently within the installation boundaries was under cultivation (see Chapter 2). Most of the area remained as prairie and was used for grazing.

The military period, from 1942 to the present, resulted in significant land use changes. Agriculture was largely discontinued and most cropland was allowed to revert to native vegetation (see Appendix F.1). Following a short period of intensive use for training during WWII, human activity on the installation moderated. Later, agriculture was re-introduced through private leases for livestock grazing and hay and crop production. Woody vegetation increased.

1.4.3. Current Ecological Conditions

The dominant land cover type on the installation is tallgrass prairie (Chapter 2). The other major land cover type is former cropland from the pre-military era that now is dominated by prairie species. Continuous bands of woodland line most streams and riparian zones, and scattered trees are well established in the uplands. The condition of upland grassland communities is generally good; vegetation quality in the hayed areas and in the Impact Area is higher than in pastures (see Chapter 2.4). Surveys of vascular plants (see Chapter 3) and vertebrate animals (see Chapter 4) documented a flora and fauna representative of the habitats present on the installation. The majority of expected plant and animal species associated with upland tallgrass prairie in this region of central Kansas were encountered. Plant and animal species associated with woodland, wetland, and aquatic environments also are present, but to a more limited degree as would be expected given the relatively small amount of appropriate habitat. Large mammalian grazers and carnivores, a group with few species that played a large ecological role, is only functional set of species missing. Sixteen percent of the flora is composed of non-native species, a proportion typical in Kansas. Only five species of non-native vertebrates were documented, and none are considered strongly invasive. The few species of potentially invasive plant species occur in low densities and none currently pose a serious threat to the natural communities on the installation.

1.4.4. Current Land Management

At present, most areas outside of the Impact Area are managed with private agricultural leases. The majority of leases are for cattle grazing, with smaller numbers of native hay and crop leases (Figure 2.1). Most of the Impact Area is reserved for training and is not in agricultural lease with the exception of several hay leases located in the northern part of the Impact Area (Figure 2.1). A few units outside the Impact Area, most with a high woody component, are not leased.

Fires on Smoky Hill ANGR occur as accidental wildfires resulting from training exercises, and as controlled burns employed as a management tool. Wildfires occur primarily on the Impact Area and under a variety of conditions at various times of year. Controlled burns are conducted in grazing leases primarily in the spring and at a burn interval of about 3—8 years. Fire management is discussed in more detail in Chapter 5 and in Section 4.9 of the INRMP.

Current invasive species control targets musk-thistle and bull thistle through a combination of aerial herbicide application, spot-spraying, and fire and grazing management. Woody invasion in uplands is managed with fire and mechanical methods (see Appendix G).

1.4.5. Land Management Discussion and Recommendations

Ecological conditions and land management practices are generally good on Smoky Hill ANGR. The most impressive ecological feature is the large, intact coverage of tallgrass prairie. Military stewardship has seen the maintenance of prairie habitat and a reduction in habitat fragmentation since the 1940s through the restoration of cultivated areas back to native grassland. After more than 60 years, the vegetation of many of these "go-back" areas is similar to native prairie. The healthy ecological conditions on the installation are largely attributable to judicious use of grazing and fire, the two main sources of natural disturbance that have shaped the prairie over time. Fire was reintroduced as a management tool during the military era, and grazing was continued from the pre-military period. Native plants and animals are adapted to these natural disturbances; most non-native species are not. Another factor favoring healthy ecological conditions on the installation has been the low level of incompatible human activities, such as intensive agricultural use and facilities and infrastructure development

If improvement in ecological conditions is to continue—if the Air National Guard wishes natural resource quality to go from good to great, so to speak—enhancements to management practices should be considered. First, grazing practices could be improved. In general, grazing systems are developed to grow livestock, not to maintain natural communities or to enhance biodiversity (Fuhlendorf and Engle 2001). In natural communities that evolved with native grazers, well-managed livestock grazing is usually beneficial to, or at least compatible with, the maintenance of natural communities. However, differences between native grazing systems and livestock grazing systems can result in significant changes in vegetation composition and structure. Livestock grazing can cause a loss of vegetative diversity and, in turn, adversely influence native animals. Timing, duration, intensity, and forage selectivity are among the factors that vary with grazing system and that influence vegetation. The main recommendation of range and wildlife experts (see Chapter 5) was to incorporate more mixed management; i.e., not do the same thing every year. Rest from grazing, and changing grazing timing and intensity, are some of the components of mixed management. Lower values of Floristic Quality Index and lower numbers of conservative plant species in grazed vs. hayed and ungrazed units (see Chapter 2.3) are indicative of the need for adjustments in grazing practices. Practices such as season-long grazing, when maintained for many years, are associated with a decline in conservative (decreaser) plant species. A recommended goal is to improve vegetation condition (as measured by the Floristic Quality Index) in grazing leases to the levels currently found in hay leases and in the Impact Area.

Evaluation of burn practices has not been a focus in this study, and accordingly, suggestions offered here should be considered preliminary. The general consensus of range and wildlife experts was that the burn regime was appropriate for the site. The two types of fire that occur, controlled burns and wildfires, are very different. Controlled burn practices in the agricultural leases generally appear sound, although greater variation in the seasonal timing and intensity of burns would likely result in increased ecological benefits. Late summer and fall burns, and occasional hotter burns, would create more heterogeneity in conditions and would better simulate historical fire patterns. Hotter burns would improve control of woody vegetation and might be accomplished by burns following a period of rest from grazing when fuel levels are higher.

Wildfires resulting from training can occur at any season and under a wide range of weather and moisture conditions. In this sense, they may be more similar to fires in pre-settlement times. The variation in seasonal timing of wildfires in training areas is likely to have a positive effect on biodiversity. Of course, wildfires have distinct disadvantages from a safety perspective. In addition, the high frequency of fire in the Impact Area, where annual fires occur in some areas, leads to increased soil erosion and, in dry years, water stress. In recognition of problems associated with annual burning, Smoky Hill ANGR policy has been changed, directing that burn frequency be reduced in the Impact Area where practical. This change in burn practice should benefit natural communities and most wildlife species in the Impact Area. (As a footnote to this topic, it should be noted that some of the high erosion apparent in the Impact Area may be due to past agricultural use rather than recent burn practices. Much of the Impact Area was in cultivation prior to military ownership (see Figure 2.3), and considerable erosion may have occurred at that time.)

Invasive species issues are addressed in detail in Appendix G. Recommendations for monitoring and control of 11 species of non-native invasive plants are presented. Managing for healthy, native vegetation with appropriate use of fire, grazing, and rest will reduce invasive plant threats.

Chemical, biological, and mechanical methods are recommended for selected species. In general, threats posed by current populations of invasive plants are not high on the installation. Few non-native or invasive vertebrate animals occur and none require serious control measures. Woody invasion of grassland communities is a major problem and will require ongoing efforts to bring under control.

Adoption of recommended management changes to benefit grassland communities will involve additional costs. For example, if pastures are rested or if stocking rates are reduced, this will mean a loss in income from agricultural leases. However, the INRMP calls for managing the prairie ecosystem to promote greater ecosystem diversity and increase biodiversity (4.11.2 RM-2). Achievement of this goal is compatible with the military training mission and with agricultural use. While ecosystem management for biodiversity is secondary to the primary purpose of achieving the military mission, ecosystem management should not be secondary to generation of income from agricultural uses. If tangible enhancements to biodiversity can be achieved by management changes, these changes should be seriously evaluated and encouraged independent of their effect on agricultural income. Any loss of agricultural income may be offset in the long term by increases in the health and vigor of plant communities.

TABLE 1.2. Cross reference to the location of land management recommendations in the report.

Management Recommendations: Location and Topic	**Section**
Rare Species: Henslow's Sparrow, Loggerhead Shrike	4.2.2.2
Discussion: Reptiles and Amphibians	4.3.1.3
Species Accounts: Reptiles and Amphibians	4.3.1.4
Discussion: Mammals	4.3.2.3
Species Accounts: Mammals	4.3.2.4
Grassland Management: Grassland Birds	4.4.3
Overview of Recommendations: Range Management	5.3
Invasive Plant Species	G.2
Invasive Woody Vegetation	G.2.4.12
Invasive Animal Species	G.3
5-year Management Schedule	G.5

CHAPTER 2. PLANT COMMUNITIES AND LANDSCAPE FEATURES

Kelly Kindscher and Hillary Loring

2.1. INTRODUCTION

Smoky Hill ANGR encompasses approximately 34,000 acres. Most of the landscape is native prairie, making it the largest public holding of the Dakota Hills tallgrass prairie vegetation type. The major management categories on Smoky Hill ANGR include pasture, hay meadow, and the Impact Area.

2.1.1. Management Areas on the Smoky Hill ANGR

2.1.1.1. Impact Area

The management of the Impact Area (see Figure 2.1) at Smoky Hill ANGR may be unique across the entire Great Plains as it is a large acreage of native prairie managed only by the use of fire. While there are other parcels of land within the tallgrass prairie that are neither hayed nor grazed, those parcels are not as large as the Smoky Hill ANGR or burned as frequently. The prescribed and accidental burns, often wind-blown and especially hot occur at least once annually, and have resulted in a local landscape primarily devoid of thatch.

These conditions result in comparatively high percentages of bare ground and a species composition largely of perennial, highly conservative prairie plants (desirable plants that do not tolerate disturbance except fire). The assemblage of plants within the Impact Area may reflect the beauty and composition of the prairies before the advent of European settlement and confined livestock grazing, but the frequency of burning is probably uncharacteristically high.

2.1.1.2. Native Prairie Pastures

The pasture areas at Smoky Hill ANGR are leased for grazing from 1 May— 31 October and are stocked at a rate of 1000 pounds per 7 acres. Double-stocked grazing for a shorter duration (1 May—29 July) also is possible under the lease agreement.

Grazing by livestock in a confined area affects the quality and quantity of vegetation. Cattle seek certain plants (decreasers) and avoid other species (increasers or weeds) based on palatability. Continuous moderate to heavy grazing often results in the decline or elimination of the most palatable species. For this reason we were especially interested in studying areas of pastures at Smoky Hill ANGR.

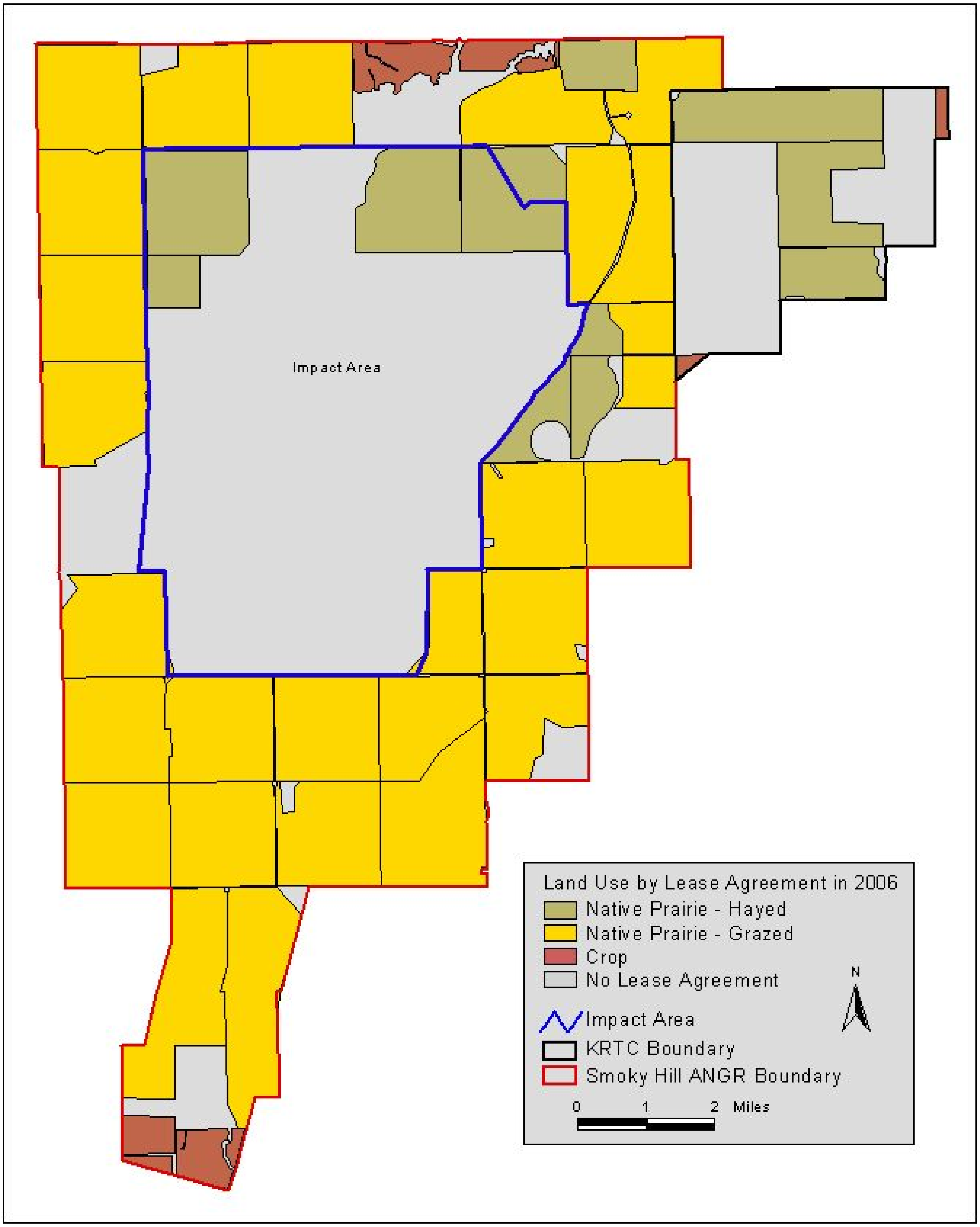


FIGURE 2.1. Land use by agricultural lease agreement at Smoky Hill ANGR.

2.1.1.3. Native Prairie Hay Meadows

Hay meadows at Smoky Hill ANGR are cut and baled once a year between 1 July and 1 August. Haying as a management technique puts less selective pressure on plant species composition than does grazing. The cutting of hay takes equally of all plants in a unit. However, it does select against some plants that mature seed in the late summer by preventing them from reproducing by seed. Many grasses, after being cut, are capable of flowering and setting seed before frost. Typically, few forbs (non-woody, broad-leaved plants) manage to mature and produce seed after being mowed. Nevertheless, long-lived perennial plants seem to flourish under a haying regime.

2.1.1.4. Riparian Areas

The majority of wooded areas on Smoky Hill ANGR are found within a narrow strip along Spring Creek. Few mature trees were noted during formal and informal surveys of riparian zones of Smoky Hill ANGR. Some of these wooded areas have increased in size due to fire suppression.

2.1.2. Past Land Uses

2.1.2.1. Public Land Surveys

The pre-settlement vegetation in this part of Kansas was mostly native tallgrass prairie. For Saline County, prairie was observed on 96% of the county. Public land surveys were conducted in 1859 to delineate the boundaries of section lines for every square mile so that they could soon be settled. For this reason every section line was walked by surveyors and measured. Surveyors mapped the lands (Figure 2.2) as prairie or forest and recorded field notes. We felt it would be important to incorporate this data as a baseline for our report. The result of the survey work shows that over 99.7% of Smoky Hill ANGR was native prairie and trees were confined to 91 acres primarily along the creeks in the north portion of the installation. Tree species observed included cottonwood, elm, walnut, and willows (Kansas Society of Land Surveyors 2006).

2.1.2.2. Land Use before Smoky Hill ANGR Establishment

The tallgrass prairie that blankets the undulating terrain of the Smoky Hill ANGR is a mosaic of varying types and qualities of grassland. Within the mostly virgin (unplowed) prairie are small areas of former cropland, as well as other vestiges of early homesteads. From historical documents, we know that there was some land under cultivation in the 1940s when Smoky Hill ANGR was being established. To determine the past land use, we purchased contact prints for 39 black and white aerial photos taken in 1938 (obtained through King Visual Archives of Hyattsville, Maryland). Each photo was scanned, saved in the TIFF file format, and georeferenced to the UTM zone 14, NAD 1983 projection. Three polygon shapefiles were created from these images using ArcView GIS. Fields clearly identifiable as being under cultivation were digitized as former cropland. Fields for which there was some uncertainty as to whether they were under cultivation were digitized as possible crop fields. Developed areas

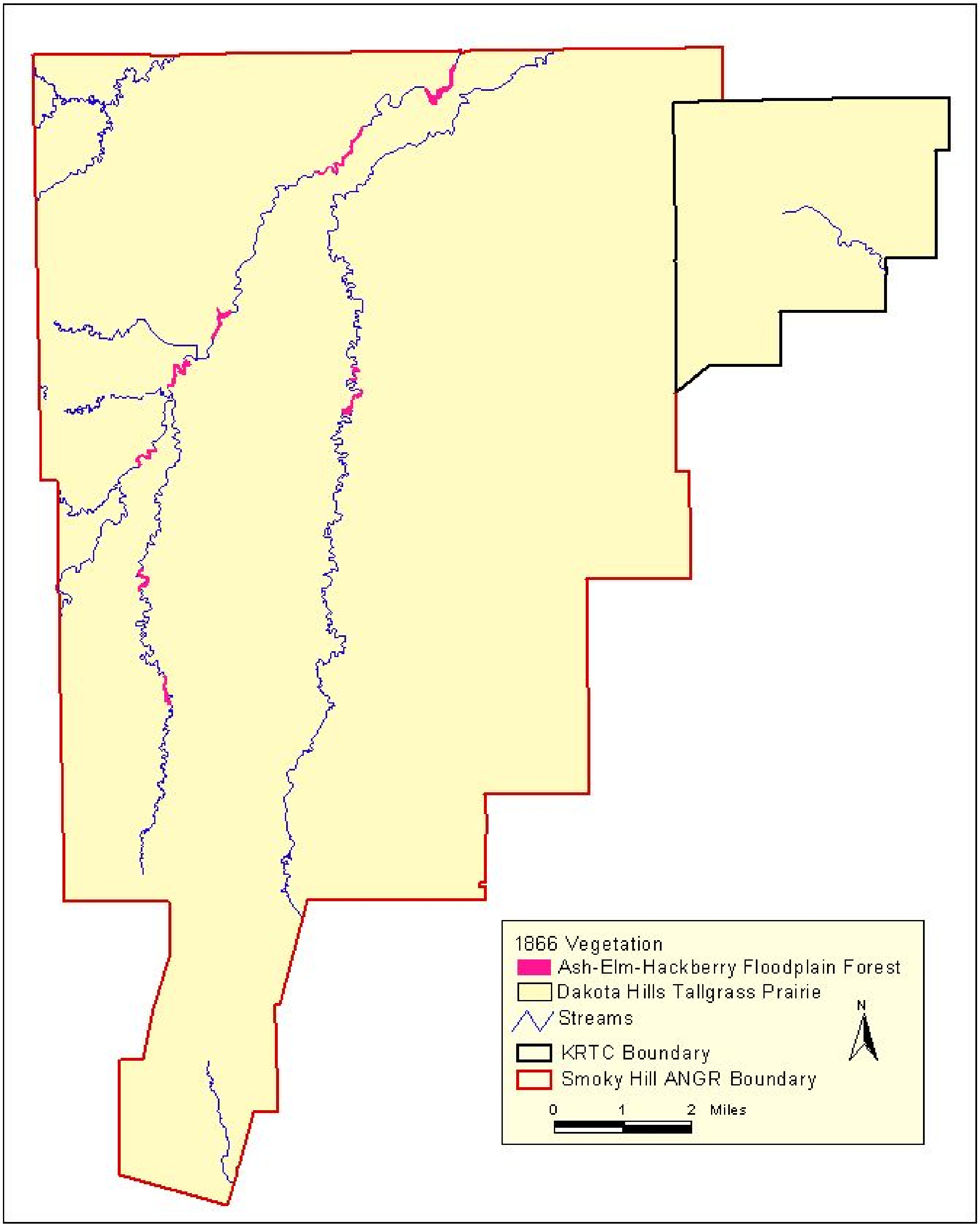


FIGURE 2.2. Map of public land survey of 1859.

containing groups of structures were digitized as former farmsteads. Polygon boundaries were adjusted using the public land survey system (PLSS) grid to correct for minor deviations in georeferencing. From this work we were able to map the historical land use of Smoky Hill ANGR (Figure 2.3). We determined that more than 2,700 acres formerly had been cropland, which comprises about 8% of the land area. In some cases it was difficult to tell if the area was cropland or significantly disturbed due to over-grazing or other management practices. This past cropland has a significant affect on the plant species diversity today. In areas that are managed as native prairie today but formerly were cropped, many of the conservative species have not returned or are present in much lower frequency. Throughout Smoky Hill ANGR, inconsistencies in the quality of the grasslands can be seen. Some of these differences are attributable to past land uses. Familiarity with weedy plants, as well as the species composition of native high quality prairies, enables a subjective, qualitative judgment of prairie parcels. A more quantitative procedure, the floristic quality index, is detailed below. Both subjective and quantitative procedures were used to characterize the condition of sites in this study.

2.1.3. Objectives of Community Vegetation Data Collection

We had several objectives in collecting vegetation data:

a) To create permanent plots to enable long-term studies of land management effects;
b) To assess the effects of recent management practices (e.g., grazed vs. hayed vs. Impact Area) on diversity and quality of plant communities of all units; and
c) To map all natural communities and identify outstanding examples thereof.

2.2. METHODS

2.2.1. Community Assessments

Many factors related to plant species composition and the density of both the vegetation and of individual species are considered in order to determine the quality of the plant communities of an area. These factors, recorded and quantified as percent cover, are used in determining condition grades and floristic quality assessment. Within each section or management area, three locations for plots were randomly selected (Table 2.1) for upland areas. Plot data were used to characterize the vegetation of the area (Figure 2.4). Some plots were marked permanently (Figure 2.5).

2.2.2. Percent Cover of Plant Species

Square plots measuring 20 m^2 were laid out using a measuring tape. All plant species occurring within the plots were identified. An estimate of cover (the area covered by each plant species as a percentage of the whole plot) was recorded following the techniques of Daubenmire (1959). The same procedure was repeated for a 1 m^2 plot nested within the 20 m^2 plot. Nested vegetation plots form an efficient method for collecting plant community data and insuring maximum accuracy of species identification.

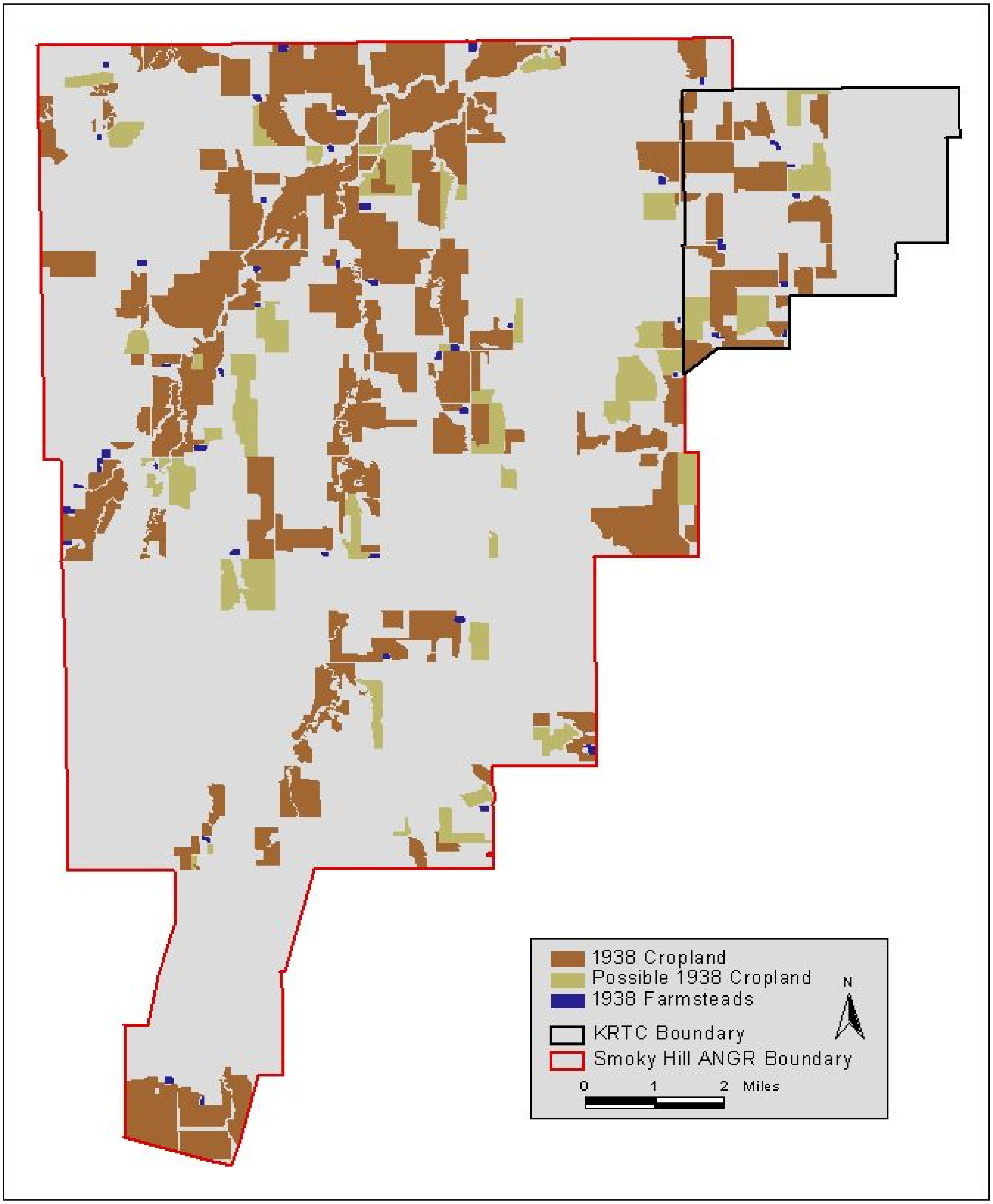


FIGURE 2.3. Land use at Smoky Hill ANGR in the late 1930s. Land use of eastern half of KRTC area was not determined.

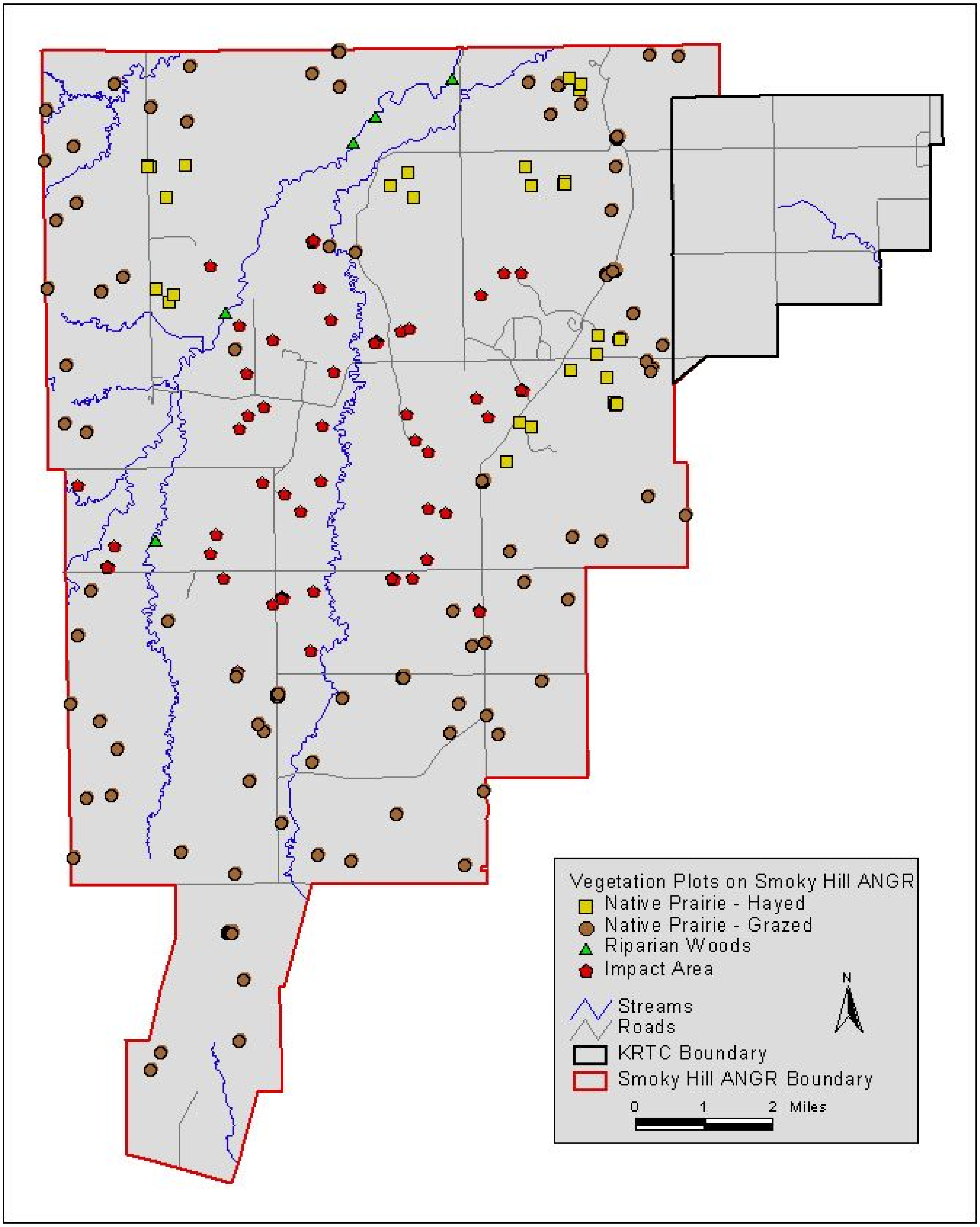


FIGURE 2.4. Locations of all vegetation plots on Smoky Hill ANGR.

TABLE 2.1. Management Unit and condition grade.

Mgmt. Unit	°N	°W	Averaged Condition Grade
Impact Area			
23	38.72796	-97.84370	B
32	38.71309	-97.85777	B
33	38.72152	-97.84281	A
34	38.71389	-97.83287	A
35	38.72312	-97.80692	A
42	38.70201	-97.85731	A
43	38.70232	-97.84252	B
44	38.70010	-97.82618	A
45	38.70676	-97.80710	B
52	38.68469	-97.86276	B
53	38.69292	-97.84944	A
54	38.68999	-97.82071	A
62	38.66821	-97.85809	B
63	38.67847	-97.85020	B
64West	38.68090	-97.83032	A
Hay Meadows			
24 (H1)	38.73738	-97.82693	B
25 (H2)	38.73550	-97.79948	B
45 (H7)	38.69695	-97.81001	A
46 (H8)	38.70495	-97.79082	A
36 (H9)	38.71377	-97.78976	B
22 (H10)	38.73854	-97.87268	B
32 (H11)	38.71968	-97.86961	B
16 (H16)	38.74847	-97.79630	A

Mgmt. Unit	°N	°W	Averaged Condition Grade
Pastures			
11	38.74677	-97.89091	B
12	38.74712	-97.87238	B
13	38.75446	-97.83890	C
15	38.74930	-97.79997	B
16	38.74201	-97.78928	B
21	38.73970	-97.89121	C
26	38.72302	-97.79188	B
31	38.72204	-97.89095	C
36	38.72336	-97.79002	B
36C	38.71390	-97.78934	C
41	38.71117	-97.88775	D
46	38.71088	-97.78472	B
55	38.69451	-97.81407	C
56	38.68918	-97.77822	C
61	38.67536	-97.87043	B
64	38.67634	-97.81520	B
65	38.67194	-97.81402	C
71	38.66415	-97.88772	C
72	38.66768	-97.85829	C
73	38.66481	-97.85093	C
74	38.66733	-97.82861	C
75	38.66175	-97.81403	B
81	38.64269	-97.88761	C
82	38.65301	-97.85625	B
83	38.64721	-97.85067	C
84	38.65128	-97.81469	C
91	38.63178	-97.86035	C
92	38.63196	-97.85980	C

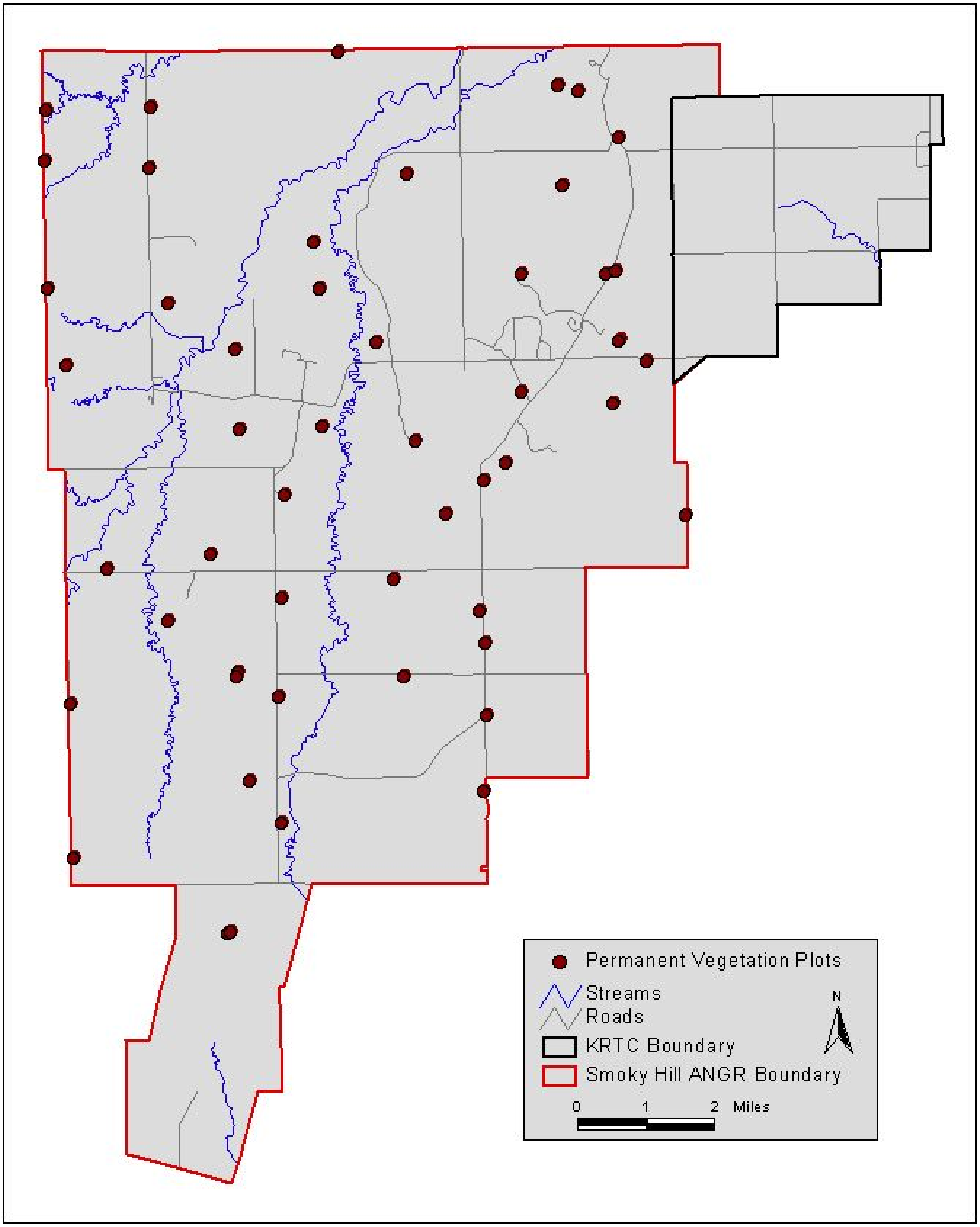


FIGURE 2.5. Locations of permanent vegetation plots.

Within each section or management unit, one of the three plots surveyed was marked permanently. At each corner of that 20 m^2 plot, a 30 cm-long piece of rebar was driven in the soil to ground level. Global positioning system (GPS) coordinates were recorded at each corner of that plot. To facilitate relocation of these plots, permanent fixtures, such as fence posts, were painted red and used as starting points for triangulation to one corner of the permanent plot. In the Impact Area, where fence posts were not always available, target vehicles were used as triangulation points. Locations of the permanent plots are provided in Table 2.1 and Figure 2.5. Permanent plots will enable resampling of exact areas in order to track more accurately changes in the condition of the prairies. For each of the non-permanent plots, one set of GPS coordinates was recorded. The cover data collected in the plots will provide a basis for assessing changes to the vegetation over time.

Most plants within plots were identified in the field. Plant species that could not be identified with confidence in the field were pressed, dried, and taken to the R. L. McGregor Herbarium at the University of Kansas for identification by Craig Freeman and Caleb Morse.

2.2.3. Condition Grades

We used standard Natural Heritage methodology (NatureServe 2005) to assign condition grades to all management units. A condition grade is a subjective field assessment of the impact of human disturbance on a site based on estimates of native species richness, abundance of exotic species, and ecological processes. Potential grades range from A to D. A-grade sites are pristine or relatively undisturbed while D-grade sites are severely disturbed but still retain some semblance of their pre-settlement character.

2.2.4. Floristic Quality Assessment and Shannon Diversity Index

Floristic quality assessment (FQA) is a standardized tool used to estimate the overall ecological quality of a site based on the presence of vascular plants growing there (Freeman and Morse 2002, Swink and Wilhelm 1994, Taft et al.1997). This quantitative measure can facilitate comparison of different sites within a plant community as well as the tracking of changes over time at a single site.

Native Kansas plant species have been assigned a coefficient of conservatism (CoC) from 0 to 10 by a panel of experts. These values are based on their relative tolerance to disturbance and fidelity to natural plant communities. The CoC values range from 0—1 for species that thrive in severely disturbed habitats to 9—10 for plant species restricted to intact, high quality natural areas.

An inventory of the plant species at a site is used in conjunction with the CoC values to calculate an average coefficient of conservatism (C) and a floristic quality index (FQI) for each site according to methods outlined in Freeman and Morse (2002). The FQI is the mean C multiplied by the square root of the total number of plant species in the plot (FQI = mean C x $\sqrt{N}$).

A one-way ANOVA and the LSD post-hoc test were used to determine pair-wise comparisons among the different management types.

Using Shannon's Diversity Index, species diversity was calculated for each vegetation plot. This index is useful for characterizing species diversity because it provides more information about the structure of a plant community than does species richness alone by accounting for both the abundance and evenness of the species within a community.

2.2.5. Soils

Soil samples were collected from every management unit on Smoky Hill ANGR and from every section in the Impact Area. In each unit or section, soil was taken from two locations. The first sample was taken from within the permanent plots that were established during the vegetation sampling. A second sample was obtained from a location near one of the other vegetation plots sites in each unit.

Soil was obtained by sinking a soil coring device into the ground to a depth of 20 cm. At each location, three core samples were taken and placed into a plastic bag labeled with the location. The samples were air dried, ground with mortar and pestle, sieved, and sent to the Soils Laboratory at Kansas State University for analysis of nitrogen, phosphorus, and organic matter.

2.2.6. Rangeland Areas Adjacent to Smoky Hill ANGR

We sampled private rangeland areas immediately adjacent to Smoky Hill ANGR to see if there were any significant differences between them and areas on the installation; both area were managed similarly before World War II. We selected areas of rangeland immediately to the west and northeast of the range (Figure 2.6) because they were still being used as rangeland and had the same general soils as those in the grazed areas of Smoky Hill ANGR.

2.2.7. Riparian Area

To characterize the woodland areas of Smoky Hill ANGR, five 20 m^2 plots and five nested 1 m^2 plots were surveyed within the riparian areas along Spring Creek (Figure 2.4). Spring Creek is the largest drainage within Smoky Hill ANGR, and trees line both side of the creek in a band of varying width.

Cover data for all plant species within these plots will provide a basis for assessing changes to the riparian corridor over time and for comparison with historical records. Species richness data for the riparian plots also were assessed. Because the riparian areas on Smoky Hill ANGR cover so few acres, statistical analysis was not performed on the plot data.

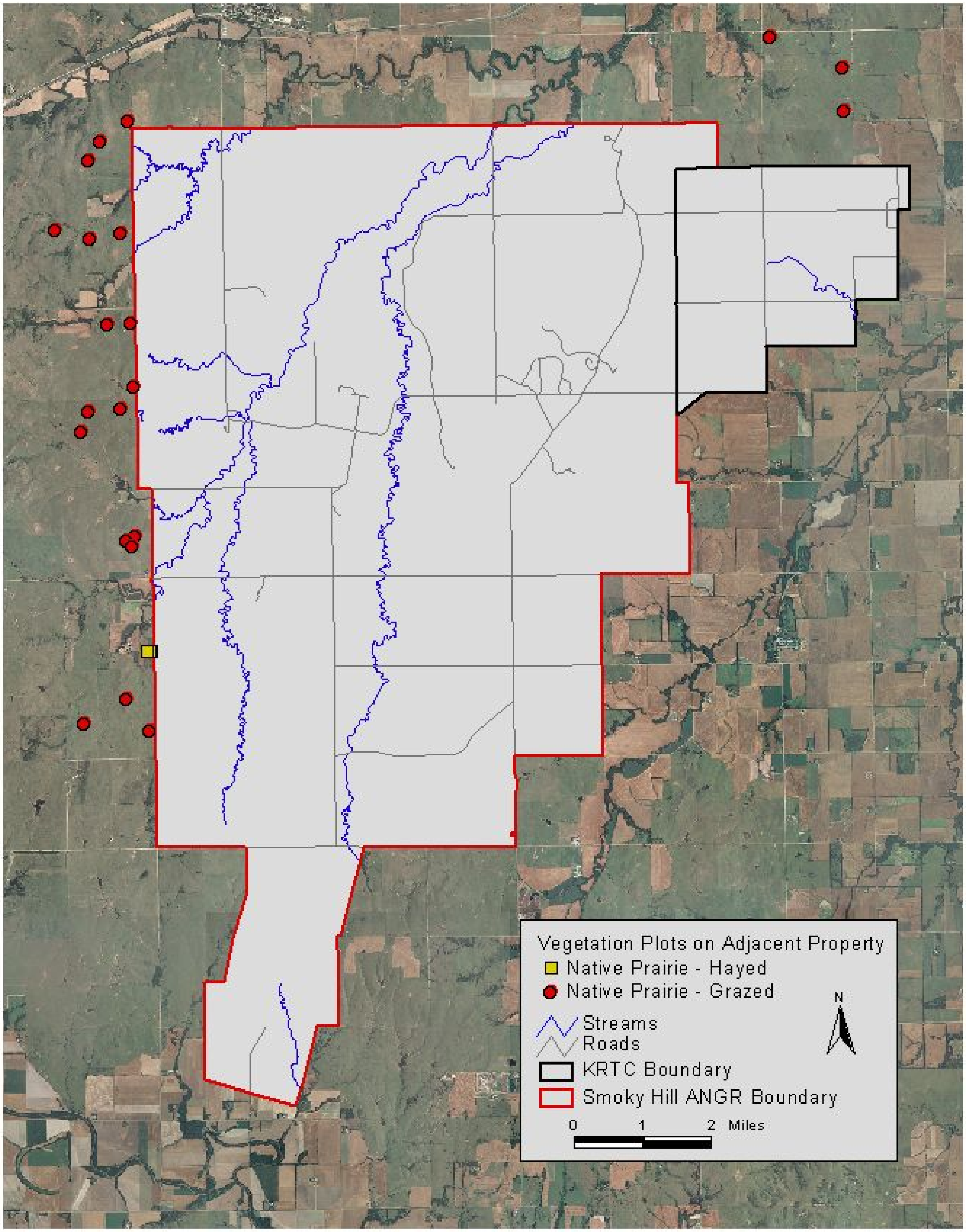


FIGURE 2.6. Locations of vegetation plots sampled from adjacent private ranches.

2.3. RESULTS

2.3.1. Former Crop Fields and Historic Landscape

Areas of former cropland were found in many places throughout Smoky Hill ANGR but were most common along the creeks in the north-central part of the installation. Other evidence of the past land use was the hedge rows and farmsteads, mapped in Figure 2.3. The wind breaks and hedgerows amount to 65 acres of land and, although they are not native, they do provide some habitat for birds and animals. Ponds with 10-meter buffers also were mapped as they provide habitat for birds and wildlife and these buffer areas near ponds were some of the most likely sites to find musk-thistle (*Carduus nutans*), due to recurring disturbance by livestock.

2.3.2. Plant Communities and Landscape Features

The Smoky Hill ANGR contains examples of the following plant communities and landscape features. While there may be some other plant communities reflecting seeps, small wetland areas and other types, these are very small and not easily located, mapped, and characterized. The classification is discussed below and mapped locations are given in Figure 2.7.

1. Natural/Near-natural Vegetation
    a. Dakota Hills Tallgrass Prairie (*Andropogon gerardii-Panicum virgatum-Schizachyrium scoparium*)
    b. Ash-Elm-Hackberry (*Fraxinus-Ulmus-Celtis*) Floodplain Forest
    c. Dakota Sandstone Sparse Vegetation

2. Semi-natural/Altered
    a. Go-back Land/Tallgrass Prairie
    b. Cultivated Fields
    c. Wind breaks and Hedgerows
    d. Ponds
    e. Firebreaks
    f. Developed Areas
    g. Former Farmsteads
    h. Military Practice Disturbance

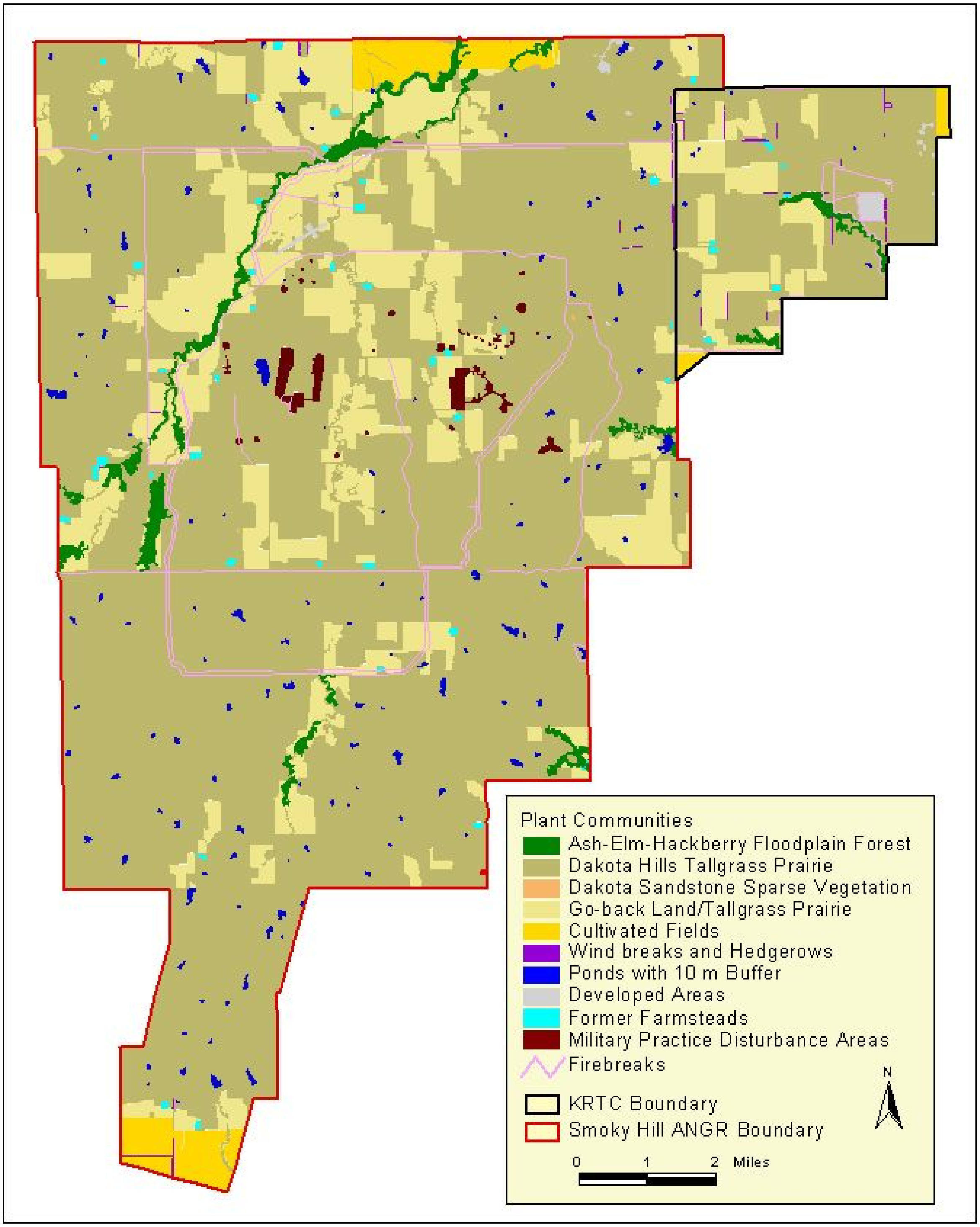


FIGURE 2.7. Plant communities and landscape features.

2.3.2.1. Natural Communities at Smoky Hill ANGR

Dakota Hills Tallgrass Prairie are areas also known as the *Andropogon gerardii - Panicum virgatum - Schizachyrium scoparium* Dakota Sandstone Herbaceous Vegetation (Code for National Classification is CEGL 005231) (Lauver et al. 1999). This community type is know from the Smoky Hills physiographic province in north-central Kansas and into a very small, adjacent area in Nebraska. It is an extensive vegetation type, which occurs in large patches across the landscape. It typically occurs on moderately sloping to steep side slopes and ridge tops on uplands, and in hills with numerous Dakota sandstone outcrops. It is the dominant plant community at Smoky Hill ANGR and covers more than 25,000 acres. The soils are shallow, somewhat excessively drained to moderately deep, and well-drained loamy soils, formed in material weathered from sandstone and sandy shale. It is the dominant natural vegetation across the uplands of Smoky Hill ANGR. Other species found in this community type are listed in the plant community data summary in Appendix A.1.

Ash-Elm-Hackberry Floodplain Forest are areas also known as the *Fraxinus pennsylvanica - Ulmus* sp. - *Celtis occidentalis* Forest (CEGL 002014) (Lauver et al. 1999). This community type is found in the eastern half of Kansas and in the following states: IA, IL, IN, MI, NE, and OH. It also is a large patch type of landscape. Its occurs on nearly level bottoms and terraces along major streams, rivers, and creeks. The soils for this community are typically deep, poorly drained to well drained, formed in silty and clayey, recent alluvium. It is only found along the major creek drainages on the north portion of the Smoky Hill ANGR and covers more than 600 acres. Other species are listed in Appendix A.2.

Dakota Sandstone Sparse Vegetation are the rock outcrop areas on Smoky Hill ANGR. This community type is found across the Dakota Sandstone Formation areas of the Smoky Hill physiographic province, usually at the top of a rock hill or around cliffs. The soils are very thin or absent, and very sandy. Only a very few examples of this natural community could be found on Smoky Hill ANGR, but they include Soldier's Cap Mound and Potato Hill. Characteristic species occur in these areas include: Tharp's spiderwort, *Tradescantia tharpii*; Virginia hoary-pea, *Tephrosia virginiana*; and blue funnel-lily, *Androstephium caeruleum*.

2.3.2.2. Semi-natural Communities and Landscape Features at Smoky Hill ANGR

The following types of semi-natural vegetation and landscape features were observed:

Go-back Land/Tallgrass Prairie comprise areas on Smoky Hill ANGR that were cultivated before World War II (see Figure 2.7) but have since regained a tallgrass prairie character because they have been managed through grazing and burning. Many of these areas do not have the high plant species richness as other sites, but they are important habitat. They typically are found near creeks and in areas with deeper soil. These are an important component of the landscape and cover more than 6,000 acres.

Cultivated Fields are areas still being farmed; they comprise about 760 acres in the northern and southern portions of the property.

Wind breaks and Hedgerows are scattered around old farmsteads and fields but also occur along roads in the northeast part of Smoky Hill ANGR. They are planted with a variety of trees, and cover about 65 acres.

Ponds are located throughout the property. We have mapped a 10-m buffer around them as the buffer is often a disturbed area that is more likely to have musk-thistle, *Carduus nutans*, and other weeds. Including buffers, they total about 270 acres.

Firebreaks are a management disturbance dominated by weedy annual vegetation due to annual tilling. They are linear features, actually tilled strips, used to control fires.

Developed Areas are buildings and the lands immediately around them that may be planted to lawn grasses or that are disturbed by human activity. These areas total about 70 acres.

Former Farmsteads are scattered across the facility, usually are disturbed, and have some trees. There are about 40 that we have found and were able to map.

Military Practice Disturbance areas also typically have more weedy species due to the disturbance of the soil. They total a little less than 200 acres.

2.3.3. Plant Community Data from Tallgrass Prairie

During the spring and summer of 2003 and 2004, grassland surveys were completed on 156 plots (20 m^2 with nested 1 m^2) in 52 management units across Smoky Hill ANGR. Factors recorded during the study included species richness, percent cover of each plant species, and a condition grade for each plot. Statistical analysis of the results is reported using the data from the 20 m^2 plots, which captured greater plant species diversity.

2.3.3.1. Species Richness

Species richness is the total number of species in a given area. It was determined for each plot (Figure 2.8) and ranged from a high of 69 species in one hay meadow (management unit 11) to 19 species in a pasture (management unit 13).

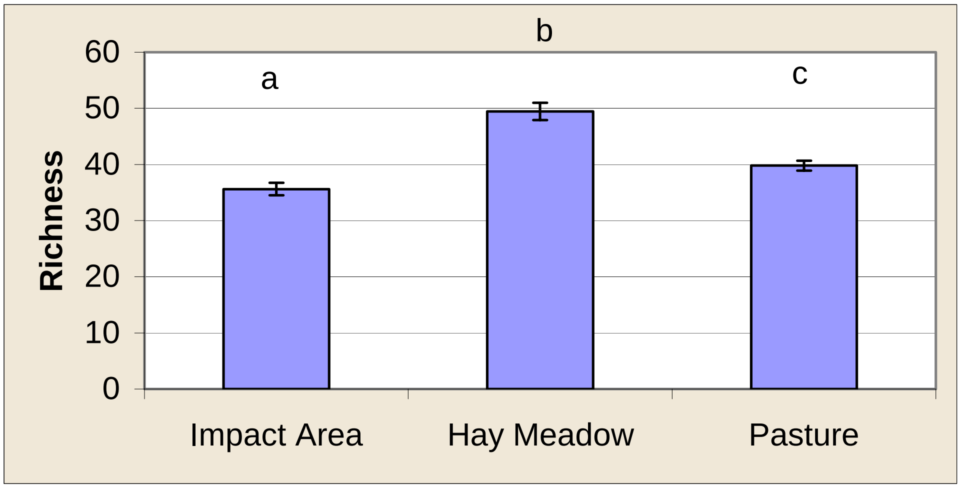


FIGURE 2.8. Mean richness values (average of all species by plot) and standard errors by management type. Different letters above the bars indicate significant differences among treatments ($p<0.05$).

A total of 238 plant species, representing 51 families, was identified across all plots on the installation. There were 213 (90%) native species and 23 (10%) species not native to Kansas. See Appendix A.1 for a list of all plant species recorded within the plots along with the average cover of each species by management type. Nomenclature follows the R. L. McGregor Herbarium Collection Information Management System (CIMS). Plot data are recorded on the CD included with this report.

2.3.3.2. Percent Cover

The percent cover of individual plant species in the plots is one of the criteria used to estimate the condition grade of a site. A synopsis of the cover values is shown in Table 2.2. A percentage greater than 100% indicates that plants of more than one species cover the ground densely with overlapping canopies. Hay meadows had the highest average cover of plants among the three treatments (174.8%). Conversely, the Impact Area had the highest average cover of bare ground (6.3%). The higher cover of bare ground in the Impact Area probably is due to frequent burning, although some sites have been disturbed by previous land use practices. Hay meadows had the least bare ground on average. Hay meadows seem to experience the least disturbance of the three management types, with neither the frequent burning of the Impact Area nor the hoof disturbance and loss of vegetative cover due to grazing seen on the pastures.

Throughout the Smoky Hill ANGR, little bluestem (*Schizachyrium scoparium*) had the highest average cover (37.93%) followed by big bluestem (*Andropogon gerardii*) at 24.18% and rough dropseed (*Sporobolus asper)* at 14.04% (Table 2.3). Little bluestem and big bluestem are characteristic and desirable species. Rough dropseed is an increaser species (one that becomes more abundant in the presence of grazing or other disturbances; see Fraser and Kindscher 1997). Cover values of the top 10 species include three forbs. Western ragweed (*Ambrosia psilostachya)*, a native species considered to be fairly weedy, had an average cover of 6.0%;

heath aster (*Symphyotrichum ericoides)*, considered to be fairly neutral in terms of disturbance, had an average cover of 2.2%, and narrow-leaf scurf-pea (*Psoralidium tenuiflorum*), a legume of moderate palatability, had an average cover of 2.1%.

TABLE 2.2. Synopsis of percent cover by management type. Vegetation layers overlap so plant cover can total more than 100%.

	Impact Area	**Hay Meadows**	**Pastures**	**Overall Average**
Total average cover per plot	140.4%	174.8%	147.5%	149.7%
Average cover of bare ground per plot	6.3%	1.9%	4.5%	4.6%

TABLE 2.3. Comparison of the 10 grassland species with the highest average percent cover values per plot by management type on Smoky Hill ANGR. An asterisk (*) indicates species not native to Kansas.

Scientific Name	**Common Name**	**CoC Values**	**Hay Meadows**	**Impact Area**	**Pastures**
Schizachyrium scoparium	little bluestem	5	56.0	36.7	33.4
Andropogon gerardii	big bluestem	4	38.5	30.2	17.0
Erigeron strigosus	daisy fleabane	4	10.2		
Sorghastrum nutans	Indiangrass	5	8.3	3.9	7.8
Sporobolus asper	rough dropseed	3	7.8	3.9	21.1
Bromus japonicus	Japanese Brome	*	5.4		10.8
Psoralidium tenuiflorum	many-flowered scurfpea	3	4.8		2.2
Rudbeckia hirta	black-eyed Susan	2	4.5		
Artemisia ludoviciana	Louisiana sagewort	2	2.6		
Hesperostipa spartea	porcupinegrass	8	2.4		
Ambrosia psilostachya	western ragweed	3		3.4	8.9
Poa pratensis	Kentucky bluegrass	*			6.9
Bouteloua curtipendula	side-oats grama	5		10.0	5.1
Bouteloua gracilis	blue grama	5		7.3	3.6
Pascopyrum smithii	western wheatgrass	2		3.4	
Symphyotrichum ericoides	heath aster	5		5.2	
Koeleria macranthra	Junegrass	6		3.1	
Average total cover by management type			**174.8**	**140.4**	**147.5**

Other forbs with substantial coverage include daisy fleabane (*Erigeron strigosus)* and Louisiana sagewort (*Artemisia ludoviciana)*. Only two non-native species had average plot coverages in the top 10; Japanese brome (*Bromus japonicus*) and Kentucky blue grass (*Poa pratensis*). These weedy grasses are indicative of a high degree of physical disturbance.

An analysis of the top 10 species with the highest average percent cover by management type provides some insights:

- Average total percent cover of these species was significantly higher in hay meadows than in either the Impact Area or pastures.
- Little bluestem has the highest cover values among all three management types.
- Hay meadows are distinctive in having porcupine grass (*Hesperostipa spartea)*, a highly desirable and palatable forage grass. Six of the 10 most abundant species are grasses; one of these is the non-native Japanese brome.
- The Impact Area differs from the hay meadows in having no non-native species present in the top 10 coverages. Eight of the 10 most abundant species are grasses.
- On pastures, eight of the 10 most abundant species are grasses; two of these are non-native.

2.3.3.3. Condition Grade

Based on estimates of species composition, percent cover of those species, and ecological processes, a grade was assigned to each plot at the time of our field survey work. The Impact Area and hay meadows had significantly higher grades than did the pasture sites (Figure 2.9), reflecting the local loss of some species in pasture areas and increased weediness.

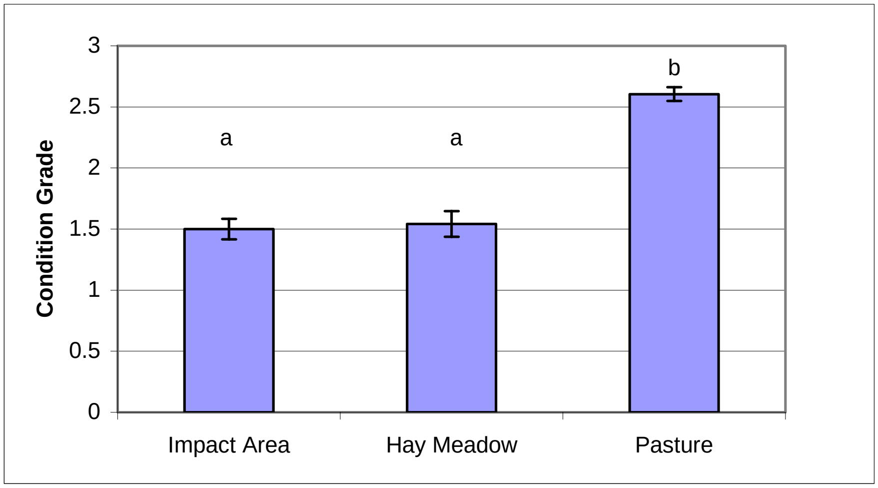


FIGURE 2.9. Comparison of mean condition grades assigned to plots by management type. For condition grade, A=1, B=2, C=3. Shorter bars indicate higher condition grades. Different letters above the bars indicate significant differences among treatments (*p*<0.05).

2.3.3.4. Floristic Quality Assessment

Floristic quality assessment is calculated based on the Coefficient of Conservatism (CoC) values of each plant species present in a given area. The CoC values and number of species representing those values within the Smoky Hill plots is shown in Table 2.4.

TABLE 2.4. Number of species in each of the coefficients of conservatism values. An asterisk (*) indicates species not native to Kansas.

CoC value	*	0	1	2	3	4	5	6	7	8	9	10
Number of species	23	36	25	24	32	23	33	22	14	4	0	0

None of the 238 species recorded within the $20m^2$ plots had a CoC value greater than 8. While much of Smoky Hill ANGR qualifies as a high-quality, intact natural area, all of it has been impacted by grazing, homesteading, military use, roads, or other human disturbances. These factors make it unlikely that conservative species with a CoC of 9 or 10 would occur there very frequently, if at all. It is even less likely that those species would show up in the vegetation plots, which were located in representative locations rather than either the best or least disturbed areas of each unit.

Each of the three management types was statistically different in terms of floristic quality assessment (Figure 2.10). Hay meadows had the highest average score, followed by the Impact Area, and then pastures. Annual haying seems to be a superior method of managing the prairie for high-quality diversity. Many, if not all, of the hay meadows on Smoky Hill ANGR were probably grazed prior to World War II, making the statistical difference even more noteworthy.

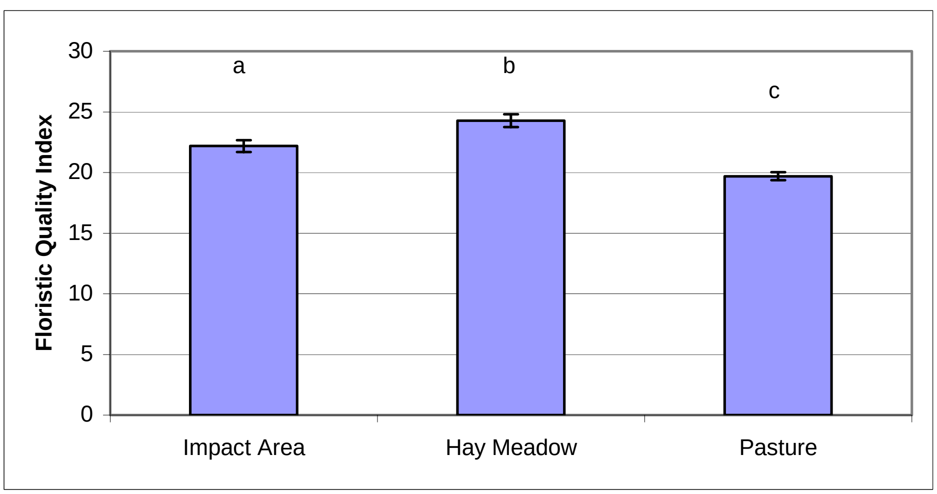


FIGURE 2.10. Comparison of mean floristic quality indices by management type. Different letters above the bars indicate significant differences among treatments (p<0.05).

This indicates that haying (cutting tracts once per year and removing the biomass), maintains or improves the quality of the prairie vegetation. Long-term annual haying could be improved as a management technique by including some years of rest for recovery of plant stature and seed development.

2.3.3.5. Shannon's Diversity Index

Shannon's Diversity Index values were calculated for each management type (Figure 2.11). The Impact Area had the lowest diversity (2.0333) and was significantly different from the other two management types. Hay meadows (2.1725) and pastures (2.1693) had higher values and were not significantly different from each other.

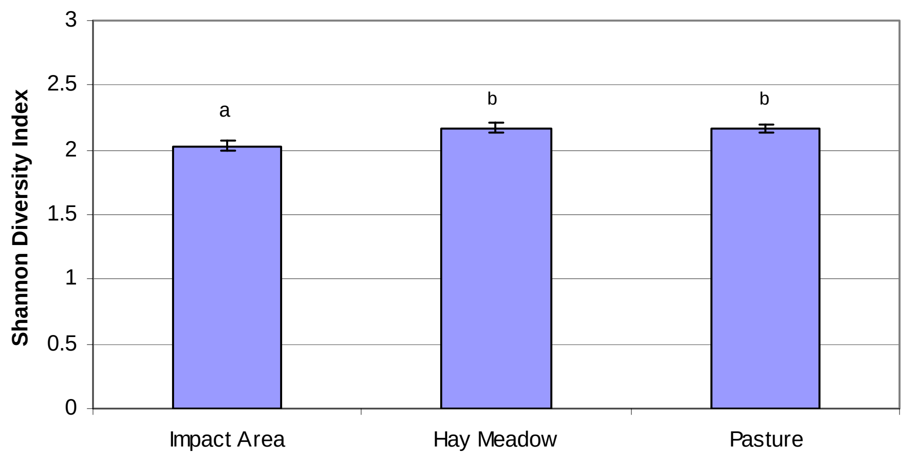


FIGURE 2.11. Comparison of mean Shannon's Diversity indices by management type. Different letters above the bars indicate significant differences among treatments ($p<0.05$).

Shannon's Diversity Index, unlike the floristic quality index, treats all species as being of equal value. Therefore, a site with numerous invasive or weedy species would score higher than a site with fewer but more conservative species (Andreas et al. 2004).

2.3.3.6. Soils

The results of the soil testing at all vegetation sampling sites indicate that the soil quality does not vary much among the haying, impact, or pasture areas on Smoky Hill ANGR (Figure 2.12). There may be many reasons for their similarity, but one important factor could be that their management has been relatively consistent during the last 10—20 years.

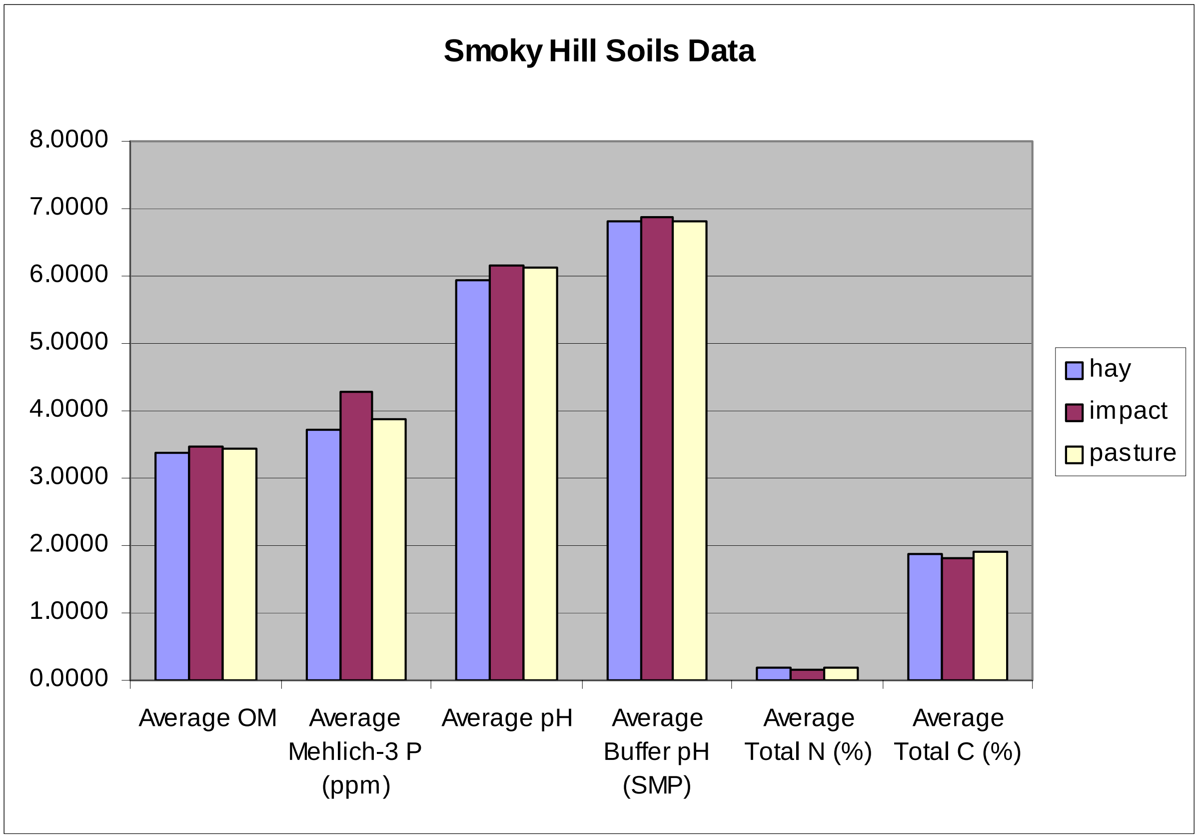


FIGURE 2.12. Soil nutrients in hay, impact, and, pasture areas.

2.3.3.7. Comparison with Adjacent Privately-Owned Pasture

Surveys were conducted on 18 plots on six private properties adjoining Smoky Hill ANGR (Figure 2.6). While the number of plots examined is not large enough for statistical analysis, we can gain some insight from the data.

The adjoining ranches had vegetation very similar to the areas that we sampled on pastures on Smoky Hill ANGR. Differences might emerge if substantially more off-range pastures were surveyed. Stated stocking rates on neighboring ranches were similar to those mandated on the Smoky Hill ANGR, and in many respects the areas had similar management.

During the course of interviews with three neighboring ranchers, each one complained about the musk-thistle (*Carduus nutans*) populations on Smoky Hill ANGR. Two of the ranchers interviewed stated that the aerial spraying performed on Smoky Hill ANGR was ineffective and that the best technique was either hand-digging or a combination of hand-digging and spot-spraying. Hand-digging and spot-spraying were the preferred methods of all the ranchers interviewed. Because few musk-thistles were seen on Smoky Hill ANGR during the plot monitoring, rancher's perception may not be in line with the actual situation. Whereas ranchers pull up thistles as they see them during the summer, the leaseholders on Smoky Hill ANGR seem to do little follow-up care of the pastures. Musk-thistle was noted in only 12 of 85 pasture plots on Smoky Hill ANGR, although the method for selecting plots excluded areas most likely to contain musk-thistle such as ravines and the disturbed areas around ponds. Where musk-thistle was found, the cover was only a trace. Grazing does seem to encourage musk-thistle as it was only seen in one of 24 plots sampled on hay meadows and in none of the 43 plots in the Impact Area.

2.3.4. Riparian Woodland Results

The cover data for all plant species noted in the riparian plots are summarized in Appendix B. Species richness within the riparian woodland sites ranged from 4 to 33 species. A total of 49 vascular plant species was recorded, of which 92% were native and 8% were introduced in Kansas.

A summary of the Coefficients of Conservatism values for the species recorded in the riparian plots is shown in Table 2.5. None of the CoC values is greater than 5, indicating the lack of conservative woodland species.

TABLE 2.5. Coefficients of conservatism for all species recorded in riparian plots. An asterisk (*) indicates a non-native plant species.

CoC value	*	0	1	2	3	4	5	6	7	8	9	10
Number of species	4	11	9	11	9	2	3	9	0	0	0	0

Because CoC values were not high, the average FQI of the riparian plots was low, indicating a fairly low-quality woodland resource (Table 2.6). The most common tree species in the plots were common hackberry (*Celtis occidentalis*), black walnut (*Juglans nigra),* American elm (*Ulmus americana)*, and green ash (*Fraxinus pennsylvanica)*. All of these species have CoC values in the 0–3 range. Native trees commonly occur in early successional woodland areas.

TABLE 2.6. Average richness and Floristic Quality Index (FQI) values for riparian plots.

Average richness / plot	16.4
Average number of native species / plot	15.5
Average FQI / plot	6.7

Statistical analysis of these data was not performed because the sample size was small (five plots) as riparian vegetation covers less than 2% of Smoky Hill ANGR.

2.4. CONCLUSIONS

Smoky Hill ANGR encompasses a large and uniquely preserved example of the tallgrass prairie. The size of this largely unfragmented tallgrass prairie makes it a valuable reservoir of biological diversity for the Great Plains.

Thoughtful management of Smoky Hill ANGR has resulted in a generally good quality of grassland communities throughout the property. The absence of any major weed infestation attests to the quality of the range, its management, and good grazing practices. The Impact Area is unique. It contains a low component of weedy species and the highest percent cover of conservative plant species (with coefficient of conservatism values of 6–8). The hay meadows contain the greatest species richness, the highest average cover of vegetation, the least bare ground, and the highest floristic quality index of the three management types.

Plant surveys conducted on Smoky Hill ANGR provided a quantitative assessment of the effects of current management practices on plant diversity and plant community quality. The permanent plots provide valuable baseline data on the condition of the vegetation and can be used to track changes over time.

CHAPTER 3. FLORISTIC SURVEYS

Craig C. Freeman

3.1. INTRODUCTION

Botanical studies on Smoky Hill ANGR during the 2003–2006 field seasons were carried out as a complement to faunistic and vegetation surveys. The five primary objectives of the botanical studies were to: 1) compile a list of rare species that might occur on the installation, 2) plan and conduct surveys for those species, 3) document all discoveries of rare species and compile a report detailing all occurrences of rare species, 4) conduct a comprehensive floristic survey of the installation, and 5) using standardized survey procedures, gather baseline information about introduced plant species that may threaten the military's training mission and the ecological integrity of plant communities on Smoky Hill ANGR.

Hancin (1939) published a flora of Saline County, listing more that 700 species, infraspecific taxa, and hybrids; many taxa on his list now are considered synonyms of other accepted taxa. A comprehensive flora of McPherson County never has been published. Kansas botanists have carried out general collecting in both counties for more than 120 years. Some parts of the counties, particularly public lands, have been scrutinized since the 1970s, yielding many specimens that now document the flora. The vegetation of the Kansas Region Training Center Range of the Kansas Army National Guard, located immediately east of the Smoky Hill ANGR, was studied from 1989—1999 (Charlton et al. 2000). Two hundred seventy-five species of vascular plants were reported on the 1,417-hectare site; vouchers from that study were deposited in the Kansas State University Herbarium (Winter and Charlton 2000). In 1994, vouchers in the R. L. McGregor Herbarium (KANU), University of Kansas, documented 515 taxa (species, subspecies, and varieties) in Saline County and 459 taxa in McPherson County. Prior to this study, KANU had more than 850 specimens from Saline County and nearly 950 specimens from McPherson County.

The Kansas Nongame and Endangered Species Conservation Act (K.S.A. 32-501 through 32-510) places responsibility for identifying and undertaking conservation measures for threatened and endangered wildlife with the Kansas Department of Wildlife and Parks. The Act protects rare and declining animal species, but it does not protect native plants. State-rare species, which have no legal protection in Kansas, are identified and tracked by the Kansas Natural Heritage Inventory, a program of the Kansas Biological Survey at the University of Kansas. The federal Endangered Species Act of 1973 is administered by the Fish and Wildlife Service of the U.S. Department of Interior. The Act provides federal protection for animals and plants listed as endangered or threatened. Three vascular plant species documented in Kansas are protected under the Act: *Asclepias meadii* Torr. (Asclepiadaceae; Mead's milkweed), *Platanthera praeclara* Shev. & M. Bowles (Orchidaceae; western prairie fringed orchid), and *Trifolium stoloniferum* Muhl. ex Eaton (Fabaceae; running buffalo clover).

Invasive plants, especially those that are non-native, are among the greatest threats to natural ecosystems worldwide. Problems associated with them have increased with expanding human populations, world travel, and international trade. An estimated 5,000 non-native plant species (also called exotic, alien, or introduced) occur in the U.S. today (Morse et al. 1995). Non-indigenous plants occupy an additional 4,600 acres of wildlife habitat each day in the U.S. (Babbitt 1998), and invasive weeds on croplands cost the U.S. an estimated $26.4 billion annually (Pimentel et al. 2000). Combined annual losses and damages plus control costs from aquatic weeds, crop weeds, weeds in pastures, and weeds in lawns, gardens, and golf courses are close to $34 billion (Pimentel et al. 2000).

Four hundred forty-seven of the 2,123 species (21%) of vascular plants documented in Kansas have been introduced since the arrival of Euro-Americans. Exotic plants are of particular concern because many natural controls formerly regulating their populations are absent in the new, non-native environment. Among their many adverse impacts on natural communities (Randall 1995, 1996), non-native plant species often out-compete native species, reducing biodiversity and modifying habitat structure.

The State of Kansas, based on recommendations from the Kansas Department of Agriculture (KDA), labels a plant species as "noxious" when it threatens economic activities. Kansas Statute 2-1314 (Information Network of Kansas, Inc. 2002—2003) assigns responsibility to all people who own or supervise land in Kansas to, "control the spread of and to eradicate all weeds declared by legislative action to be noxious on all lands owned or supervised by them and to use such methods for that purpose and at such times as are approved and adopted by the department of agriculture." State law deems noxious weeds as plants that are such a nuisance to the economy that landowners and extension agents are bound by law to destroy them (Information Network of Kansas, Inc. 2002–2003). The KDA Plant Protection and Weed Control Program lists 12 species as noxious in Kansas: kudzu (*Pueraria lobata* (Willd.) Ohwi [accepted name = *P. montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen & S. M. Almeida]), field bindweed (*Convolvulus arvensis* L.), Russian knapweed (*Centaurea repens* L. [accepted name = *Acroptilon repens* (L.) DC.]), hoary cress (*Cardaria draba* (L.) Desv. [accepted name = *Lepidium draba* L. subsp. *draba*]), Canada thistle (*Cirsium arvense* (L.) Scop.), quackgrass (*Agropyron repens* (L.) P. Beauv. [accepted name = *Elymus repens* (L.) Gould]), leafy spurge (*Euphorbia esula* L.), bur ragweed (*Ambrosia grayii* (A. Nelson) Shinners), pignut (*Hoffmannseggia densiflora* Benth. [accepted name = *Hoffmannseggia glauca* (Ortega) Eifert], musk-thistle (*Carduus nutans* L.), Johnsongrass (*Sorghum halepense* L.), and sericea lespedeza (*Lespedeza cuneata* (Dum. Cours.) G. Don). In addition, two species are listed as county-option, meaning that counties have the option of listing the species as noxious if they are deemed threats to economic activities: multiflora rose (*Rosa multiflora* Thunb.) and bull thistle (*Cirsium vulgare* (Savi) Ten.). Neither species is listed as noxious in Saline County (see www.ksda.gov/plant_protection/content/181).

3.2. METHODS

A list of more than 500 vascular plant taxa documented in Saline County based on specimens in the R. L. McGregor Herbarium was produced in 2003 using the KANU Collection Information Management System (CIMS). CIMS is used by KANU to capture and manage specimen label data for approximately 184,000 vascular plant and lichen specimens, currently approximately

50% of the specimens housed in KANU. This list then was checked against a master checklist of the Kansas flora, which is maintained by KANU. The master checklist contains information about the nomenclature, rarity, conservatism, wetland status, alien status, longevity, and life form of all Kansas plants.

Sixteen state-rare species were identified as having been documented in Saline County prior to this study (Table 3.2). State-rare species were defined as those species assigned a state rarity rank of S1, S2, or SH by the Kansas Natural Heritage Inventory (see results section for rank definitions). Using habitat information about these rare species, survey crews targeted for survey those habitats most likely to support populations of rare species, as well as common species.

The CIMS-generated list served as the starting point for production of a comprehensive species list for the installation. A checklist version of the list was carried in the field by collectors. For each species encountered on the installation, at least one voucher specimen was collected, pressed, and dried. The latitude and longitude of each collection site was recorded with a hand-held Garmin GPS II$^+$; information about the habitat, abundance, and other attributes of species that were collected were recorded in collectors' field notebooks and used to produce specimen labels for voucher specimens. Specimens subsequently were mounted, databased, and deposited in the R. L. McGregor Herbarium.

Intensive floristic surveys were carried out from April—September 2003. Collecting trips to the installation that year were made at least monthly to increase the chances of discovering new species as plants progressed through phenological changes during the growing season. Collections were made opportunistically in 2004, 2005, and 2006 to document previously undiscovered species.

Surveys for certain weedy, non-native species were conducted to inform the action plan for control and abatement of invasive and non-native species (Appendix G). Three non-native plant species of particular interest as potential threats to the military's training mission and to the ecological integrity of plant communities on Smoky Hill ANGR were studied. Surveys for *Carduus nutans*, *Elaeagnus angustifolia*, and *Lespedeza cuneata* were conducted from May—August 2006, after which time surveys for *Carduus nutans* could not be done reliably due to senescence of flowering plants. It was realized that not all management units on the installation could be surveyed in one field season because of access issues and personnel schedules. Nevertheless, baseline information gathered according to standardized procedures for these species would be useful for future comparisons and in the development of management strategies for the installation. Survey priority was given to management units used for haying and grazing leases. Surveys for one other species, *Robinia pseudoacacia* L. (black locust), a woody, pest species in some parts of eastern Kansas, were conducted. Surveyors recorded populations of this species in Managements Units 36, 46, and 84 (0.47, 1.41, and 1.14 acres, respectively). Because it appears not to be a threat currently at Smoky Hill ANGR, locations of this species are not included in this report.

Field data were recorded on field forms (Figure 3.1). Mapping procedures followed the recommendations in Carpenter et al. (2002) and Anonymous (2002), with minor modifications. The minimum mapping unit for each occurrence was <1m^2 (individuals mapped), and the minimum distance between adjacent occurrences was 30 m (i.e., any two plants closer than 30 m were mapped as part of the same occurrence). The minimum mapping distance was increased to 50—60 m in some fields because plants occurred at very low but uniform densities. Without increasing the minimum mapping distance between occurrences, excessive time would have been spent mapping dozens of small occurrences with no foreseeable management benefits. Latitude and longitude of isolated occurrences (points, or polygons with at least one dimension up to 5 m) were determined with a hand-held Garmin GPS II^{+}. Boundaries of larger occurrences were drawn onto aerial photos taken 30 July 2001 by Western Air Maps, Inc. of Overland Park, Kansas, and at least one GPS reading within the occurrence polygon was recorded as a quality control measure. Population boundaries were approximated by digitizing polygons directly from aerial photographs. Each point or polygon was assigned the following attributes: date observed, observer(s), centroid position, canopy cover (using 10 cover classes), and area (calculated in ArcView).

3.3. RESULTS AND DISCUSSION

3.3.1. General Surveys

Surveys of more than 40 sites were performed by Jeff Elliott and Craig C. Freeman on 17 days (Table 3.1) for an estimated total of 136 hours. Dozens of other sites that were checked briefly (survey time <30 minutes) by Elliott or Freeman are not reported here. In addition, collections from 39 sites were made by Hillary Loring on 20 days in 2003 and 2004. Collecting by Loring, estimated to have been 40 hours, was carried out in association with vegetation surveys of the installation. Only sites from which Loring made three or more collections are listed in Table 3.1. Locations of major plant collection sites listed in Table 3.1 are shown on Figure 3.2.

We emphasized documenting all taxa on the installation. Plant surveys were carried out in as many different habitats as possible to document as much of the flora as possible. Some 700 specimens of vascular plants were collected on or near the installation; an accurate count cannot be made because some specimens have not been processed. Because McPherson County occupies an exceedingly small part of the Smoky Hill ANGR, summaries below are restricted to Saline County to simplify discussions. Approximately 50 specimens were collected in McPherson County; these all represented species also documented on the Saline County portion of Smoky Hill ANGR.

SMOKY HILL AIR NATIONAL GUARD RANGE WEED INVENTORY FORM

General Information

Mgmt. Unit No.: ________________

Survey Date (YYYYMMDD): 2006--____--____

Surveyor: ________________________ **Base Map Reference No.** ______

Location Information

Centroid: N Latitude ____.______ **Centroid: W Longitude ____.______**

Point (Y / N) **Polygon (Y / N)**

If polygon, boundaries are defined by map ______ or GPS coordinates ______

N boundary ____.______ **S boundary ____.______**

E boundary ____.______ **W boundary ____.______**

Plant Information

Species:

____ **Carduus nutans**

____ **Elaeagnus angustifolia**

____ **Lespedeza cuneata**

Infested Area ______________ **Unit of Measure:** **acre** **hectare**

(Actual infested area of weeds.)

Gross Area ______________ **Unit of Measure:** **acre** **hectare**

Canopy Cover (How dense are the weeds. Check appropriate amount)

1-10% 11-20% 21-30% 31-40% 41-50% 51-60% 61-70% 71-80% 81-90% 91-100%

FIGURE 3.1. Weed survey form used on Smoky Hill ANGR in 2006.

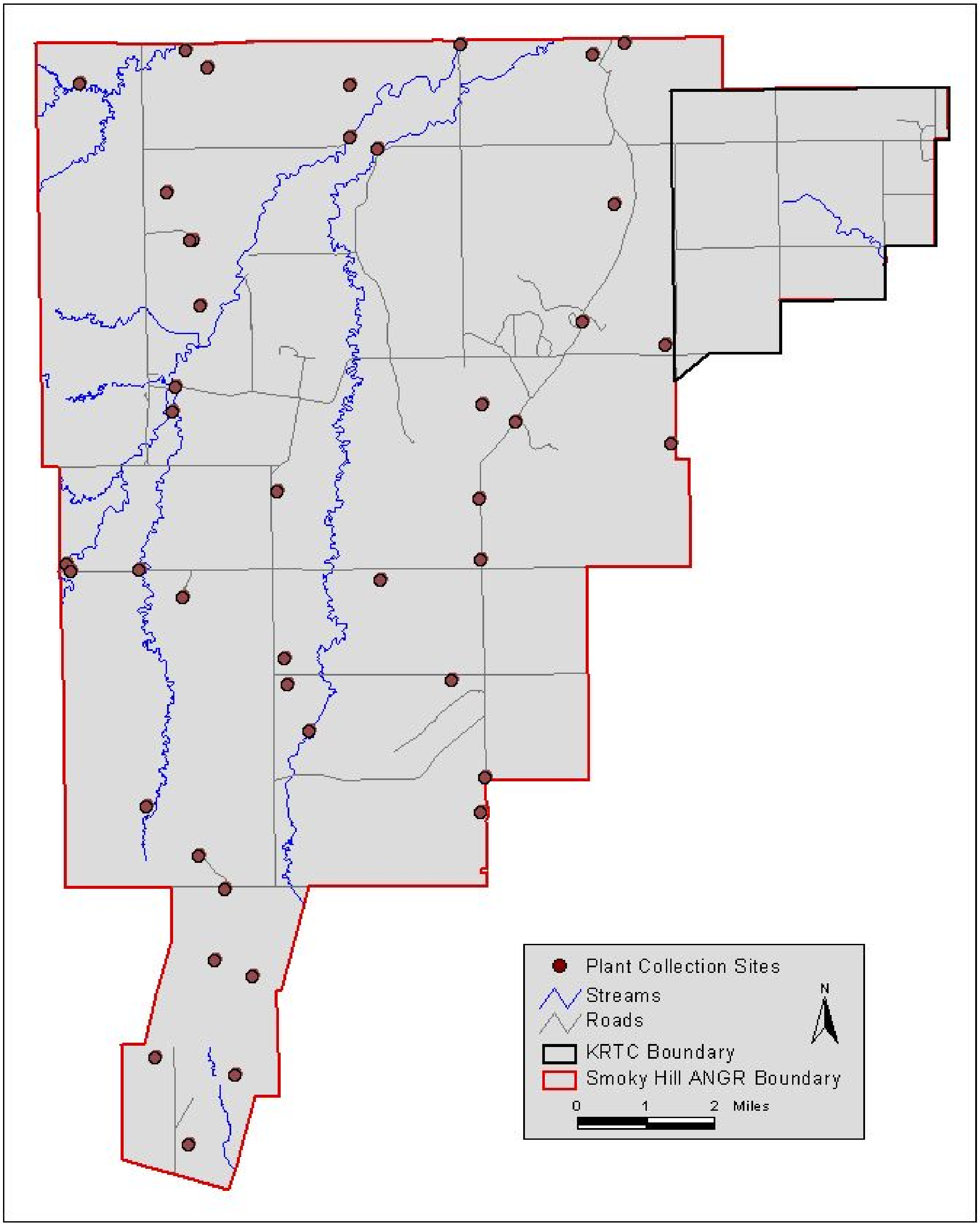


FIGURE 3.2. Locations of major plant collection sites on Smoky Hill ANGR; 2003—2006.

TABLE 3.1. Summary of major collection sites and dates for vascular plant species on Smoky Hill ANGR. Collectors are: Elliott (Jeff Elliott), Freeman (Craig C. Freeman), and Loring (Hillary Loring). Datum for Freeman and Elliott collections is WGS84; for Loring collections it is NAD27.

DATE	COLLECTION SITE	LATITUDE N	LONGITUDE W	COLLECTOR
2003-04-22	T15S, R5W, sec 22 S½	38.7278º	97.8644º	Freeman
2003-04-22	T16S, R5W, sec 13 SE¼ SE¼	38.6533º	97.8145º	Freeman
2003-05-20	T15S, R4W, sec 31 SE¼	38.7021º	97.8082º	Freeman
2003-05-21	T16S, R5W, sec 34 S½	38.61278º	97.85889º	Elliott
2003-05-21	T16S, R5W, sec 03 NW¼	38.60722º	97.86361º	Elliott
2003-05-21	T16S, R5W, sec 03 S½ NW¼	38.60333º	97.86722º	Elliott
2003-05-21	T16S, R5W, sec 27 SW¼	38.62861º	97.86222º	Elliott
2003-05-21	T15S, R4W, sec 29 NW¼ SW¼	38.71583º	97.79639º	Elliott
2003-05-21	T15S, R4W, sec 34 NW¼ NW¼	38.70750º	97.86778º	Elliott
2003-05-21	T16S, R5W, sec 13 NW¼ NE¼	38.66667º	97.82000º	Elliott
2003-05-21	T16S, R5W, sec 01 SE¼ NE¼	38.68333º	97.81472º	Elliott
2003-06-06	T15S, R5W, sec 28 NE¼ NE¼	38.73444º	97.86889º	Elliott
2003-06-06	T15S, R5W, sec 34 SW¼ NE¼	38.70417º	97.86833º	Elliott
2003-06-06	T15S, R5W, sec 24 N½	38.74000º	97.83194º	Elliott
2003-06-08	T16S, R5W, sec 21 NE¼	38.65000º	97.87389º	Elliott
2003-06-08	T16S, R5W, sec 16 SW¼	38.66000º	97.84500º	Elliott
2003-06-08	T15S, R4W, sec 29 SE¼	38.71250º	97.78194º	Elliott
2003-06-22	T16S, R5W, sec 04 SW¼	38.68333º	97.88722º	Elliott
2003-06-22	T16S, R5W, sec 27 SW¼	38.62861º	97.86222º	Elliott
2003-06-22	T16S, R5W, sec 24 NE¼	38.64861º	97.81528º	Elliott
2003-06-22	T16S, R5W, sec 01 SE¼ NE¼	38.69167º	97.81472º	Elliott
2003-06-22	T15S, R4W, sec 29 SE¼	38.71250º	97.78194º	Elliott
2003-06-22	T15S, R5W, sec 28 NE¼ NE¼	38.73444º	97.86889º	Elliott
2003-07-05	T16S, R5W, sec 21 NE¼	38.65000º	97.87389º	Elliott
2003-07-05	T16S, R5W, sec 14 NW¼ NW¼	38.66639º	97.84889º	Elliott
2003-07-05	T16S, R5W, sec 11 SW¼	38.67000º	97.84917º	Elliott
2003-07-05	T15S, R5W, sec 24 N½	38.74000º	97.83194º	Elliott
2003-07-06	T16S, R5W, sec 34 S½	38.61278º	97.85889º	Elliott
2003-07-06	T15S, R4W, sec 32 SE¼	38.69889º	97.78111º	Elliott
2003-07-27	T15S, R5W, sec 34 SW¼ NE¼	38.70417º	97.86833º	Elliott
2003-08-16	T15S, R5W, sec 15 NW¼	38.75389º	97.86528º	Elliott
2003-08-16	T15S, R4W, sec 32 SE¼	38.69889º	97.78111º	Elliott
2003-09-01	T15S, R4W, sec 17 NW¼ NW¼	38.75417º	97.78833º	Elliott
2003-09-19	T15S, R5W, sec 15 NW¼ NW¼	38.75389º	97.86528º	Elliott
2003-09-19	T15S, R5W, sec 34 SW¼ NE¼	38.70417º	97.86833º	Elliott
2003-09-27	T15S, R5W, sec 2	38.6930°	97.8498°	Loring
2004-06-24	T15S, R4W, sec 26	38.7319°	97.7902°	Loring
2004-08-25	T16S, R5W, sec 33	38.6153°	97.8726°	Loring
2004-08-30	T15S, R5W, sec 9, NW ¼ NW ¼	38.6824°	97.8861°	Loring
2004-08-31	T15S, R5W, sec 12, NW ¼ NW ¼	38.6806°	97.8320°	Loring
2004-08-31	T15S, R4W, sec 31, SW ¼ NW ¼	38.7047°	97.8138°	Loring
2004-09-01	T16S, R5W, sec 27, N ½	38.6385°	97.8600°	Loring
2004-09-06	T15S, R5W, sec22, S ½	38.7277°	97.8647°	Loring
2004-09-06	T15S, R5W, sec 27	38.7187°	97.8631°	Loring
2004-09-21	T15S, R5W, sec 14, SE ¼ SE ¼	38.7416°	97.8364°	Loring
2004-09-22	T15S, R5W, sec 17, N ½	38.7389°	97.9078°	Loring
2004-09-22	T16S, R5W, sec 9, N ½ NE ¼	38.6824°	97.8742°	Loring
2006-06-21	T16S, R5W, sec 22 SW ¼	38.64302º	97.86472º	Freeman
2006-06-22	T16S, R5W, sec 27 SE ¼	38.62640º	97.85568º	Freeman
2006-06-22	T15S, R5W, sec 17 NW ¼	38.75250º	97.79390º	Freeman
2006-07-15	T16S, R5W, sec 10 NW ¼ NW ¼	38.67869º	97.86705º	Freeman

2006-08-07	T15S, R4W, sec 18 NW ¼ NW ¼	38.7542º	97.8171º	Freeman
2006-08-08	T15S, R5W, sec 14 E ½	38.74882º	97.83649º	Freeman
2006-08-08	T15S, R5W, sec 16 N ½	38.74937º	97.88398º	Freeman
2006-08-08	T15S, R5W, sec 15 NE ¼	38.75138º	97.86159º	Freeman

3.3.2. Rare Vascular Plants

3.3.2.1. Federal-listed Species

The three federal-listed plant species documented in Kansas, *Asclepias meadii* (Mead's milkweed), *Platanthera praeclara* (western prairie fringed orchid), and *Trifolium stoloniferum* (running buffalo clover) are known from historic and extant populations in the central Flint Hills and areas eastward. Most populations are at sites east of the Flint Hills. No federal-listed plant species ever have been reported from Saline or McPherson counties, and with very low probability that any of these species occurs on the Smoky Hill ANGR, we elected not to carry out surveys specifically for these species.

3.3.2.2. State-rare Species

The Kansas Natural Heritage Inventory has assigned a rarity rank to each native vascular plant occurring in Kansas. Ranks estimate the rarity of each species based on the number of populations that are known in the state: S1 = critically imperiled in Kansas, 5 or fewer occurrences; S2 = imperiled in Kansas, 6—20 occurrences; S3 = rare in Kansas, 21—100 occurrences; S4 = apparently secure in Kansas, many occurrences; S5 = demonstrably secure in Kansas; SH = of historical occurrence in Kansas, not seen in >30 years; and SX = apparently extirpated in Kansas. The Kansas Natural Heritage Inventory tracks site-specific information for roughly 400 species ranked S1, S2, SH, or SX. These species are considered sufficiently rare to be tracked, although additional field work eventually will show that many S2-ranked species are indeed much more common than currently estimated.

Six of 22 state-rare (rank = S1 or S2) vascular plant species known from Saline County were documented by at least one occurrence each on or near Smoky Hill ANGR during this study (Table 3.2). Five of the six species were reported for the first time from Saline County during this study: *Eleocharis coloradoensis* (Britton) Gilly (Cyperaceae; Colorado spike-rush), *Eragrostis curtipedicillata* Buckley (Poaceae; gummy love grass), *Fimbristylis vahlii* (Lam.) Link (Cyperaceae; Vahl's fimbry), *Sagittaria ambigua* J. G. Sm. (Alismataceae; Kansas arrowhead), and *Scrophularia lanceolata* Pursh (Scrophulariaceae; lance-leaf figwort). The sixth species, *Asclepias lanuginosa* Nutt., was known from one previous report. Three state-rare species occur in wetlands or in moist to wet soil around ponds, one species occurs on upland prairies, and one species occurs in wooded riparian habitats. A brief description of each state-rare species follows.

Asclepias lanuginosa (woolly milkweed) is an inconspicuous, perennial herb that occurs from Wisconsin west to North Dakota and south to Kansas. Plants grow on sandy to loamy tallgrass, mixed-grass, and sand prairies. Kansas populations are documented in 13 counties (Figure 3.3); plants have been seen only in Morris, Republic, and Saline counties in the past 30 years. Prior to this study, wooly milkweed had been found on the Kansas Regional Training Center Range, northeast of Smoky Hill ANGR (Winters and Charlton 2000). During this study, plants were discovered at two sites on Smoky Hill ANGR. Because of the rarity of plants at these two sites, it is not known if these occurrences represent reproductively viable populations.

VOUCHERS: Kansas. Saline Co., T15S R04W sec 31, SW ¼. 38.7021ºN, 97.8082ºW. Elev. 1420—1470 ft. Brookville, 4.5 mi S, 2.5 mi E. Smoky Hill ANGR. Rolling, upland, tallgrass prairie on ridge near headwaters of unnamed tributary to Ralston Creek. Sandy, soil over sandstone bedrock. Rare; 1 genet with 4 ramets, 1 with an inflorescence. Growing near top of ridge in well drained site. 20 May 2003. *C. C. Freeman & J. Elliott 19771* (KANU); Saline Co., T16S, R05W, sec 3, SE ¼, SW ¼. 38.68389ºN, 97.86322ºW. Elev. 1450 ft. Brookville, 6 mi S. Smoky Hill ANGR. N side of Falun Rd. 16 May 2005. *A. Powel & B. Busby s.n.* (KANU).

TABLE 3.2. State-rare Kansas plants documented in Saline County (Status = s) or on Smoky Hill ANGR (Status = r). Named hybrids are excluded from the list.

Family	Scientific Name	Common Name	Status	S-Rank	CoC
Asclepiadaceae	Asclepias lanuginosa Nutt.	woolly milkweed	r	S1	9
Asteraceae	Plectocephalus americanus (Nutt.) D. Don	American basket-flower	s	S1	3
Cyperaceae	Schoenoplectus heterochaetus (Chase) Soják	slender twine-bulrush	s	S1	6
Isoetaceae	Isoetes melanopoda J. Gay & Durieu	black-foot quillwort	s	S1	8
Poaceae	Aristida desmantha Trin. & Rupr.	curly threeawn	s	S1	6
Poaceae	Panicum hillmanii Chase	Hillman's panicum	s	S1	5
Rosaceae	Rosa blanda Aiton	smooth rose	s	S1	6
Rosaceae	Rubus mollior L.H. Bailey	soft blackberry	s	S1	4
Zygophyllaceae	Kallstroemia parviflora Norton	warty caltrop	s	S1	1
Alismataceae	Sagittaria ambigua J.G. Sm.	Kansas arrowhead	r	S2	8
Asteraceae	Artemisia campestris L. subsp. caudata (Michx.) H.M. Hall & Clem.	western sagewort	s	S2	5
Asteraceae	Artemisia dracunculus L.	silky wormwood	s	S2	4
Cyperaceae	Eleocharis coloradoensis (Britton) Gilly	Colorado spike-rush	r	S2	4
Cyperaceae	Fimbristylis vahlii (Lam.) Link	Vahl's fimbry	r	S2	5
Elatinaceae	Bergia texana (Hook.) Seub. ex Walp.	Texas bergia	s	S2	2
Lythraceae	Didiplis diandra (Nutt. ex DC.) A.W. Wood	common water-purslane	s	S2	7
Nyctaginaceae	Mirabilis carletonii (Heimerl ex Standl.) Standl.	Carleton's four-o'clock	s	S2	7
Plantaginaceae	Plantago elongata Pursh subsp. elongata	slender plantain	s	S2	3
Poaceae	Eragrostis curtipedicellata Buckley	gummy love grass	r	S2	3
Rosaceae	Rubus hancinianus L.H. Bailey	Hancin's dewberry	s	S2	4
Scrophulariaceae	Gratiola neglecta Torr.	common hedge-hyssop	s	S2	4
Scrophulariaceae	Scrophularia lanceolata Pursh	lance-leaf figwort	r	S2	5

Eleocharis coloradoensis (Colorado spike-rush) is a diminutive, rhizomatous, perennial spike-rush that occurs sporadically across the southeast, central, and western U.S. Populations occur from Manitoba west to Oregon, and south Alabama, Texas, and California. Plants usually occur at the edges of fresh or brackish lakes and ponds, in stream beds, and in tidal wetlands. Twelve Kansas populations are documented in as many counties (Figure 3.3). A single population on Smoky Hill ANGR co-occurs with *Fimbristylis vahlii* (Lam.) Link, another state-rare wetland species. This is the first report for the county. Because if its size and superficial similarity to the more common *Eleocharis acicularis* (L.) Roem. & Schult. (needle spike-rush), other Kansas populations of Colorado spike-rush likely have been overlooked.

VOUCHER: Kansas. Saline Co., T15S R04W sec 32, SE ¼. 38º41'56"N, 97º46'52"W. Elev. ca 1530 ft. Brookville, 5 mi S, 5 mi E. Smoky Hill ANGR. Along banks of pond, heavy silt, moist-marshy, not grazed. Scattered. 6 July 2003. *J. Elliott 1762* (KANU).

Eragrostis curtipedicillata (gummy love grass) is a caespitose, perennial grass of central North America, occurring from south-central Missouri west to southeast Colorado, and south to Louisiana, northern Mexico, and eastern New Mexico. Plants often are found in disturbed grasslands, along fields and roadsides, and at the margins of woods. The species is known in Kansas from 16 sites in 10 counties; most reports are from the Red Hills (Figure 3.3). A single population was discovered in 2004 on grazed prairie on private land just west the Smoky Hill ANGR, the northern-most population documented in Kansas and the first from Saline County.

VOUCHER: Kansas. Saline Co., T15S, R05W, sec 32, N ½. 38.70934ºN, 97.90108ºW. Elev. 457 m. Rolling Hills Ranch, west of Smoky Hill ANGR. Grazed, upland prairie. 14 October 2004. *H. Loring s.n.* (KANU).

Fimbristylis vahlii (Vahl's fimbry) is a short, annual sedge found primarily in the southeastern U.S., occurring northward to Illinois and Nebraska and with disjunct populations in Arizona and California. It also occurs in Central and South America. In Kansas it is known from 15 sites (2 of these historical) in 11 counties, mostly in the southeast sixth of the state (Figure 3.3). Plants grow mostly along moist, sandy margins of reservoirs, ponds, and lakes. A small population was discovered on Smoky Hill ANGR in 2003, the northern-most population in the state and the first from the county. It co-occurs with *Eleocharis coloradoensis* (Britton) Gilly, another state-rare wetland species.

VOUCHERS: Kansas. Saline Co., T15S R04W sec 32, SE ¼. 38º41'56"N, 97º46'52"W. Elev. ca 1530 ft. Brookville, 5 mi S, 5 mi E. Smoky Hill ANGR. Along banks of pond, heavy silt, moist-marshy, not grazed. Locally abundant. Scattered along E and N side of pond. 6 July 2003. *J. Elliott 1762* (KANU); 16 August 2003. *J. Elliott 1833* (KANU).

Sagittaria ambigua (Kansas arrowhead), a perennial, aquatic herb known only from Arkansas, Kansas, Missouri, and Oklahoma in the central U.S. Plants typically occur in natural and man-made wetlands and around edges of ponds. Eight populations in seven Kansas counties have been documented (Figure 3.3). A population discovered on Smoky Hill ANGR is the first from Saline County and is disjunct from other southeastern Kansas populations by nearly 160 km.

VOUCHERS: Kansas. Saline Co., T16S R05W sec 27, NE ¼. 38°37'43"N, 97°51'44"W. Elev. 1520—1550 ft. Brookville, 9.5 mi S, 0.5 mi E. Smoky Hill ANGR. Upland rolling prairie, grazed, shallow sandstone soil. Scattered. Single population, ca 100 plants in shallow prairie slough. 29 May 2003. *J. Elliott 1569* (KANU); 22 June 2003. *J. Elliott 1668* (KANU).

Scrophularia lanceolata (lance-leaf figwort) is a widespread perennial herb in North America, occurring from Quebec west to British Columbia, and south to South Carolina, Oklahoma, New Mexico, and California. Plants grow along streams, in thickets, and in moist sites in prairies and woodlands. The species is known in Kansas from five populations in five counties in the Smoky Hills (Figure 3.3). A small population was discovered on Smoky Hill ANGR in 2003, the first report from the county. Other populations may be expected on or near the installation.

VOUCHER: Kansas. Saline Co., T15S R04W sec 29, NW ¼, SW ¼. 38°42'48"N, 97°47'47"W. Elev. ca 1500 ft. Brookville, 3.5 mi S, 4 mi E. Smoky Hill ANGR. Common. Upland prairie and sandstone outcrop. Disturbed area on and around Soldiers Cap Mound. 21 May 2003. *J. Elliott 1519* (KANU).

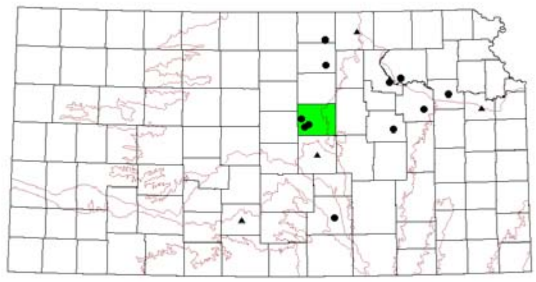
3.3.3. Floristic Surveys

All taxa documented by voucher specimens at KANU as occurring in Saline County are listed in Appendix B. Taxa are arranged alphabetically by family, genus, species, subspecies, and variety, respectively. Nomenclature follows that used in the KANU CIMS. Included are data about the rarity, conservatism, wetland status, alien status, longevity, and habit (life form) of each species.

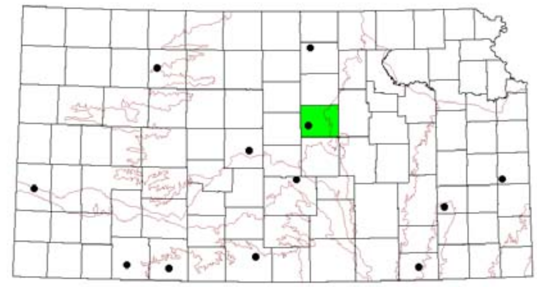
Vouchers at KANU provide evidence for 85 families, 331 genera, and 619 taxa (609 species) of vascular plants in Saline County (Appendix B). Of this number, 76 families (89%), 262 genera (79%), and 415 taxa (412 species) (67% and 68%, respectively) have been documented on Smoky Hill ANGR (Appendix B).

The 10 most species-rich families (Table 3.3) include 60% and 62% of the taxa known in the county and on the installation, respectively. Typical of grassland-dominated sites in the Great Plains, the Asteraceae, Poaceae, Fabaceae, and Cyperaceae collectively make up more than 40% of the species in the county and on the installation.

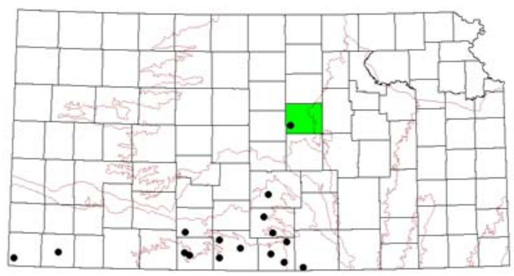
Provenance. Based on provenance data presented in Appendix B, the percentage of native taxa reported for Saline County and the installation are 82% and 84%, respectively (Table 3.4). Percentages of introduced taxa (18% and 16% for the county and installation, respectively) are in line with numbers reported for other intensively studied sites in the state (e.g., Freeman et al. 1997).



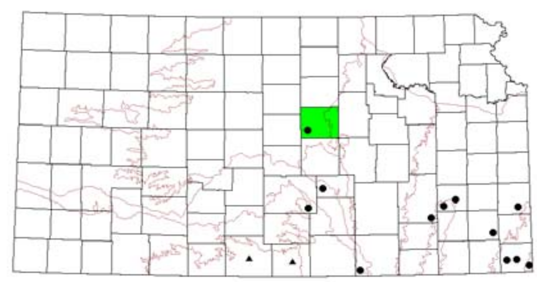
A. Asclepias lanuginosa



B. Eleocharis coloradoensis

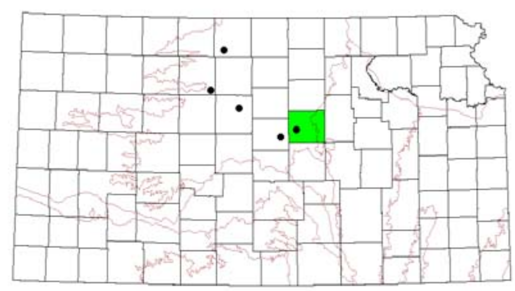


C. Eragrostis curtipedicellata



D. Fimbristylis vahlii

E. Sagittaria ambigua



F. Scrophularia lanceolata

FIGURE 3.3. Kansas distribution of six state-rare plant species documented on or near Smoky Hill ANGR. Solid lines are county boundaries; dotted lines are physiographic province boundaries. Dots indicate locations of populations known precisely. Triangles indicate locations of populations known only with county-level precision. Shaded polygon is Saline County.

TABLE 3.3. Number of taxa and cumulative percentage of the 10 most species-rich vascular plant families known from Saline County and on Smoky Hill ANGR. Cumulative % =

cumulative percent of taxa relative to totals reported for county (619) and Smoky Hill ANGR (415).

Family	Saline County	Cumulative %	SHANGR	Cumulative %
Asteraceae	93	15	65	16
Poaceae	92	30	61	30
Fabaceae	44	37	32	38
Cyperaceae	39	43	28	45
Brassicaceae	23	47	13	48
Scrophulariaceae	21	50	11	52
Euphorbiaceae	19	53	15	55
Polygonaceae	15	56	9	58
Lamiaceae	14	58	10	60
Asclepiadaceae	14	60	9	62

TABLE 3.4. Number and cumulative percentage of native and introduced taxa in Saline County and on Smoky Hill ANGR. Cumulative % = cumulative percent of taxa relative to totals reported for Saline County (619) and Smoky Hill ANGR (415).

Provenance	Saline County	Cumulative %	SHANGR	Cumulative %
Native	505	82	348	84
Introduced	114	100	67	100

The alien status and invasiveness of each species appears in the "Alien Status" column in Appendix B. Ranks are as follows: 0 = native; 1 = casual alien (includes persisting and non-persisting casual aliens); 2 = non-invasive, naturalized, 3 = invasive, non-transformer (rarely capable of causing major ecological changes in plant communities if established); and 4 = invasive, transformer (capable of causing major ecological changes in plant communities if established). The distribution of ranks among introduced taxa documented in Saline County and on Smoky Hill ANGR is summarized in Figure 3.4.

Introduced taxa with a rank of 1, 2, or 3 rarely become serious weeds in Kansas; however, under some circumstances, taxa with a rank of 3 can cause local management problems in native plant communities. These taxa make up 83% and 90% of all introduced taxa documented in Saline County and on Smoky Hill ANGR, respectively. By comparison, taxa with an alien status rank of 4 have the demonstrated capability of transforming native plant communities and should be considered as serious potential threats that, under appropriate conditions, can compromise community function if left unchecked. Ten such species were found on Smoky Hill ANGR: *Carduus nutans* L. (musk-thistle), *Convolvulus arvensis* L. (field bindweed), *Elaeagnus angustifolia* L. (Russian-olive), *Lespedeza cuneata* (Dum. Cours.) G. Don (sericea lespedeza), *Securigera varia* L. (common crown-vetch), *Bothriochloa bladhii* (Retz.) S. T. Blake (Caucasian bluestem), *Bromus inermis* L. (smooth brome), *B. japonicus* Thunb. (Japanese brome), *B.*

tectorum L. (downy brome), and *Rosa multiflora* Thunb. (multiflora rose). Three of the 12 species listed by the Kansas Department of Agriculture as noxious are included on this list: *Carduus nutans*, *Convolvulus arvensis*, and *Lespedeza cuneata*. *Rosa multiflora*, with a rank of 4, and *Cirsium vulgare* (Savi) Ten. (bull thistle), with a rank of 3, both occur on the installation and both are listed as county-option species by the Kansas Department of Agriculture. Neither of these species is listed as noxious by the Saline County Noxious Weed Department. *Rosa multiflora* appears to pose no serious management problems on the installation. *Cirsium vulgare*, on the other hand, often is locally abundant, especially in ravines, around livestock ponds, and in other sites where cattle frequently congregate, causing local soil disturbance and compaction and reducing native forb and grass cover. It often co-occurs with *Carduus nutans*, and when encountered, lessees often spray plants of both species in an effort to control them. Five species, *Convolvulus arvensis*, *Bothriochloa bladhii*, *Bromus inermis*, *B. japonicus*, and *B. tectorum*, are widespread on the installation; in places, they are local pests. However, at least on Smoky Hill ANGR, they probably do not represent immediate threats to native plant communities that are managed well and support healthy stands of native grasses and forbs. *Securigera varia* is rare on the installation, and populations could be easily eradicated. Managers keep a close watch for *Lespedeza cuneata*; the only occurrences on the installation appear to have been eradicated; no new occurrences were discovered during this study.

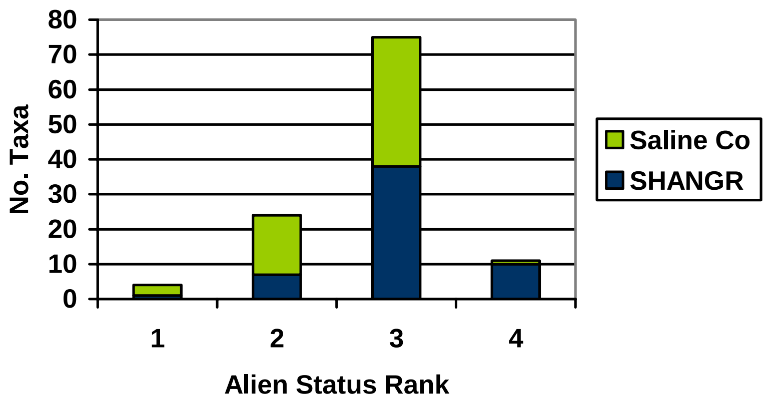


FIGURE 3.4. Distribution of alien status ranks among introduced vascular plant taxa in Saline County and on Smoky Hill ANGR. Data are summarized from Appendix B.

Longevity. Longevity data for vascular plants documented in Saline County and Smoky Hill ANGR are summarized in Table 3.5. Characteristic of sites dominated by grasslands with associated forested riparian habitats, herbaceous perennials make up a majority of the vascular plants (54% and 53% of all taxa in the county and on the installation, respectively). Annuals also are well represented (32% of taxa in the county and on the installation). Woody perennials (7% and 9% of all taxa in the county and on the installation, respectively) and other longevity classes contribute small numbers of species compared to herbaceous perennials and annuals.

TABLE 3.5. Number and cumulative percentage of annual, biennial, and perennial taxa in Saline County and on Smoky Hill ANGR. Cumulative % = cumulative percent of taxa relative to totals reported for county (619) and Smoky Hill ANGR (415).

Longevity	Saline County	Cumulative %	SHANGR	Cumulative %
Perennial herbaceous	332	54	217	53
Annual	196	85	131	84
Perennial woody	44	92	39	93
Biennial	16	93	9	95
Annual or biennial	14	96	8	97
Annual, biennial, or perennial herbaceous	7	97	4	98
Annual or perennial herbaceous	7	98	6	>99
Biennial or perennial herbaceous	3	100	1	100

Coefficients of Conservatism. Coefficients of conservatism express two basic ecological tenets: plants differ in their tolerance of the type, frequency, and amplitude of anthropogenic disturbance, and plants vary in their fidelity to remnant natural plant communities (Taft et al. 1997). As employed in floristic quality assessment, these two principles exhibit an inverse relationship: the lower a species' tolerance of human-mediated disturbance, the higher its likelihood of occurring only in a natural plant community. Low coefficient values (0—3) denote taxa often found in highly disturbed habitats and without a strong affinity for natural communities. High coefficient values (7—10) denote species that tolerate only limited disturbance and usually are found in natural communities. With these principles as a guide, the C value applied to each species represents a relative rank based on observed behavior and patterns of occurrence in Kansas natural communities. Non-native species are not assigned coefficients because they were not part of the pre-settlement landscape. They do have an effect on floristic quality assessment, however, and they may be incorporated in the assessment process.

Coefficients of conservatism for vascular plants documented in Saline County and Smoky Hill ANGR, summarized from Appendix B, are summarized in Figure 3.5. Of 619 taxa documented in the county, 120 (18%) do not have coefficients because they are non-native or named hybrids. As expected, most taxa have low coefficients, indicating a low level of fidelity with high quality habitats (and a tendency to occur in disturbed plant communities). Excluding the 120 taxa without coefficients, 71% have coefficients of 4 or less. Only seven taxa on Smoky Hill ANGR have coefficients of 8—10; these coefficients are indicative of highly conservative taxa.

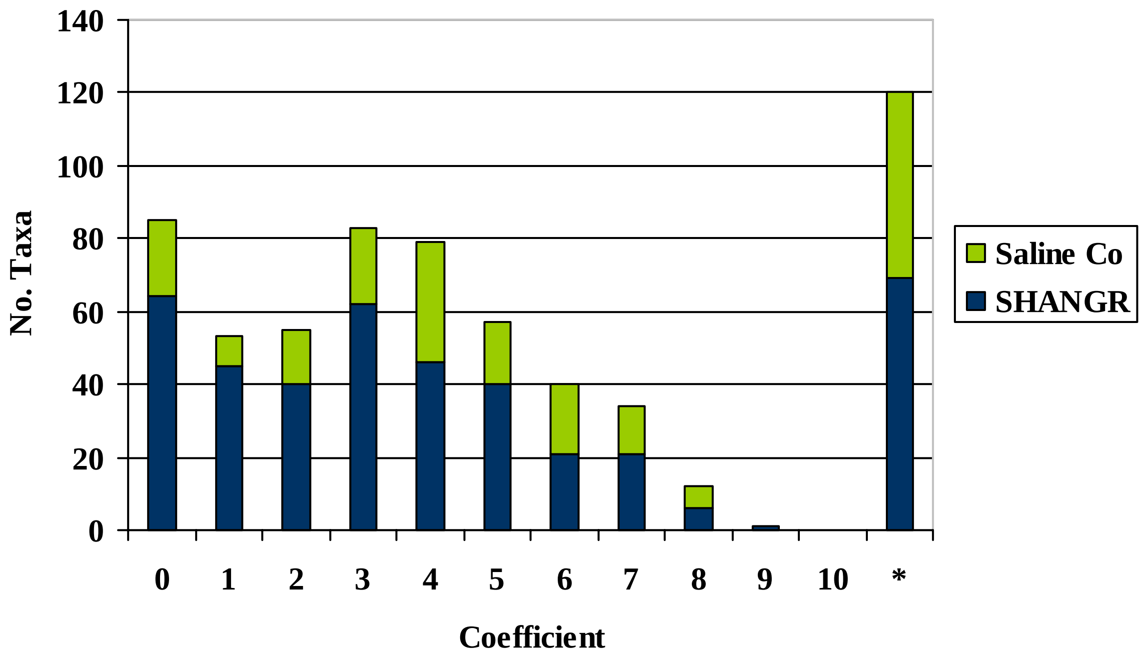


FIGURE 3.5. Distribution of coefficients of conservatism among vascular plant taxa documented in Saline County and on Smoky Hill ANGR. Data are summarized from Appendix B. The asterisk (*) indicates taxa for which coefficients are not assigned (non-natives or named hybrids) following standard floristic quality assessment procedures.

3.3.4. Weed Surveys

Background information about each of the three weed species targeted for surveys is summarized from Freeman et al. (2003) and Miller (2003). Control and management information about these and other potentially invasive weed species is presented in Appendix G.

Carduus nutans is native to Europe and was introduced into the U.S. in the 1850s. It is a biennial herb that grows to 2 m tall. Musk-thistle favors abandoned fields, overgrazed pastures, roadsides, and other sites where frequent disturbance exposes the soil. It can occur in native grassland but usually is restricted to areas of localized disturbance. It usually does not tolerate shading. Varying degrees of control have been achieved with chemical, biological, mechanical, and cultural methods. Many types of control are ineffective if carried out while thistles are in bloom. Fire has not been proven to be an effective control measure unless it ultimately increases the vigor of native, perennial grasses and forbs, thereby reducing the amount of suitable habitat.

Elaeagnus angustifolia is native to eastern Europe and western Asia. It is a usually thorny shrub or tree that can grow to 10 m tall. Russian-olive was introduced into the U.S. in the late 1800s as an ornamental. Until recently, it has been recommended for wildlife plantings and windbreaks. Russian-olive fixes nitrogen in its roots, which gives it a competitive advantage over other species on bare, mineral substrates. It can out-compete native vegetation, interfere with natural plant succession and nutrient cycling, and cause groundwater depletion. Its abundant, drupe-like fruits are consumed by birds, which spread the seeds. Plants also spread vegetatively by suckers and root shoots, making eradication difficult. Widely grown in Kansas, naturalized plants are found most frequently west of the Flint Hills, especially in riparian corridors. Cutting of stems, followed by application of systemic herbicides to stumps, is the most effective control procedure.

Lespedeza cuneata is native to eastern Asia. It is a perennial legume with slightly woody stems that can grow to 1.5 m tall. It was introduced into many parts of the U.S. for erosion control and as food and cover for wildlife. Compared to native grassland species, sericea lespedeza is unpalatable to livestock because of the high concentration of tannins in its tissues. Seeds are dispersed in the fall, may be spread by birds, and can remain viable for over 20 years. It is found extensively along roadsides but also can invade other sites, including thickets, fields, meadows, prairies, and woodlands. It is very drought hardy. Burning, grazing, and fertilization can provide some control on rangeland. Late spring burns on non-rangeland have achieved some success. Sericea lespedeza can become highly invasive, forming dense populations that diminish native biodiversity or impede efforts at ecosystem restoration; it is particularly problematic in rangeland in the southern Flint Hills of Kansas. The species is a serious threat to prairie and woodland communities.

Twenty-nine of 51 management units on Smoky Hill ANGR (units on the Kansas Region Training Center Range excluded) were surveyed for target weed species (Table 3.6). Part of Management Unit 25 also was surveyed. Survey dates are dates when surveys of unit were completed if surveys took place on two or more days. Number of hectares of each species was estimated in a GIS from polygons digitized from field maps.

TABLE 3.6. Management units in which *Carduus nutans*, *Elaeagnus angustifolia*, and *Lespedeza cuneata* were documented, and total area infested (acres). Area figures exclude populations recorded as points; a plus (+) signifies a unit in which occurrences of a species were recorded only as points. The asterisk (*) by Management Unit 25 indicates that only part of the unit was surveyed.

Management Unit	**Survey Date**	**Acres**		
		Carduus nutans	***Elaeagnus angustifolia***	***Lespedeza cuneata***
11	2006-08-08	0	+	0
12	2006-08-08	3.28	18.07	0
13	2006-08-08	0.67	0.38	0
14	not surveyed	-	-	-
15	2006-07-15	10.69	3.67	0
16	2006-06-23	2.25	0.74	0
21	2006-06-22	8.42	0.26	0
22	not surveyed	-	-	-
23	not surveyed	-	-	-
24	not surveyed	-	-	-
25*	2006-07-15	0	3.82	-
26	not surveyed	-	-	-

31	not surveyed	-	-	-
32	not surveyed	-	-	-
33	not surveyed	-	-	-
34	not surveyed	-	-	-
35	not surveyed	-	-	-
36	2006-07-15	3.58	2.35	0
41	not surveyed	-	-	-
42	not surveyed	-	-	-
43	not surveyed	-	-	-
44	not surveyed	-	-	-
45	2006-06-29	1.03	2.98	0
46	2006-06-29	1.35	0.17	0
47	not surveyed	-	-	-
52	2006-07-15	0	0.94	0
53	not surveyed	-	-	-
54	not surveyed	-	-	-
55	not surveyed	-	-	-
56	not surveyed	-	-	-
61	2006-07-14	5.92	0	0
62	2006-07-15	+	0	0
63	not surveyed	-	-	-
64	2006-07-23	+	0	0
65	not surveyed	-	-	0
71	2006-06-23	51.76	+	0
72	2006-06-15	119.87	0	0
73	2006-06-22	2.24	+	0
74	2006-07-22	0.35	22.37	0
75	2006-07-23	0.49	+	0
81	2006-06-23	30.47	0	0
82	2006-06-21	42.81	0.49	0
83	2006-06-22	18.59	+	0
84	2006-07-22	3.07	0.69	0
91	2006-06-22	3.81	3.81	0
92	2006-06-22	59.89	3.96	0
93	2006-06-22	1.12	1.52	0
101	2006-06-28	34.54	4.76	0
102	2006-06-28	12.41	16.88	0
111	2006-06-28	0	0	0
112	2006-06-28	0	0	0
Total		418.61	87.86	0

Carduus nutans was recorded in 23 of 30 management units that were surveyed; it infested an estimated 418.61 acres (Table 3.6, Figure 3.6). Canopy cover for all polygons was 1–10%. Populations were observed in prairies, former cropland, and in cultural vegetation types, but in nearly all cases they comprised scattered individuals in habitats exposed to recent disturbance, most often from grazing. Patches of exposed soil often were present where populations occurred. A quantitative comparison of 2001 and 2006 survey data could not be attempted because of differences in survey and mapping procedures. A qualitative comparison of maps for those two years does suggest roughly similar distribution patterns of *Carduus nutans* on the installation.

The 2006 survey data indicate that low-density populations were fairly common in management units containing the upper reaches of Spring Creek. By comparison, *Carduus nutans* occurs most often as isolated individuals along the upper reaches of Ralston Creek, east of Spring Creek. In units in the north half of Smoky Hill ANGR, most occurrences of *Carduus nutans* were small, often consisting of a few isolated individuals. Surveys indicate that the species occurs most frequently along streams and in mesic habitats in grazed pastures. Weed surveys were not conducted in the central part of the installation, so it is impossible to estimate the extent or significance of populations there.

A second, non-native, biennial thistle, *Cirsium vulgare* (Savi) Ten. (bull thistle), frequently occurred in the same habitats as *Carduus nutans*, often in mixed populations with that species. Installation managers have attempted to control these species using aerial spraying. Based on survey data, this approach seems excessive and indiscriminant, potentially reducing native broadleaf cover at the expense of thistles. Various control options exist, including mechanical, chemical, and biological. The approach employed should be dictated by the severity and location of the infestation, and based on the resources available for control. Experience suggests that management practices that promote healthy native vegetation, especially good graminoid cover, probably will lead to competitive exclusion of these two species, as well as other weedy annuals and perennials. *Carduus nutans* likely will remain a nuisance primarily in areas where perennial vegetation is damaged or destroyed and where the soil has been exposed.

Elaeagnus angustifolia was recorded in 23 of 30 management units surveyed and infested an estimated 87.86 acres (Table 3.6, Figure 3.7). Most occurrences consisted of a few scattered individuals, usually in riparian corridors and sheltered draws. In very few areas did the trees grow sufficiently close to form a continuous overstory canopy, and all but one of the polygons had a cover of 1–10%. Not infrequently on the installation, isolated individuals were found on grazed, upland prairies. We were unable to complete surveys in several units along the northwest edge of the installation (Units 31, 41, 51) where several large populations could be seen along tributaries to Castle Creek.

Survey data from this study suggest that *Elaeagnus angustifolia* is not a serious pest on Smoky Hill ANGR. However, some populations in riparian habitats are large enough to have degraded native biodiversity. Left unchecked, these populations likely will continue to expand. *Elaeagnus angustifolia* probably can be controlled with a modest investment of energy and resources. A combination of mechanical and chemical controls usually is effective, involving cutting trees just above the ground and treating the stump with appropriate herbicides to kill roots and suckers.

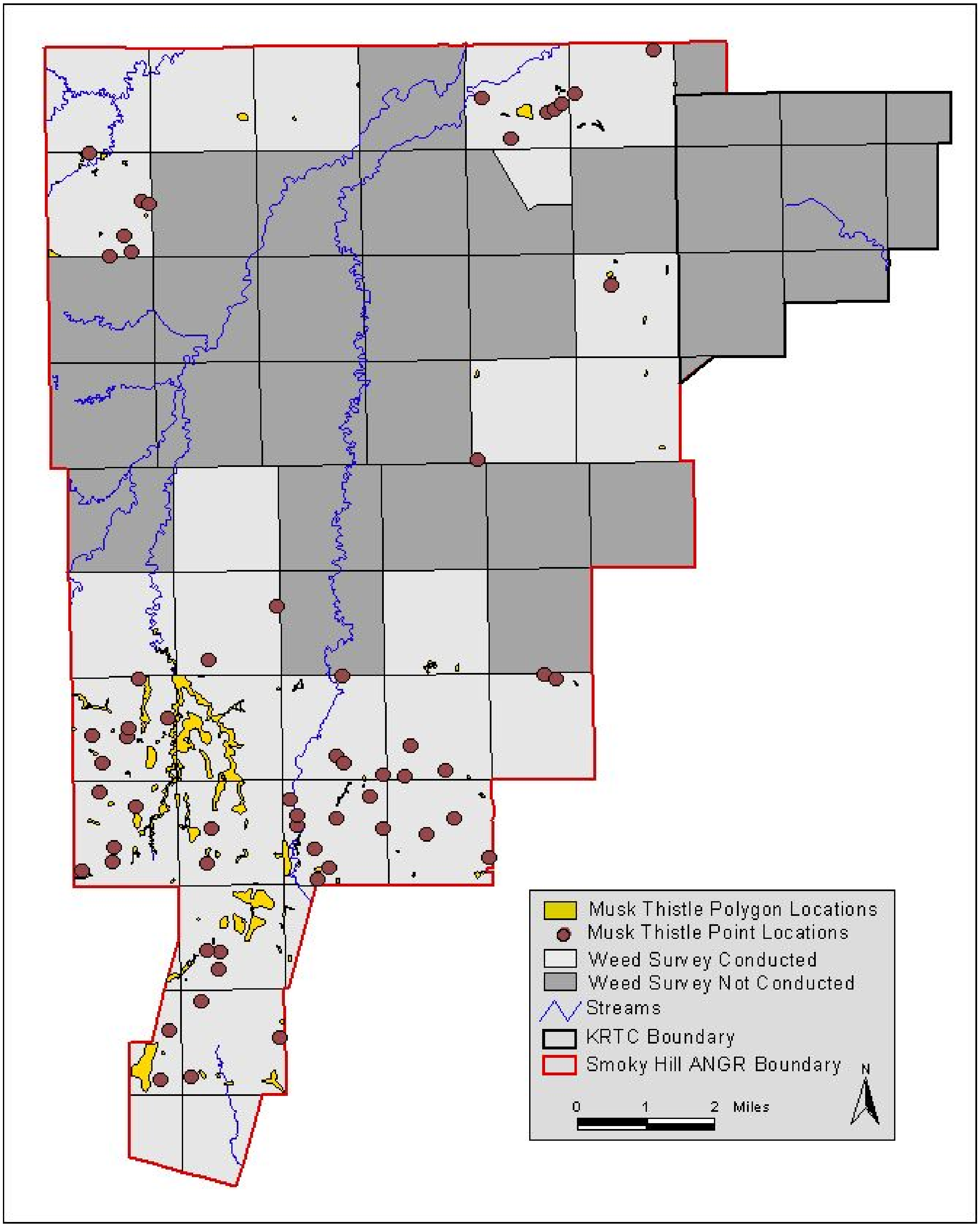


FIGURE 3.6. Populations of *Carduus nutans* documented on Smoky Hill ANGR in 2006.

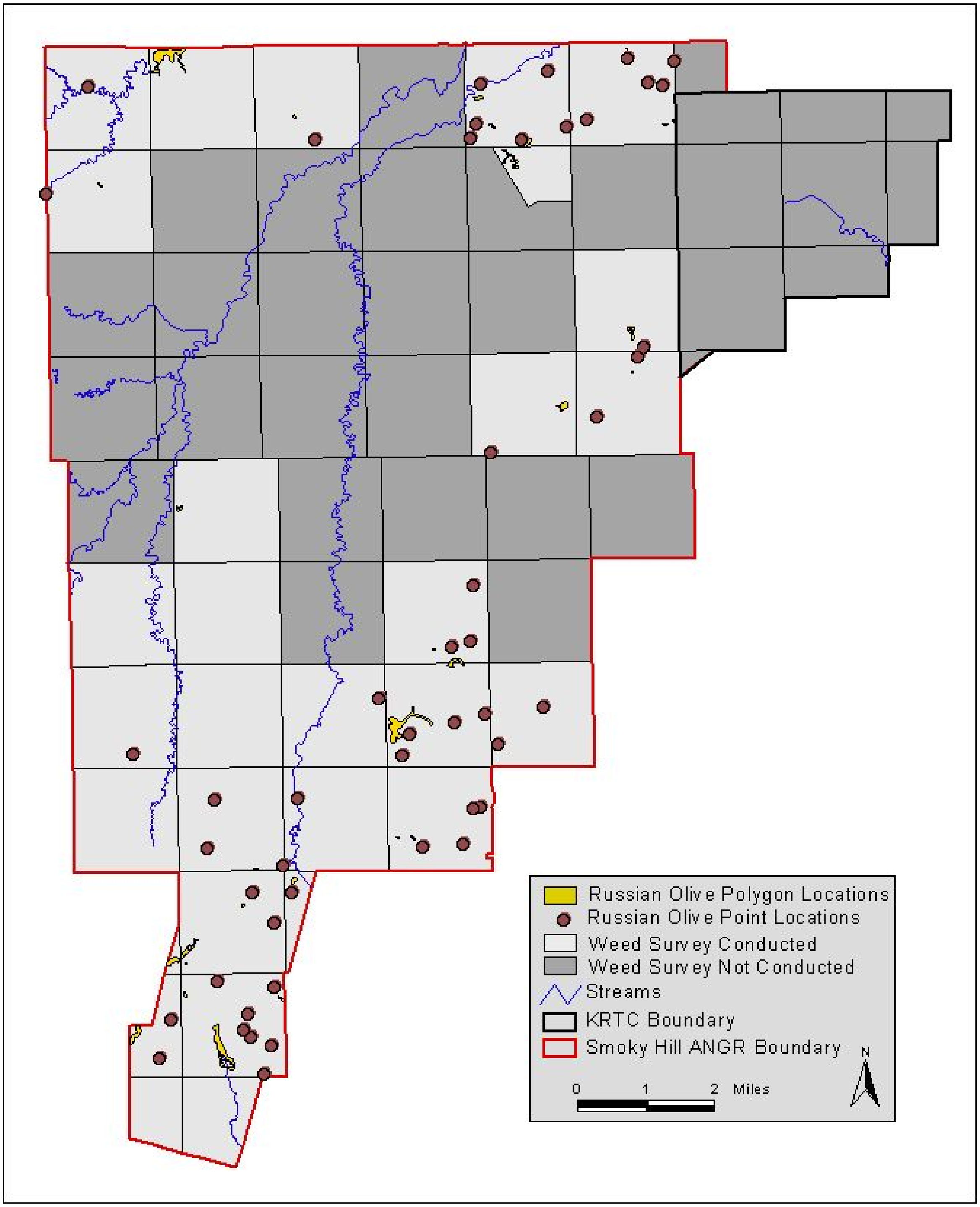


FIGURE 3.7. Populations of *Elaeagnus angustifolia* documented on Smoky Hill ANGR in 2006.

Lespedeza cuneata was not recorded in any of the management units (Table 3.6). The only report of this aggressive, pernicious weed is from the far south end of the installation, where two populations were discovered. Management staff took quick, aggressive action to eradicate the population. Fortunately, no new populations were discovered in the units surveyed in 2006.

3.4. CONCLUSIONS

Plant surveys on the installation have not revealed any great surprises. Terrestrial elements of the flora are generally what one would predict for a tallgrass-dominated site in the eastern Smoky Hills physiographic province. A dearth of riverine and aquatic habitats on the site probably limits mesophytic and aquatic elements of the flora.

Major surveys (involving >0.5 hr/site) of 79 sites involving an estimated 176 hours were carried out; dozens of other sites were checked briefly. Plant surveys were carried out in as many different habitats as possible to document as much of the flora as possible. Roughly 700 specimens of vascular plants were collected on or near the installation. Voucher specimens for all species documented on the installation have been deposited in the R. L. McGregor Herbarium at the University of Kansas.

Field surveys were not conducted specifically for populations of the federal-listed species *Asclepias meadii*, *Platanthera praeclara*, or *Trifolium stoloniferum*. Historic and extant populations of theses species in Kansas mostly are from east of the Flint Hills. However, other field activities during the 3-year study likely would have revealed plants had they been present. Six of 22 state-rare vascular plant species known from Saline County were documented by at least one occurrence each on or near Smoky Hill ANGR. Five of the six species were reported for the first time from Saline County: *Eleocharis coloradoensis* (Britton) Gilly (Cyperaceae; Colorado spike-rush), *Eragrostis curtipedicillata* Buckley (Poaceae; gummy love grass), *Fimbristylis vahlii* (Lam.) Link (Cyperaceae; Vahl's fimbry), *Sagittaria ambigua* J. G. Sm. (Alismataceae; Kansas arrowhead), and *Scrophularia lanceolata* Pursh (Scrophulariaceae; lance-leaf figwort). A sixth species, *Asclepias lanuginosa* Nutt., was known from a previous report on the Kansas Regional Training Center Range. Two small populations were discovered on Smoky Hill ANGR during this study. Three of the state-rare species occur in wetlands or in moist to wet soil around ponds, one species occurs on upland prairies, and one species occurs in wooded riparian habitats.

Floristic inventories documented 76 families, 262 genera, and 415 taxa (412 species) of vascular plants; this compares to 85 families, 331 genera, and 619 taxa (609 species) known from Saline County. The most species-rich families, Asteraceae, Poaceae, Fabaceae, and Cyperaceae, are what would be expected of a grassland-dominated site in the eastern Great Plains. Introduced taxa make up 16% of all documented taxa on the installation. Also characteristic of grassland-dominated sites, herbaceous perennials make up a majority of taxa, with annuals also well represented. Woody perennials contribute small numbers of species to the flora.

Field surveys were carried out to identify the locations and severity of infestations of *Carduus nutans* (musk-thistle), *Elaeagnus angustifolia* (Russian-olive), and *Lespedeza cuneata* (sericea lespedeza). *Carduus nutans* was recorded in 23 of 30 management units that were surveyed and occupied approximately 418.61 acres. Populations were found in prairies, former cropland, and in cultural vegetation types, but the largest were found along streams and in mesic habitats in grazed pastures, frequently in association with *Cirsium vulgare*. *Elaeagnus angustifolia* was recorded in 23 of 30 management units surveyed and infested an estimated 87.86 acres. Most occurrences consisted of scattered individuals in riparian corridors and sheltered draws. Survey data from this study suggest that *Elaeagnus angustifolia* is not a serious pest on Smoky Hill ANGR. However, some populations in riparian habitats are large enough to have degraded native biodiversity, and the species likely will continue to expand slowly if left unchecked. *Lespedeza cuneata* was not recorded in any of the management units.

Management practices that promote healthy, native, prairie and forest vegetation probably will lead to competitive exclusion of many weedy species that already are established on Smoky Hill ANGR, or will help at least to keep them in check. Such practices also will help prevent invasion by new weedy annual and perennial species. It some cases, it may be necessary to employ mechanical, chemical, or biological controls, or perhaps integrated strategies, to eradicate aggressive exotic species or to knock them back to levels where they can be controlled effectively by approaches that have fewer collateral impacts or that are less costly.

CHAPTER 4. ANIMAL SURVEYS

William H. Busby and Curtis J. Schmidt

4.1. INTRODUCTION

Zoological studies on Smoky Hill ANGR during the 2003—2006 field seasons were designed to fulfill five primary objectives: 1) compile a list of threatened, endangered, and rare species that might occur on the installation, 2) plan and conduct surveys for those species, 3) document all discoveries of threatened, endangered, and rare species and compile a report detailing all occurrences of these species, 4) conduct a comprehensive survey of terrestrial vertebrates (amphibians, reptiles, mammals, and birds) of the installation, and 5) conduct a study assessing the effect of land management practices on the abundance of grassland breeding birds on Smoky Hill ANGR.

The fauna of the Kansas Region Training Center Range of the Kansas Army National Guard, located immediately east of the Smoky Hill ANGR, was studied from 1998—1999 (Charlton et al. 2000). During the two-year study, 25 mammal species, 121 bird species, 21 reptile species, 5 amphibian species, and several hundred insect taxa were documented on the Army National Guard area. As a part of this same study, Cully and Winter (2000) reported on habitat associations of birds of this area. Saline County records based on museum vouchers are available for mammals (Bee et al. 1981), birds (Thompson and Ely 1989, 1991), and reptiles and amphibians (Collins 1993, Taggart 2007).

Regulatory authority for threatened and endangered species in Kansas is held at the federal and state levels. The federal Endangered Species Act of 1973 is administered by the Fish and Wildlife Service of the U.S. Department of Interior. The Act provides federal protection for animals and plants listed as endangered or threatened. The Kansas Nongame and Endangered Species Conservation Act of 1975 (K.S.A. 32-501 through 32-510) is the state counterpart to the federal act. It places responsibility for identifying and undertaking conservation measures for threatened and endangered wildlife with the Kansas Department of Wildlife and Parks. The Kansas Department of Wildlife and Parks also maintains a list of Species in Need of Conservation (SINC), which are nongame species deemed to require conservation measures in attempt to keep the species from becoming a threatened or endangered species. SINC species do not have the level of statutory protection as species listed as threatened or endangered in Kansas. State-rare species, which have no legal protection in Kansas, are identified and tracked by the Kansas Natural Heritage Inventory, a program of the Kansas Biological Survey at the University of Kansas.

Animal surveys were conducted 2002—2006. Field activities varied from year to year. Rare species surveys were conducted over the entire 5-year period but most data were collected in 2002—2003. Mammal, reptile, and amphibian surveys were conducted largely in 2003. Data on bird species were gathered throughout the study period with most emphasis in 2002—2004. The study of the effect of habitat management on grassland breeding birds was conducted in 2005.

4.2. RARE AND ENDANGERED ANIMAL SPECIES

4.2.1. Methods

Survey methods for rare and endangered animals were tailored to each target species depending on appropriate field techniques and seasonal and daily activity patterns. Generally, surveys for rare and endangered birds, mammals, reptiles, and amphibians were conducted as part of the survey protocol for that vertebrate class. Rare and endangered mammal surveys, for example, were done as a component of the general mammal surveys in 2003 and relied on the techniques employed as a part of that effort.

For invertebrates, species-specific surveys were conducted. Regal Fritillary (*Speyeria idalia*) censuses were conducted in June 2005 along 300-m transects designed for the bird habitat study (see 4.4.1). Censuses were conducted by W. Busby and G. Pittman during suitable conditions (warm days with winds under 15 mph). All Regal Fritillary butterflies within 20 m of the transect line were recorded. Prairie Mole Cricket (*Gryllotalpa major*) surveys were conducted in 2002 and 2003 by listening for calling males in upland prairie. Calling conditions consist of relatively calm, rainless evenings in April and May, from sunset until dark with temperatures above 63º F. Driving surveys with periodic listening stops were conducted by W. Busby on several evenings in the central portion of Smoky Hill ANGR. No targeted surveys for American Burying Beetle (*Nicrophorus americanus*) were conducted in this study.

4.2.2. Results and Discussion

4.2.2.1. Federal-listed Species

Six federal-listed animal species, Eskimo Curlew, Least Tern, Piping Plover, Whooping Crane, Topeka Shiner, and American Burying Beetle, have current or historic ranges that include central Kansas and potentially occur on Smoky Hill ANGR (Table 4.1). The four birds in this group are migratory, and any occurrence of these species on Smoky Hill ANGR would be individuals passing through during spring or fall migration. None of these four bird species was documented during this study. All four species usually are associated with water bodies or wetlands, and given the scarcity of these habitats on the installation, the odds of any of these species spending more than a brief time is unlikely.

The two remaining federal-listed species, Topeka Shiner and American Burying Beetle, also were not found during this study, although targeted surveys were not conducted. An earlier survey conducted by the Kansas Biological Survey for these two animals was unsuccessful in documenting either species on Smoky Hill ANGR (Busby and Guarisco 2000).

Accounts of all six federal listed species listed in Table 4.1 are provided below, with comments on the potential for their occurrence on Smoky Hill ANGR.

Eskimo Curlew. The Eskimo Curlew is listed as an endangered species at the federal and state levels. This large shorebird formerly migrated in large numbers through Kansas en route from wintering grounds in South America to breeding sites in Canada. During migration through the

Great Plains, it is believed to have foraged for invertebrate prey primarily in upland prairie. However, market hunting, habitat loss, and perhaps other factors, led to a population collapse in the late 19th century. The species never recovered and is now extinct or nearly so. Despite the fact that Smoky Hill ANGR lies on the main historic migration route of the Eskimo Curlew, the chances of the species occurring on the base today are remote.

Least Tern. This diminutive tern is listed as an endangered species at the federal and state levels. The Least Tern typically nests in small colonies on beaches, salt flats, or other areas with bare substrates near water. Breeding sites in Kansas include Quivira National Wildlife Refuge, the Kansas River, and the Arkansas River in Wichita. During late spring and post-breeding, birds wander widely and have been reported at water bodies throughout Kansas. This species may occasionally pass through Smoky Hill ANGR, but due to limited aquatic habitat, would not be likely to remain.

Piping Plover. This small shorebird is listed as a threatened species at the federal and state levels. Like its larger relative the Killdeer, the Piping Plover forages in open habitats where it picks invertebrate prey from the soil surface. The Piping Plover was known only as a migrant in Kansas until birds were found nesting on the Kansas River in association with Least Tern colonies in the 1990s (Busby et al. 1997). During spring and late summer, this species frequents mud flats and shorelines throughout Kansas in small numbers. Frequent stopover sites include Cheyenne Bottoms Wildlife Area and Quivira National Wildlife Refuge. Smoky Hill ANGR is on the migration route of this species and could occur at pond edges in the base. However, the Piping Plover usually is found at larger water bodies and wetlands.

Whooping Crane. The federal- and state-listed Whooping Crane has a global population of less than 500 birds. Most birds winter on the Texas coast and migrate to breeding grounds in Canada. Their route takes them through central and western Kansas each year in spring and fall, and birds are observed most years at stopover sites such as Cheyenne Bottoms Wildlife Area and Quivira National Wildlife Refuge, both of which are within 50 miles of Smoky Hill ANGR. During migration seasons, which peak in October and April, Whooping Cranes travel in small family groups alone or with flocks of the slightly smaller Sandhill Crane. The potential for the Whooping Crane to occur on Smoky Hill ANGR is low due to limited habitat. However, the species will roost overnight on farm ponds on occasion.

Topeka Shiner. This small minnow is listed as endangered at the state and federal levels. Populations are found in small streams in six states in the central U.S., usually in prairie or areas of former prairie. Current Kansas populations are located mainly in the Flint Hills. Busby and Guarisco (2000) surveyed streams on Smoky Hill ANGR and did not find any Topeka Shiners. They described the habitat as marginal to unsuitable due to lack of perennial streams or springs, frequency of watershed ponds that alter stream hydrology and harbor predatory fish, and other factors.

American Burying Beetle. This large, colorful carrion beetle is listed as endangered at the federal and state levels. Historically, the species occurred widely in the eastern United States as far west as central Kansas and Nebraska. The species now is limited to a few areas, mostly along the western edge of it former range, including sites in Oklahoma, southeast Kansas, and Nebraska. Reasons for its decline are not well documented, and its habitat requirements are not well understood. Busby and Guarisco (2000) conducted trapping on Smoky Hill ANGR and did not find the species. Potential for occurrence on Smoky Hill ANGR is unknown, but trapping efforts for American Burying Beetle at many sites in Kansas in the past ten years have been unsuccessful, with the exception of a small area in the Chautauqua Hills in Wilson, Elk, and Montgomery counties.

TABLE 4.1. Species tracked by the Kansas Natural Heritage Inventory, including species protected by federal and/or state laws, potentially occurring on Smoky Hill ANGR.

Common Name	Scientific Name	Status[1]	S Rank[2]	SHANGR[3]
Mammals				
Eastern Spotted Skunk	*Spilogale putorius*	--, T	S1	No
Franklin's Ground Squirrel	*Spermophilus franklinii*	--, C	S2	No
Birds				
Bald Eagle	*Haliaeetus leucocephalus*	--, T	S2B,S4N	No
Black Tern	*Chlidonias niger*	--, C	S1B	No
Bobolink	*Dolichonyx oryzivorus*	--, C	SIB	No
Eskimo Curlew	*Numenius borealis*	LE, E	SH	No
Ferruginous Hawk	*Buteo regalis*	--, C	S2B,S4N	No
Golden Eagle	*Aquila chrysaetos*	--, C	SIB	No
Henslow's Sparrow	*Ammodramus henslowii*	--, C	S3B	Yes
Least Bittern	*Ixobrychus exilis*	----	S2B	Yes
Least Tern	*Sterna antillarum*	LE, E	S1B	No
Loggerhead Shrike	*Lanius ludovicianus*	----	S4B	Yes
Peregrine Falcon	*Falco peregrinus*	--, E	S1B,S3N	Yes
Piping Plover	*Charadrius melodus*	LT, T	S1B,S2N	No
Short-eared Owl	*Asio flammeus*	--, C	S2B,S3N	Yes
Whooping Crane	*Grus americanus*	LE, E	S1N	No
Yellow-crowned Night Heron	*Nyctanassa violacea*	----	S2B,S3N	No
Reptiles				
Texas Horned Lizard	*Phrynosoma cornutum*	----	S3S4	Yes
Eastern Hog-nosed Snake	*Heterodon platirhinos*	--, C	S5	No
Western Hog-nosed Snake	*Heterodon nasicus*	--, C	S4	Yes
Fish				
Topeka Shiner	*Notropis topeka*	LE, E	S2	No
Invertebrates				
American Burying Beetle	*Nicrophorus americanus*	LE, E	S1	No
Regal Fritillary	*Speyeria idalia*	----	S4	Yes
Prairie Mole Cricket	*Gryllotalpa major*	--, C	S3	No

[1] Status abbreviations (federal, then state) are as follows:
- LE = listed as endangered by the U.S. Fish & Wildlife Service
- LT = listed as threatened by the U.S. Fish & Wildlife Service
- C = species in need of conservation, listed by Kansas Dept. of Wildlife and Parks
- E = listed as endangered by the Kansas Dept. of Wildlife and Parks
- T = listed as threatened by the Kansas Dept. of Wildlife and Parks

[2] See section 4.2.2.2., paragraph 1, for an explanation of state ranks

[3] Recorded on Smoky Hill ANGR

4.2.2.2. State-listed and Rare Species

The Kansas Natural Heritage Inventory has assigned a rarity rank to each vertebrate and selected invertebrate species occurring in Kansas. Ranks estimate the rarity of each species based on the number of populations that are known in the state: S1 = critically imperiled in Kansas, 5 or fewer occurrences; S2 = imperiled in Kansas, 6—20 occurrences; S3 = rare in Kansas, 21—100 occurrences; S4 = apparently secure in Kansas, many occurrences; S5 = demonstrably secure in Kansas; SH = of historical occurrence in Kansas, not seen in >30 years; and SX = apparently extirpated in Kansas. Letters after the numbers refer to the seasonal status of migratory species (B = breeding season, and N = non-breeding season), and many migratory species have two-part ranks reflecting differing conservation status for the breeding and non-breeding season. The Kansas Natural Heritage Inventory tracks site-specific information for roughly 150 rare vertebrate and invertebrate animal species. This corresponds to species ranked S1, S2, SH, or SX, and in some cases where the species is of regional or rangewide conservation concern, S3 and S4.

Eight of 17 state-rare animal species (excluding federal-listed species addressed in 4.2.2.1.) potentially occurring in Saline County (Table 4.1) were documented on Smoky Hill ANGR during this study. The eight species include one Kansas threatened species, (Peregrine Falcon), three Kansas species in need of conservation (Henslow's Sparrow, Short-eared Owl, and Western Hog-nosed Snake), and four species without KDWP conservation designation (Loggerhead Shrike, Texas Horned Lizard, Least Bittern, and Regal Fritillary). A brief account of each of the 17 state-rare species follows:

Bald Eagle. (Kansas Threatened). The Bald Eagle was also listed as threatened at the federal level until June, 2007, when it was officially de-listed. Populations have been recovering from lows in the mid-20th century when pesticide poisoning, habitat destruction, and persecution led to a precipitous decline in populations in the coterminous United States. In Kansas, the Bald Eagle primarily occurs as a winter visitor from populations that breed in the northcentral U.S. and Canada. These birds concentrate at major reservoirs and large rivers where they feed largely on live and scavenged fish and waterfowl. It is not unusual for more than 100 eagles to occur at reservoirs such as Milford, Perry, and John Redmond. In addition, Kansas supports an expanding breeding population that currently stands at about 20 pair, most of which are located in eastern Kansas near large water bodies and rivers. The Bald Eagle no doubt visits Smoky Hill ANGR from time to time during the winter months and possibly during other seasons. However, unless pond levels were high and supporting large populations of waterfowl or fish, Bald Eagles would be unlikely to linger in the area.

Eastern Spotted Skunk (Kansas Threatened). Also known as the civet cat, this skunk formerly was common throughout Kansas in a wide variety of habitats where escape cover was present. Since the 1960s, the species has declined throughout the Great Plains and in Kansas recently has been documented only in the southeastern corner of the state. The Eastern Spotted Skunk was not found during this study and probably does not occur in the area.

Franklin's Ground Squirrel (Kansas Species in Need of Conservation). This medium-sized squirrel lives in colonies in grassland and shrubland in the tallgrass and mixed-grass prairie region of central North America. Formerly found as far south as central and east-central Kansas, the species is declining in the southern parts of its range; there are few recent records from Kansas. Historically, the closest record to Smoky Hill ANGR is from McPherson County. No evidence of Franklin's Ground Squirrel was found in this study. While suitable habitat is present, the range of the species probably no longer includes Kansas.

Black Tern (Kansas Species in Need of Conservation). The Black Tern migrates between wintering areas in the Pacific and freshwater breeding sites in the northern U.S. and Canada. In Kansas, the species is a regular migrant and infrequent and local breeder. It regularly is observed during migration at major wetlands and reservoirs and has occasionally nested at Cheyenne Bottoms Wildlife Area and Quivira National Wildlife Refuge. No Black Terns were observed during this study, although the species probably migrates through Smoky Hill ANGR during spring and fall.

Bobolink (Kansas Species in Need of Conservation). This grassland bird breeds in large numbers in the northern U.S. and Canada. In Kansas, small numbers of birds breed at Quivira National Wildlife Refuge and in extreme northeast Kansas, but primarily the Bobolink occurs as a migrant. No Bobolinks were detected in this study. Flocks of Bobolinks probably pass through Smoky Hill ANGR during spring and fall and should be watched for in early May when they may stop to forage and rest in grasslands and wheat and alfalfa fields.

Ferruginous Hawk (Kansas Species in Need of Conservation). This large relative of the Red-tailed Hawk inhabits open plains where it feeds primarily on small and medium-sized mammals. It breeds in the shortgrass prairie region of the Great Plains and in winter wanders as far east as central Kansas. It was not observed during this study, but occasional individuals may occur on Smoky Hill ANGR during the non-breeding season.

Golden Eagle (Kansas Species in Need of Conservation). An eagle of the buttes and canyons of the western U.S., the Golden Eagle breeds east out on to the Plains in areas where cliffs or tall trees provide nest sites, including a few locations in western Kansas. In winter this large raptor wanders widely in search of mammalian prey and carrion. No individuals were observed on Smoky Hill ANGR during this study. Golden Eagles are likely to occur on rare occasions during the non-breeding season.

Henslow's Sparrow (Kansas Species in Need of Conservation). Populations of this sparrow have declined sharply throughout its range in the central and eastern United States, and loss of habitat—grassland with tall, dense cover—is believed to be an important factor. Henslow's Sparrow occurs primarily in the tallgrass prairie region, and Smoky Hill ANGR is at the western edge of its range. This species was first documented on the area in 2000 on hay leases where hay had not been harvested in the previous season (Busby and Guarisco 2000). In this study, Henslow's Sparrow was documented in unburned portions of the Impact Area, and to a lesser degree, in lightly grazed pastures. Birds were not reported in all years of this study, and evidence suggests Henslow's Sparrow only attempts to breed in central Kansas in years when grass height and density is sufficient for good nesting habitat. This species was not observed in years with below- average grass growth. Observations during this study are shown in Table 4.2. Recommended conservation management practices for this species involve creating areas with a dense cover of native grasses and a thick litter layer. Areas that have not been disturbed by fire, grazing, or hay harvest the previous growing season generally are required for nesting, and areas that have been undisturbed for two or more years are preferred. Habitat should be located in large blocks of open grassland (80 acres or more) and away from trees.

TABLE 4.2. Locations and dates of Henslow's Sparrow observations on Smoky Hill ANGR.

Date	Notes	Latitude	Longitude
2005/06/06	Singing male just W of OPS pond	38.7073	-97.8568
2005/06/06	Two singing birds. Also 2005/06/19	38.6948	-97.8519
2005/06/06	Two singing birds. Also 2005/06/19	38.6895	-97.8513
2006/06/23	One singing bird	38.6671	-97.8718
2005/06/04	Transect G10. Also 2005/06/13	38.7313	-97.7924
2005/05/27	Transect G11	38.7220	-97.7972
2005/05/25	Transect U05	38.6848	-97.8560
2005/05/25	Transect U08	38.6916	-97.8503
2005/05/25	Transect U10	38.6960	-97.8469
2005/05/25	Transect U11	38.6955	-97.8551
2005/05/27	Transect U12. Also 2005/06/13	38.7075	-97.8269
2005/05/27	Transect U13. Also 2005/06/13	38.7031	-97.8266
2005/05/27	Transect U14	38.7179	-97.8129
2005/05/27	Transect U15. Also 2005/06/13	38.7031	-97.8612
2005/06/12	Transect G13	38.6772	-97.8192
2005/06/18	Transect U02	38.6788	-97.8661
2005/06/18	Transect U07	38.6882	-97.8559
2005/06/18	Transect U09	38.6916	-97.8561

Least Bittern. This small wading bird frequents dense cover in marshes and wetlands where it hunts for insects and small fish. The Least Bittern is a common breeding bird at central Kansas marshes such as Cheyenne Bottoms and Quivira National Wildlife Refuge, but because of its secretive habitats, it is observed infrequently. In this study, a Least Bittern was observed at OPS Pond (Latitude 38.7093N, Longitude –97.8517W) on 5 June 2003, and a pair was seen on 20 June 2003. It is likely that these birds bred at the site that year. In subsequent years, this pond failed to hold water and did not provide suitable Least Bittern habitat. Few other ponds at Smoky Hill ANGR provide sufficient habitat for this species, and it is likely that the Least Bittern is found on the area only on the rare occasions when one of the large ponds has high water levels and supports abundant cattail or bulrush.

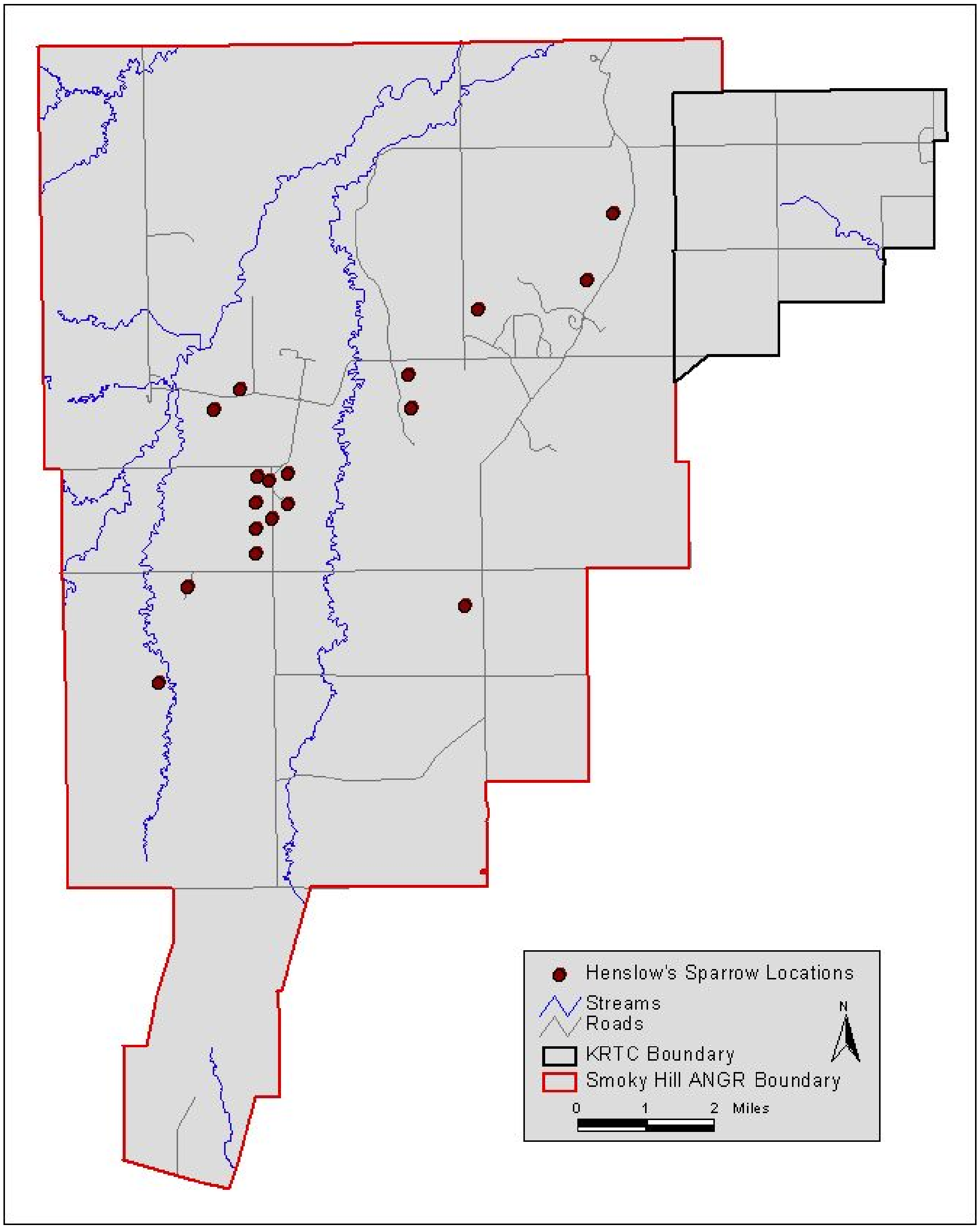


FIGURE 4.1. Locations of Henslow's Sparrow observations in this study. The concentration of records was in an unburned portion of the Impact Area south of OPS in 2005.

Loggerhead Shrike. This predatory songbird, also known as the butcherbird, migrates from wintering areas in the southern U.S. in late winter or early spring and begins nesting in March or April. The open nest is usually constructed in a small tree in open grassland. Widely distributed in North America, populations of Loggerhead Shrikes are declining in many areas for reasons that are not well documented. Threats on the wintering grounds are suspected. During this study, shrikes were found to be a widespread, low-density breeder. Shrike observations were recorded when encountered, but no attempt was made to conduct an exhaustive survey throughout Smoky Hill ANGR. The distribution of shrikes (Figure 4.2 and Table 4.3) suggests that territorial birds may occur at intervals of about 0.5 to 1 mile in suitable habitat. The frequency of records along roads is to some degree due to sampling bias because of more frequent survey of roadsides. However, shrikes prefer to forage from elevated perches in areas where vegetation is short or absent, and roadsides often have both perches (fences) and bare areas for foraging.

Recommended conservation management for Loggerhead Shrike involves maintaining open grassland with patches of short vegetation near elevated perches such as fences, powerlines, and isolated trees and shrubs. Such habitat is abundant at Smoky Hill ANG and no additional management beyond that currently employed is needed for this species.

TABLE 4.3. Geographic coordinates of Loggerhead Shrike observations on Smoky Hill ANGR.

Date	Notes	Latitude	Longitude
2004/09/15		38.7475	-97.8906
2004/05/27	On BBS route, stop 8	38.7477	-97.8738
2005/03/01	Singing male	38.7313	-97.8349
2005/03/01	Singing male	38.7319	-97.8180
2004/04/08	One bird	38.7134	-97.8720
2006/06/23	On BBS route, stop 19	38.6894	-97.8521
2004/04/07	One bird	38.6824	-97.8510
2006/06/23	On BBS route, stop 22	38.6687	-97.8501
2003/06/20	On BBS route, stop 24	38.6683	-97.8332
2006/06/15	Old shrike nest in small hedge tree. Two shrikes nearby.	38.6668	-97.8613
2006/06/15	Used shrike nest in small hedge tree	38.6670	-97.8639
2006/06/22	One shrike. Used nest	38.6547	-97.8341
2003/05/09	Nest with fledged birds. Also 2004/04/28	38.6808	-97.8117
2004/04/28	Also 2003/05/09	38.6897	-97.8133

Peregrine Falcon (Kansas Endangered Species). The Peregrine Falcon was until recently listed as a federal endangered species. Populations, decimated by organo-chlorine pesticides and other factors, have recovered since the 1970s. This large falcon nests on tall cliffs and buildings and feeds primarily on birds taken in flight. In Kansas, recent breeding records are known from several cities but not from natural sites. Migrant and wandering individuals are encountered statewide, most frequently at large wetlands that attract concentrations of birds. One Peregrine Falcon was observed during this study, a bird feeding on a Cattle Egret in a field northwest of the junction of Falun and Soderborg roads (latitude 38.6856N, longitude –97.8174W) on 8 May 2003. This observation occurred during the normal breeding season for this species (April-June) and probably represented a non-breeding bird that was passing through the area. No conservation management is recommended for Peregrine Falcon due to its infrequent occurrence and wide habitat tolerances.

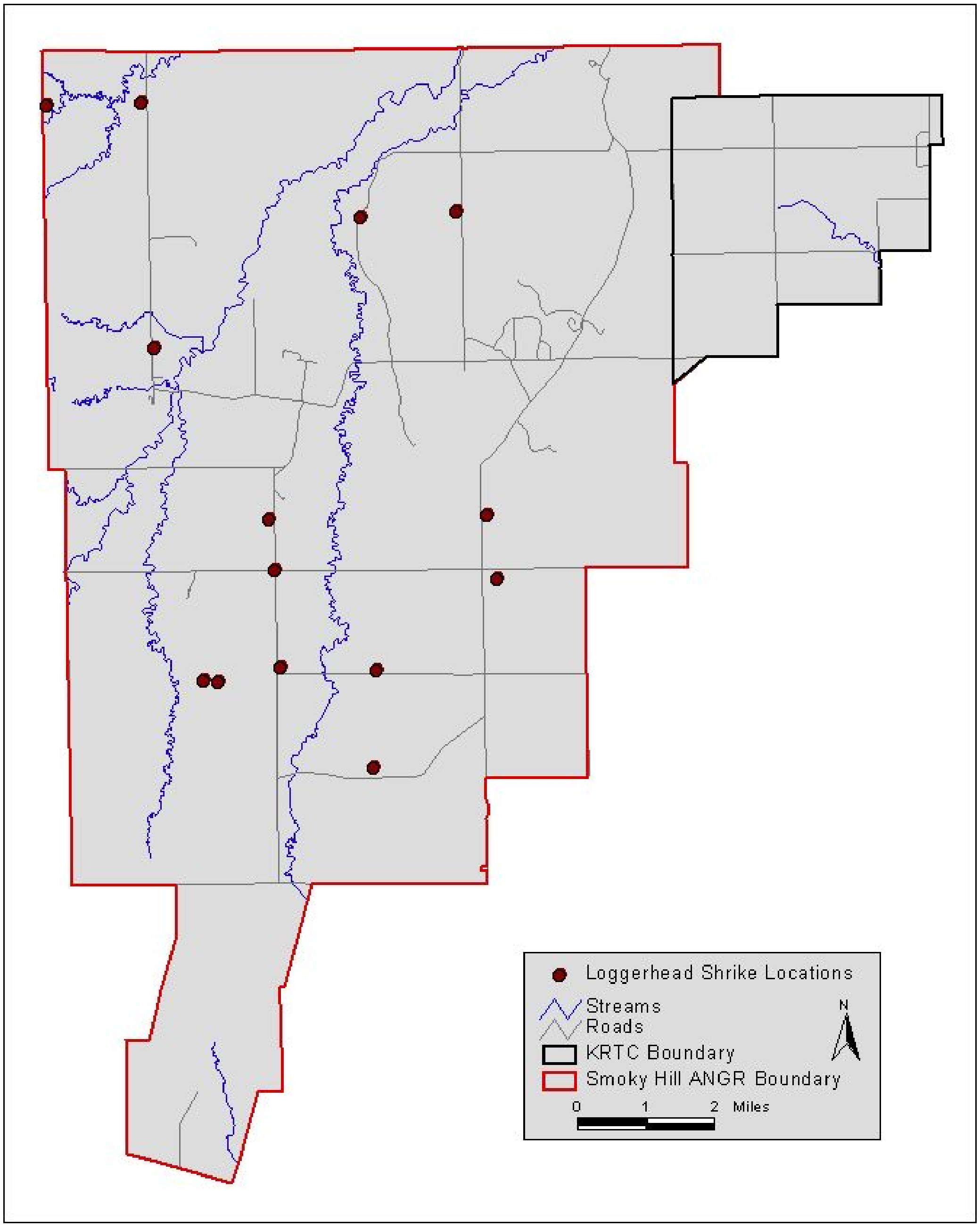


FIGURE 4.2. Locations of Loggerhead Shrike observations during this study.

Short-eared Owl (Kansas Species in Need of Conservation). This medium-sized owl inhabits open grasslands where it hunts on the wing for small mammals, much like the ecologically similar Northern Harrier. Its breeding range is mainly north of Kansas and most individuals in the state are migrants and winter residents. Short-eared Owls were reported by Kurt Keeler to be common on Smoky Hill ANGR during the winter of 2004, and about 30 were reported on 30 March 2004 near the installation by Kate Farres (and with smaller numbers reported on many other dates in late winter in other years). This species can be episodic in occurrence, being observed commonly in some years and not in others, perhaps as a function of small mammal population cycles.

Yellow-crowned Night Heron. This secretive heron nests in trees and cattails near ponds or wetlands in the eastern two-thirds of Kansas. Most nest records are from Cheyenne Bottoms Wildlife Area and in Wichita. No records of Yellow-crowned Night Heron were made during this study, and little suitable habitat exists on the area.

Texas Horned Lizard. This lizard feeds mostly on ants and inhabits grasslands and deserts from Mexico north to eastern Colorado and Kansas. Populations in eastern Texas have declined coincident with the invasion of the fire ant, an exotic species. On Smoky Hill ANGR, the Texas Horned Lizard was found to be one of the most common lizards during herpetological studies in 2003. Locations where the species was encountered are shown in Figure 4.3. Geographic coordinates for the locations are found in Table 4.4. This species was widely distributed on the installation in prairies, on roads, and at other sites with minimal cover, and was active throughout the study period. Animals were recorded from 30 May through 9 September in 2003.

Eastern Hog-nosed Snake (Kansas Species in Need of Conservation). This snake feeds mostly on toads and is widespread in the eastern U.S., particularly in riparian areas where food is plentiful. Populations in eastern Kansas appear to have declined greatly, but the species is persisting in parts of central Kansas. No Eastern Hog-nosed Snakes were observed in this study.

Western Hog-nosed Snake (Kansas Species in Need of Conservation). As its name implies, this snake is closely related to the Eastern Hog-nosed Snake and has a distribution in the western U.S. It is abundant in western Kansas in sandy floodplains and other habitats. This species was detected in this study. See species account in 4.3.1.3. for additional information.

TABLE 4.4. GIS coordinates (degree decimal) of Texas Horned Lizard observations in 2003.

Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
38.7103	-97.8584	38.7060	-97.8392	38.7153	-97.7958
38.7225	-97.8073	38.7477	-97.7916	38.7183	-97.7951
38.6638	-97.8356	38.7129	-97.7978	38.7181	-97.7975
38.7071	-97.8037	38.6823	-97.8256	38.7226	-97.7913
38.6837	-97.8340	38.6992	-97.8111	38.7207	-97.8041
38.7065	-97.8380	38.7031	-97.8467	38.7185	-97.8033
38.7278	-97.8647	38.6229	-97.8602	38.7335	-97.7866
38.7405	-97.7909	38.6388	-97.8709	38.7287	-97.8719
38.6647	-97.8109	38.6388	-97.8679	38.7347	-97.8724
38.7161	-97.7986	38.6387	-97.8400	38.7290	-97.8913
38.6265	-97.8603	38.6386	-97.8317	38.7232	-97.8912
38.7402	-97.7878	38.6386	-97.8240	38.7441	-97.7909
38.7498	-97.8545	38.6540	-97.8142	38.7517	-97.7921
38.7190	-97.7994	38.6676	-97.8172	38.7547	-97.7949
38.7403	-97.7878	38.6679	-97.8510	38.7547	-97.8196
38.7546	-97.7903	38.6853	-97.8511	38.7549	-97.8346
38.6989	-97.8474	38.6905	-97.8513	38.7549	-97.8380
38.7115	-97.8143	38.6986	-97.8006	38.7548	-97.8499
38.6823	-97.8154	38.7058	-97.8049	38.7549	-97.8782
38.7088	-97.8657	38.7079	-97.8024	38.7549	-97.8824
38.7289	-97.8677	38.7112	-97.8333	38.7550	-97.8879
38.6822	-97.8375	38.7112	-97.8305	38.7525	-97.8915
38.7113	-97.8364	38.7112	-97.8279	38.7114	-97.8005
38.7353	-97.7867	38.7114	-97.8074		
38.7209	-97.7924	38.7078	-97.8909		

Regal Fritillary. This large orange butterfly is a grassland specialist that feeds on violets in the larval stage. Regal Fritillary populations have declined rangewide and the species has disappeared from much of its eastern range. Remaining populations are found in the prairie regions of the central U.S.; the species largely is restricted to prairie habitats. On Smoky Hill ANGR, this butterfly was found widely distributed in low to moderate numbers in open grassland and grassy swales (Figure 4.4 and Table 4.5). It is adversely affected by fire (eggs and young are killed by fire) but will readily colonize post-burn habitat. To evaluate the species' response to habitat, Regal Fritillaries within 30 m of 300-m line transects were counted in four habitats (see 4.4.1 for additional information on habitats and transect locations). Sample sizes were small and variability high, so effects were not significant, but the trend was for mean abundance to be lower in burned, ungrazed sites than unburned grazed, hayed, and unburned and ungrazed sites (Figure 4.5). Conservation management for this species consists of managing for forb and wildflower diversity (particularly violets and nectar plants such as milkweeds, *Liatris*, thistles, *Echinacea*, and ironweed), and avoiding frequent use of fire.

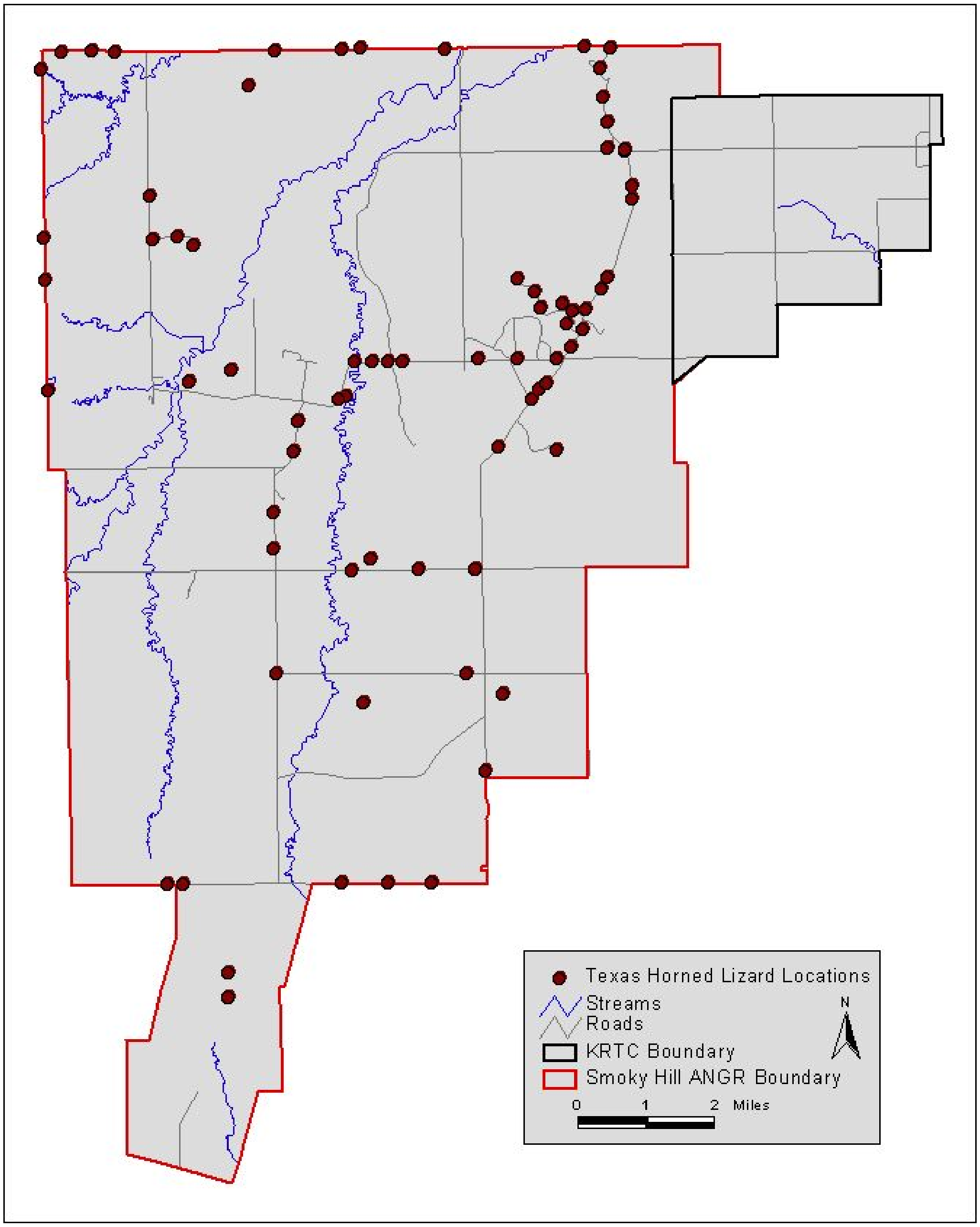


FIGURE 4.3. Locations of Texas Horned Lizard observations in 2003. Most locations were along roadways, which is a reflection of sampling method and not habitat preference.

TABLE 4.5. Locations and dates where Regal Fritillary butterflies were recorded in 2005. Transects refer to bird habitat transects (see 4.4.1).

Date	No. Observed	Transect	Latitude	Longitude
2005/06/25	1	B02	38.6784	-97.8266
2005/06/08	1	B09	38.7229	-97.8128
2005/06/18	1	G06	38.7443	-97.8045
2005/06/25	1	G09	38.7350	-97.7919
2005/06/25	1	G12	38.6941	-97.8100
2005/06/25	2	G13	38.6772	-97.8192
2005/06/25	1	G14	38.6770	-97.8101
2005/06/25	2	H03	38.7333	-97.8685
2005/06/25	2	H06	38.7375	-97.8629
2005/06/19	2	H10	38.7383	-97.8128
2005/06/18	1	H11	38.7367	-97.8050
2005/06/26	3	H14	38.7338	-97.8295
2005/06/26	1	H15	38.7383	-97.8301
2005/06/25	2	U03	38.6784	-97.8624
2005/06/26	2	U12	38.7075	-97.8269
2005/06/26	1	U13	38.7031	-97.8266
2005/06/19	1	U14	38.7179	-97.8129

Prairie Mole Cricket (Kansas Species in Need of Conservation). This large, burrowing cricket is endemic to the southern tallgrass prairie region in Kansas, Missouri, Arkansas, and Oklahoma. Believed to be extinct in the early 1980s, surveys have since shown that the species persists in prairies with appropriate soil structure and vegetation. In Kansas, the Prairie Mole Cricket inhabits prairie hay meadows east of the Flint Hills and rangeland in the Flint Hills and Chautauqua Hills. Targeted surveys during this study failed to locate the species. The nearest known populations to Smoky Hill ANGR are near Junction City and on Fort Riley.

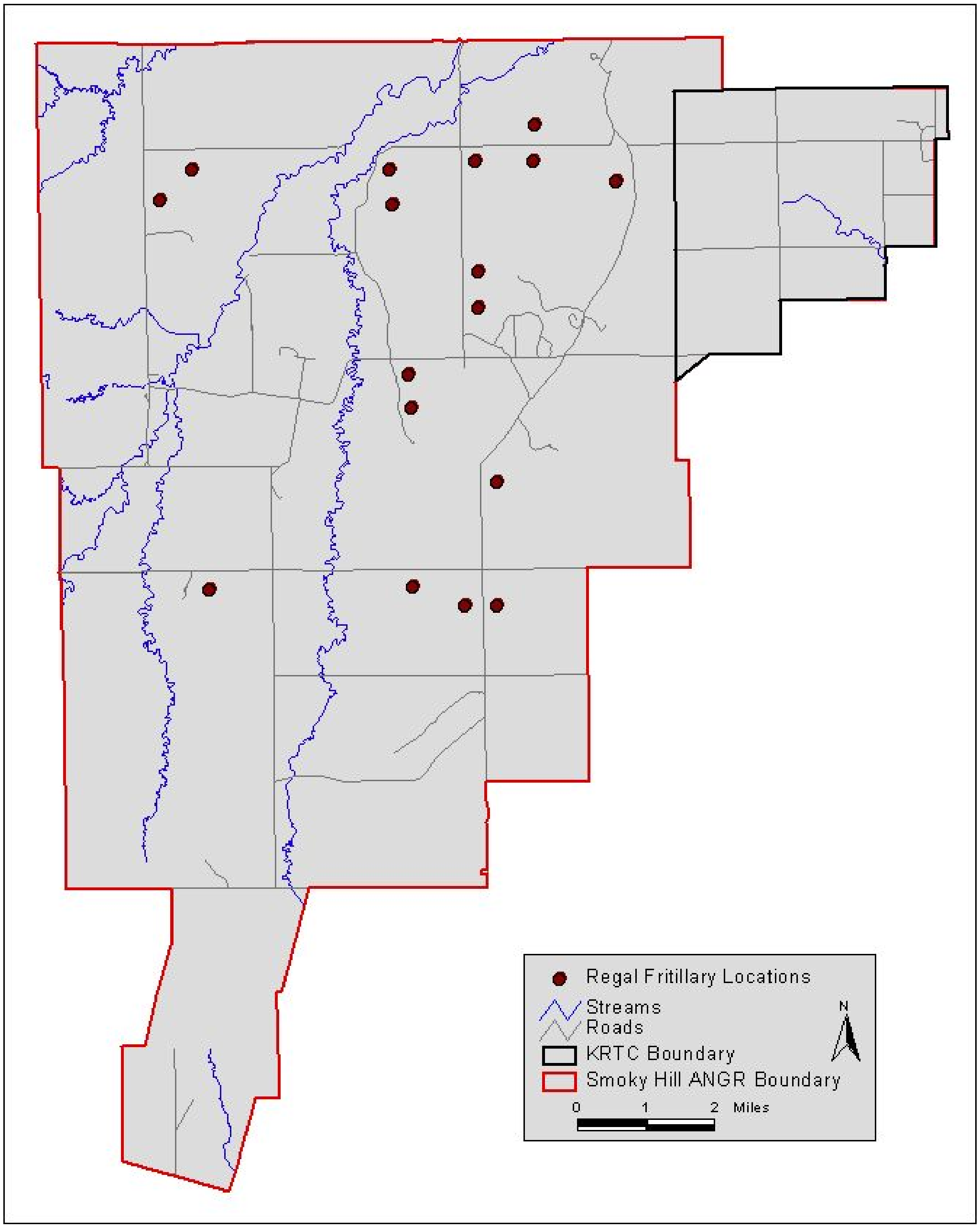


FIGURE 4.4. Locations of Regal Fritillary observations recorded in 2005.

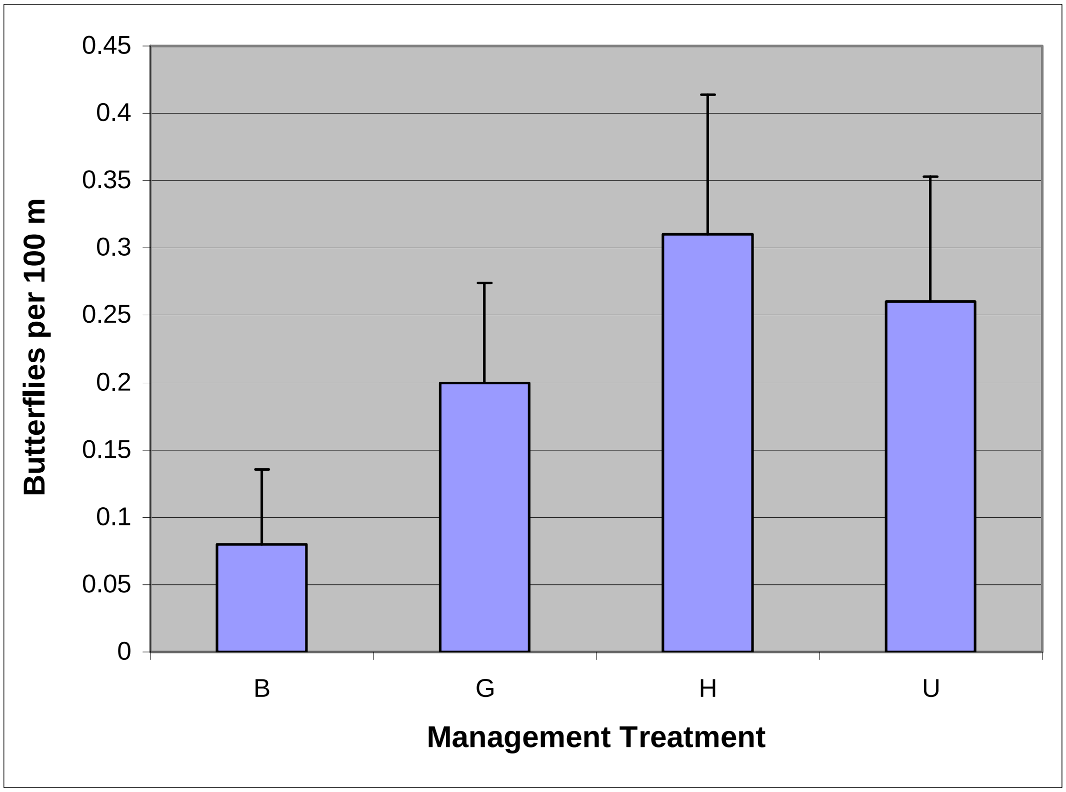


FIGURE 4.5. Abundance of Regal Fritillary butterflies by management treatment in June 2005 on Smoky Hill ANGR (B = burned idle, G = grazed and unburned, H = hayed, and U = unburned idle).

4.3. GENERAL VERTEBRATE SURVEYS

4.3.1. Reptiles and Amphibians

4.3.1.1. Materials and Methods

The herpetological inventory took place from 8 May through 1 October, 2003. Participants included Curtis Schmidt, Richard Hayes, William Busby, Galen Pittman, Galen Wiens, and Travis Taggart. Individual localities of observations were recorded in decimal degrees (NAD84) using a Garmin 12 handheld Global Positioning System (GPS) unit, or plotted directly onto maps provided by the Smoky Hill ANGR personnel. The date and time of each observation were recorded, as well as the sex and snout-vent length (SVL) of selected, commonly encountered species. Such individuals also were marked to evaluate recaptures. Lizards were marked by toe-clipping, snakes were marked by clipping ventral scales in a manner similar to that described in Ferner (1979), and turtles were marked by painting a number on the carapace using red model paint. For most species, a voucher specimen was collected, preserved, and accessioned into the collection at the Museum of the High Plains, Sternberg Museum of Natural History, Fort Hays State University (MHP). Common and scientific names are taken from Crother et al. (2001) and Crother et al. (2003).

Visual Encounter Survey

A primary survey technique was the general visual encounter survey (Crump and Scott 1994), which involves thorough searches of available natural habitat. A total of 51 person-hours (one person searching for one hour) was spent searching rock outcrops and upland prairie sites. At these sites, search methods included turning over rocks and searching rock crevices and burrows for resting individuals, and searching vegetation for active or basking individuals. Also, 77 person-hours were spent searching ponds and creeks. We thoroughly searched 28 ponds, walking the perimeters and searching for basking or swimming animals using binoculars. We searched three sites along Spring Creek by walking in the creek and searching banks and log jams. Only presence of most frog and turtle species was recorded because of the difficulty of counting individuals. These aquatic and semi-aquatic habitats primarily were searched at mid-day during the summer when daytime temperatures were too high for most terrestrial activity.

Seining

During the mid-day heat of the summer months, ponds and ephemeral pools were seined for turtles and amphibians. Using a 30-foot commercial seining net provided by Fort Hays State University, we seined 10 small ponds and temporary pools. Effort was not quantified.

Road Surveys

The other primary survey technique was the driving of maintained roads, trails, and plowed firebreaks. This often is the most effective way of observing surface-active species, particularly during the summer months when many species become primarily nocturnal. Throughout the project we spent 181 hours driving a total of 2,493 miles throughout the installation and on maintained county roads adjacent to the installation. This time included searching for animals, obtaining and recording GPS coordinates, and tending drift fence arrays. Also included in the road surveys were aural surveys for amphibian breeding choruses, particularly at night during and after periods of rain. All major roads on the installation were surveyed on a regular basis.

Drift Fence Trapping Arrays

Nine drift fence units were placed in habitats with differing land use practices. Each drift fence unit consisted of one 100’ x 2’ commercial polypropylene silt fence with wooden stakes every 10 feet. A funnel trap constructed of 0.25” hail screen was placed at both ends of the silt fence. Plastic buckets of varying sizes (3-5 gallons) were buried in the center of each silt fence to serve as pitfall traps, targeting small, secretive species. The pitfall was omitted from drift fence Unit 2 because the substrate was primarily rock, which made placement of the pitfall difficult.

Drift fence localities were chosen based on accessibility and habitat/land use diversity. Locations of each unit are shown in Figure 4.6. The general habitat types of each unit are as follows: two in hayed prairie (Units 3 and 7), one adjacent to a pond (Unit 1), two in riparian/riparian edge (Units 5 and 9), two in unhayed, ungrazed prairie (Units 4 and 6), one in grazed prairie (Unit 8), and one along a rock outcrop (Unit 2). A single-stranded barbed wire fence was constructed around drift fence Unit 8 (grazed) to exclude cattle and deter them from destroying the drift fence or traps. Fence construction began on 10 May and took approximately two weeks to complete. Traps then were run until 25 September. Traps generally were opened the first day of each week on site and closed the final day on site. Traps were checked daily for a total of three to four checks per visit-week. Funnel traps were closed by plugging the funnel openings with available materials (vegetation, soil clumps, sticks, rocks), and pitfalls were covered with flat, plastic trays. Some individuals were captured while traps were closed. These were considered incidental captures and were not included in the number of trap-nights. All traps were maintained for the duration of the study, with the exception of drift fence Unit 2. At Unit 2, the fence was destroyed by wind; because trap success was minimal (only one lizard species and one mouse species were captured), the fence was not repaired. Also, drift fence Unit 4 (ungrazed, unhayed) was run only through 19 August because fire completely destroyed the unit. A total of 276 trap-nights (one trap open for one night) were utilized during the survey.

Cover Boards

Clusters of various-sized plywood sheets were utilized as artificial cover at three sites (Figure 4.6). The first site had 15 boards placed in a heavily wooded area near some old building foundations. The second site had 18 boards in a sparsely wooded, heavily grazed pasture. The third site had five large sheets near a small cluster of trees along the dike adjacent to a large permanent pond. All boards were laid out on 18 July and checked sporadically, at least once per week, through 10 October. Initially, all individuals observed underneath the plywood were recorded; however, most individuals used the boards for the remainder of the study and subsequently were not recorded. Specific localities for the three sites are given in Table 4.6.

TABLE 4.6. Locations of drift fence units and cover board clusters.

Drift Fence Unit	Description	Latitude	Longitude
1	On dike adjacent to Headquarters Pond	38.75451	97.78944
2	Upland sandstone outcrop at Camera Site 6	38.72255	97.80734
3	Roadside near hayed prairie on Main Road	38.70709	97.80374
4	Hayed, upland prairie on Falun Road	38.6837	97.83400
5	Heavily wooded riparian near foundations	38.69503	97.88177
6	Periodically-burned mixed grass prairie	38.7065	97.83806
7	Sandy upland prairie at Camera Site 5	38.72782	97.86471
8	Heavily-grazed prairie near Redhead Pond	38.63896	97.86652
9	Mixed grass/riparian edge habitat	38.74729	97.81778
Cover Board Cluster			
1	Heavily-wooded riparian area with foundations	38.73554	97.83393
2	Heavily-grazed, wooded habitat	38.66757	97.84064
3	Sparsely wooded area next to large pond	38.66765	97.82069

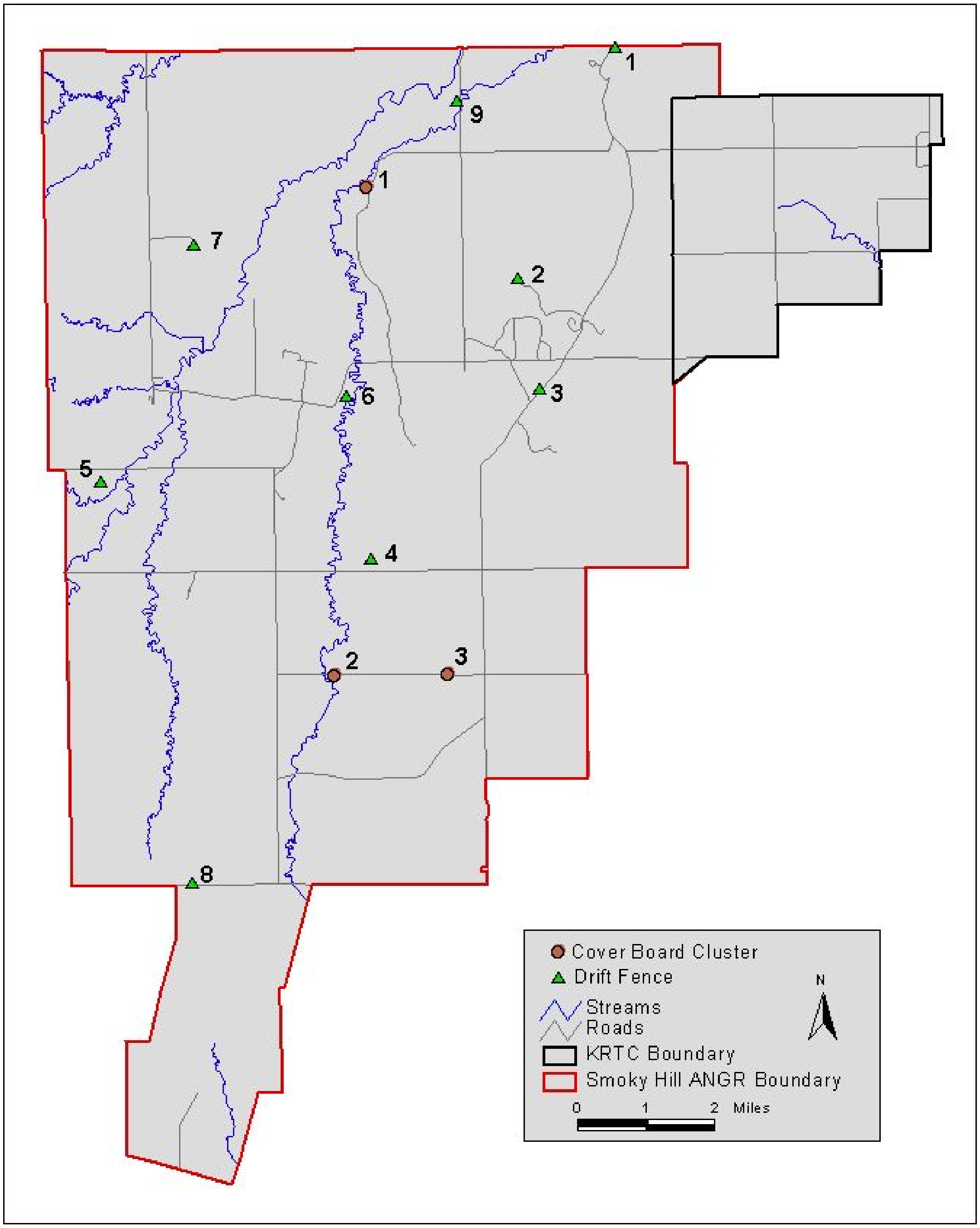


FIGURE 4.6. Locations of drift fences and cover board clusters used to sample reptiles and amphibians in 2003.

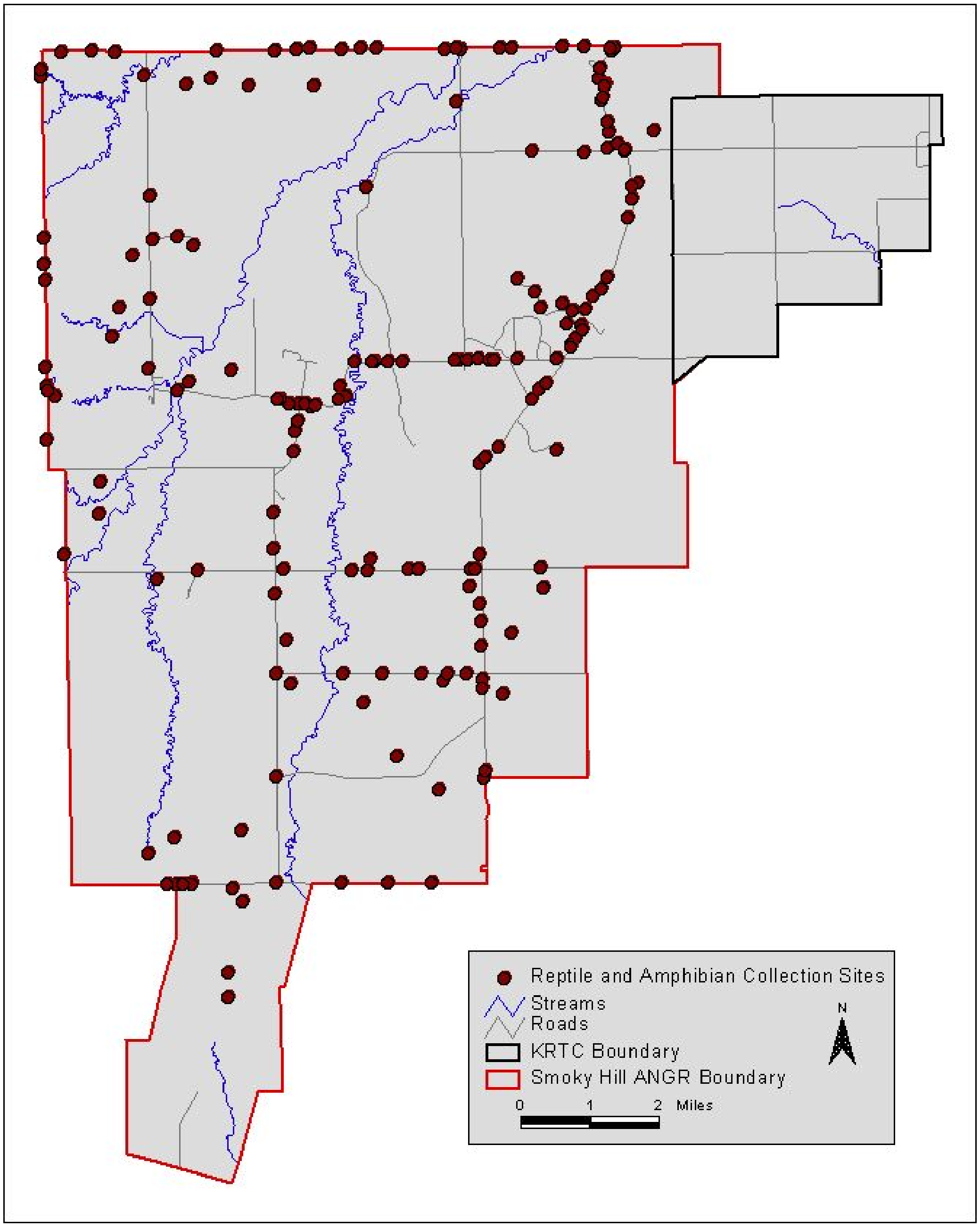


FIGURE 4.7. Collecting sites for reptiles and amphibians in 2003. Each site represents a location where one or more specimens were observed.

TABLE 4.7. Summary of amphibian and reptile observation by survey technique and total number of individuals detected during the study. VES = visual encounter survey.

Common Name	VES	Driving	Seining	Pitfall	Funnel	Total
Tiger Salamander	0	1	2358	0	1	2359
Northern Cricket Frog	23 L	0	3 L	0	0	26
Plains Leopard Frog	21 L	5	5 L	0	2	33
Boreal Chorus Frog	4 L	0	0	6	0	10
Bullfrog	13 L	0	2 L	0	0	15
Woodhouse's Toad	0	12	0	0	0	12
Great Plains Toad	0	7	0	0	0	7
Common Snapping Turtle	12	1	3	0	0	16
Slider	12 L	1	3	0	0	16
Northern Painted Turtle	21 L	1	2	1	1	26
Ornate Box Turtle	10	51	0	0	0	61
Yellow Mud Turtle	4 L	1	5	0	0	10
Texas Horned Lizard	12	115	0	1	9	137
Prairie Lizard	1	0	0	0	0	1
Six-lined Racerunner	126	0	0	20	9	155
Great Plains Skink	48	0	0	5	1	54
Prairie Skink	24	0	0	1	0	25
Ring-necked Snake	7	2	0	0	0	9
Dekay's Brownsnake	0	0	0	1	0	1
Lined Snake	6	3	0	1	0	10
Gophersnake	8	27	0	0	2	37
Graham's Crayfishsnake	2	1	0	0	0	3
Common Gartersnake	6	10	0	1	4	21
Plains Gartersnake	3	5	0	0	1	9
Western Ribbonsnake	17	9	0	0	2	28
Northern Watersnake	15	0	0	0	0	15
Plain-bellied Watersnake	38	3	0	0	3	44
Eastern Racer	2	4	0	0	6	12
Milksnake	1	0	0	0	0	1
Yellow-bellied Kingsnake	2	2	0	0	0	4
Common Kingsnake	0	2	0	0	1	3
Western Hog-nosed Snake	0	1	0	0	0	1
Texas Rat Snake	1	0	0	0	0	1
Massasauga	6	14	0	0	1	21
Totals	347	278	2371	37	43	3183

L = number of locations where species was observed

4.3.1.2. Results

We documented 34 species of amphibians and reptiles on the Smoky Hill ANGR, with well over 3,000 individuals observed (Table 4.7). Collection localities are shown in Figure 4.7. These species included one salamander, six frogs, five turtles, five lizards, and 17 snakes. Of the 34 species, five were documented for the first time in Saline County (Collins 1993). These new county records included the Tiger Salamander (*Ambystoma tigrinum*), Prairie Skink (*Eumeces septentrionalis*), Milksnake (*Lampropeltis triangulum*), Plain-bellied Watersnake (*Nerodia erythrogaster*), and Graham's Crayfishsnake (*Regina grahamii*). Two of the three species of interest were recorded, the Texas Horned Lizard (*Phrynosoma cornutum*), which was previously recorded from the Smoky Hill ANGR, and the Western Hog-nosed Snake (*Heterodon nasicus*), which was not previously recorded. A list of the species observed, the numbers of individuals captured by each technique, and the total number of individuals observed is given in Table 4.7. For species that were difficult to count at particular sites (i.e. turtles at ponds) only the number of localities (L) are given in the table. A brief species account and occurrence map for each species also is given.

Visual Encounter Survey

Twenty-eight species were observed during the Visual Encounter Survey (VES) (Table 4.7). Of these, four species were observed by this method only. These species were the Prairie Lizard (*Sceloporus consobrinus*), Northern Watersnake (*Nerodia sipedon*), Milksnake, and Texas Ratsnake (*Elaphe obsoleta*).

Seining

Eight species were observed by seining small ponds and ephemeral pools (Table 4.7). This was the most productive way of sampling anuran larvae and Barred Tiger Salamander larvae. We collected 2,358 Tiger Salamanders from nine sites. Although seining is a productive way of sampling larval amphibians, adults of most species are observed easily using other methods.

Road Surveys

Twenty-three species were observed while conducting road surveys (Table 4.7). This was the only method in which Woodhouse's Toad (*Bufo woodhousii*), Great Plains Toad (*Bufo cognatus*), and Western Hog-nosed Snake were observed. Road surveys also were the best way to observe the Texas Horned Lizard. More than 115 individuals of this cryptic species were observed by driving roads and trails. Road surveys also were successful in locating breeding sites for the Boreal Chorus Frog (*Pseudacris maculata*) and the Northern Cricket Frog (*Acris crepitans*).

Drift Fence Trapping Arrays

The nine trapping arrays resulted in the capture of 79 individuals of 18 species, including nine species collected in the pitfall traps and 13 species collected in the funnel traps (Table 4.8). The use of pitfall traps resulted in the only collection of the Dekay's Brownsnake (*Storeria dekayi*) during the survey. The pitfall traps and funnel traps were successful in providing a better understanding of the distribution of most terrestrial species on the Smoky Hill ANGR.

Cover Boards

The use of cover boards provided little information. Only two species were found utilizing cover boards; the Prairie Skink and the Common Gartersnake (*Thamnophis sirtalis*) (Table 4.7). Both species previously had been observed in areas near the boards during the VES. Cover boards might be more productive if they were employed for a longer time period so that more animals would become accustomed to using them.

TABLE 4.8. Number of individual amphibian and reptile species captured in drift fences in 2003.

Common Name	Drift Fence Unit									Total
	1	2	3	4	5	6	7	8	9	
Tiger Salamander								1		1
Plains Leopard Frog								2		2
Boreal Chorus Frog				4			1		1	6
Texas Horned Lizard			2	4		3	1			10
Six-lined Racerunner	3				2		22		2	29
Great Plains Skink				2	2	1	1			6
Prairie Skink						1				1
Dekay's Brownsnake				1						1
Gophersnake					1			1		2
Common Gartersnake	2			1		1			1	5
Plains Gartersnake									1	1
Western Ribbonsnake				2						2
Lined Snake									1	1
Plain-bellied Watersnake	2						1			3
Eastern Racer			1		1	3		1		6
Common Kingsnake				1						1
Massasauga				1						1

4.3.1.3. Discussion

This study documented the presence of 34 species of reptiles and amphibians on Smoky Hill ANGR (Table 4.7). The herp community on the installation is comprised of a mixture of species with woodland, grassland, aquatic, and generalist habitat affiliations (Table 4.9). Most species are associated with grassland and aquatic habitats. Relatively few species require woodlands.

The geographic affinities of the species on the installation are dominated by species with ranges centered in eastern or central North America. Many of the eastern species (for example, Bullfrog, Northern Cricket Frog, Texas Rat Snake, Dekay's Brownsnake, Plain-bellied Watersnake) prefer relatively moist environments and are near the western edges of their range at Smoky Hill ANGR. Species with ranges in central North America or in the Plains states include Prairie Skink, Great Plains Skink, Great Plains Toad, Ornate Box Turtle, and Western Ribbonsnake. A handful of species are widespread in North America (Tiger Salamander, Common Gartersnake, and Gophersnake). No truly western species occur on Smoky Hill ANGR, although the Western Hog-nosed Snake is one of few species near the eastern edge of its range in central Kansas.

This one-year study used a variety of methods in order to document as much of the herpetofauna as practical. Visual encounter and road surveys were by far the most successful techniques (Table 4.7). Seining of ponds was important to document turtles and larval amphibians. Drift fences and Sherman traps were employed primarily for small mammals but also proved effective techniques for sampling amphibians, lizards, and snakes (Table 4.8). The variety of techniques used in this study was probably sufficient to document all species of reptiles and amphibians on the installation. However, some species that occur on Smoky Hill ANGR may still remain unreported. The main limitation of this study was that most all field work was conducted in a single year; multiple years of effort are usually required to document all rare or secretive species.

General information on the habitat requirements and management needs of individual species are presented in the species accounts and summarized in Table 4.9. Because of the species-specific nature of these habitat needs, providing management recommendations for reptiles and amphibians as a group is difficult. Management that benefits one species may be detrimental to the populations of another species. For example, increasing habitat for both grassland obligate and woodland obligate species is problematic if management for one habitat must come at the expense of the other. In general, ecosystem management is recommended over species level management. Following consistent management guidelines to enhance and maintain high quality natural communities and provide healthy ecosystem conditions is an effective approach and one that will be beneficial to most species of herps. Species level management may be warranted for species of special concern (for example, endangered, threatened, Kansas species in need of conservation), and invasive or otherwise undesirable species. Special management actions may be needed for such species in an attempt to increase or decrease populations of desirable or undesirable species, respectively. Where species of conservation or management concern are present, the habitat needs of these species should be addressed as long as they do not conflict with other management priorities. As an example, one of the general management guidelines suggested in this document is to reduce the expansion of woody vegetation into prairie habitats on the installation. This will benefit many species while leading to population declines for others. No woodland-associated mammal species on the installation are conservation priority species, so this recommendation should not create conflicts for overall conservation and management of reptiles and amphibians.

Pond and wetland management has direct effects on many reptiles and amphibians. Smoky Hill ANGR has no natural permanent water sources other than a few springs. Consequently, species that prefer permanent or semi-permanent water sources (for example, Bullfrog, Northern Waternake, Western Ribbonsnake, Sliders and Northern Painted Turtle) benefit from the creation of ponds for livestock water. At the same time, ponds that are stocked with predatory fish (bass, bluegill, catfish) do not provide habitat for amphibians whose larvae become food items and fail to survive in the presence of predatory fish. This includes all amphibian species except Bullfrog. Predatory fish also feed on adult amphibians and on some young and adult reptiles. While the young of predatory fish do provide a limited food source for certain species of reptiles and amphibians, the nest effect of predatory fish on reptile and amphians populations is negative.

4.3.1.4. Species Accounts

General natural history information for each species comes from reviews found in Collins (1993), unless otherwise cited. The specific habitat associations and behaviors refer only to those observed on the Smoky Hill ANGR during the survey period.

Ambystoma tigrinum (Green), Tiger Salamander. The Tiger Salamander occurs statewide and is the only salamander species that occurs naturally in Saline County. This secretive animal is active year-round and spends most of its adult life underground in burrows, surfacing to forage on rainy nights and to migrate to breeding pools. It breeds from December to March during sufficient rains that allow the animals to reach breeding sites, usually small, permanent ponds devoid of predatory fishes. The larvae hatch after a few weeks and can take up to two years to metamorphose. Several populations contained neotenic individuals that reach sexual maturity in the larval form.

Due to the secretiveness of adults, the best way to sample areas for Tiger Salamanders is to seine small, temporary ponds for larvae. The abundance of such ponds on the Smoky Hill ANGR gave us a good indication that Tiger Salamanders were abundant throughout the installation. We seined 10 pools for larvae, including seven permanent cattle ponds and three temporary pools created by abundant rainfall. We found Tiger Salamander larvae in nine of the 10 pools. The only pond that did not contain Tiger Salamanders was a relatively deep, permanent cattle pond that contained Green Sunfish (*Lepomis cyanellus*), Bluegill (*L. macrochirus*), and Largemouth Bass (*Micropterus salmoides*). One of the permanent ponds that did contain Tiger Salamanders also contained Green Sunfish. Our seining of this pond produced more than 150 young sunfish and more than 100 Tiger Salamanders, suggesting that pools that contain predatory fishes occasionally are used as breeding sites.

The seining of these pools produced approximately 2,358 individuals, including various sizes of larvae, newly metamorphosed adults, and a few neotenic individuals. A single, small cattle pond contained more than 1,000 individuals.

Most of the ponds containing larvae also contained an abundance of reptilian predators, including Common Snapping Turtles, Painted Turtles, Sliders, Common Gartersnakes, Plains Gartersnakes, Western Ribbonsnakes, Plain-bellied Watersnakes, and Northern Watersnakes. The abundance of these predators, particularly the snakes, often indicated the presence of large numbers of Tiger Salamander larvae. The muddy perimeters of many of the pools also contained Northern Raccoon (*Procyon lotor*) tracks, indicating this species as a possible predator as well.

Two adult Tiger Salamanders were observed during the study. One adult was captured on 2 August in a funnel trap at drift fence Unit 8, which was in a grazed pasture across a maintained county road from a large pond. The other individual was observed crossing an interior road at 2200 h on 9 July after a short rain. The road was bordered on both sides by undisturbed prairie (periodically burned).

TABLE 4.9. Summary of habitat affiliations and land management recommendations for amphibian and reptile species on Smoky Hill ANGR. See Species Accounts for more information. Habitat codes: AQ = aquatic or wetland; GR = grassland or open habitat; WO = woodland, woodland edge, or other woody habitat; OT = other habitat (urban or habitat generalist).

Common Name	Habitat	Habitat Description	Species Level Management
Tiger Salamander	AQ	Fishless ponds for breeding	Increase fishless ponds and pools
Northern Cricket Frog	AQ	Temporary or permanent water bodies	Increase water bodies with open shorelines; minimize siltation
Boreal Chorus Frog	AQ	Fishless ponds for breeding	Increase fishless ponds and pools; minimize siltation
Plains Leopard Frog	AQ	Fishless ponds for breeding	Increase fishless ponds and pools
Bullfrog	AQ	Permanent water bodies	[undesirable species]
Woodhouse's Toad	AQ	Fishless ponds for breeding; most common in open floodplains with loose soil	Maintain open grasslands; increase fishless pools, especially in floodplains
Great Plains Toad	AQ	Upland prairie; fishless ponds for breeding	Maintain upland prairie; increase fishless pools, especially in floodplains
Common Snapping Turtle	AQ	Permanent or temporary water bodies with soft substrates	Increase open water habitats
Slider	AQ	Permanent water bodies	Maintain ponds with permanent water and basking substrates
Northern Painted Turtle	AQ	Permanent or temporary water bodies	Maintain ponds and basking substrates
Ornate Box Turtle	GR	Grassland and woodland edge	Reduce mortality on roads and from warm season fire and mowing
Yellow Mud Turtle	AQ	Temporary water bodies with soft substrates	Increase temporary ponds and pools
Texas Horned Lizard	GR	Open habitats with sparse vegetation	Maintain unfragmented grassland; increase grazing levels to provide sparse vegetation
Prairie Lizard	GR	Open areas and rocky outcrops	Maintain rocky areas
Six-lined Racerunner	GR	Sparsely vegetated areas; sandy open areas	Increase grazing to provide sparse vegetation
Great Plains Skink	GR	Grazed prairie; rocky areas	Maintain unfragmented prairie and rocky areas
Prairie Skink	GR	Open grassy and rocky areas, often near	Maintain prairies near streams

		water	
Ring-necked Snake	WO	Woodland or woodland edge; also open areas	Maintain riparian woodlands and other moist soil habitats; limit burning
Dekay's Brownsnake	WO	Woodland or open areas near woodlands	Maintain riparian woodlands and other moist soil habitats; limit burning
Lined Snake	GR	Open grassland with thatch; woodland edge	Maintain upland grassland habitat with current burn interval
Gophersnake	GR	Open areas with high rodent populations	Reduce woody habitat; maintain rodent food supply
Graham's Crayfishsnake	AQ	Ponds and streams with good crayfish populations	Maintain or increase aquatic habitat and water quality
Common Gartersnake	OT	Habitat generalist; often near water	Maintain or increase aquatic and wetland habitats; reduce grazing near wetlands and ponds
Plains Gartersnake	OT	Grasslands and open areas; often near water	Reduce woody habitat; increase aquatic and wetland habitat
Western Ribbonsnake	AQ	Grasslands and woodlands near water	Maintain or increase aquatic and wetland habitats
Northern Watersnake	AQ	Prefers permanent water bodies, especially streams	Maintain aquatic habitats along Spring Creek
Plain-bellied Watersnake	AQ	Permanent and temporary water bodies	Maintain or increase open water habitats; especially those with larval amphibians
Eastern Racer	OT	Habitat generalist; prefers grasslands and open areas	Maintain grassland habitats and open areas
Milksnake	GR	Grasslands, woodland edge, rocky hillsides	Maintain rocky prairie hillsides
Yellow-bellied Kingsnake	OT	Open grasslands, woodlands, rocky and sandy areas	Maintain native habitats
Common Kingsnake	OT	Various upland habitats	Maintain native habitats
Western Hog-nosed Snake	GR	Open areas with loose soils; sandy floodplains	Reduce woody vegetation in sandy floodplains; increase toad populations
Texas Rat Snake	WO	Woodland and woodland edge	Increase woodlands, especially in riparian zones
Massasauga	GR	Prairie and open wetlands	Maintain prairies; reduce grazing levels, especially near ponds and wetlands

The Tiger Salamander appears to be abundant throughout the Smoky Hill ANGR. All major habitats on the installation contain numerous rodent burrows which are used by adult salamanders. The presence of several active breeding sites suggests that populations on the installation are stable. To ensure the stability of populations, breeding pools should be maintained.

Acris crepitans Baird, Northern Cricket Frog. The Northern Cricket Frog is found throughout Kansas and typically inhabits any aquatic habitat with shallow water and muddy, beach-like edges. This small frog is active year-round and breeds from April to July in most aquatic environments, including flooded ditches, ponds, and streams.

Numerous individuals were observed throughout the Smoky Hill ANGR in a variety of aquatic situations, including nearly all of the semi-permanent and permanent ponds, as well as Spring Creek. This species was observed to be abundant at 26 surveyed localities. Individuals were observed most easily during the VES by walking the perimeters of ponds and creeks, but tadpoles and adults also were seined from ponds. A few individuals also were observed away from water in lowland areas that retained much soil moisture. This frog was found easily during the survey from 8 May through 9 September. Breeding choruses were heard at various localities (both pond and creek) throughout the month of May, with males calling both day and night.

Northern Cricket Frogs fall prey to a number of predators, including raccoons, skunks, opossums, larger frogs, snakes, and even aquatic insects. On one occasion, we observed an adult Plain-bellied Watersnake consuming an adult Northern Cricket Frog along the perimeter of a pond.

The Northern Cricket Frog is considered to be abundant on the Smoky Hill ANGR and populations probably are stable. The biggest threat to cricket frog populations probably is loss of aquatic habitat. If ponds are maintained and not drained, most of these populations will remain stable. Our biggest concern regarding Northern Cricket Frog habitat is the quality of adequate breeding sites along Spring Creek. A possible threat to the quality of this habitat is siltation of the creek. Because firebreaks near the creek are plowed and actively maintained throughout the year, erosion and runoff from these plowed areas might cause increased siltation, which eventually can lead to a decrease in aquatic vegetation. Such aquatic vegetation serves as egg deposition sites and provides critical shelter for developing tadpoles.

Although this species remains abundant throughout most of its range in Kansas, the Northern Cricket Frog has experienced substantial declines and extirpations in many regions throughout its historic range. This species is threatened in many areas of the Midwest and has not been observed in Colorado since the 1970s. Recent detailed surveys throughout the species' range in Kansas have shown that populations also appear to be disappearing throughout western Kansas.

Pseudacris maculata (Agassiz), Boreal Chorus Frog. The Boreal Chorus Frog is found in a wide variety of habitats, including prairies and pastures, woodlands, and around streams and ponds. They are active year-round, spending much of their adult lives underground and emerging when sufficient moisture is present. Breeding is opportunistic from February to May, with the majority of breeding taking place in March and April.

Boreal Chorus Frogs were observed at seven localities on the Smoky Hill ANGR. The small size and secretive habits of adults made observing this species difficult during the VES. The only breeding chorus heard was along Spring Creek on 8 May. On 29 May, several newly metamorphosed frogs were observed in grass surrounding a small, flooded, grassy pool. All other observations of the VES were single individuals, an adult under a rock that was part of an old building foundation in a recently burned prairie, and an adult found active along the Headquarters building after an evening rain.

Seven Boreal Chorus Frogs were collected in pitfall traps at three of the drift fence arrays. One individual was captured the night of 24 July in prairie/riparian edge habitat (Unit 9). Another individual was captured the same night in prairie habitat (Unit 4). This same pitfall captured three individuals on the night of 19 July. The other individual was in sandy upland habitat (Unit 7) and was trapped the night of 24 September. These captures support the idea that this species occupies a wide variety of habitats.

The observation of this species at only seven localities suggests that this species is uncommon on the Smoky Hill ANGR. However, surveys began in May, which is late in the breeding season for this species. Aural surveys are the best way to search for this species. Earlier surveys would have given a better indication of the distribution and abundance of this species on the Smoky Hill ANGR. We believe this species is abundant throughout the installation and that populations are stable. Possible threats are the same as those listed for the Northern Cricket Frog.

Rana blairi Mecham, Littlejohn, Oldham, Brown, and Brown, Plains Leopard Frog. The Plains Leopard Frog is common throughout Kansas in or near nearly any source of water, both temporary and permanent. This species also can be found away from water if humidity levels are high. Plains Leopard Frogs are active mainly from February through October but can be active year-round if weather permits. Breeding occurs opportunistically from February through late spring or summer.

The Plains Leopard Frog was observed at 33 localities on the Smoky Hill ANGR, including 17 ponds and Spring Creek. Five of the 10 ponds seined contained tadpoles and/or adult frogs. Adults also were found active away from water on a number of occasions, particularly after periods of rain when the soil and vegetation remained wet and the air was humid for extended periods. Five individuals were observed on roads at night, one individual was observed in a rocky area, and two individuals were near buildings. Also, two individuals were captured in a funnel trap in grazed prairie near a large pond (Unit 8) on the night of 2 August. No breeding choruses were observed, which likely was because we began the survey late in the breeding season.

The Plains Leopard Frog is abundant throughout most of the Smoky Hill ANGR. Most aquatic sites contained numerous individuals, suggesting that populations likely are large and stable. The current management practices pose little threat to populations of this resilient amphibian. As temporary water sources dry up, adults likely have little difficulty migrating to more suitable sites. Again, maintenance of adequate water sources will ensure that this species remain abundant.

Rana catesbeiana Shaw, Bullfrog. The Bullfrog is found throughout Kansas and prefers habitats that contain permanent, deep water, such as lakes, rivers, streams, and large ponds. It is active from February through October with breeding taking place from April through July.

On the Smoky Hill ANGR, the Bullfrog was found in 15 ponds - usually the larger, more permanent ponds. Tadpoles were seined from two smaller ponds, but no adults were observed at these sites. This species was heard calling only on 10 June from a single pond (Giant's Pond).

We considered the Bullfrog to be common on the Smoky Hill ANGR, but populations appeared to be small and localized. Most ponds appeared to have a few mature adults. These populations are either stable or declining. This species is considered a game species and is hunted by individuals on the installation. It is not known what impact harvesting is having on local populations.

The Bullfrog probably was not found throughout most of Kansas prior to the damming of rivers and construction of reservoirs and other impoundments. Such construction, together with man-made ponds, likely played a large role in Bullfrog dispersal into many regions of the state. In some instances, the Bullfrog is considered an invasive species because of its potential influence on "natural" community structures (Hammerson 1999). We think that Bullfrog populations on the Smoky Hill ANGR are entirely dependent upon the large, man-made ponds that are scattered throughout the installation. It is important to consider these points when dealing with management concerns relating to this species.

Bufo cognatus Say, Great Plains Toad. The Great Plains Toad is found throughout the prairie regions of Kansas and is most common on the High Plains of the western part of the state. This species inhabits mixed-grass and shortgrass prairie, as well as floodplains, but rarely is found in wooded areas. These toads remain hidden during the day, becoming active at night, particularly after periods of rain. Primary activity is from April to September, with breeding occurring opportunistically from March through early summer. Breeding occurs mainly in temporary upland pools and flooded areas.

We encountered seven individuals on the Smoky Hill ANGR at seven different locations. All seven individuals were adults that were observed in July (3), August (1), and September (3) during night road surveys. The toads were observed from 2045 h to 2200 h on nights when it was rainy or wet from previous rains. All individuals were encountered on roads that bisected upland prairie habitats. No individuals were heard chorusing during the survey. However, sufficient rainfall for breeding events only occurred on a few occasions while on site, primarily after the breeding season. Also, heavy rains made travel difficult, impeding a thorough aural survey at these times.

Although a small number of individuals was observed during the survey, the Great Plains Toad likely is common throughout the Smoky Hill ANGR. The installation contains an abundance of good quality habitat, with loose soil that retains moisture well. We expect this toad to be common in both disturbed and undisturbed prairie habitats and uncommon or absent in riparian or riparian edge habitats. The topography of the installation provides many seasonally flooded areas that can be utilized by this species for breeding. Populations likely are stable with little threat of decline.

Bufo woodhousii Girard, Woodhouse's Toad. Woodhouse's Toad is abundant throughout most of Kansas and is probably the most common toad in central Kansas. It is abundant in a wide variety of habitats but prefers lowland prairie areas and floodplains with loose soil and an abundance of mammal burrows. This toad is active from March through October, with daily activity similar to that described for the Great Plains Toad. This species appears to be more tolerant of high temperatures and dry weather than the Great Plains Toad. Woodhouse's Toads also are opportunistic breeders, breeding in a variety of permanent and ephemeral water sources from March through early summer.

Woodhouse's Toad appeared to be more common on the Smoky Hill ANGR than the Great Plains Toad but seemed to exhibit the same activity patterns. We recorded 12 adults during the same conditions listed as for the Great Plains Toad, with activity in July, August, and September from 2035 to 2225 h. One adult also was found active on a road at 1040 h on 31 July. No breeding choruses were heard (See the account for the Great Plains Toad). Again, Woodhouse's Toad likely is abundant throughout the installation in undisturbed and disturbed prairie, and less common, but present in riparian areas. Populations probably are stable with little threat of decline.

Chelydra serpentina (Linnaeus), Common Snapping Turtle. The Common Snapping Turtle is common throughout Kansas in nearly every aquatic situation. The preferred habitat is aquatic environments that possess a soft, muddy substrate in which the turtles bury themselves. These turtles often are nomadic, traveling from one source of water to another as ponds and creeks dry. Gravid females often are seen on land during spring and summer searching for appropriate nesting sites, which usually consist of a sandy or loamy substrate, often distant from water. Activity is primarily from March to November, but individuals have been observed in nearly every month.

We observed 16 Common Snapping Turtles at 10 localities on the Smoky Hill ANGR. Individuals commonly were observed throughout the installation in a variety of aquatic situations, including ephemeral pools, muddy cattle ponds, large permanent ponds, and along Spring Creek and a small tributary. We observed Common Snapping Turtles at six of the 28 ponds searched during the VES and seined 4 individuals from small, muddy cattle ponds. We also observed one large road-killed adult on 13 June near a large pond. Individuals were observed from 29 May to 4 September.

Only 16 individuals were observed during the survey, but the snapping turtle likely is abundant throughout the Smoky Hill ANGR wherever water is present. This species spends most of the day submerged or buried in the mud, making observation difficult. Further attempts at seining ponds, as well as the use of commercial turtle traps, probably would yield large numbers of these turtles. We expect populations to be large and stable. Population densities may be high at some localities. On 30 May we observed three large individuals under a bridge over a small tributary of Spring Creek that contained a small amount of water.

Current management practices pose little threat to Common Snapping Turtle populations on the installation, as long as water sources are maintained. Because snapping turtle meat is commercially valuable, care should be taken not to over-harvest large adults. Individuals are long-lived, and the over-harvest of mature, reproducing adults might have a negative impact on populations.

Trachemys scripta (Schoepff), Slider. The Slider occurs throughout central and eastern Kansas and is abundant in nearly every permanent body of water, particularly those with soft, muddy bottoms and abundant basking sites. These turtles are primarily active from March through October. Sliders are diurnal, spending most of the day basking or foraging, making them easy to observe. Like the Common Snapping Turtle, individuals are adept at migrating from one water source to another, and gravid females often are observed on land during spring and summer as they search for suitable nesting sites.

Hundreds, if not thousands, of Sliders were observed at 16 localities on the Smoky Hill ANGR during our study. Numerous individuals were observed basking or swimming at many of the permanent bodies of water, including 11 ponds and Spring Creek. Three individuals were seined from two of the smaller ponds. One large, gravid female was observed in a sandy rock outcrop on 10 June, far from any permanent water. Sliders regularly were observed throughout the installation during the project.

We consider the Slider abundant throughout the Smoky Hill ANGR, with large, local populations. On one occasion, we attempted to estimate the number of Sliders in two large ponds by counting heads and identifying the species using binoculars. At one pond we counted 437 turtle heads protruding above the water at one time and identified 77 of 168 positive identifications as Sliders. The second pond contained an estimated 187 heads, of which 4 of 76 could be identified as Sliders. Such high densities appear to be typical of the permanent ponds on the facility. Sliders have no economic value; few threats to populations exist with current management practices.

Chrysemys picta (Schneider), Painted Turtle. The Painted Turtle is common throughout Kansas and is similar to the Slider in habits and preferred habitat. However, the Painted Turtle is more common that the Slider in smaller, less permanent aquatic habitats. This species is primarily active from March through October, but individuals have been observed during every month. The Painted Turtle is tolerant of colder temperatures than the Slider.

The Painted Turtle was found in large numbers throughout the Smoky Hill ANGR wherever there was permanent water. We observed Painted Turtles at 26 localities, including 19 of 28 ponds surveyed during the VES and two sites along Spring Creek. We also seined individuals from three small cattle ponds. Two individuals were captured in a drift fence unit placed atop the levee of a large pond (Unit 1). A juvenile was captured in a funnel trap, and an adult was captured in the pitfall trap. One adult was observed crossing a road during road surveys. Painted Turtles were observed easily throughout the project.

The Painted Turtle is abundant throughout the installation with large populations that probably are stable with few or no immediate threats. As with the Slider, local population densities can be large. We estimated the number of Painted Turtle heads at the two ponds mentioned in the account for the Slider. In the pond that contained an estimated 437 heads, we identified 96 of 168 positive identifications to be Painted Turtles. In the ponds that contained 187 heads, 72 of 76 were Painted Turtles.

Kinosternon flavescens (Agassiz), Yellow Mud Turtle. The Yellow Mud Turtle is abundant west of the Flint Hills in Kansas and prefers still waters with a soft, muddy or sandy substrate. This species has been found in a wide variety of permanent and ephemeral aquatic situations including sloughs, swamps, sinkholes, cattle ponds, creeks, and roadside ditches. Individuals often are found on land traveling from one water source to another, particularly during and after periods of rain or when humidity is high. Yellow Mud Turtles are active primarily from April through September.

We found the Yellow Mud Turtle at 10 localities on the Smoky Hill ANGR. This species was observed during the VES at three small, ephemeral ponds where protruding heads were identified with binoculars. They also were collected from five other small ponds by seining. One individual was observed crossing a low-water bridge spanning Spring Creek. The remaining locality was from a shell collected in a muddy, dried-up pool.

The Yellow Mud Turtle is considered common on the Smoky Hill ANGR. The abundance of permanent and temporary water sources provides much suitable habitat. Population densities appear to be moderately low, as few individuals were observed at each site. This might be misleading because of the tendency of individuals to wander. As long as water sources and seasonally flooded pools are available on the installation, populations likely will remain stable. Unlike some other aquatic and semi-aquatic turtle species, siltation from runoff likely has little or no negative effect on populations of this species.

Terrapene ornata (Agassiz), Ornate Box Turtle. The Ornate Box Turtle, the state reptile of Kansas, is found throughout Kansas and appears to reach its highest abundance in the open prairies of western Kansas. It prefers open habitat and can be found in fields, open woodlands, and pastures. This species is active from April through October, spending the days foraging, thermoregulating, and resting. Ornate Box Turtles overwinter in burrows, either those dug by themselves or other animals. Population densities have been shown to be high in some areas, with densities of up to two turtles per acre (Rose 1978). Home ranges are small (about five acres) and usually overlapping. Individuals often are observed while crossing roads. Schmidt (2004) suggested that open roads and trails might be utilized to a large degree during foraging activities, making the turtles easily observable. Unfortunately, great numbers of Ornate Box Turtles are killed on roads and highways every year.

A total of 61 Ornate Box Turtles was observed throughout the Smoky Hill ANGR during the study. Not surprisingly, 51 of these individuals were observed during the road surveys. Ten other individuals were observed active while searching during the VES.

The Ornate Box Turtle is one of the most observably abundant species on the Smoky Hill ANGR. These turtles are easily observed throughout the installation in all habitat types and management regimes, particularly as they cross the roads and trails that divide the installation.

Population density probably is high, possibly reaching or exceeding two individuals per acre. Populations appeared to be dominated by adults. Other studies have also shown this pattern (Hammerson 1999; Schmidt 2004), but this is likely because juveniles are highly cryptic and have much smaller home ranges (Dodd 2001).

Populations of the Ornate Box Turtle appear to be large and thriving on the Smoky Hill ANGR. The current established management practices of grazing and haying likely are beneficial to Ornate Box Turtle populations, providing areas of open prairie that are utilized frequently by this species. However, the common practice of prescribed burning likely increases turtle mortality; numerous shells were observed in several recently burned areas. Burning in March and early April would have the least negative effect because many turtles are still inactive in burrows at this time. In such instances, burning likely would also benefit this species by creating open areas. Also, the current management regimes support diverse plant communities, which provide the Ornate Box Turtle with a variety of food.

Sceloporus consobrinus Baird and Girard, Prairie Lizard. The Prairie Lizard is common throughout the western two-thirds of Kansas in a wide variety of habitats including sandy lowlands and open prairies, particularly areas with sandstone and limestone outcrops. This diurnal lizard is active from March through October, generally at air temperatures above 70° F. It has a bimodal daily activity period, with primary activity during the late morning hours and again in late afternoon to early evening. Most of this time is spent basking on rocks or logs and foraging. Home ranges are small (around one-tenth an acre). Male defend territories that often include several females.

Surprisingly, only one Prairie Lizard was observed on the Smoky Hill ANGR during the survey. This was an adult individual captured by Smoky Hill ANGR staff at the operations building. Because only one Prairie Lizard was observed, little is known about the population status of this species on the installation. Given that this lizard is easy to observe where populations are at least moderate-sized, it appears that the installation supports a small population. Prairie Lizards prefer areas with rock outcrops, a common habitat feature at Smoky Hill ANGR. Current management practices pose little threat to this species, as areas surrounding sandstone outcrops typically remain unaltered, and grazing poses little threat to a species that prefers open areas.

Aspidoscelis sexlineata (Linnaeus), Six-lined Racerunner. The Six-lined Racerunner occurs throughout Kansas in sparsely vegetated, dry, sandy or rocky areas. This species also can be found in open grazed or cultivated areas. Populations are the largest in areas with a minimum amount of vegetative cover, such as sand prairie and sandy river floodplains. Vegetation limits the ability of the lizard to escape predators by using its speed, its primary defense mechanism. Six-lined Racerunners are active primarily from May to late August or September and require relatively high temperatures to remain active. The lizards are diurnal and activity peaks in the early afternoon (1200—1400 h).

More than 150 individuals were observed in this study from all parts of the installation. Populations appeared most dense along sparsely vegetated sandstone outcrops (such as Camera Site 6), sandy upland prairie sites (such as Camera Site 5 and the Strafe Pits). Population densities appeared to be high at most of these sites, as dozens of active individuals could be observed in a short period of time. Individuals also were observed near one of the maintenance sheds. This site contained numerous objects that provided shelter in an open area consisting of a mixed substrate of gravel, asphalt, and mowed grass.

During VES, 126 individuals were observed, most of which were active on the surface. Some individuals were found under sandstone rocks, primarily when temperatures were low. Twenty-nine Six-lined Racerunners were captured using the drift-fence arrays. Of these, 20 were captured in pitfall traps and nine were captured in funnel traps. Twenty of the captures were from Camera Site 5 (Unit 7), a sandy upland site with vegetation typical of such habitats, including small soapweed and plains prickly pear cactus. All captured individuals were marked and released away from the fence and no individuals were recaptured. Three Six-lined Racerunners were captured at Camera Site 6 (Unit 2). This trap array likely would have yielded more captures, but the array was only functional for a short period. Interestingly, the remaining four individuals were captured in a grassy riparian edge habitat with dense vegetation (Unit 9). This habitat likely is not used frequently, and these individuals might have colonized the area from the nearby sandy road by traveling along the tire ruts that were created from daily checking of traps.

The Six-lined Racerunner is the most observably abundant lizard species on the installation. Populations appear to be large and probably are stable. The open rocky and sandy habitats preferred by this species face few immediate threats. These areas typically are unsuitable for agriculture. The grazing of cattle on the installation probably is beneficial to this species by reducing vegetative cover and creating openings. Periodic burning removes thatch and creates temporary bare areas that favor this species and may be important in racerunner dispersal. Overall, current management practices are suitable for maintaining Six-lined Racerunner habitat.

Eumeces obsoletus (Baird and Girard), Great Plains Skink. The Great Plains Skink occurs throughout most of Kansas; it is least common in the High Plains of northwest Kansas. This species typically inhabits open prairie habitats with relatively short vegetation. It appears to be most abundant in and around rock outcrops. However, this habitat preference might be biased because Great Plains Skinks are most easily found by turning over rocks. These lizards are active from March through October but spend most of the day thermoregulating beneath rocks. Surface activity occurs mainly during mid-day from 1000 to 1600 h.

A total of 54 Great Plains Skinks were observed on the Smoky Hill ANGR during the survey. This species easily was observed throughout the installation under surface objects, primarily at sandstone outcrops. Multiple individuals could be observed at any of the small outcrops, suggesting that population densities are high. Individuals were observed during the VES from 9 May through 1 August. Six individuals also were captured at four of the drift fence arrays between 23 May and 10 September, five individuals in pitfall traps and one in a funnel trap (Table 4.8). Trapping results suggested a diversity of habitats are utilized. Two individuals were captured in a periodically hayed prairie (Unit 4) that consisted primarily of short forbs and grasses where patches of low, dense vegetation were interspersed with more open areas. No surface cover objects, such as rocks or logs, were present. Two individuals were captured in a riparian area (Unit 5) near some old foundations. Several logs and concrete slabs were in the area, and the vegetation was primarily dense, tall grass. One individual was captured in an open, sandy, rocky area (Unit 7). The final individual was captured in a periodically burned prairie site that had been burned in early spring. However, at the time of capture, vegetation was quite dense and consisted of tall grasses and dense forbs, typical of riparian/prairie edge. A small wooded area was nearby.

Great Plains Skinks appear to be abundant throughout the Smoky Hill ANGR. They were mostly observed in areas with rock outcrops, but our findings suggest that Great Plains Skinks may be more habitat generalists than previously suggested and may not require structure, such as rock and debris. Current management practices pose little threat to populations, and the combination of haying, grazing, and burning across the installation probably creates a habitat mosaic that is beneficial to this species.

Eumeces septentrionalis (Baird), Prairie Skink. The Prairie Skink has a sporadic distribution in Kansas. It occurs in the Glaciated Region, Flint Hills and Osage Cuestas of eastern Kansas, and from the Low Plains of north-central Kansas south through the Red Hills. The lizards prefer open, grassy, rocky hillsides, particularly those near sources of water. They also have been found in forest or forest edge habitats. Prairie Skinks are active from April through early October. Like the Great Plains Skink, individuals spend most of the day beneath rocks thermoregulating.

We found 25 individuals of this species, 24 during the VES and one in a pitfall trap. Similar to the Great Plains Skink, the Prairie Skink appeared to prefer areas with sandstone outcrops. The majority of the individuals were found in close association with water and utilized any type of surface debris as cover, including rocks, logs, and artificial cover boards. Individuals in these areas also were found active near the water on numerous occasions, often retreating into the water when disturbed. One individual also was found underneath a clump of soil along the perimeter of a maintained road that crossed a small creek. Two individuals were captured underneath artificial cover boards in a riparian area near some old foundations. The single individual captured in a pitfall was located in a periodically burned prairie that contained a dense grass and forb cover (Unit 6).

The Prairie Skink was not officially documented in Saline County prior to this survey (Collins 1993). A previous survey of the Kansas Army National Guard Smoky Hills Training Site, adjacent to the Smoky Hill ANGR cited the presence of this species in the area (Charlton et al. 2000). Similar to the Great Plains Skink, the Prairie Skink is abundant on the Smoky Hill ANGR and can be found in similar habitats. Refer to the account for the Great Plains Skink for details on populations and management implications.

Diadophis punctatus (Linnaeus), Ring-necked Snake. The Ring-necked Snake is common throughout most of Kansas. It is least abundant in the shortgrass and sand prairies of western Kansas. The species reaches its peak abundance in the eastern third of the state. Throughout its range it frequents rocky and wooded hillsides. Ring-necked snakes are active from March through November, with little activity during the hot, dry summer months. Individuals spend most of the day hidden beneath surface cover, often in large numbers, emerging at night to move about on the surface.

We observed nine Ring-necked Snakes on the Smoky Hill ANGR. Seven individuals were found under the following types of cover objects: four beneath boards near the maintenance storage facility, two underneath concrete blocks at an old building foundation in a wooded area, and one underneath a sandstone rock on a grassy hillside. These individuals were observed in May (2), June (1), and September (4). One individual was observed alive on a maintained road at night on 4 September. The surrounding habitat was moderately grazed prairie containing no observable surface objects. The final individual was in the headquarters parking lot the morning of 1 October. It had rained the previous night and the roads and vegetation still were wet.

Based on the number of individuals observed, the Ring-necked Snake appears to be uncommon on the Smoky Hill ANGR. However, this small, secretive species likely is much more common than numbers indicate. Historical records show that the Ring-necked snake is not restricted to rocky or wooded areas and actually inhabits a wide variety of habitats. The presence of easily searched surface objects such as rocks, boards, and logs makes this species more detectable. This species likely occurs throughout the installation, especially in valleys that retain soil moisture. In such habitats, the Ring-necked Snake probably spends most of the day in burrows. Based on our observations, population numbers appear to be low to moderate. Current management practices appear compatible with the habitat needs of the Ring-necked Snake. Overgrazing may be an unfavorable practice given the species' scarcity in shortgrass prairie in western Kansas; however, little is know about the response of this species to land management practices.

Storeria dekayi (Holbrook), Dekay's Brownsnake. Dekay's Brownsnake ranges throughout the eastern two-thirds of Kansas but is most common in moist woodland areas of eastern Kansas. This species is active from March through November, but individuals have been observed in every month except January. Brownsnakes are primarily diurnal but become nocturnal during the hot summer months. This snake often is found active or under logs and other debris near sources of water.

One Brownsnake was observed during the survey on the Smoky Hill ANGR. This was an adult captured in a pitfall situated along a roadside, adjacent to a periodically hayed prairie (Unit 4). This site may have been attractive due to the high soil moisture. Otherwise, there was no source of water nearby, and there were few trees in the vicinity. No surface cover objects were apparent.

The Brownsnake appears to be rare to uncommon on the installation. Few records exist from Saline County and the surrounding area. Our team spent many hours in what we considered to be ideal habitat for this snake, and found none. This species might be more common than is apparent due to its small size and secretive habits. The riparian zone along Spring Creek and other wooded areas are the mostly likely places to find this snake on the installation. Destruction of riparian and wooded areas, and drought conditions are the most likely threats to this species.

Tropidoclonion lineatum (Hallowell), Lined Snake. The Lined Snake occurs throughout most of Kansas and inhabits open prairies, woodland edge, and urban areas. This species is active mainly from April to October, and is primarily nocturnal, spending the days beneath surface objects or in burrows.

Ten Lined Snakes were documented in this study. Three individuals (one per night) were observed on 29 May, 6 June, and 10 September while driving roads at night. One adult was captured in a pitfall trap in riparian/prairie edge habitat (Unit 9) on 2 July. The other six Lined Snakes were observed by turning various surface objects. On 23 May we uncovered two adults in an asphalt pile at the maintenance storage lot. A third individual was found at the same site on 10 June. Three adults were found under sandstone rocks at two different outcrops, two snakes on 5 June and one on 11 June.

The Lined Snake is probably common throughout the Smoky Hill ANGR in most habitats. Lined Snakes generally prefer hillsides and open prairies - habitats that are common on the installation. The snakes appear to be rather tolerant of habitat disturbance and human interference. It is active on or near the surface mostly at night when conditions are moist; this limited surface activity makes individuals somewhat difficult to observe. Populations are probably larger than the small number of observations suggest.

Regina grahamii Baird and Girard, Graham's Crayfishsnake. Graham's Crayfishsnake is found in south-central Kansas and eastern Kansas near ponds and streams, particularly those bordered by rocks. This species is active primarily from April through October. Activity is primarily during the day in spring and fall and switches to the night during the hot summer months. This snake commonly basks or forages in or near the water. Periods of inactivity are spent under rocks or in crayfish burrows.

The first record of Graham's Crayfishsnake in Saline County was recorded during this study. Three individuals were observed during the survey, all of which were small subadults. The first individual was observed foraging in the shallow waters of Spring Creek at 1915 h on 8 May. The second individual was collected dead on a maintained road adjacent to a large, permanent pond on 21 May. The third Graham's Crayfishsnake was observed on 26 June in a crayfish burrow underneath a limestone rock at the edge of a small pond.

The small number of records indicated that Graham's Crayfishsnake is an uncommon resident of aquatic habitats on the Smoky Hill ANGR. Population size is apparently small, which can be attributed to the fact that this species is at the northwestern limit of its range, and environmental conditions are marginal for its existence. Suitable habitat is widely distributed on the installation and current management practices seem compatible with the maintenance of that habitat.

Thamnophis sirtalis (Linnaeus), Common Gartersnake. The Common Gartersnake is a common snake throughout the eastern two-thirds of Kansas and is found in a wide variety of habitats. This snake is often encountered in and around marshes, meadows, woodlands, ponds, streams, and rocky prairie hillsides. It seems to be most abundant in areas near sources of water. Common Gartersnakes are active from March through November, but they have been observed during warm spells during the winter months. This species is known to be active primarily during the day.

Twenty-one Common Gartersnakes were observed on the Smoky Hill ANGR during the survey. This species was captured by all collecting methods. Six individuals were collected during the VES, primarily by walking the perimeters of ponds (5). One individual was collected beneath an artificial cover board near a large pond on 28 August. These snakes were observed to be active around ponds from 1030 to 1900 h. Ten Common Gartersnakes were collected on roads (eight were alive and two dead) in June, July, and September, primarily in the morning (0940-1110 h) and late afternoon/early evenings (1730-2135 h). One small individual was collected in a pitfall trap in riparian/prairie edge habitat on 16 October. Four adult individuals were captured in funnel traps at three different trapping arrays. Two individuals were captured in an array adjacent to a large pond (Unit 1), one each on 26 July and 11 September. An individual was captured on 11 September in ungrazed prairie (Unit 4), and another on 19 September in ungrazed, burned prairie that contained tall, dense vegetation (Unit 6).

We consider the Common Gartersnake to be abundant throughout the Smoky Hill ANGR. The many ponds on the installation provide good habitat for this species, and this is where most specimens were observed. Other individuals were captured during driving surveys and in drift fence arrays in upland prairie habitats, suggesting that this species is relatively active and occupies a variety of habitats. Populations appeared to be high. Current management practices appear to have little or no negative effect on Common Gartersnake populations. As with other species that depend on aquatic sites, the largest potential threat is sustained drought and the drying of ponds and wetlands. Heavy grazing is another threat, as this species tends to avoid areas with sparse or short vegetation.

Thamnophis radix (Baird and Girard), Plains Gartersnake. The Plains Gartersnake is common throughout the western two-thirds of Kansas and also ranges into northeastern Kansas. Similar to the Common Gartersnake, the Plains Gartersnake is most abundant near water sources such as marshes, streams, ponds, rivers, and lakes. This species also is found in grassland habitats away from water. Compared to the Common Gartersnake, the Plains Gartersnake prefers open areas and is less likely to be observed in riparian or other wooded habitats. Its activity season is from March to November and it is mostly active during the day.

We collected nine Plains Gartersnakes on Smoky Hill ANGR. Three individuals were collected during the VES while walking the perimeters of ponds. These individuals were observed on 29 May, 30 May, and 11 June at 1640 h, 1600 h, and 1520 h, respectively. Five Plains Gartersnakes were collected on roads during vehicle surveys, including two in May, one in June, one in July, and one in September. Similar to the Common Gartersnake, these individuals were found in the mornings (0745 h and 1000 h) and late afternoons/early evenings (1615 to 1800 h). One adult individual was captured in a funnel trap on 25 June in riparian/prairie edge habitat (Unit 9).

The Plains Gartersnake probably is common on the Smoky Hill ANGR but appears to be less common than the Common Gartersnake. On the installation, this species frequented ponds and creeks but was encountered more commonly in upland prairie habitats. Population densities are probably moderate throughout the installation. Compared to the Common Gartersnake (see above) the Plains Gartersnake is less likely to be affected by increased grazing intensity because of its affinity for open areas. Changes in grazing intensity might have opposite effects on the populations of these two species.

Thamnophis proximus (Say), Western Ribbonsnake. The Western Ribbonsnake is found throughout most of Kansas but appears to be absent from parts of western and northern Kansas.

This species appears to be most abundant in the Red Hills, Osage Cuestas, Cherokee Plain, and Ozark Plateau of Kansas. Like other species of *Thamnophis* in the state, the Western Ribbonsnake frequents moist areas near water sources. However, this species seems more tied to water than the other two species in the genus. This species is active from March through October and is primarily diurnal.

Twenty-eight Western Ribbonsnakes were observed during the survey. Seventeen individuals (60.7%) were observed during the VES around sources of water, including 16 around the edges of ponds and one along Spring Creek. These individuals were active between 1130-1900 h during the period from 29 May through 31 July. We observed nine individuals on roads in May (3 snakes), June (1), July (2), and September (3, of which two were found dead). Our road surveys suggest that Western Ribbonsnake activity also is high during the evening (1800—2020 h). Two small individuals were captured on 1 September and 4 September in a funnel trap located in a roadside ditch adjacent to a hayed pasture (Unit 4). It is not known whether this was the same individual.

We consider the Western Ribbonsnake to be common throughout the Smoky Hill ANGR. This species is most observable and appears to be most abundant around sources of water, including ponds, creeks, and ephemeral pools. However, this species probably uses all habitat types on the installation as it wanders between areas of preferred habitat. Populations likely are large with no immediate threats. As with most species that prefer wet habitats, periods of drought might be the biggest threat to Western Ribbonsnake populations.

Nerodia sipedon (Linnaeus), Northern Watersnake. The Northern Watersnake occurs throughout Kansas in areas with permanent water. This snake is found in nearly any aquatic situation, including rivers, lakes, and marshes. They appear to be less common around ephemeral water sources than around permanent water sources. Northern Watersnakes are active primarily from March through November. These snakes are easily observed basking on logs, in branches, or on rocks near water during the spring and fall months, and easily can be found swimming or resting beneath rocks along the margin of water during the hot summer.

We observed a total of 15 Northern Watersnakes during the survey, 12 of which were observed along Spring Creek and three along the perimeter of ponds. These observations support the idea that this species prefers more permanent water sources. Northern Watersnakes were easily observed on numerous occasions in Spring Creek below the "Crooked Bridge" on Farrelly Road on the northern boundary of the installation. Up to five individuals were observed at any one time from the bridge. Northern Watersnakes were primarily active during the day and were observed from June through September, all during the VES.

We consider the Northern Watersnake to be common on the Smoky Hill ANGR, reaching its peak abundance along Spring Creek. Population densities appear to be high in this habitat, but appear to be low throughout the remainder of the installation, with few individuals occupying larger ponds. Current management practices likely pose little threat to populations. The largest potential threat is prolonged drought that would result in the drying up of Spring Creek. This temporarily could eliminate preferred habitat, as well as fish and amphibians, the primary diet of Northern Watersnakes.

Nerodia erythrogaster (Forster), Plain-bellied Watersnake. The Plain-bellied Watersnake occurs throughout much of southern and eastern Kansas in nearly any aquatic habitat. Unlike the Northern Watersnake, this species also inhabits ephemeral ponds and creeks and often wanders far from water. Because of this tendency to wander, the Plain-bellied Watersnake can be found in a wide variety of habitats. This species is active primarily from March to October, but individuals have been observed basking on warm winter days. Daily activity is similar to that described for the Northern Watersnake (see above).

The Plain-bellied Watersnake was officially documented for the first time in Saline County during our survey (Collins 1993); however, a literature report does exist (Garrigues 1962). A total of 44 individuals were observed on the Smoky Hill ANGR during the survey, making this species the most observably abundant snake. Individuals were captured throughout the installation in a wide variety of habitats, with 36 observed along the perimeter of ponds and ephemeral pools, four along Spring Creek, three on roads surrounded by upland prairie, and one in a sandy upland prairie site. Thirty-eight of the observations were during the VES from 29 May through 10 September throughout the daylight hours. Three individuals were observed while driving, of which one was dead and two active on 10 June at 1039 h and 10 September at 2040 h, respectively. Three adults were also captured in drift fence arrays. Two snakes were captured in the array adjacent to a large pond (Unit 1) on 10 June and 26 July, respectively. Surprisingly, a large adult individual was captured on 7 June in an upland prairie site (Unit 7) characterized by a sandy substrate and vegetation typical of such soil, such as small soapweed and plains prickly pear cactus. There were no apparent sources of water nearby. This observation supports the idea that these snakes inhabit a wide variety of habitats and have a tendency to wander.

Plain-bellied Watersnakes were abundant throughout the Smoky Hill ANGR wherever water was present. However, the tendency for this species to wander also was observed. Population densities appear to be high at most sites that permanently hold water, while populations likely are smaller around ephemeral pools. This species appears to be successful because of the number of breeding sites for the Tiger Salamander. Plain-bellied Watersnakes were particularly abundant in ponds that contained numerous adults and larvae of the Tiger Salamander. Foraging and predation on salamanders was observed on many occasions. Populations likely will thrive as long as ponds are available for amphibian breeding. This snake may not be sensitive to terrestrial management practices.

Pituophis catenifer (Blainville, 1835), Gophersnake. The Gophersnake is abundant throughout most of Kansas, occupying a variety of habitats, including open grasslands, rock outcrops, woodlands, woodland edges, and cultivated fields. The largest snake in Kansas, the Gophersnake, regionally known as the Bullsnake, is primarily active from April to November at air temperatures above 60°F. This species is mostly diurnal, spending the days basking and foraging for rodents. Activity becomes more crepuscular during the hot summer months.

We observed 37 Gophersnakes during our survey. Eight individuals were observed during the VES, including four shed skins. The other four individuals were found either active or beneath cover objects during the day. These snakes were observed from 29 May through 24 September.

Twenty-seven Gophersnakes were observed during road surveys. Of these 27 snakes, eight were observed in May from 1730 to 1908 h, one was observed on 6 June at 1700 h, one on both 16 and 17 July at 2030 h and 0950 h, and 19 were observed during September, at times ranging from 1130 to 2155 h. Of the 19 found in September, 14 were neonates, indicating the high density of these snakes in September, immediately following hatching. Road surveys are the most efficient means of observing Gophersnakes on the installation.

Two Gophersnakes were captured in funnel traps during the survey, including one adult and one neonate. The adult was captured in a heavily wooded area (Unit 5) on 29 May and the neonate was captured in a heavily grazed pasture (Unit 8) on 27 September.

Gophersnakes were one of the most abundant and easily observed snake species on the Smoky Hill ANGR. They occur throughout the installation and are one of the few animals that can be observed in all habitat types, including ponds, prairies, rock outcrops, and even cultivated fields. Gophersnakes feed primarily on small mammals and accordingly, management practices that favor high small mammal populations will favor the Gophersnake.

Coluber constrictor Linnaeus, Eastern Racer. The Eastern Racer is an abundant snake throughout Kansas, inhabiting a wide variety of terrestrial habitats. This species appears to prefer open grasslands and prairies, but also frequents rocky, wooded hillsides and agricultural areas. Eastern Racers are active primarily from April through October at air temperatures from 60° - 90°F. Activity is mostly during the day, with individuals either basking or foraging for prey, which includes a wide variety of vertebrates and invertebrates.

We observed 12 Eastern Racers on the Smoky Hill ANGR during the survey. Of these, only two individuals were observed during the VES. The alert and active nature of this species can make observing individuals by this technique difficult. However, individuals often are encountered under surface objects or artificial cover. A single juvenile was observed by this means beneath a rock along the dike of a pond. The other individual was an adult found active on 17 May in a mixed-grass prairie near drift fence Unit 6.

Four individuals were observed while driving roads, of which three were dead (24 May, 13 June, and 9 September) and one was alive (24 May). The use of drift fence units was a highly effective way of sampling this highly active species (see also Schmidt 2004). During this survey, six individuals were captured using this method. Two individuals were captured in a recently burned mixed-grass prairie site (Unit 6) on 22 May. The vegetation still was short from the burn at this time. One individual was captured on 29 May in a heavily wooded area (Unit 5). Another snake was caught on 25 June near a large pond (Unit 1), another a month later in grazed prairie near a large pond (Unit 8), and another on 31 July in a hayed upland prairie site (Unit 3). These captures support the idea that the Eastern Racer inhabits a wide variety of habitats.

Eastern Racers are common throughout the Smoky Hill ANGR and can be found in all habitat types. Population densities probably are high throughout the installation because of the amount of open prairie habitat. Current management practices likely have little negative effect on Eastern Racer populations. This generalist species is tolerant of a variety of environmental disturbances.

Lampropeltis triangulum (Lacépède), Milksnake. The Milksnake occurs statewide and is found in a wide variety of habitats, including woodland edge, rocky hillsides, and valleys. It is a secretive species and is most easily observed beneath rocks and other surface cover. Milksnakes appear to be most abundant in eastern Kansas and along the Smoky Hill and Saline River valleys of western Kansas, and least abundant in the prairies of western Kansas. This species probably is common throughout the state, but its secretive habits make it difficult to observe in habitats that lack surface cover. Milksnakes are active primarily from April through November.

We documented the Milksnake for the first time in Saline County (Collins, 1993). A single individual was found beneath a rock on a rocky hillside ("Soldier's Cap") on 6 June. This species appears to be uncommon on the installation. However, the secretiveness of this species may be misleading as to its actual abundance on the installation. Based on the availability of suitable habitat, the Milksnake might be common on the installation. Because this species frequents rocky hillsides, few threats to Milksnake populations exist with respect to land management practices.

Lampropeltis calligaster (Harlan), Yellow-bellied Kingsnake. The Yellow-bellied Kingsnake occurs throughout most of eastern and southern Kansas but appears to be absent from the northern High Plains and the shortgrass prairies of western Kansas. Individuals inhabit a variety of habitat types, including rocky, wooded hillsides, open grasslands, and sand prairies. This primarily nocturnal species is most often encountered while actively searching for food. The Yellow-bellied Kingsnakes is active primarily from April to October.

Four Yellow-bellied Kingsnakes were observed during the survey. Two individuals were observed during the VES, including the shed skin of a large adult found on 21 May in a recently burned mixed-grass prairie site (near drift fence Unit 6). The other individual was a juvenile that we observed drinking out of Spring Creek from the "Crooked Bridge" on the northern boundary of the installation. Two adults were found while driving roads. On 10 June, a road-killed individual was observed. The other individual was found in a relatively undisturbed upland prairie on 9 September at 2005 h.

Yellow-bellied Kingsnakes are common throughout the Flint Hills and most of the Smoky Hills. While few specimens were observed during this study, this species is not easily detected and may also be common on the Smoky Hill ANGR. The majority of the installation is excellent habitat for these snakes, particularly the lightly disturbed mixed-grass prairie.

Lampropeltis getula (Linnaeus), Common Kingsnake. The Common Kingsnake is found throughout the state. It appears to be most abundant in the Flint Hills and least abundant in the High Plains. Similar to the Milksnake, this apparent habitat preference might be the result of biases associated with the availability of rock outcrops and other surface cover. Common Kingsnakes inhabit a wide variety of habitats, including woodlands, woodland edge, rocky hillsides, and open prairies. In eastern Kansas, this species appears to prefer moist areas. Common Kingsnakes are active from April to October, being primarily diurnal during the spring and fall months and primarily nocturnal during the hot summer months.

We observed three Common Kingsnakes on the Smoky Hill ANGR. Two of the snakes were found while driving roads. The first was captured on 30 May at 1940 h and the second was found on 24 July at 0830 h. The third Common Kingsnake was captured in a drift fence array in upland prairie (Unit 4) on 18 July.

In Kansas, Common Kingsnakes inhabit a wider variety of habitats than Yellow-bellied Kingnakes, but on the Smoky Hill ANGR the two species have similar habitat preferences and abundances. See the above account for details.

Heterodon nasicus Baird and Girard, Western Hog-nosed Snake. The Western Hog-nosed Snake is listed as a Species in Need of Conservation (SINC) in Kansas and was consequently considered a species of special concern for this project. Western Hog-nosed Snakes occur throughout the western two-thirds of Kansas, west of the Flint Hills region. This species appears to reach its peak abundance in the High Plains region of western Kansas. It prefers open, sandy river floodplains but also occupies a variety of open habitats containing loose soils in which to burrow. Although a SINC species, the Western Hog-nosed Snake appears to be locally abundant in many areas within its Kansas range.

A single Western Hog-nosed Snake was observed on the Smoky Hill ANGR during our survey. This individual was an adult found near the operations building during a road survey at 1355 h on 6 June. The air temperature at this time was 75° F. Habitat in the immediate area consisted primarily of mixed-grass prairie. The soil was loose and contained many burrows.

Based on the single sighting and the amount of habitat present, we consider the Western Hog-nosed Snake to be uncommon on the Smoky Hill ANGR. Records in the Smoky Hills are scattered and appear to be located primarily near the major rivers and larger tributaries. The installation lacks the large riverine habitat that this species prefers but does contain some suitable habitat: sandy areas with loose soil and numerous mammal burrows. Western Hog-nosed Snake populations are dependent on open, sandy habitats with plentiful populations of toads, its favored prey.

Elaphe obsoleta (Say), Texas Ratsnake. The Texas Ratsnake occurs throughout the eastern half of Kansas. Saline County is near the western edge of the range of this species. The Texas Ratsnake prefers woodland and woodland edge habitats. It appears to be restricted to riparian areas along rivers and streams at the western edge of its range. Individuals also can be found around human habitations, such as farmhouses and barns. Its annual period of activity is primarily from March and November.

One Texas Ratsnake was observed during the survey. A shed skin of a large adult was first collected under a piece of sheet metal in one of the building foundations located in the riparian area on the west side of the installation (“The Big Woods Area 51”). The skin was collected on 9 September. At 1320 h on 17 September, a large adult snake was found beneath the same piece of sheet metal. Whether the shed skin was from this individual is unknown.

On the installation, the Texas Ratsnake is probably limited to wooded riparian areas along Spring Creek and its tributaries. This fact, together with the location near the edge of the species’ range, probably accounts for the small, localized populations. Continued expansion of woodland and woodland edge habitat in riparian areas may lead to population increases and westward expansion of the range of this species. The main threat to Texas Ratsnake populations on the Smoky Hill ANGR is loss of riparian woodlands.

Sistrurus catenatus (Rafinesque), Massasauga. The Massasauga is the only venomous snake known to occur on the Smoky Hill ANGR. It is found throughout the eastern half of Kansas, primarily east of the High Plains region. Few records exist in the arid High Plains of western Kansas, but local populations do exist within this region (Hammerson, 1999). Massasaugas are found in a variety of habitats but appear to prefer open grasslands with or without rock outcrops and grasslands associated with wetlands. Seasonal activity is primarily from April through October. As with many species, the Massasauga is mainly diurnal during the spring and fall months but becomes more nocturnal during the hot, summer months.

A total of 21 Massasaugas was observed on the Smoky Hill ANGR. One individual was captured in a drift fence array in an upland prairie site (Unit 4) on 25 June. Six individuals were observed during the VES, two under cover and four active or coiled on the surface. Two of these latter individuals were in a mixed-grass prairie site that had been burned about one month previously and that contained numerous rodent burrows. These snakes were observed at 1000 h and 1015 h on 22 May and 23 May, respectively. The other two individuals were basking on the surface at rock outcrops on 6 June and 18 June. One adult individual was found beneath a tarp near the operations building and sewage lagoons on 24 July at 1030 h. On 4 September a neonate was found beneath a board at the maintenance storage facility.

The majority of Massasaugas encountered was found while driving roads, primarily at night. The first was an adult found on 8 May at 1935 h. On 22 May, we found an adult active during the day at 1140 h. The other adults were found during the summer and early fall at night. Three individuals were observed in July between 2100-2200 h. Beginning in early September, neonates were observably abundant on roads during the late afternoon and evening. From 2-25 September, seven neonates were observed crossing roads between 1515-2127 h. On 17 September, a single adult was captured at 2125 h.

The Massasauga is abundant on the Smoky Hill ANGR and might be the most abundant snake species on the installation. The installation contains a large amount of open grassland and some wetland habitat, the preferred habitats for this species. Populations are probably large and densities high throughout the installation. The large number of neonates observed provides evidence for large populations. The current management regimes throughout the installation probably benefit this species, particularly patches of prairie that are periodically burned or remain relatively undisturbed. The many ponds that are interspersed throughout these patches probably increase the quality of the prairie habitat for the Massasauga. The land practice that likely is the least beneficial for the Massasauga is cattle grazing. Massasaugas prefer taller vegetation and loose soils containing numerous rodent burrows. Cattle tend to keep vegetation short and may compact the soil.

4.3.1.5. Potential Species

Seven species of reptiles and amphibians that have not been documented on Smoky Hill ANGR may occur based on their known occurrence in central Kansas and their habitat preferences. Although this one-year study was relatively thorough, many species of reptiles and amphibians are difficult to detect, in most cases because they spend most of their time below ground and little time active on the surface. The list below includes two amphibians and five reptiles that may occur on Smoky Hill ANGR.

Plains Spadefoot	*Spea bombifrons*
Great Plains Narrow-mouthed Toad	*Gastrophryne olivacea*
Eastern Collared Lizard	*Crotaphytus collaris*
Western Slender Glass Lizard	*Ophisaurus attenuatus*
Eastern Hog-nosed Snake	*Heterodon platirhinos*
Cornsnake	*Elaphe guttata*
Coachwhip	*Masticophis flagellum*

4.3.2. Mammal Surveys

4.3.2.1. Material and Methods

The mammal inventory also took place from 8 May through 1 October, 2003. In order to document as much of the mammalian fauna on the installation as possible during one field season, five survey methods were employed. These were visual encounter surveys, road (driving) surveys, drift fences with funnel and pitfall traps, and Sherman live trap arrays. Details of each field method are described below. Field participants in the study included Curtis Schmidt, Richard Hayes, Galen Wiens, and Travis Taggart. Individual localities of observations were recorded in decimal degrees (NAD84 projection) using a Garmin 12 handheld GPS unit, or plotted directly onto maps provided by the Smoky Hill ANGR personnel. The date and time of each observation were recorded. In order to make efficient use of time, data were not recorded for certain abundant species that were regularly observed throughout the Smoky Hill ANGR. In these instances, accurate counts of individuals were difficult, as many individuals likely were observed on a regular basis. For this reason, the maps of these species underestimate the respective abundances and distributions on the installation. In addition, bat surveys were not conducted as part of this project. Refer to Jones et al. (1985) for bat species that might occur on the installation and see Potential Species at the end of this section. Voucher specimens for select species (see species accounts) were collected, skinned, skeletonized, and accessioned into the collection at the Museum of the High Plains, Sternberg Museum of Natural History, Fort Hays State University (MHP). Common and scientific names are taken from Potts and Collins (2005).

Visual Encounter Survey

One of the primary survey techniques was the general visual encounter survey (VES) (Crump and Scott 1994), which involves thoroughly searching available natural habitat. A total of 51 person-hours (one person searching for one hour) was spent searching rock outcrops and upland prairie sites. At these sites, searching methods included turning over rocks and searching rock crevices and burrows. Additionally, 77 person-hours were spent searching ponds and creeks. We thoroughly searched 28 ponds by walking the perimeters, searching in and under fallen timber, and looking for swimming animals. We also searched three sites along Spring Creek by walking through the creek and searching the banks and log jams, as well as the surrounding trees. These aquatic and semi-aquatic habitats primarily were searched at mid-day during the summer when daytime temperatures were too high for most terrestrial activity.

Road Surveys

The other primary survey technique was the driving of maintained roads, trails, and plowed firebreaks. This method often is the most effective way of observing the larger crepuscular and nocturnal, surface-active species. Throughout the project we spent 181 hours driving a total of 2,493 miles throughout the installation and on maintained county roads adjacent to the installation. This time included searching for animals, obtaining and recording GPS coordinates, and tending drift fence arrays. All major roads on the installation were surveyed regularly.

Drift Fence Trap Arrays

Nine drift fence units were placed in a variety of habitats with differing land use practices. Each drift fence unit consisted of one 100’ x 2’ commercial polypropylene silt fence with wooden stakes every 10 feet. A funnel trap constructed of 0.25” hail screen was placed at both ends of the silt fence. Plastic buckets of varying sizes (3-5 gallons) were buried in the center of each silt fence to serve as pitfall traps, targeting small, secretive species. The pitfall was omitted from drift fence Unit 2 because the substrate was primarily rock, which made placement of the pitfall difficult.

Drift fence localities were chosen based on accessibility and habitat/land use diversity. Locations of the drift fences are shown in Figure 4.6 and geographic coordinates are provided in Table 4.6. The general habitat types of each unit are as follows: two in hayed prairie (Units 3, 7), one adjacent to a large, permanent pond (1), two in riparian or riparian/prairie edge (5, 9), two in unhayed, ungrazed prairie (4, 6), one in grazed prairie (8), and one along a rock outcrop (2). A single-stranded barbed wire fence was constructed around drift fence Unit 8 (grazed) to exclude cattle and deter them from destroying the drift fence or traps.

Fence construction began on 10 May and took approximately two weeks to complete. Traps then were run until 25 September. Traps generally were opened the first day of each week on site and closed the final day on site. Traps were checked daily for a total of three to four checks per week. Funnel traps were closed by plugging the funnel openings with various objects (vegetation, soil clumps, sticks, rocks) and pitfalls were covered with flat, plastic trays. Some individuals were captured while traps were closed. These were considered incidental captures and were not included in the number of trap-nights.

All traps were maintained for the majority of the study, with the exception of drift fence Unit 2. At Unit 2, the fence was destroyed by wind and because trap success was minimal (only one lizard species and one mouse species were captured), the fence was not repaired. Also, drift fence Unit 4 (ungrazed, unhayed) was run only through 19 August because fire completely destroyed the unit. A total of 276 trap-nights (one trap open for one night) was utilized during the survey.

Cover boards

Three clusters of various-sized plywood sheets were utilized as artificial cover at three sites. The first site had 15 boards placed in a heavily wooded area near some old building foundations. The second site had 18 boards in a sparsely wooded, heavily grazed pasture. The third site had five large sheets near a small cluster of trees along the dike adjacent to a large, permanent pond. All boards were laid out on 18 July and checked sporadically, at least once per week, through 10 October. Initially, all individuals observed underneath the plywood were recorded; however, most individuals used the boards for the remainder of the study and subsequently were not recorded. Locations and geographic coordinates of the cover board arrays are provided in Figure 4.6 and Table 4.6, respectively.

Sherman Trap Transects

Six sites were surveyed for small mammals by using transects of Sherman live traps. Each trap was baited with a combination of peanut butter and oats wrapped in wax paper and suspended over the trigger of the trap. Traps were baited and set in the evenings and checked at sunrise the following day. Habitat descriptions and coordinates of the trap arrays are provided in Table 4.10; a map showing array locations is found in Figure 4.6.

TABLE 4.10. Habitat characteristics and geographic coordinates of Sherman trap arrays in 2003.

Trap Array	Description	Latitude	Longitude
A	Lightly-grazed mixed grass prairie near riparian	38.7411	97.8086
B	Lightly-grazed mixed grass prairie near pond	38.7315	97.7875
C	Mixed grass/riparian edge habitat	38.74729	97.81778
D	Headquarters Pond (HQ Pond)	38.75379	97.78777
E	Recently-burned upland prairie with foundations	38.68292	97.83412
F	Weedy, heavily-disturbed prairie habitat	38.7054	97.8457

Trap array A was set on 23 May in grazed, lowland, mixed-grass prairie near a riparian area in the north-central portion of the installation. Six parallel transects of 8 traps each were set out at 10 m intervals with traps placed at 10 m intervals. The total number of traps was 48, with anarea trapped of approximately 4,800 m^2.

Trap array B was set on 30 May in grazed, upland, mixed-grass prairie. Transects were oriented east to west down a gradual decline and ended near a small pond. Three parallel transects of 10 traps each were placed 10 m apart. Total number of traps was 30, with a total area trapped of 3000 m^2.

Trap array C was set on 4 September in lowland, mixed-grass prairie and riparian edge habitat. Vegetation consisted mainly of grasses and forbs with many cottonwood trees nearby. The vegetation in the immediate area was dense and tall, with primary species being Sumac and Big Bluestem. Four parallel transects were established at 10 m intervals with a total of 35 traps.

Trap array D was set on 16, 17, and 18 September and checked on three consecutive days. The total number of traps was 53, 40, and 53 traps, respectively. Traps were set on the south, east, and north sides of HQ Pond. Traps were set at 5-m intervals along 265 m of transect, and were placed in both vegetation and on bare ground near the water. Vegetation included willows, cottonwood, asters, annual sunflower, smartweed, common horseweed, cattail, and sedges.

Trap array E was set on 24, and 25 September and checked for two consecutive days. Traps were set in recently burned upland grassland in the Impact Area. The site had burned less than 30 d previously and the ground was primarily bare with numerous mammal burrows present. A total of 81 traps were set. Some traps were placed around the foundations and structures of some old buildings and then a single linear transect was laid out with traps at 15-m intervals. The transect bisected two small, dry ponds encircled by cottonwood trees. Practice targets were located nearby and the ground in much of the area was heavily disturbed.

Trap array F was set on 1 October and consisted of four parallel transects of 20 traps each placed at 15-m intervals for a total of 80 traps. The location of the array was just southeast of the Operations Building in the Impact Area. The habitat was upland grassland that was heavily disturbed and dominated by weedy vegetation. It appeared as if most of this area had been plowed at some point in the recent past. The soil was extremely soft, with numerous small mammal burrows throughout.

4.3.2.2. Results

A total of 28 mammal species and >339 individuals were documented on the Smoky Hill ANGR (Table 4.11). All but two species were recorded from observations of live or dead animals. Two species, Eastern Mole (*Scalopus aquaticus*) and the American Beaver (*Castor canadensis*), were documented from indirect evidence. Two rare target species, Eastern Spotted Skunk (*Spilogale putorius*) and Franklin's Ground Squirrel (*Spermophilus franklinii*), were not recorded. A new county record for the Meadow Jumping Mouse (*Zapus hudsonius*) was documented, representing a significant range extension in Kansas (Choate et al. 1991). Species accounts are provided for documented species. Individual locations are provided in an ArcView GIS shapefile but are not presented in this report. Figure 4.9 shows all sites in 2003 where mammals were recorded.

Visual Encounter Survey

Nine species (individuals or sign) were observed during the VES. These nine species included the Eastern Mole (foraging tunnels only), Eastern Cottontail (*Sylvilagus floridanus*), Eastern Fox Squirrel (*Sciurus niger*), Plains Pocket Gopher (*Geomys bursarius*) (soil mounds only), Hispid

Pocket Mouse (*Chaetodipus hispidus*), American Beaver, Eastern Woodrat (*Neotoma floridana*), Deer Mouse (*Peromyscus maniculatus*), and Southern Bog Lemming (*Synaptomys cooperi*). Of these species, only the Eastern Mole and American Beaver were documented by this method only. Again, no individuals of these two species were observed, but their presence on the installation was documented by physical evidence of both species' presence. Foraging tunnels were observed for the Eastern Mole, and bite markings and cut down trees were observed for the American Beaver.

Road Surveys

We observed 11 species while conducting road surveys. This was the only method in which we observed many of the larger, more conspicuous species, as well as nocturnal species. These included the Virginia Opossum (*Didelphis virginiana*), Black-tailed Jack Rabbit (*Lepus californicus*), Coyote (*Canis latrans*), Northern Raccoon (*Procyon lotor*), American Badger (*Taxidea taxus*), Striped Skunk (*Mephitis mephitis*), Bobcat (*Lynx rufus*), and White-tailed Deer (*Odocoileus virginianus*).

Drift Fence Trap Arrays

The nine trapping arrays resulted in the capture of 130 individuals of 15 species (Table 4.12). Eight species were collected in the pitfall traps (41 individuals) and 12 species were collected in the funnel traps (89 individuals). The use of pitfall traps resulted in the only collections of the Least Shrew (*Cryptotis parva*) and Plains Pocket Gopher during the survey. Similarly, the funnel traps provided the only examples of the Plains Pocket Mouse (*Perognathus flavescens*) and Meadow Jumping Mouse. The pitfall traps were successful in giving us a better understanding of the distribution of shrews on the Smoky Hill ANGR, and the drift fence arrays in general were effective in capturing species that are not attracted to oats and peanut butter and therefore not adequately sampled using Sherman traps.

Cover Boards

The use of cover boards provided little information. Only three mammal species were found utilizing the cover, the Prairie Vole (*Microtus ochrogaster*), White-footed Mouse (*Peromyscus leucopus*), and Hispid Cotton Rat (*Sigmodon hispidus*). Other unidentified, young *Peromyscus* also were observed. These were most likely *P. leucopus*, but it is possible that some were *P. maniculatus*. After the initial utilization of the cover boards by both Prairie Voles and White-footed Mice, several individuals of both species could be observed routinely. Both species also used the cover for rearing young. For these reasons, the true number of individuals observed is difficult to estimate. The greatest number of any species observed under a set of boards at any one time was five Prairie Voles. Only one Hispid Cotton Rat was observed on one occasion. The use of cover boards was not an efficient sampling technique for mammals. The three species observed by the use of cover boards were easily captured in traps.

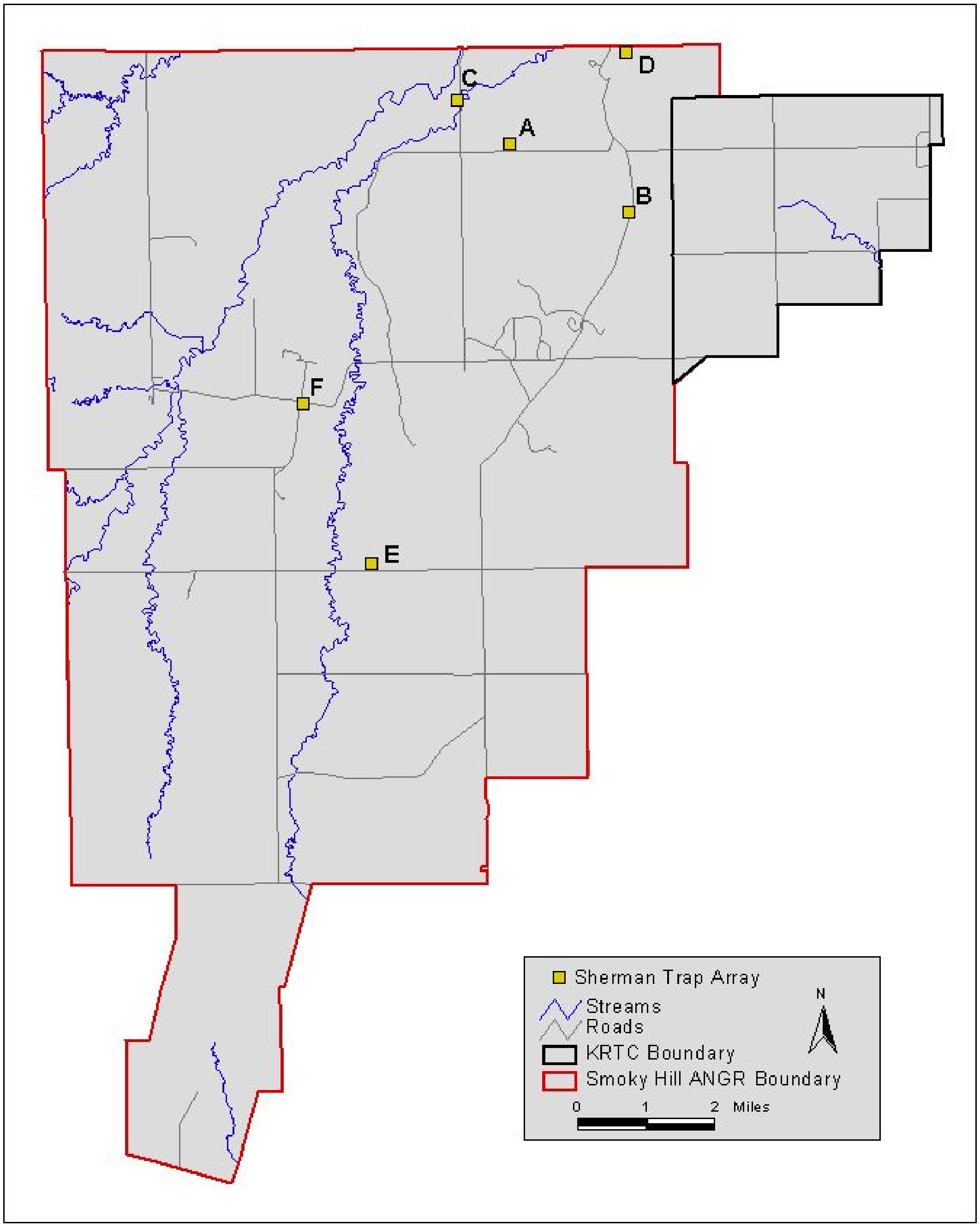


FIGURE 4.8. Locations of Sherman trap arrays used for sampling small mammal populations in 2003.

TABLE 4.11. Mammal species and numbers of individuals observed on Smoky Hill ANGR in 2003.

Common Name	Scientific Name	Individuals Observed	Other Evidence
Virginia Opossum	*Didelphis virginiana*	1	
Elliot's Short-tailed Shrew	*Blarina hylophaga*	10	
Least Shrew	*Cryptotis parva*	7	
Eastern Mole	*Scalopus aquaticus*	0	tunnels
Black-tailed Jack Rabbit	*Lepus californicus*	5	
Eastern Cottontail	*Sylvilagus floridanus*	several	
Eastern Fox Squirrel	*Sciurus niger*	4	
Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*	15	
Plains Pocket Gopher	*Geomys bursarius*	2	tunnels
Hispid Pocket Mouse	*Chaetodipus hispidus*	15	
Plains Pocket Mouse	*Perognathus flavescens*	2	
American Beaver	*Castor canadensis*	0	trees
Prairie Vole	*Microtus ochrogaster*	39	
House Mouse	*Mus musculus*	4	
Eastern Woodrat	*Neotoma floridana*	11	
Northern Grasshopper Mouse	*Onychomys leucogaster*	6	
White-footed Mouse	*Peromyscus leucopus*	55	
Deer Mouse	*Peromyscus maniculatus*	83	
Western Harvest Mouse	*Reithrodontomys megalotis*	8	
Hispid Cotton Rat	*Sigmodon hispidus*	22	
Southern Bog Lemming	*Synaptomys cooperi*	2	
Meadow Jumping Mouse	*Zapus hudsonius*	3	
Coyote	*Canis latrans*	3	
Northern Raccoon	*Procyon lotor*	12	
American Badger	*Taxidea taxus*	5	
Striped Skunk	*Mephitis mephitis*	10	
Bobcat	*Lynx rufus*	3	tracks
White-tailed Deer	*Odocoileus virginianus*	several	
Total Individuals		327+	

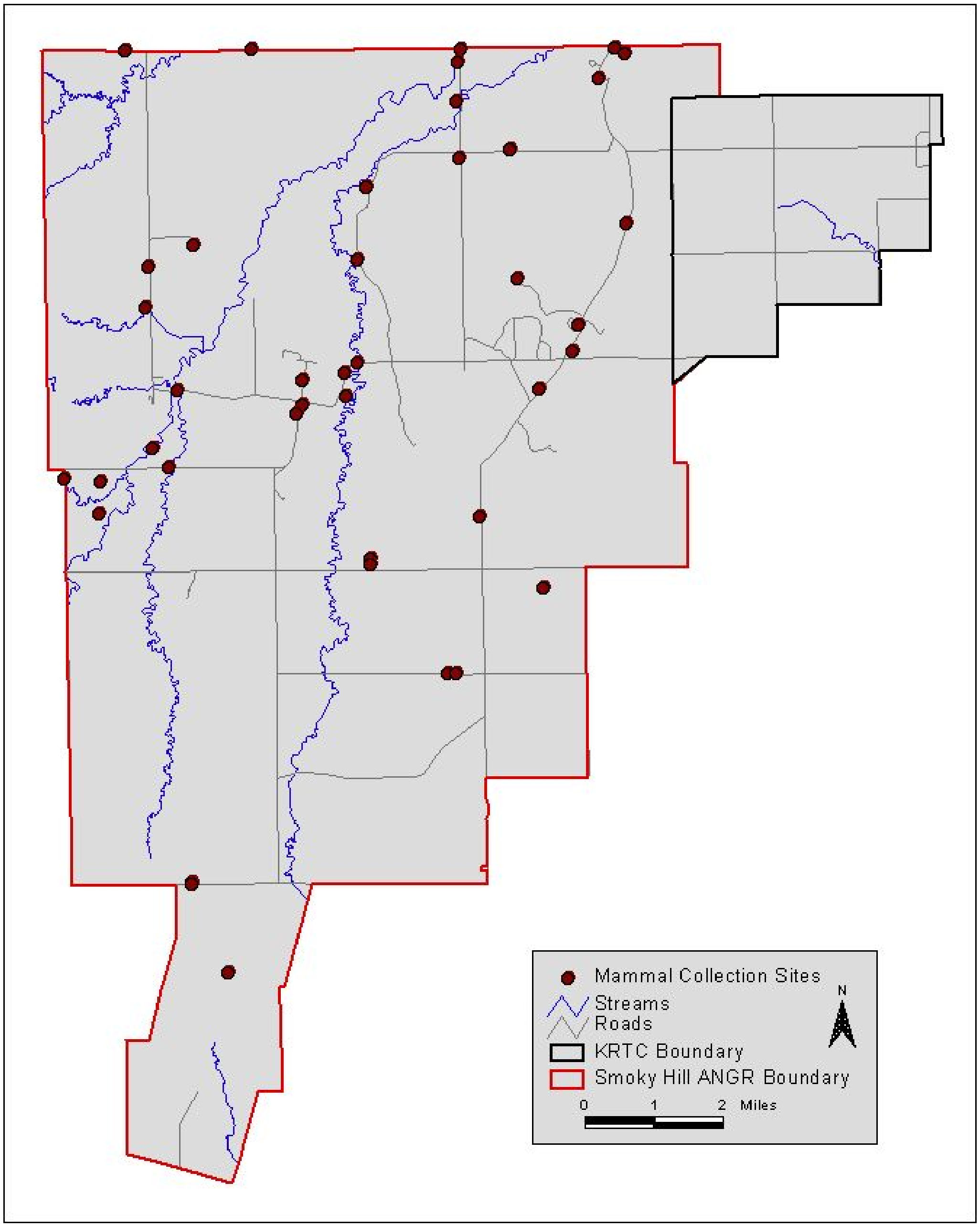


FIGURE 4.9. Sites where mammals were reported during this study in 2003.

TABLE 4.12. Numbers of small mammals captured in funnel traps (F) and pitfall traps (P) at drift fences on Smoky Hill ANGR in 2003.

Common Name	Drift Fence Unit																		Total
	1		2		3		4		5		6		7		8		9		
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	
Elliot's Short-tailed Shrew		1						2	1					3			1	2	10
Least Shrew		1						4		1				1				1	8
Thirteen-lined Ground Squirrel					2		1				1		1		1				6
Plains Pocket Gopher								1				1							2
Hispid Pocket Mouse							1		2						3		2		8
Plains Pocket Mouse											1		1						2
Prairie Vole	4	4	1			6	3	1	7	1			4	3			2	1	37
House Mouse																1			1
Eastern Woodrat	2								1		1						2		6
White-footed Mouse	1								1									1	3
Deer Mouse	1		2				5	1	1		1		5		1	3	1		21
Western Harvest Mouse													2	2			2		6
Hispid Cotton Rat	1				1		3		4		1		3		1		1		15
Southern Bog Lemming	1																1		2
Meadow Jumping Mouse	1																2		3

Sherman Trap Transects

Using Sherman live traps, a total of 128 individuals of nine species was collected at six sites between 27 May and 1 October, 2003 (Table 4.13). Of the nine species, two were only observed with this technique, the House Mouse (*Mus musculus*) and Northern Grasshopper Mouse (*Onychomys leucogaster*). Because most captured individuals were released unmarked, some captures in Arrays D and E, where trapping was conducted for multiple nights, may have been of the same individuals. Trapping success was much higher in the fall (Arrays C, D, E, and F) than in the spring (Arrays A and B).

The use of Sherman trap transects is probably the best way to document the presence of small rodents and rodent-like mammals. They also are an efficient way of characterizing species richness and diversity in various habitats and land use practices. The use of more transects during the survey likely would have provided good data on the diversity of mammals on the installation; however, we think the number of arrays utilized during the survey, together with the drift fence arrays, was effective in providing adequate species richness data for the installation.

TABLE 4.13. Numbers of small mammals captured in Sherman trap arrays in May-October, 2003.

Common Name	Sherman Trap Array						Total
	A	B	C	D	E	F	
Thirteen-lined Ground Squirrel					1		1
Hispid Pocket Mouse					6		6
House Mouse				3			3
Eastern Woodrat					2		2
Northern Grasshopper Mouse					6		6
White-footed Mouse			8	28	7		43
Deer Mouse	1		1	3	42	12	59
Western Harvest Mouse			2				2
Hispid Cotton Rat			1	5			6
Total captures	1	0	12	39	64	12	128
Trap nights	48	30	35	146	162	80	501
Trapping success	0.02	0.00	0.34	0.27	0.40	0.15	0.26

4.3.2.3. Discussion

This study documented the presence of 28 species of mammals on Smoky Hill ANGR (Table 4.11). The mammal community at the installation is comprised of a mixture of species with woodland, grassland, aquatic, and generalist habitat affiliations. Numerically, small mammals associated with grassland habitats such as Prairie Vole, Deer Mouse, and Hispid Cotton Rat, are dominant. Another large group of species are associated with grassland-woodland edge habitats. Some of the more common species in this group are White-footed Mouse, Eastern Woodrat, Eastern Cottontail, and White-tailed Deer.

This one-year study used a variety of methods in order to document as much of the mammalian fauna as practical. Drift fences and Sherman traps are both effective techniques for sampling small mammals. Visual encounter and road surveys were successful in documenting additional species, especially medium and large-bodied mammals. Additional approaches that could be used to document additional mammal species include bat survey methods (using mist-netting and bat detectors), tracking plates to identify species by footprints, trapping efforts for medium-sized mammals, and nocturnal survey approaches. These methods, many of them labor intensive, would no doubt successfully document some of the species listed in Potential Species (Section 4.3.4).

General information on the habitat requirements and management needs of individual species are presented in the species accounts and summarized in Table 4.14. Because of the species-specific nature of these habitat needs, providing management recommendations for mammals as a group is difficult. Management that benefits one species may be detrimental to the populations of another species. For example, grassland-dwelling species will benefit from expansion of grassland habitat and woodland-dwelling species will benefit from woodland expansion;

management that results increased habitat for one species is at the expense of habitat for the other. In general, ecosystem management is recommended over species level management. Following consistent management guidelines to enhance and maintain high quality natural communities and provide healthy ecosytem conditions is an effective approach and one that will be beneficial to most native mammal species. Species level management may be warranted for species of special concern (for example, endangered, threatened, Kansas species in need of conservation), game species, and invasive or otherwise undesirable species. Special management actions may be needed for such species in an attempt to increase or decrease populations of desirable or undesirable species., respectively. Where species of conservation or management concern are present, the habitat needs of these species should be addressed as long as they do not conflict with other management priorities. As an example, one of the general management guidelines suggested in this document is to reduce the expansion of woody vegetation into prairie habitats on the installation. This will benefit some mammal species while leading to population declines for others. No woodland-associated mammal species on the installation are conservation priority species, so this recommendation should not create conflicts for overall mammal conservation and management.

4.3.2.4. Species Accounts

The following are short accounts for each of the 28 species of mammals documented on the Smoky Hill ANGR during our survey. General natural history information for each species comes from the reviews found in Jones et al. (1985), unless otherwise cited. The specific habitat associations and behaviors refer only to those observed on the Smoky Hill ANGR during the survey period.

Didelphis virginiana, Virginia Opossum. The Virginia Opossum is the only species of marsupial native to North America. This species is common throughout Kansas, preferring wooded areas near streams or rivers. The Virginia Opossum, noted for its resilience, is omnivorous, consuming a wide variety of plant and animal items. Females generally produce two litters of six to nine young per year. This species is strictly nocturnal.

During our survey, only one Virginia Opossum was observed. The individual was found dead-on-road (DOR) during the road survey on Parson's Road, where the road crossed riparian habitat along a small, dry tributary of Spring Creek.

We think this species is a more common resident of the Smoky Hill ANGR than the single record indicates. The opossum's nocturnal activity pattern, together with its secretiveness and preference for heavily wooded habitats, make it difficult to detect. The use of traps likely would have resulted in the capture of more individuals. More intensive spotlighting in wooded habitats might also have resulted in more observations. Current land management practices pose little threat to this omnivorous generalist, and populations are, therefore, probably stable. The removal of trees likely would be the most detrimental to this species.

Blarina hylophaga, Elliot's Short-tailed Shrew. Elliot's Short-tailed Shrews are common throughout most of Kansas, but appear to be absent from the southwestern portion of the state. This large shrew inhabits a wide variety of habitats, including grasslands, wooded areas, and weedy, disturbed areas. This species is active both day and night, with much activity restricted to underground tunnels. Food includes a variety of invertebrates and a small amount of vegetative matter.

Ten Elliot's Short-tailed Shrews were captured at five different sites throughout the installation. All of these individuals were captured in the drift fence arrays, two in funnel traps and eight in pitfalls. A variety of habitats were utilized by this species. Three individuals were captured in mixed grass prairie/riparian edge (Unit 9), three were captured in sandy upland prairie (Unit 7), two in a periodically-burned, upland prairie site (Unit 4), one near a large pond (Unit 1), and one in a heavily-wooded riparian area (Unit 5). Elliot's Short-tailed Shrews were captured from 24 July through 27 September, with five (50%) individuals captured on 27 September.

Elliot's Short-tailed Shrew is common throughout the Smoky Hill ANGR in most habitats. Populations probably are high and stable throughout most of the installation. Because this species is a common inhabitant of heavily disturbed areas, current land practices likely pose little threat to Elliot's Short-tailed Shrew populations. Populations likely are largest in undisturbed prairie habitats.

Cryptotis parva, Least Shrew. The Least Shrew is found throughout Kansas, but is least common in the arid habitats of extreme western Kansas. Least shrews are locally abundant in many open prairie habitats, meadows, and weedy pastures and roadsides. They also are known to be gregarious, with as many as 30 individuals sharing the same nests. This species often is found beneath rocks, logs, and other types of ground cover. Least Shrews utilize the burrows of other mammals, but also create their own burrows in areas with loose soils. Activity is mainly at night, with some activity during the day.

Seven Least Shrews were captured during the survey, all of which were captured in pitfall traps associated with drift fence arrays. These shrews were collected at the same five sites as Elliot's Short-tailed Shrew. Three individuals were captured at a periodically burned upland prairie site (Unit 4), and single individuals were captured at a wooded riparian area (Unit 5), near a large pond (Unit 1), and in a riparian/prairie edge habitat. Least Shrews were captured from 30 May through 2 September. Three individuals (43%) were captured on the night of 4 August.

Least Shrews also are common throughout most of the installation, but might be absent from sandy, sparsely vegetated areas. Populations probably are largest in undisturbed prairie sites. Due to its gregarious behaviors, population densities of this species probably are high. Like Elliot's Short-tailed Shrew, this species probably is not negatively impacted by current land practices on the installation, and populations likely are stable.

Scalopus aquaticus, Eastern Mole. The Eastern Mole occurs throughout Kansas in areas with sufficient soil moisture. In western Kansas, this species occupies areas near sources of water or other mesic environments, such as lawns and golf courses. Eastern Moles spend the bulk of their lives underground in tunnels. These tunnels are either permanent tunnels (6-10 inches deep) or foraging tunnels, shallow tunnels that create the characteristic ridges or mounds of soil that often indicate the presence of this species. The diet consists mainly of soil-dwelling invertebrates.

TABLE 4.14. Summary of habitat affiliations and land management recommendations for mammal species on Smoky Hill ANGR. See Species Accounts for more details. Habitat codes: AQ = aquatic or wetland; GR = grassland or open habitat; WO = woodland, woodland edge, or other woody habitat; OT = other habitat (urban or habitat generalist).

Common Name	Habitat	Habitat Description	Species Level Management
Virginia Opossum	WO	Woodland and woodland edge; generalist	Maintain or increase woodland habitat
Elliot's Short-tailed Shrew	OT	Habitat generalist	Maintain native habitats
Least Shrew	GR	Grassland and woodland edge	Maintain native habitats
Eastern Mole	OT	Moist soils with earthworms and other invertebrates	Maintain native habitats in areas with moist soils
Black-tailed Jack Rabbit	GR	Large, open areas with sparse vegetation	Graze heavily; eliminate woody vegetation
Eastern Cottontail	WO	Woodland edge and brushy areas	Increase woodland edge and shrub habitat
Eastern Fox Squirrel	WO	Woodland	Maintain or increase woodland habitat
Thirteen-lined Ground Squirrel	GR	Short to mid-height grasslands	Maintain prairie habitat; favored by moderate to heavy grazing or periodic mowing
Plains Pocket Gopher	GR	Prairies and other grassland with fertile, light-textured soils.	Maintain deep-soiled prairies
Hispid Pocket Mouse	GR	Mainly upland prairie habitats	Maintain upland prairie
Plains Pocket Mouse	GR	Short-statured prairie with sandy soil	Maintain sandy prairies with grazing
American Beaver	AQ	Permanent ponds and streams bordering trees	Impractical to manage for without permanent water
Prairie Vole	GR	Dense grassy vegetation	Maintain areas with lightly-grazed or ungrazed prairie
House Mouse	OT	Urban areas; buildings; disturbed areas	[Undesirable species]
Eastern Woodrat	WO	Woodland, woodland edge, rocky areas	Increase woody habitat; reduce fire frequency
Northern Grasshopper Mouse	GR	Short grasslands with sandy soils	Maintain short grasslands with fire and moderate to heavy grazing
White-footed Mouse	WO	Woodland and woodland edge	Increase woody and edge habitat

Deer Mouse	GR	Grasslands, cultivated areas, and other open, disturbed sites; habitat generalist	Maintain prairies and other open areas with light to heavy disturbance
Western Harvest Mouse	GR	Prairie and other grassy habitats	Maintain good quality prairie
Hispid Cotton Rat	GR	Areas with dense herbaceous vegetation	Maintain prairie with light or no grazing
Southern Bog Lemming	GR	Wet areas with dense grassy vegetation	Reduce grazing levels near ponds and wetlands
Meadow Jumping Mouse	GR	Tall grass and woodland edge	Maintain ungrazed riparian areas of grassland-woodland edge
Coyote	GR	Open areas; habitat generalist	Maintain open areas with healthy small mammal populations
Northern Raccoon	WO	Woodland and woodland edge	Increase woody habitat
American Badger	GR	Open grasslands with deep soils	Maintain deep-soiled prairie with healthy populations of burrowing small mammals
Striped Skunk	OT	Woodland, woodland edge, grassland	Increase woody habitat and habitat structure
Bobcat	WO	Woodland, woodland edge and brushy habitats	Increase woody habitat; reduce grazing levels
White-tailed Deer	WO	Woodland, woodland edge and brushy habitats	Increase woody habitat and cropland

No specific attempts at trapping Eastern Moles were made during our survey. Although no individuals of this species were observed during the survey, their presence on the Smoky Hill ANGR was confirmed by the presence of their characteristic foraging tunnels. These tunnels were observed during both the VES and road surveys in areas with loose soil and riparian woodland areas. One such tunnel crossed a maintained road near drift fence Unit 9 in a riparian area.

Based on the number of tunnels that we observed, Eastern Moles are probably common on the Smoky Hill ANGR in mesic habitats. Such habitats are common and widely distributed throughout the installation. Because no individuals were observed, it is difficult to speculate on population size and density. However, populations likely are stable. Current land practices probably pose little threat to populations of this subterranean mammal. Periods of drought might have a negative impact on mole populations.

Lepus californicus, Black-tailed Jack Rabbit. The Black-tailed Jack Rabbit occurs throughout Kansas, and is most common in the arid and semi-arid regions of western and central Kansas. This large hare prefers open habitats, including shortgrass prairies, cultivated fields, and heavily-grazed pastures, allowing them to utilize their keen eyesight and speed to avoid predators. Black-tailed Jack Rabbits are active year-round, feeding on a wide variety of native and cultivated plants, including dried herbage, twigs, and cacti in the winter months. They are important for seed dispersal. Populations of Black-tailed Jack Rabbits appear to be cyclic.

Approximately five adult Black-tailed Jack Rabbits were observed on the installation. Individuals often were observed in the same areas on different dates, and, therefore, were only counted once. However, some of the rabbits might have been different individuals. These individuals primarily were observed during the road surveys from 1600-2100 h. The rabbits occupied grazed pastures and plowed fire breaks on the southern sections of the installation.

At the time of this survey, the Black-tailed Jack Rabbit appeared to be uncommon on the Smoky Hill ANGR. Small populations existed in heavily disturbed habitats on the southern section of the installation. Small populations of this species might be kept small by predation pressures. The current land management practices on the installation do not favor this species. The Black-tailed Jackrabbit prefers shortgrass prairies and heavily grazed pastures. Few pastures are heavily grazed on the installation. For this reason, populations likely will remain low, but probably stable.

Sylvilagus floridanus, Eastern Cottontail. The Eastern Cottontail is abundant throughout Kansas, particularly in wooded areas and residential areas. In western Kansas, the Eastern Cottontail is mainly restricted to riparian habitats and urban areas. This prolific species has many litters of up to nine young each year. Survival beyond one year is rare, mainly because this species is an important prey item for many mammals, reptiles, and birds. Activity is year-round and daily activity is mainly crepuscular. A variety of vegetation is eaten.

Many Eastern Cottontails were observed throughout the Smoky Hill ANGR throughout the duration of the survey. At least 40 individuals were observed, but most observations of this species were undocumented. A variety of habitats were occupied, including upland prairie, riparian areas, weedy areas, and rock outcrops. This species appeared to be most numerous in grassy, wooded or woodland edge habitats and least abundant in heavily grazed pastures. Daily activity appeared to be primarily during the morning and evening daylight hours.

Eastern Cottontails are abundant throughout the installation. Populations probably are largest in wooded areas and woodland/prairie edge habitats. The largest threat to populations would be the destruction of woody and shrubby habitats. Large cottontail populations likely support healthy populations of large carnivores.

Sciurus niger, Eastern Fox Squirrel. The Eastern Fox Squirrel is common throughout Kansas, but is restricted to wooded areas. This squirrel is most widespread in the deciduous forests of eastern Kansas, and mainly inhabits riparian areas and urban areas in central and western Kansas. This diurnal species spends most of its time in trees, coming to the ground to forage, cache nuts, or move between trees. They are known to eat nearly all plant material, fungi, birds' eggs, and insects. Fox squirrels are active year-round.

Four Eastern Fox Squirrels were observed during the survey, at four different sites. All four sites were riparian woodlands along Spring Creek. They were observed on 30 May, 2 August, and 2 September. Activity was during daylight hours from as early as 0910 h to as late as 1615 h.

The Eastern Fox Squirrel is a common resident of wooded areas on the installation. Populations likely are moderate and stable, with few threats. Obviously, the destruction of riparian habitats and other wooded areas would be detrimental to this species.

Spermophilus tridecemlineatus, Thirteen-lined Ground Squirrel. The Thirteen-lined Ground Squirrel is found statewide and is abundant in western and central Kansas. It occupies grassland habitats, as well as urban areas and avoids wooded areas. This species utilizes disturbed areas, particularly those with short vegetation, for foraging and dispersal. The Thirteen-lined Ground Squirrel is known for its extensive tunnel systems that typically connect burrows to foraging areas. These squirrels are almost exclusively diurnal, spending the day foraging for seeds, leaves, and roots. Insects also are a major part of the diet, particularly in summer and autumn. Occasionally, other small mammals and birds are eaten.

We observed approximately 15 Thirteen-lined Ground Squirrels during the survey at 15 different locations. These individuals were observed using a variety of methods. One individual was captured in a Sherman live trap (Array E) on 26 September, six individuals were captured in funnel traps (Arrays 3, 4, 6, 7, and 8) from 30 May through 10 September, and eight individuals were observed during the road surveys between 24 July and 24 September. Thirteen-lined Ground Squirrels occupied a variety of upland prairie habitats. These areas included sandy areas with sparse vegetation and grassland that were heavily-grazed, recently burned, hayed, or undisturbed. Daily activity was observed during daylight between 0850 and 1705 h.

Thirteen-lined Ground Squirrels are abundant throughout the majority of the installation in upland grasslands. This species avoids wooded areas and areas with heavily disturbed soils. The main threat to Thirteen-lined Ground Squirrel populations is the tilling of soil for agricultural purposes. This technique is only used for a small percentage of land on the installation, and probably has minimal impact on this species.

Geomys bursarius, Plains Pocket Gopher. The Plains Pocket Gopher occurs throughout most of Kansas except for the extreme southeastern corner of the state. It is most abundant in areas with deep soil, and utilizes hayfields, roadside ditches, and pastures. Cultivated fields are generally avoided. Oval mounds of loose soil mark the entrances of the extensive tunnels used by these gophers. There are two main tunnels in each system, the foraging tunnel, just below the surface, and the main tunnel that is up to one meter deep. The foraging tunnels are used to access roots, bulbs, and other underground vegetation. Plains Pocket Gophers are rarely observed above ground. Activity is year-round.

Only two Plains Pocket Gophers were captured on the installation, both of which were captured in pitfalls. The first gopher was captured on 30 May in a periodically burned, lowland area characterized by soft soils and a variety of grasses and forbs (Array 6). The second individual was captured on 13 June in a hayed, upland prairie (Array 4). Although only two individuals were observed, the presence of this species throughout much of the Smoky Hill ANGR was confirmed by the characteristic mounds created at the mouths of the burrows of this species.

Based on the abundance of "gopher mounds", the Plains Pocket Gopher is common throughout much of the Smoky Hill ANGR, particularly in prairie habitats with deep soil. This species likely avoids rocky hillsides and wooded areas, as well as the few cultivated areas on the installation. Passive traps such as the drift fences that captured the two gophers, generally do not work for these subterranean mammals that are rarely surface-active. The fact that two individuals were captured in this way suggests high population densities. Trapping attempts geared directly toward the Plains Pocket Gopher likely would give a good indication of population densities and the species' distribution. The subterranean habitats of this species are not threatened by current management practices.

Chaetodipus hispidus, Hispid Pocket Mouse. The Hispid Pocket Mouse is found throughout most of Kansas, with the exception of the deciduous forests of extreme eastern Kansas. Like most species of pocket mice, this species prefers sandy soils and open areas. The Hispid Pocket Mouse occurs in various upland prairie habitats and will tolerate rocky and loamy soils. It avoids riparian areas. Seeds of various grasses and forbs represent the bulk of the diet. Some insects also are eaten during the summer months. Activity is primarily at night, with little surface activity during the winter.

Fifteen Hispid Pocket Mice were captured during the survey at six localities. Six individuals were captured in Sherman traps, all in Array E. In this array, one mouse was captured on 25 September and five were captured on 26 September. The habitat was open, recently burned, upland prairie, with little vegetation. The soil was soft and contained numerous rodent burrows. A single individual was observed during the VES underneath a sandstone rock. The remaining individuals were captured in funnel traps. Individuals were captured in four different arrays: one in a hayed, upland prairie site (Unit 4), two in a heavily-wooded riparian area (Unit 5), two in a heavily-grazed pasture (Unit 8), and two in a riparian/prairie edge habitat (Unit 9). Hispid Pocket Mice were captured in funnels from 25 June through 18 September.

The Hispid Pocket Mouse is common throughout the Smoky Hill ANGR. This species was captured in nearly all habitat types from heavily grazed, open prairie habitats to dense woods. Its presence in woodland was a surprise as this species generally found in open habitats (Bee et al. 1981). Populations probably are largest in upland prairie habitats. Populations likely are stable, and current land management practices pose little threat to this species.

Perognathus flavescens, Plains Pocket Mouse. The Plains Pocket Mouse occurs throughout the western two-thirds of Kansas in mixed-grass and shortgrass prairie and reaches its peak abundance in the arid shortgrass and sandsage prairies of western Kansas. This mouse is usually found in association with sagebrush and yucca. In central Kansas it prefers areas with sandy soils and short vegetation. This nocturnal species also creates extensive burrow systems in which it spends the day. Food primarily includes seeds of various grasses and forbs.

Two Plains Pocket Mice were captured during the survey, both in funnel traps. The first individual was captured on 29 May in a sparsely vegetated upland prairie site (Unit 7), characterized by extremely sandy soil and associated plant species, uncharacteristic of the region, such as Small Soapweed (*Yucca glauca*) and Plains Prickly Pear (*Opuntia macrorhiza*). The second mouse was captured on 25 September in mixed-grass prairie (Unit 6) with loose soils and relatively tall, dense herbaceous vegetation.

The Plains Pocket Mouse is uncommon on the installation. Populations are probably small because of the small amount of preferred habitat for this species. The sandy soils and sparse vegetation at some sites in the northwest portion of the installation probably support the largest populations.

Castor Canadensis, American Beaver. The American Beaver occurs throughout Kansas wherever permanent water exists. This large, aquatic rodent feeds primarily on willows (*Salix* sp.), cottonwoods (*Populus* sp.), and other woody plants. The presence of beavers is usually easily detected due to their habitat-modifying behavior. Where water depth is insufficient, beavers create ponds by damming the flow of water, a process that generally is done by hauling limbs to the site and securing them with mud and plant matter. Beavers construct dens by burrowing underwater into the streambank, or in smaller streams, build lodges in the water from branches and mud. The den or lodge provides a water-accessible retreat above the water level.

No beavers were observed during the survey. However, considerable physical evidence, similar to that described above, was found around one large pond. This pond was one of few ponds on the installation with abundant trees around it. The American Beaver is apparently rare within the installation, and only a few individuals, if any, are permanent residents. While the installation has many ponds, as a whole they provide only marginal habitat due to the lack of sufficient trees to support beaver populations. In addition, the intermittent nature of most ponds reduces their value as beaver habitat. Spring Creek has good forage for beaver, but its ephemeral flow reduces its value to this species.

Microtus ochrogaster, Prairie Vole. The Prairie Vole is found throughout Kansas in most grassland habitats that contain dense vegetation. This species creates runways by clipping vegetation. These runways are used to connect foraging areas with burrows. This generally abundant species rarely lives more than one year and is an important food source for many avian, reptilian, and mammalian predators.

Approximately 39 Prairie Voles were observed during the survey. They were captured in seven of the nine drift fence arrays. Table 4.11 shows the number of Prairie Voles captured in both funnels and pitfalls in each drift fence unit. These numbers are approximations because individuals were not marked and were immediately released after identification. For this reason, individuals might have been recaptured and counted multiple times. Several individuals also utilized the artificial cover boards that were placed in the riparian habitat. Once the voles sought refuge beneath the boards, they appeared to inhabit them for the duration of the survey. The boards also were used as shelter while rearing young. Prairie Voles were captured from 29 May through 24 September.

The Prairie Vole is abundant throughout the Smoky Hill ANGR and occurs in a variety of habitats. Habitats with dense, grassy vegetation appear to support the highest populations.. Prairie Voles probably avoid heavily grazed and recently burned areas. Because of the abundance of prairie habitat on the installation, populations likely are stable and provide a good prey base for a variety of carnivores, including mammals, birds, and snakes. While moderate to heavy grazing and burning negatively impacts this species there appears to be plenty of suitable habitat on the installation under current management practices.

Mus musculus, House Mouse. The House Mouse is an Old World species that has been introduced into the United States. It is common and often abundant in Kansas, inhabiting areas in or near human habitations.

Four House Mice were captured on the installation during the survey. One individual was captured in a pitfall trap in a heavily grazed pasture near a large pond (Unit 8) on 25 July. The other three individuals were captured in Sherman traps around the perimeter of a large pond near the Headquarters Building (array D). A single individual was captured on 18 September, representing 11.1% of all captured mammals that day. Two more House Mice were captured the next night, representing 10 % of the total daily capture.

The House Mouse is rare on the installation, and probably only occurs in areas heavily disturbed by humans. House Mice might be common in and around the various buildings but these areas were not surveyed for mammals. Because this species is non-native, its presence on the installation should not be encouraged.

Neotoma floridana, Eastern Woodrat. The Eastern Woodrat occurs throughout Kansas with the exception of much of southwest and south-central Kansas where the closely related and allopatric Southern Plains Woodrat (*Neotoma micropus*) is found. The Eastern Woodrat prefers rocky or wooded habitats with fairly heavy cover. A variety of items are used to create the characteristic “houses” of these rats, including sticks, dung, trash, leaves, and rocks. Eastern Woodrats are nocturnal and active year-round. Daylight hours are spent in the “houses” or beneath rocks or man-made structures. The mostly vegetarian diet includes the leaves and fruits of many forbs, shrubs and trees.

We captured 11 Eastern Woodrats at eight different localities. Two adult individuals were captured in Sherman traps that were placed around old building foundations in a recently burned, upland prairie (Array E). Evidence of this species was common around these foundations. One of these individuals was captured on 25 September, and the other was captured the next night. Six adult woodrats were captured in funnel traps at four sites. Single individuals were captured on 25 June and 6 August in riparian/prairie edge (Unit 9), on 26 July in heavily disturbed mixed grass prairie (Unit 6), and on 18 September in riparian woodlands (Unit 5). Two individuals were captured near a large pond (Unit 1) on 27 September. The remaining three individuals were observed during the VES. One adult was observed beneath a plywood board near the storage shed. The board was located in dense grass at the base of a small group of trees. Two woodrats were seen on 17 September beneath a woodpile at an old building foundation located in a heavily wooded area. The rats were inactive in their nests at 1415 h. The final individual was an adult found inactive beneath a large sandstone rock on 24 September.

Eastern Woodrats are common throughout the installation wherever vertical physical structures are present. These habitats consist primarily of wooded areas, rock outcrops, and abandoned man-made structures, such as building foundations. This species probably reaches its peak abundance in the wooded riparian areas along Spring Creek.

Onychomys leucogaster, Northern Grasshopper Mouse. The Northern Grasshopper Mouse occurs throughout the western two-thirds of Kansas, inhabiting grassland and shrubland habitats with sandy or lights soils. This species is most common in the shortgrass prairies of western Kansas and heavily grazed areas of central and eastern Kansas. This unique mouse has adapted a carnivorous, predatory behavior, eating primarily insects and small vertebrates. Grasshopper mice are highly territorial and have large, marked home ranges. Population densities are generally low throughout the species range.

Six Northern Grasshopper Mice were recorded on the installation, all from one locality. All six were adults captured in Sherman traps in a recently burned, upland prairie (Array E). The ground was bare and numerous rodent burrows were present. One individual was captured on 25 September, representing 4.5% of the total daily capture. This individual was collected as a voucher specimen. Five more grasshopper mice were captured in the same array the next night, representing 11.9% of the total daily capture.

We consider the Northern Grasshopper Mouse to be uncommon on the Smoky Hill ANGR. We found it only on recently burned prairie but it also probably occurs in grazed prairie. Although this species was only captured from a single trap array, further trapping in similar habitats likely would result in similar success. As with many of the rodent species present on the installation, the Northern Grasshopper Mouse probably benefits from many of the land management techniques employed by the installation personnel, primarily grazing and periodic burning.

Peromyscus leucopus, White-footed Mouse. The White-footed Mouse is found throughout Kansas, primarily in areas in or near wooded or shrubby habitats that provide vertical structure. In western Kansas, this species seems restricted to riparian or urban areas. These nocturnal mice spend the day in nests beneath rocks or inside fallen timber. Activity is year-round. A wide variety of items are eaten, including seeds, fruits, insects, and carrion.

Approximately 55 White-footed Mice were observed on the installation at six localities. The majority of these individuals were captured in Sherman traps in Array C, D, and E. In Array C, this species comprised the majority of captures (66.7%), as it also did for Array D, comprising 90%, 66.7%, and 65% of the total daily captures on three consecutive trap-nights. These trap arrays were in habitats dominated by trees, the preferred habitat of this species. White-footed Mice only comprised 9.1% and 11.9% of total captures in two nights of trapping at array E. This low rate of capture was to be expected because the majority of the trap array was in open, treeless habitat. However, the array crossed through a small group of trees around a dry pond and this is where the species was captured.

Another nine individuals of various ages were observed beneath our artificial cover boards at two sites. They were observed inactive beneath the boards on 3 September, and continued to utilize the cover boards for the duration of the survey. Again, both sites contained numerous trees.

Two individuals were captured in funnel traps, and one individual was captured in a pitfall. On 29 May, a single adult was captured in a heavily wooded area (Unit 5), and on 2 August a single adult was captured along the perimeter of a pond, near a large group of trees (Unit 1). Another individual was captured at Unit 1 on 21 August.

Both the White-footed Mouse and the closely related Deer Mouse (see below) are extremely abundant throughout the Smoky Hill ANGR, occur in a wide variety of habitats, and are probably the dominant vertebrate in many areas. These two species are probably the most abundant mammals on the installation, and are, therefore, important prey items for many species. The Deer Mouse is a habitat generalist that is found in nearly every habitat on the installation. This species is one of the few species that will inhabit heavily disturbed areas, including tilled agricultural areas and the ever-changing "drop zone" on the installation. The slightly larger White-footed Mouse usually is not found far from woody or shrubby vegetation. In the presence of such habitat, the White-footed Mouse replaces the Deer Mouse as the dominant species. These two species are difficult to tell apart, resulting in numerous unidentified *Peromyscus*, which were not counted. Only adults were identified to species, but some were undoubtedly misidentified. . The major threat to White-footed Mouse populations would be the destruction of woody and shrubby habitats. Few threats exist to Deer Mouse populations on the installation. Deer mice appear to favor disturbance.

Peromyscus maniculatus, Deer Mouse. The Deer Mouse also is found throughout Kansas. It prefers more open habitats than the White-footed Mouse. This species is known as a habitat generalist, occurring in nearly all habitat types, and is thought to be the most abundant terrestrial vertebrate throughout the plains. This species is primarily nocturnal, spending the day beneath surface debris or underground. Activity is year-round and diet consists primarily of insects during the warmer months, and seeds during the winter.

Numerous Deer Mice were observed throughout the installation. Approximately 83 individuals were captured using both Sherman traps and drift fence arrays. Table 4.11 shows the number of Deer Mice captured in funnel traps and pitfalls. Individuals of this species were captured in these traps throughout the duration of the survey. A few individuals also were observed during the VES, primarily beneath sandstone rocks in upland prairie habitats. Deer mice were trapped in all successful Sherman trap arrays, and often were the most abundant mammal species captured. For example, 12 individuals were captured on 2 October in a heavily disturbed site near the center of the "drop zone". This was the only species captured in this array. Table 4.12 shows the number of individuals captured in each Sherman trap array. See the account for the White-footed Mouse above for information on habitat utilization and status on the Smoky Hill ANGR.

Reithrodontomys megalotis, Western Harvest Mouse. The Western Harvest Mouse is found throughout Kansas in a wide variety of habitats, from heavily disturbed fields to good quality tallgrass and mixed-grass prairie. This species is strictly nocturnal, spending the day in nests constructed above ground. The diet consists mainly of various seeds, and also includes insects and some herbage. These mice are active throughout the year and often are gregarious, nesting in groups.

Eight individuals of this species were captured during the survey. Two adults were captured on 4 September in Sherman traps in a riparian woodland/mixed-grass prairie edge habitat (Array C), representing 16.7 % of total mammals captured. The other six individuals were captured in drift fence arrays. Four individuals were captured at a sandy, upland prairie site with sparse vegetation (Unit 7 on 12, 19, and 25 June, and 18 July. The other two individuals were captured on 25 June at the same site of Sherman trap array C (Unit 9).

The Western Harvest Mouse is probably common on the installation, although we captured only eight individuals. This species occupies a wide variety of prairie habitats, including disturbed areas and roadside ditches. The abundant prairie habitat throughout the installation probably supports moderate, stable populations of this mouse. Current management practices likely have little effect on this species although overgrazing and increased disturbance of the soil might have a negative impact.

Sigmodon hispidus, Hispid Cotton Rat. The Hispid Cotton Rat occurs throughout Kansas, inhabiting a wide variety of habitats. Preferred habitats include any areas with dense herbaceous vegetation, including ditches, prairies, and croplands. Cotton rats are known for the large runways they construct by clipping vegetation. ,. This species is crepuscular and nocturnal and feeds on a variety of herbaceous vegetation, insects, and other small rodents.

Twenty-two Hispid Cotton Rats were captured during the survey in a variety of habitats. Sixteen individuals were captured in funnel traps. Table 4.11 shows the number of individuals captured in each drift fence array. This species was captured in funnel traps from 31 May through 18 September. The remaining six individuals were captured in Sherman trap arrays. Single individuals were captured in Array C and D, comprising only 8.3% and 10% of the total captures, respectively. However, four individuals were captured in array E, comprising 20% of the total.
The Hispid Cotton Rat is abundant throughout the installation in nearly all habitat types. Lowland areas with dense vegetation probably support the highest densities, while heavily grazed and recently burned pastures probably support the much lower densities.

Synaptomys cooperi, Southern Bog Lemming. The Southern Bog Lemming occurs throughout the eastern two-thirds of Kansas, but is absent from most of the more arid plains of western Kansas. This species prefers mesic habitats, occupying wet areas that generally provide dense vegetative cover. This habitat preference is exaggerated in areas where both the Southern Bog Lemming and Prairie Vole occur. The lemmings often occupy burrows just above the water table and construct runways similar to those of Prairie Voles.

Only two Southern Bog Lemmings were captured during the survey, both of which were captured in funnel traps near wet, wooded areas in the northern portion of the installation. The first individual was captured on 26 July in a riparian woodland/prairie edge habitat (Unit 9), and the second was captured on 25 August along the perimeter of a large pond (Unit 1). At this second site, numerous individuals were observed active in their runways during the mornings and evenings. These runways were constructed through the dense grasses and forbs along the perimeter of the pond. No such runways were observed around any other ponds surveyed.

The Southern Bog Lemming is probably local and uncommon on the installation, but our results might be misleading. This species is difficult to capture by traditional trapping methods, primarily because it is not attracted to the baits used for small mammal trapping. We think this rodent is uncommon because of the small amount of preferred habitat on the installation, mainly mesic riparian areas with tall, dense vegetation. The Southern Bog Lemming occupies wet areas with dense vegetation in the northern portion of the installation, including the riparian zone along Spring Creek and its tributaries and a few nearby ponds that retain dense surrounding vegetation. Populations in these areas are probably moderate and stable. However, as you move away from these habitats, the Prairie Vole likely becomes dominant over the Southern Bog Lemming. Aside from the loss of these heavily vegetated habitats by grazing, the largest threat to this species likely is drought. This species appears to undergo drastic bottleneck events during periods of drought, and rebounds during wet periods (Choate, pers. comm., 2005). Thus, as with lemmings in general, this species experiences strongly fluctuating populations.

Zapus hudsonius, Meadow Jumping Mouse. Prior to 1986, the Meadow Jumping Mouse was known only from the eastern third of Kansas, from the Flint Hills eastward (Jones et al. 1985). It was also believed that the species' range in Kansas was receding to the northeast. However, in 1986 and 1987, numerous individuals were captured at 10 localities in and west of the Flint Hills, reaching as far west as Jewell and Mitchell counties, and as far south as Ottawa County, indicating that the species actually was dispersing to the west and to the south (Choate et al. 1991). The habitats in which these individuals were captured included roadside ditches, riparian areas, and tallgrass prairies, particularly those near wooded or shrubby areas. The prairie habitats were dominated by tallgrass prairie species, such as Big Bluestem (*Andropogon gerardi*), Little Bluestem (*A. scoparius*), Indiangrass (*Sorghastrum nutans*), and various forbs (Choate et al. 1991). Choate et al. (1991) hypothesized that the Meadow Jumping Mouse is dispersing west and south along mesic roadside ditches and riparian habitat.

During our survey, we recorded the Meadow Jumping Mouse for the first time in Saline County (Bee et al. 1981, Choate et al. 1991). Our findings suggest the continued expansion of this species west of the Flint Hills. We captured three individuals at two different sites on the installation, all captured in funnel traps. Two individuals were captured in a riparian/prairie edge habitat that appeared to be dominated by tallgrass species and various forbs (Unit 9), the preferred habitat of this species. These mice were captured on 25 July and 6 August. On 5 August, a single individual was captured near a large pond, adjacent to a heavily wooded, riparian area (Unit 1). One individual was collected as a voucher specimen to document the range extension. The species is probably uncommon, but might be increasing as it expands its range. Again, the largest threat to this species is the loss of its habitat because of grazing. Cattle should continue to be excluded from these riparian and riparian/prairie edge habitats.

Canis latrans, Coyote. The Coyote is an abundant carnivore throughout Kansas, and occurs in nearly all habitat types. Coyotes are one of the few mammal species that appear to have benefited from agricultural development. Coyotes consume a wide variety of vertebrates, invertebrates, and even fruits. Coyotes are active year-round, primarily at night, with their characteristic vocalizations announcing their presence almost nightly.

Three adult Coyotes were observed during road surveys. The first Coyote was seen on 25 July at 1945 h. On 23 September, two adult individuals were observed, the first at approximately 1800 h and the second at 1930 h.

The adaptable Coyote is a common inhabitant of the installation. Although we observed only three individuals, more extensive spotlighting surveys at night likely would have resulted in numerous observations. Populations are probably moderate and stable with few threats. The high populations of mammalian prey, such as Eastern Cottontails, Hispid Cotton Rats, and Prairie Voles probably support healthy Coyote populations.

Procyon lotor, Northern Raccoon. Another highly adaptable mammal, the Northern Raccoon is abundant throughout Kansas. A wide variety of habitats are utilized, including caves, man-made structures, hay fields, and muskrat lodges. However, the preferred habitat is wooded areas, where raccoons utilize hollow trees and squirrel nests. These opportunistic omnivores eat a wide variety of items, including carrion, vertebrates, invertebrates, grains, nuts, fruits, and other plant materials. Raccoons often leave their unique tracks in mud along the shorelines of any water source, as they drink water and forage for aquatic prey. Northern Raccoons are active year-round.

We observed 12 Northern Raccoons at four sites during our road surveys. On 29 May at 2015 h, we observed three raccoons along Spring Creek at the low-water crossing. The raccoons appeared to be foraging, and quickly sought refuge in a nearby tree. Another group, comprised of one adult and three young raccoons, was observed at 2245 h on 16 July, as it crossed a road in upland prairie habitat. Some scattered trees were nearby. Two adults were observed on 18 July, as they made their way through a recently hayed, upland pasture. Again, some patches of trees were nearby. The final three individuals were observed at 1935 h on 10 September as they crossed the road near the site of the group mentioned above.

The Northern Raccoon is common on Smoky Hill ANGR, particularly in and near wooded habitats. The largest populations are likely found in the riparian zone surrounding Spring Creek. Raccoons also can be found wandering throughout the installation in search of prey, particularly around ponds. Populations are probably moderate and stable, but are probably highest in wet years when water sources are abundant. This highly adaptable, omnivorous mammal benefits from ponds and woody riparian habitat and given the increase in these features relative to historic conditions, has probably increased accordingly.

Taxidea taxus, American Badger. The American Badger occurs throughout Kansas in grasslands and grassland-edge habitats. Badgers also inhabit agricultural areas, often taking up residence in roadside ditches and fencerows. Badgers are most abundant in deep soils where they can easily excavate the smaller burrowing mammals on which they prey. A wide variety of vertebrates are eaten, but the primary diet is mammals such as Thirteen-lined Ground Squirrels and Plains Pocket Gophers. Activity is year-round.

Five American Badgers were observed at four localities on the installation during our road surveys. The first individual was an adult seen at 2000 h on19 June at an upland prairie site. Two adult individuals were observed together in a recently hayed pasture on 18 July at 2100 h. Six days later, another adult individual was observed in tall grasses near the large pond by the operations building also about 2100 h. The final badger was observed in a roadside ditch on the southern boundary of the installation. The ditch was adjacent to a large pond and across from a heavily grazed pasture. This individual was seen at 2100 h on 30 July.

Because of the extensive prairie habitat on the installation, the American Badger probably is common and widespread. Also, the abundance of preferred prey items, such as Thirteen-lined Ground Squirrels and Plains Pocket Gophers, probably contributes to healthy badger populations. Potential threats to badger populations would be the spread of woody vegetation and the reduction of prey populations. Again, more intensive nighttime spotlight surveys likely would present more information on the abundance and distribution of this species on the Smoky Hill ANGR.

Mephitis mephitis, Striped Skunk. The Striped Skunk is an opportunistic omnivore that is common throughout the plains in a wide variety of habitats. Skunks prefer mixed woodland and grassland habitats, habitat edges, and sites with cover provided by rocks or other structure. They eat a wide variety of plant and animal matter, but the bulk of their food consists of invertebrates. Activity can be year-round, but periods of extreme cold are usually spent in dens. Striped Skunks are primarily nocturnal.

Ten Striped Skunks were observed during the survey, all in the northern half of the installation. Eight skunks were observed during road surveys, and two were seen during the VES. All sightings were in the evening between 2010 h and 2200 h in July and September. All individuals were adults, with the exception of an adult accompanied by two young that were seen on 16 July. Striped Skunks were primarily observed in or near wooded areas. Two individuals were seen near an old building foundation in a recently hayed pasture adjacent to woods. Another individual was observed along the northern border of the installation on Farrelly Road. Surrounding habitat was upland prairie and cropland, with few nearby trees.

We think the Striped Skunk is abundant throughout the installation in nearly all habitat types. This species probably reaches its peak abundance along the riparian areas surrounding Spring

Creek, but also can be found throughout the prairie. Current management practices are compatible with skunk habitat needs.

Lynx rufus, Bobcat. The Bobcat is common throughout Kansas and occurs in a variety of habitats that contain sufficient cover, such as woodlands, woodland edge, shrublands, and rock outcroppings. Such habitat allows Bobcats to remain undetected while they stalk their prey. Generally, the more rugged the terrain is, the higher the population density of Bobcats. Bobcats feed primarily on rabbits (*Lepus* and *Sylvilagus*), but also prey on other small mammals and birds. These cats are active year-round, with daily activity primarily from dusk until dawn.

Only three Bobcats were observed during the survey. The first was an adult that was observed at 1920 h on 10 June along the margin of a riparian area near Spring Creek. The second individual was an adult was observed on Farrelly Road at 2230 h on 24 July as it entered the installation from the north. The habitat was upland mixed-grass prairie with scattered trees. Another individual was observed in an upland prairie habitat along Soderberg Road. In addition, Bobcat tracks were seen at a few locations along Spring Creek.

The Bobcat probably is more common and widespread on the installation than our surveys indicated. More intensive spotlighting surveys likely would have added some observations of this highly secretive, nocturnal species. The highest densities are predicted to be near wooded areas.

Odocoileus virginianus, White-tailed Deer. White-tailed Deer are abundant throughout Kansas and can be observed in a variety of habitats. This species is primarily associated with wooded areas, such as forests and riparian woodlands; however, the deer often are found foraging in adjacent prairies and agricultural areas. White-tailed Deer browse on a variety of plant materials, including leaves, stems, buds, bark, grasses, fungi, and crops. Deer are active year-round and can be active at all times of day and night. Primary foraging activity is at dawn and dusk.

Many White-tailed Deer were observed throughout the installation over the course of the study. Individuals were not counted because of the tendency of this species to wander over relatively large areas, and our inability to get an accurate count. Deer were often seen on a regular basis in the same areas, compounding this problem. Most were observed at dusk in woodland/prairie edge habitats. Several individuals were seen along the plowed firebreaks that surround the Impact Area. Other individuals were seen during the day in heavily wooded areas.

The White-tailed Deer is common throughout most of the installation, primarily in or near wooded areas. Deer are a managed game species on the installation. Supplemental food plots are planted and maintained, primarily along the riparian areas near Spring Creek and its tributaries. This species is hunted annually by a majority of the Smoky Hill ANGR personnel. The deer population is regularly monitored by land management staff to determine population size and appropriate harvest levels.

4.3.2.5. Potential Species

There are a number of species of mammals that have not been documented on Smoky Hill ANGR that may occur based on their known occurrence in central Kansas and their habitat preferences. This one-year study used a variety of methods in order to document as much of the mammalian fauna as practical. However, no surveys were conducted for bats and the list below includes eight species that may occur on the installation either as summer residents or as migrants. Additionally, no survey methods for targeted for medium to large bodied mammals were used in this study and the list below includes a number of mid-sized mammals that may occur on the installation. Some species, such as Nine-banded Armadillo and Mule Deer, may pass through the area without becoming permanent residents. The final species on this list, Black-tailed Prairie Dog, is documented on the Army portion of Smoky Hill ANGR, and has the potential to colonize other areas.

Little Brown Myotis	*Myotis lucifugus*
Silver-haired Bat	*Lasionycterus noctivagans*
Eastern Pipistrelle	*Pipistrellus subflavus*
Big Brown Bat	*Eptesicus fuscus*
Eastern Red Bat	*Lasiurus borealis*
Hoary Bat	*Lasiurus cinereus*
Evening Bat	*Nycticeius humeralis*
Brazilian Free-tailed Bat	*Tadarida brasiliensis*
Nine-banded Armadillo	*Dasypus novemcinctus*
Franklin's Ground Squirrel	*Spermophilus franklinii*
Plains Harvest Mouse	*Reithrodontomys montanus*
North American Porcupine	*Erethizon dorsatum*
Muskrat	*Ondatra zibethicus*
Red Fox	*Vulpes vulpes*
Long-tailed Weasel	*Mustela frenata*
Least Weasel	*Mustela nivalis*
American Mink	*Mustela vison*
Eastern Spotted Skunk	*Spilogale putorius*
Mule Deer	*Odocoileus hemionus*
Black-tailed Prairie Dog	*Cynomys ludovicianus*

4.3.3. Bird Surveys

4.3.3.1. Materials and Methods

A general survey of the birds on Smoky Hill ANGR was conducted from 2003 through 2006. The main field contributors were William Busby and Galen Pittman. Over the course of the study, all major habitats were visited during all seasons of the year, with greater emphasis placed on breeding species. The reason for this emphasis was that breeding birds generally are present for long periods of time, are present in greater abundance than birds present at other seasons, and are more strongly and predictably associated with specific habitats on the facility. For each species, date, any evidence of breeding, and in some cases, sex, age, and numbers were recorded. Evidence of breeding follows methodology of the Kansas Breeding Bird Atlas (Busby and Zimmerman 2001) including safe dates (when birds present during the breeding season are not likely to be migrants) and breeding codes (Table 4.15). Data on breeding species were collected during targeted surveys and incidental to other project tasks during this study.

TABLE 4.15. Classification of evidence for breeding birds in this study (from Busby and Zimmerman 2001). The strength of evidence of breeding increases from top to bottom.

Breeding Code	**Breeding Criteria**
Possible	
PX	Species heard or seen in breeding habitat
Probable	
PS	Seven *singing* males detected in one visit
PP	*Pair* seen (male & female together; not a flock)
PT	Bird holding *territory* (exclude colonial nesters)
PC	*Courtship* or *copulation*
PN	Visiting probable *nest* site
PA	*Agitated* behavior or *anxiety* call (not intentionally provoked)
PB	Nest *building* by wrens or woodpeckers
Confirmed	
NB	*Nest building* (by all except wrens and woodpeckers)
BP	Physiological evidence of breeding based on *brood patch*
DD	*Distraction display* or injury feigning
UN	*Used nest* or eggshells found
FL	Recently *fledged young*, including precocial young out of nest
ON	Adults entering or leaving nest site in circumstances indicating nesting
FS	Adult carrying *fecal sac*
FY	Adult seen carrying *food* for *young*
NE	*Nest* with *egg(s)*
NY	*Nest* with *young* seen or heard

Breeding Bird Survey

A roadside point count survey following the methodology of the North American Breeding Bird Survey (BBS 2007) was established on Smoky Hill ANGR in 2003. The purpose of this survey was to establish a standardized method for determining the species present and their relative abundance during the breeding season. This methodology is also effective for monitoring population changes over time, assuming the survey is repeated over a period of years. A 15-mile driving route was established with stops at 0.5-mile intervals (Figure 4.10). At each stop, the observer would get out of the vehicle and record all bird species and numbers of individuals seen or heard within a 3-minute period. The route was run twice each year from 2003 to 2006. The first survey was conducted in late May—early June and second in mid-late June on mornings with suitable weather (light wind, no rainfall). The route was run in the same direction each time, starting at 0539h and finishing approximately three hours later. Data were recorded on standard data forms and later compiled in Excel.

4.3.3.2. Results and Discussion

During the four-year period when bird studies were conducted (2003—2006) during this study, a total of 150 species were documented on Smoky Hill ANGR (Appendix C). An additional 14 species were documented on the Army portion during 1999—2000 (Charlton et al. 2002), bringing the total species documented on the area to 164.

Evidence of breeding was documented for 81 species (Table 4.16). Of these, breeding evidence was obtained at the confirmed level for 41 species. It is likely that these 81 species represent most of the regularly breeding species that occur on Smoky Hill ANGR. With more field work it is likely that confirmed breeding evidence could be obtained for the great majority of the remaining 40 species. Possible exceptions are species that occur on Smoky Hill ANGR during the breeding season but are wide-ranging and nest off-site, are migrants, or are immature birds. Species in Table 4.14. with the weakest evidence of breeding (PO code) are Cattle Egret and Tree Swallow.

Relatively less effort was devoted to documenting birds during spring and fall migration and in winter in this study. Of 114 species reported in Saline County that are not listed as occurring during summer (Appendix C), only 53 (46%) are documented on Smoky Hill ANGR. Of the 61 non-summer species reported for Saline County but not for Smoky Hill ANGR, many probably do occur on Smoky Hill ANGR during fall, winter, or spring and could be documented with additional field effort.

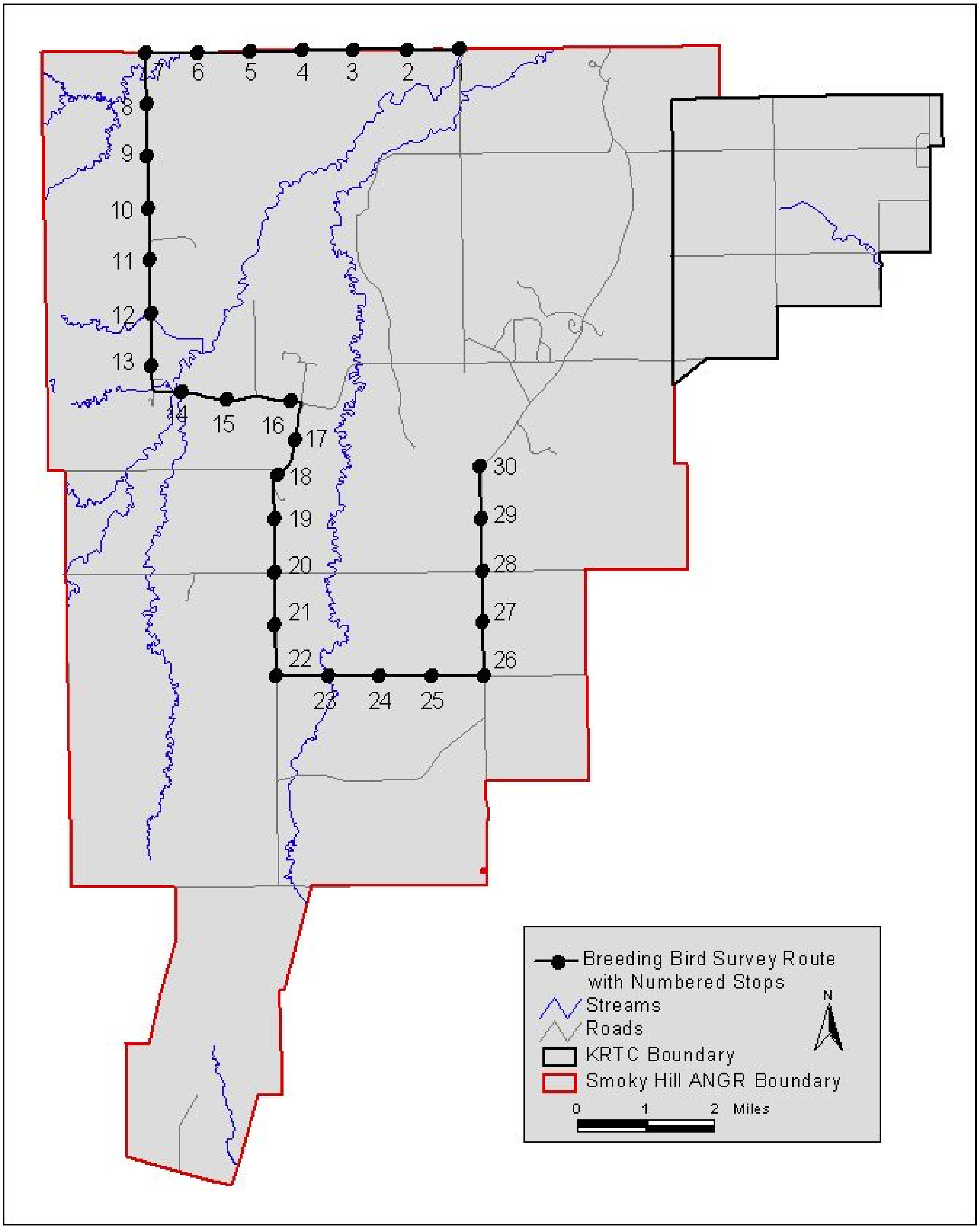


FIGURE 4.10. Map of the breeding bird survey route on Smoky Hill ANGR.

TABLE 4.16. Evidence of breeding for 81 bird species observed on Smoky Hill ANGR during this study. Bolded species have breeding codes in the confirmed category (see Table 4.15). The date is the date of highest evidence of breeding.

English name	Code	Date	English Name	Code	Date
Canada Goose	FL	6/20/03	American Crow	PX	6/20/03
Wood Duck	PP	6/18/05	Horned Lark	PP	5/27/04
Mallard	FL	6/20/04	Tree Swallow	PO	6/6/05
Ring-necked Pheasant	FL	7/22/06	N. Rough-winged Swallow	PP	5/26/04
Greater Prairie-Chicken	FL	7/22/06	**Cliff Swallow**	ON	6/20/03
Wild Turkey	FL	6/29/06	**Barn Swallow**	NE	5/8/03
Northern Bobwhite	DD	6/29/06	**Black-capped Chickadee**	FL	6/20/03
Least Bittern	PN	6/20/03	Tufted Titmouse	PX	6/21/04
Great Blue Heron	PN	6/23/06	White-breasted Nuthatch	PT	6/20/03
Cattle Egret	PO	6/15/06	Carolina Wren	PT	6/6/03
Green Heron	PA	6/29/06	**House Wren**	FL	6/20/03
Turkey Vulture	NE	5/8/03	Blue-gray Gnatcatcher	PP	6/6/03
Cooper's Hawk	PT	6/20/03	**Eastern Bluebird**	FL	5/8/03
Red-tailed Hawk	NY	5/8/03	**American Robin**	FL	6/5/03
American Kestrel	FL	6/20/03	**Gray Catbird**	ON	6/20/03
Killdeer	FL	5/8/03	Northern Mockingbird	PT	6/20/03
Upland Sandpiper	NE	4/28/04	**Brown Thrasher**	NE	6/20/03
Mourning Dove	NE	5/8/03	**European Starling**	FL	5/8/03
Black-billed Cuckoo	PX	6/20/03	Yellow Warbler	PT	6/20/03
Yellow-billed Cuckoo	PS	6/20/03	Common Yellowthroat	PT	6/20/03
Eastern Screech-Owl	PX	6/6/05	Field Sparrow	PT	6/5/03
Great Horned Owl	PN	6/5/03	**Lark Sparrow**	FY	6/20/03
Barred Owl	PT	6/22/04	**Grasshopper Sparrow**	FL	6/20/03
Common Nighthawk	NE	6/15/06	Henslow's Sparrow	PT	6/6/05
Chimney Swift	PP	6/20/03	Northern Cardinal	PT	6/20/03
Belted Kingfisher	PX	6/20/03	Rose-breasted Grosbeak	PP	5/27/04
Red-headed Woodpecker	ON	6/5/03	**Blue Grosbeak**	FY	6/20/03
Red-bellied Woodpecker	FL	6/22/04	**Indigo Bunting**	FY	9/15/04
Downy Woodpecker	PA	6/20/03	**Dickcissel**	NB	5/8/03
Hairy Woodpecker	PX	5/27/04	**Red-winged Blackbird**	ON	5/8/03
Northern Flicker	ON	5/8/03	**Eastern Meadowlark**	FY	6/20/03
Eastern Phoebe	ON	6/20/03	Western Meadowlark	PT	6/20/03
Great Crested Flycatcher	PA	6/20/03	Common Grackle	PN	5/8/03
Western Kingbird	ON	6/20/03	Great-tailed Grackle	PX	6/23/06
Eastern Kingbird	ON	6/20/03	Brown-headed Cowbird	PC	5/8/03
Scissor-tailed Flycatcher	ON	6/20/03	**Orchard Oriole**	FY	6/20/03
Loggerhead Shrike	FL	5/26/04	**Baltimore Oriole**	ON	6/20/03
Bell's Vireo	ON	6/20/03	House Finch	PT	6/5/03
Warbling Vireo	PT	6/20/03	American Goldfinch	PP	6/20/03
Red-eyed Vireo	PT	6/20/03	**House Sparrow**	ON	6/20/03
Blue Jay	PA	6/20/03			

Breeding Bird Survey

Table 4.17 summarizes results from the breeding bird survey over a four-year period during this study. Results for each individual survey are contained in Appendix D. A total of 71 species was detected on this survey over the four-year period. The consistency with which individual species were observed from one survey to the next varied widely (Appendix D). A number of the more common species were detected every survey, while less common or conspicuous species were detected less consistently.

During the first survey of the year (27 May to 8 June) birds would be expected to be actively establishing territories and to be more vocal that during the second survey (19—23 June) when many birds are incubating eggs or raising young. However, in this study, no strong differences in bird numbers are apparent between early and late census dates within a year (Figure 4.11), and in fact, more species were detected in the late surveys in three of four years. Many factors can influence results in a given census of which weather (particularly the negative effect of wind speed on detectability) and observer have been shown to be of particular importance.

Detectability varied greatly among species. Some species are highly vocal or visible whereas others are secretive. This makes quantitative comparisons among species inappropriate. The utility of the information lies in determining what species are present as potential breeders on the area and in providing baseline data on relative abundance from which trends in bird populations over time can be examined. This information should serve as baseline from which to compare future surveys.

The 15 most common birds observed during Breeding Bird Surveys at Smoky Hill ANGR averaged over the four years in which counts were conducted (2003—2006) are shown in Table 4.18. Ranks of species by the number of individuals and by percentage of stops where the species was detected yielded similar results, with the top five species having identical ranks by the two measures. Not surprisingly, most of these species are affiliated with grassland habitat given that grassland habitats are the dominant landcover on Smoky Hill ANGR. Only the last five species in Table 4.16 are not grassland birds. Of these, Eastern Kingbird, Baltimore Oriole, Brown Thrasher, and House Wren require a woody habitat component, and the Killdeer is associated with unvegetated habitats, such as roads, plowed fields, and pond edges. An important point is that several of the most commonly detected summer birds on the installation (Dickcissel, Eastern Meadowlark, Grasshopper Sparrow, and Northern Bobwhite) are species of conservation concern (Partners in Flight 2004) due to declining rangewide populations. This highlights the important contribution Smoky Hill ANGR is making to the conservation of declining grassland birds.

Many additional bird species might occur on Smoky Hill ANGR through time. Because of the great mobility of birds, species that do not regularly occur there may wander, in some cases from great distances, to the area under certain circumstances. Because of this mobility, it is not feasible to provide a complete list of potentially occurring species. Rather, a subset of the more likely potential species is contained in Appendix C based on species previously reported from Saline County (Otte 2006). Most of the potential species in Appendix C regularly are occurring in Saline County, at least in appropriate habitat at the appropriate time of year. However, some

TABLE 4.17. Summary data from the Breeding Bird Survey route on Smoky Hill ANGR. Each count had 30 stops and each route was run twice each year from 2003--2006.

Bird Species	Mean Birds/count	Std Dev Birds/count	Stops with species (%)
Wood Duck	1.00	2.14	1.3
Ring-necked Pheasant	17.88	6.24	47.1
Greater Prairie-Chicken (leks)	5.13	6.10	9.6
Wild Turkey	3.63	2.88	8.3
Northern Bobwhite	22.38	12.01	48.8
Great Blue Heron	0.88	0.83	2.9
Green Heron	0.13	0.35	0.4
Cooper's Hawk	0.13	0.35	0.4
Red-tailed Hawk	1.88	1.55	5.8
American Kestrel	1.38	1.69	2.9
Killdeer	7.63	3.66	17.1
Upland Sandpiper	47.38	21.63	62.5
Mourning Dove	67.75	32.37	70.8
Black-billed Cuckoo	0.13	0.35	0.4
Yellow-billed Cuckoo	6.25	4.53	17.1
Eastern Screech-Owl	0.13	0.35	0.4
Great Horned Owl	0.50	0.76	1.7
Barred Owl	0.13	0.35	0.4
Common Nighthawk	17.88	8.56	36.7
Red-headed Woodpecker	1.63	1.06	5.0
Red-bellied Woodpecker	2.13	1.46	6.7
Downy Woodpecker	0.88	1.13	2.5
Hairy Woodpecker	0.13	0.35	0.4
Northern Flicker	6.88	5.25	16.3
Eastern Phoebe	1.63	0.92	5.0
Great Crested Flycatcher	4.13	2.95	11.7
Western Kingbird	0.38	0.52	1.3
Eastern Kingbird	13.88	3.23	33.8
Scissor-tailed Flycatcher	1.50	1.60	4.2
Loggerhead Shrike	0.63	0.92	1.7
Bell's Vireo	0.63	0.74	1.7
Warbling Vireo	3.00	1.85	7.5
Red-eyed Vireo	0.63	0.52	2.1
Blue Jay	7.38	3.54	14.2
American Crow	2.88	3.23	6.7
Purple Martin	0.13	0.35	0.4
Tree Swallow	0.38	1.06	0.4
Northern Rough-winged Swallow	2.50	2.00	5.8

Cliff Swallow	0.25	0.46	0.8
Barn Swallow	3.63	2.39	7.1
Black-capped Chickadee	0.13	0.35	0.4
White-breasted Nuthatch	0.63	0.74	2.1
Carolina Wren	0.38	0.74	0.8
House Wren	7.63	3.29	16.3
Eastern Bluebird	2.88	3.68	7.9
American Robin	1.38	0.92	3.3
Gray Catbird	0.50	0.53	1.7
Northern Mockingbird	4.88	3.64	14.2
Brown Thrasher	8.00	4.96	21.7
European Starling	7.13	3.80	7.5
Yellow Warbler	0.63	0.92	2.1
Common Yellowthroat	2.13	1.36	6.7
Field Sparrow	0.38	0.52	1.3
Lark Sparrow	1.13	1.36	3.8
Grasshopper Sparrow	31.25	4.37	60.8
Henslow’s Sparrow	0.88	1.64	1.7
Northern Cardinal	2.88	2.17	7.5
Rose-breasted Grosbeak	0.13	0.35	0.4
Blue Grosbeak	0.13	0.35	0.4
Indigo Bunting	2.00	1.85	4.6
Dickcissel	71.50	14.35	87.1
Red-winged Blackbird	22.75	12.17	31.7
Eastern Meadowlark	68.25	30.83	84.6
Western Meadowlark	3.88	2.70	9.6
Common Grackle	1.88	1.81	4.2
Brown-headed Cowbird	25.25	10.04	40.8
Orchard Oriole	2.00	1.51	6.3
Baltimore Oriole	10.63	6.63	26.7
American Goldfinch	1.63	2.00	3.8

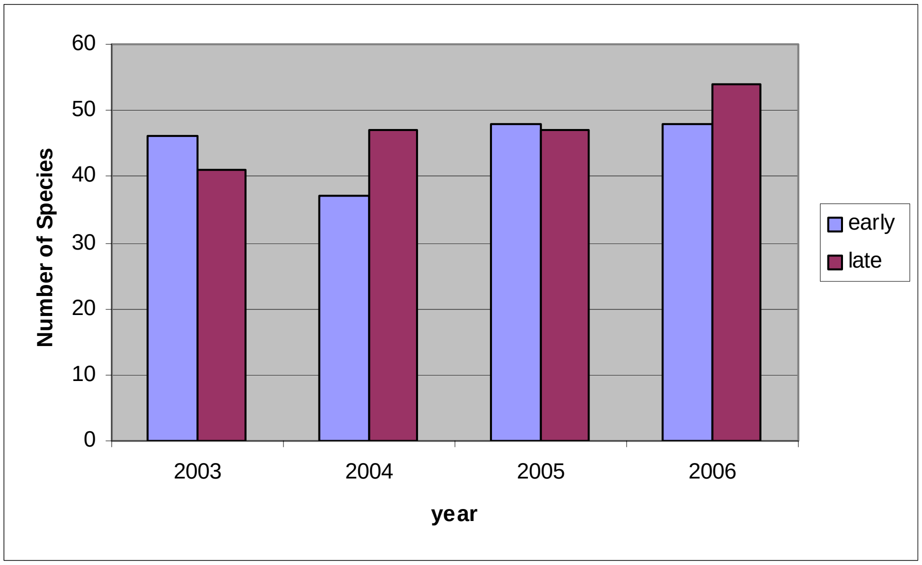


FIGURE 4.11. Number of bird species recorded on Breeding Bird Surveys on Smoky Hill ANGR. Two surveys were conducted each year, one during the early period (27 May-8 June) and one during the late period (19-23 June).

TABLE 4.18. The 15 most common birds detected on the breeding bird survey route during 2003-2006. The first rank column is based on the total number of birds counted on routes, and the second rank column is based on the percentage of census stops where the species was detected.

English Name	**Rank: No. Birds**	**Rank: Stops with species (%)**
Dickcissel	1	1
Eastern Meadowlark	2	2
Mourning Dove	3	3
Upland Sandpiper	4	4
Grasshopper Sparrow	5	5
Brown-headed Cowbird	6	8
Red-winged Blackbird	7	11
Northern Bobwhite	8	6
Ring-necked Pheasant	9	7
Common Nighthawk	10	9
Eastern Kingbird	11	10
Baltimore Oriole	12	12
Brown Thrasher	13	13
Killdeer	14	14
House Wren	15	17

require specific habitats not found on Smoky Hill ANGR and therefore are not likely to be found regularly on the installation, and others are species that infrequently occur in Saline County.

4.3.3.3. Potential Species

Additional species of birds that may breed on Smoky Hill ANGR can be determined from various sources. One such source is the Kansas Breeding Bird Atlas (Busby and Zimmerman 2001; see http://www.pwrc.usgs.gov/bba/). Only three additional bird species not reported at Smoky Hill ANGR were documented at the probable or confirmed level from Saline County in the Kansas Breeding Bird Atlas: Green Heron, Rock Dove, and Bewick's Wren. This small number of additional breeding species provides evidence that the list of breeding species reported in this study is fairly complete.

Additional species of breeding and non-breeding birds that may occur on Smoky Hill ANGR are listed in the checklist of birds reported in Saline County (Otte 2006; Appendix C). Species whose status is listed as "s" have been reported in Saline County but not on Smoky Hill ANGR.

4.4. ABUNDANCES OF BREEDING BIRDS ACCORDING TO FIRE, HAY, OR CATTLE GRAZING MANAGEMENT

4.4.1. Materials and Methods

Fieldwork for this study was conducted at the Smoky Hill ANGR in 2005. Primary personnel involved in this project were Alexis Powell (AP), William Busby (WB), and Galen Pittman (GP). The installation is divided into ~259-ha (640 ac) units, most of which are used or managed in one of four ways: (1) cattle grazing, (2) hay production, or, as (3) unburned or (4) burned areas in which to place targets for bombing practice. We established 15 bird survey transects in each of these treatment types. Cattle grazing occurred 1 May—1 October; the stocking rate of 2.8 ha (7 ac) per cow-calf unit or 455 kg (1000 pounds) animal weight is a moderate grazing intensity for the region. Hayed units were cut once annually, generally in mid-July. All grassland units were managed with periodic prescribed burning. Burn intervals were about every 5 years for grazed, and about every 3—4 years within the Impact Area. Controlled burns were generally conducted in the spring. Accidental fires occurred in the Impact Area at all times of year. Only units not burned for the past year or more were used to represent grazed, hayed, and unburned treatments in this study. With only one or two exceptions, our transects in both burned and unburned Impact Area units were effectively idle during the course of this study since they happened to be in locations not disturbed by dummy bombs or the heavy machinery used to recover them.

Each of the 60 transect centerlines was 300 m long, marked every 50 m with survey flags or metal stakes, oriented perpendicular to and ≥100 m from the nearest vehicle trail, and placed ≥250 m from any unit of a different treatment type parallel to the transect, ≥200 m from the nearest parallel transect, and ≥200 m from the nearest in-line transect. Each transect was surveyed once 23 May—4 June (by WB or AP) and again 12—18 June 2005 (nearly always by a different observer than the first time, either WB, AP, or GP). Surveys took ~20 min per transect and were conducted between 0502 h and 1100 h with winds ≤19 kph, temperatures from 8—

30°C, and during periods without significant precipitation. Surveys were conducted by walking transect centerlines and counting birds seen ahead on the transect or to each side of the observer. We counted perched singing males in the cases of Grasshopper Sparrow (*Ammodramus savannarum*), Henslow's Sparrow (*A. henslowii*), and Dickcissel (*Spiza americana*), and separately counted perched singing and nonsinging Eastern Meadowlarks (*Sturnella magna*). For each individual of the aforementioned species, we recorded its distance as measured with a laser rangefinder, as well as the angle, as measured with a sighting compass, between the sight line and transect centerline. We counted all Upland Sandpipers (*Bartramia longicauda*), including those in flight, seen ≤200 m from the transect centerline. For all other species, we counted perched individuals seen ≤80 m from the transect centerline, noting their sex when possible.

We used DISTANCE, version 5.0, beta release 4 (Thomas et al. 2005) to estimate densities of Grasshopper Sparrow, Dickcissel, and Eastern Meadowlark. Program DISTANCE fits a model detection function to the frequency distribution of perpendicular distances (calculated automatically from radial distances and sight angles) of individuals from the transect centerline; then, by accounting for the proportion of individuals present but not detected, it estimates the true density of individuals in the surveyed area. We followed guidelines detailed by Buckland et al. (2001) and the DISTANCE users guide to iteratively determine data truncation distances, assess the need to bin data into intervals, and develop models. We averaged the two surveys of each transect by pooling detections from each count round and inputting transect length into the program as double its actual value. For each species, we created global models as well as models stratified by treatment, observer, count round, or treatment × count round, using all key functions available in DISTANCE combined with adjustment terms recommended for each. We used diagnostic tools in DISTANCE to assess models—Akaike's Information Criterion (AIC) to select the most parsimonious models, and the Kolmogorav-Smirnov test to check model fit to the data. We often found that slightly different approaches produced models with equally excellent fits to the data and very similar AIC scores; since such models produced very similar density estimates, in these cases we simply selected the simplest model with the lowest AIC score rather than employing model averaging. AIC scores with a difference of <0.5 points were considered equal.

For Dickcissel, histograms of the ungrouped detection data, truncated to 150 m, revealed nearly ideal characteristics for simple and reliable density estimation: a "broad shoulder" near the transect line, very little heaping, and a similar distributional shape regardless of stratification scheme. Consequently, a simple global model (uniform key function with cosine adjustments of order 1) fit the data very well and had the lowest (i.e., best) AIC score. Whereas counts of singing Eastern Meadowlarks were considerably lower in the second round of surveys, counts of all adults (singing or not) were very similar between rounds, so those were the data we used for density estimation. The distributional shape of the ungrouped data, truncated to 200 m, was excellent, but we found that modeling detection functions separately by observer yielded a lower composite AIC than other stratifications and global models. After trying a number of approaches, all of which produced nearly identical density estimates, we settled on a global model (half-normal key function without adjustments) with observer as a covariate because it had a good fit to the data, achieved an AIC score as low as obtained by stratifying by observer, and readily lent itself to estimating density by transect or treatment. The distribution of

Grasshopper Sparrow data, truncated to 100 m, exhibited heaping around 35 m so some of the models that we tried did not have a good fit. AIC scores of the best models for the various stratification schemes tested were all slightly lower than that of the best global model. Fitting separate models according to observer was the best approach by a small margin, so as with Eastern Meadowlark, we chose to use a global model (hazard rate key function without adjustments) with observer as a covariate since it had a good fit, the lowest AIC score, and was easy to use to produce estimates according to transect and treatment.

To evaluate whether pairwise comparisons between the density estimates by treatment were significantly different, we examined their 95% confidence intervals as calculated by DISTANCE. Estimates with non-overlapping estimates were considered significant, and those with highly coincident ones not. In cases of slight overlap, we tested for significance using Welch's approximate t-test for samples with unequal variances and employed a simple Bonferroni correction ($\alpha' = \alpha/k$ tests = 0.05/6 = 0.008) to adjust our threshold of significance appropriately for multiple comparisons (Sokal and Rohlf 1995).

Encounter rates (individuals per 1000 m transect) were calculated for each species by multiplying the combined count of individuals from each survey round by 1000 m divided by twice the transect length. We evaluated effects of treatment on encounter rates with one-way analysis of variance (ANOVA) using the general linear model in MINITAB, release 12.1 (Minitab, State College, Pennsylvania), and used the Tukey test in MINITAB to make pairwise post-hoc comparisons of multilevel factors. To improve homogeneity of variances, encounter rates were log-transformed [log(1 + individuals per 1000 m)] prior to analysis (except for Dickcissel and Grasshopper Sparrow, in which cases such transformation was counterproductive).

We surveyed the vegetative structure of transects between 16—26 June. A meter stick was used to measure the maximum heights of grass, forb, thatch (standing dead vegetation) and litter (matted dead vegetation) within a one-meter radius of 10–20 locations at even intervals along and random distances ≤80 m from each transect centerline. At 5–20 such locations in each transect, we stood a 4 mm diameter metal rod on its end and counted the number of grass, forb, and litter (including thatch) contacts in the intervals <10, 10–20, 20–30, and 30+ cm from the ground. Litter contacts were difficult to interpret meaningfully when matted or degraded, so we counted no higher than ten contacts in an interval (all counts above 10 were recorded as 10). A preliminary review (using correlation matrices and principal components analysis) of the means of each measure for each transect revealed that many were highly correlated, so the vegetation contact data were simplified to two intervals, <20 and >20 cm, for each vegetation type in subsequent analyses. Differences in vegetation parameters according to transect management were evaluated using ANOVA and the Tukey test in MINITAB. We used stepwise regression and basic graphing tools in MINITAB to investigate whether any vegetation measures were strong predictors of transect counts for each species, and how such effects related to effects of treatment.

4.4.2. Results and Discussion

Bird Species Responses to Management Treatments

Sample sizes were sufficiently large to perform analysis of variance on encounter rate in the four management treatments (Table 4.20). Results for these species are presented below.

Upland Sandpiper. Abundance was highest in burned transects, significantly more so than in hayed (P = 0.02) and unburned (P = 0.004) transects (Table 4.20). This result is consistent with other studies that show that this far-ranging non-territorial species prefers burned areas for foraging. Birds tend to congregate in favored foraging areas where they are often highly vocal and conspicuous. Other studies also have found a positive effect of grazing, perhaps because of the heterogeneity in grass height it creates, which might explain higher numbers in grazed than in hayed transects in this study. For nesting, Upland Sandpipers require habitat with more cover but are more secretive during this phase of reproduction. Burned areas generally would not offer nesting cover whereas unburned, grazed areas would.

Mourning Dove. Abundance was highest in unburned transects, significantly more so than in grazed (P = 0.003), hayed (P = 0.003), and nearly more so than burned (P = 0.06) treatments (Table 4.20). It is unclear why doves would prefer unburned prairie. Most of the birds recorded in unburned habitat were perched in trees; the thick grass cover this habitat provides is not generally attractive to doves.

Eastern Kingbird. Treatment type had no effect on relative abundance of this flycatcher (Table 4.20). Eastern Kingbirds build nests in trees surrounded by open habitats. The presence of isolated trees may be more important than grassland cover characteristics for this species.

Bell's Vireo. This species was absent from burned and grazed areas. Abundance was highest in hayed transects, significantly more so than in grazed (P < 0.0001) and burned (P < 0.0001) transects (Table 4.20). Habitat for Bell's Vireo consists of low, shrubby thickets. The hayed tracts contained many areas that are not hayed, and through succession have become islands of dogwood (*Cornus sp.*), sandhill plum (*Prunus sp.*) and other shrubs within a grassy matrix, a structural habitat type much less common or absent in the other treatments. Presumably because of less frequent burning and lack of grazing, ungrazed areas also contain frequent patches of shrubby vegetation. Thus, the habitat preferences demonstrated in this study are consistent with expectations.

Dickcissel. Dickcissel abundance was highest in unburned transects, significantly more so than in burned (P = 0.02), grazed (P = 0.0005) and hayed (P = 0.003) transects (Table 4.20). Dickcissels prefer tall, dense, forb-rich vegetation for nesting (REF), and unburned areas had taller vegetation and higher grass and forb densities than other treatments. Dickcissel abundance increased substantially in round two compared to round one, especially in grazed and in burned transects where abundance doubled. Interestingly, abundance in unburned transects increased the least yet still was higher than in other treatments. The fairly high density in burned areas demonstrates that litter is unimportant to this species.

Grasshopper Sparrow. Grasshopper Sparrow abundance was lower in burned transects than in all other treatments, significantly so as compared with grazed ($P < 0.0001$) and hayed ($P < 0.0001$) areas (Table 4.20). Abundance was significantly lower in unburned transects than in grazed ($P = 0.01$) and hayed ($P = 0.001$) transects. The Grasshopper Sparrow needs litter for nesting and open patches of ground for foraging, and it generally selects areas with short to medium-height grass with some litter. Grazed and hayed areas that have not been burned generally provide the habitat characteristics preferred by this species, making the results of this study consistent with previous research.

Henslow's Sparrow. This species was encountered regularly in unburned areas, occasionally in grazed areas, and was absent from burned and hayed areas. Its abundance was higher in unburned transects than all other types: burned ($P < 0.0001$), grazed ($P = 0.0002$), and hayed ($P < 0.0001$) (Table 4.20). Henslow's Sparrow requires both litter and standing dead vegetation for breeding habitat, and grasslands that have been unburned for at least two years usually support the highest population densities. Thus, this species' habitat preference is at the extreme end of that available in native prairie: tall, dense herbaceous vegetation with abundant litter at the ground level.

Red-winged Blackbird. Treatment type had no effect on relative abundance of the Red-winged Blackbird (Table 4.20). Other habitat features, specifically the presence of ponds and swales, which were more or less randomly distributed with respect to treatments, determined the presence of this species. Red-winged Blackbirds generally were abundant on transects with these unmeasured habitat features and were absent otherwise.

Eastern Meadowlark. Eastern Meadowlark abundance was lower in burned transects than all other types: grazed ($P < 0.0001$), hayed ($P = 0.0002$), and unburned ($P < 0.0001$) (Table 4.20). The abundance of singing meadowlarks was highest in grazed, followed by unburned, hayed, and burned transects. This species requires litter and/or grassy cover, but is tolerant of a wide range of vegetation heights. Thus, recently burned areas, with their limited cover, are less attractive to this species.

Brown-headed Cowbird. Abundance was lowest in hayed areas, significantly so when compared to unburned ($P = 0.05$) transects (Table 4.20). Female abundance did not differ significantly among transects but also was lowest in the hayed transects. It is difficult to explain this result, given that cowbirds generally are not known to be responsive to the habitat treatments examined in this study.

Sample sizes for most of the remaining bird species were too small to analyze (Table 4.22). In addition, some species are known to be associated with habitat features not examined here, such as trees, ponds, or roadsides. Shrub dependent species (Bell's Vireo, Loggerhead Shrike, Northern Bobwhite, House Wren, Gray Catbird, Brown Thrasher, Yellow Warbler, and Common Yellowthroat) in general preferred ungrazed and hayed habitats presumably due to management that was more conducive to the development of a shrub component in these habitats. In the hayed areas, woody vegetation was mowed around;over time these areas developed into islands of tall shrubs and small trees. In the ungrazed areas, the absence of livestock browsing appears to have allowed shrubby vegetation to expand more rapidly than in grazed or more frequently burned areas.

Analysis with Program DISTANCE

Bird densities calculated using DISTANCE for the three most commonly detected species (Dickcissel, Grasshopper Sparrow, and Eastern Meadowlark) show that as a group, these three species made heavy use of three habitats—grazed, hayed, and ungrazed—and somewhat lower use of burned grassland (Table 4.19 and Figure 4.12). Bird use of grazed and hayed treatments was similar; both attracted high numbers of Grasshopper Sparrow and moderate densities of Dickcissel and Eastern Meadowlark. Unburned areas attracted the highest numbers of Dickcissel and moderate numbers of the other two species. In the burned areas, densities of Grasshopper Sparrow and Eastern Meadowlark were lower than other habitats while use by Dickcissel was generally similar to that in other habitats.

Because we made extensive use of tools in DISTANCE to look for and evaluate effects of treatment, observer, and other factors on detection probabilities of several species, we are confident that our use of encounter rates (rather than density estimates) in analyses of effects of treatment is justified. Using DISTANCE to check for potentially important factors was an extremely useful exercise even though effects of such turned out to be insignificant or inconsequential in this study with respect to descriptions of relative abundances. Making more extensive use of density estimates in studies of relative abundance raises its own complications (e.g., unless the detection function is modeled separately for each transect, density estimates of transects are not independent). The density estimates potentially are useful for comparison with future population monitoring surveys at Smoky Hill ANGR and with the results of studies of these species at other locations.

Vegetation Parameters and Management Treatments

The relationship of vegetation characteristics to management treatment is shown in Table 4.21. The burned treatment is different from all others in that it essentially lacks litter and thatch. All other treatments have a dense litter layer, at least near the ground (<20 cm). The unburned treatment has the tallest vegetation (both living and dead) and has a higher overall vegetation density because of its much greater densities of grass and forbs >20 cm. Grazed and hayed treatments tend to be intermediate and similar in character except that hayed areas have shorter thatch and less litter >20 cm, both of which are removed by hay cutting the previous summer. One parameter, grass density <20 cm, differs from most other measures in being highest in the burned treatment. It is inversely related to litter levels, so is highest in burned, followed by hayed, grazed, and unburned treatments, though the difference is not as great as with other measures. In summary, vegetation measurements demonstrate the expected result that ungrazed treatments had the tallest and densest living and dead vegetation, grazed and hayed treatments had intermediate vegetation height and density parameters, and burned treatments lacked litter.

Vegetation measurements were taken during the middle of the breeding season (mid-June) and essentially provide a snapshot of conditions at one point in time. This is a critical time when most grassland birds are incubating eggs and feeding young, and therefore dependent on habitat for cover to conceal nests and provide food. However, vegetation parameters are changing through the nesting season due to rapid spring and early summer vegetation growth. Birds are moving into and out of habitats as they arrive from wintering grounds, visit different potential nesting areas, establish territories, or attempt to re-nest. They no doubt respond to vegetation traits at different times during the nesting season. Vegetation measurements derived from a small subset of time cannot be expected to fully capture this dynamic nature of the vegetation.

Grassland Birds and Habitat Management

Grassland bird species have individualistic habitat requirements; not surprisingly, bird species abundances and to a lesser degree, presence or absence, varied among different management treatments. No one habitat evaluated here is "optimal" for all grassland bird species.

Grazed pastures provide habitat for a wide spectrum of species, often at high encounter rates. This is not surprising given that grassland birds in the Great Plains evolved in the presence of grazing animals and the vegetation structure and composition resulting from this process.

Bird use of hayed habitats was similar to that in grazed areas. This may be due to the similarity in vegetation structure of hayed and grazed areas with both having moderate vegetation height due to summer disturbance and moderate litter levels. Results of studies elsewhere demonstrate that hayed areas can be population sinks (areas where reproductive success is less than that needed to sustain populations) due to nest and nestling loss associated with hay harvest. While most nesting pairs will have fledged young by the start of the hay harvest at Smoky Hill ANGR (July 1), birds that initiate nests late (as first or second nesting efforts) are at risk. A better understanding of the effect of hay harvest on nesting bird success will require more study to determine how many birds have nests and unfledged young coincident with the hay harvest season. Hayed areas also contained high amounts of woody vegetation that attracted many shrub and forest edge species. This habitat feature increases the number of bird species using hayed areas but also may attract more nest predators. If woody vegetation continues to expand, grassland habitat will become increasingly fragmented and will attract fewer grassland birds.

Ungrazed grassland supported a diverse set of species and was the habitat favored by Dickcissel and Henslow's Sparrow. Henslow's Sparrow is particularly dependent on ungrazed areas and without this habitat might be eliminated from Smoky Hill ANGR as a breeding species. Ungrazed prairie is also a rare habitat. The great majority of tallgrass and mixed-grass prairie in the region is privately owned and managed for agricultural production with grazing or haying. Idle land is generally not producing income and is therefore an unusual practice. Thus, from a regional perspective, maintaining areas of idle grassland is beneficial for grassland birds.

Burned prairie had lower bird abundances for many species and was not used by two species, Bell's Vireo and Henslow's Sparrow. One grassland obligate species, Upland Sandpiper, strongly preferred burned areas. Based on these results, maintaining areas of burned prairie for Upland Sandpiper is recommended. Fire also is an important practice in maintaining the mixed-grass and tallgrass prairie through the control of woody vegetation and other effects. However, a substantial increase in fire frequency likely would have a net negative effect on grassland breeding birds. The recent policy change to reduce burn frequency in the Impact Area probably benefits grassland birds as a whole. Until 1996, all Impact Area units were burned annually. Under the current policy, areas around active targets are burned annually and all other areas within the Impact Area are burned on approximately a 3-4 year interval.

Study Limitations

Limitations of this study include its short duration and reliance on bird abundance measures. A multi-year study is desirable to better determine if the bird-habitat responses measured in this study are consistent over multiple years. This study was conducted in a year of average rainfall (29.7 inches at Brookville in 2005). Responses may have been different under dry or wet years, or may be different due to any number of unmeasured physical or biological factors.

The relative abundance of breeding birds in a habitat is a measure of it attractiveness and perhaps also of breeding effort, if we assume that the proportion of birds detected that attempted to nest was similar across habitats. However, we did not measure reproductive success of bird species in the habitat treatments. Only by monitoring nesting success can it be determined if bird abundance is positively correlated with bird productivity in a given habitat. Reproductive success was not measured in the study due to time and cost considerations.

Lastly, the techniques used in this study did not adequately sample all grassland bird species. In particular, Greater Prairie-chicken was rarely sampled during June censuses. Because its populations are declining throughout much of its range it is a conservation priority species. Its habitat needs should be considered heavily in managing prairie habitat. To a lesser extent, Upland Sandpiper was not well sampled in this study due to its mobility and non-territorial behavior.

4.4.3. Management Recommendations

- Maintain a mixture of grassland management practices. This will result in a wide variety of grassland conditions: vegetation height, structure, and relative mix of grass: forbs: litter, and consequently provide habitat suitable for a variety of bird species.
- The current dominance of grazing as a management practice is compatible with grassland bird conservation given the number of species using/preferring this habitat.
- Consider delaying hay cutting from 1 July to 15 July or later. Harvest of hay will result in the mortality of eggs and unfledged young birds. Because the nesting season is prolonged for some species, some nest mortality associated with hay harvest is unavoidable. Recommended dates represent a compromise between lowering nest mortality, the effect of cutting date on vegetation, and farm economics.
- Burned prairie supported lower densities of most grassland birds. However, it was the preferred habitat for one species (Upland Sandpiper). While we do not recommend a substantial increase in burning frequency from the perspective of grassland birds, it is a desirable practice for maintaining prairie vegetation and limiting the invasion of woody vegetation. In addition, the relatively low burn frequency means that a small proportion of the installation is burned in any given year.
- Continue managing some areas without grazing or annual burning. This habitat provides the tall structure and dense litter layer that is not present under other management

practices. Several grassland birds (Henslow's Sparrow, Dickcissel) strongly prefer this habitat. Evidence from this study suggest that the shift in management of the Impact Area from annual burning to burning most areas on longer burn interval has benefited the grassland bird community by providing large blocks of unburned and ungrazed habitat. This study does not address the question of how many years idle habitat should be maintained between burns. Other studies have shown that Henslow's Sparrow densities are highest in habitat with two or more years since fire. A variable fire return interval of 2-5 years for those areas of the Impact Area that do not need to be burned annually at Smoky Hill is suggested from the perspective of grassland birds.

TABLE 4.19. Density estimates [individuals per hectare ± 1 SE (95% CI)] by treatment for the three most frequently encountered species.

Species	Burned	Grazed	Hayed	Unburned
Dickcissel[a]	0.58 ± 0.073 (0.45–0.76)	0.46 ± 0.076 (0.32–0.65)	0.52 ± 0.083 (0.37–0.73)	0.92 ± 0.085 (0.75–1.11)
Grasshopper Sparrow[b]	0.29 ± 0.065 (0.18–0.47)	0.79 ± 0.072 (0.66–0.96)	0.86 ± 0.092 (0.69–1.08)	0.48 ± 0.044 (0.39–0.58)
Eastern Meadowlark[c]	0.28 ± 0.035 (0.22–0.37)	0.63 ± 0.070 (0.50–0.80)	0.53 ± 0.044 (0.45–0.63)	0.61 ± 0.062 (0.49–0.75)

[a] Singing males within 150 m.
[b] Singing males within 100 m.
[c] All detections within 200 m.

TABLE 4.20. Encounter rates ($\bar{x}$ detections per 1000 m transect ± 1 SE, n = 15) by treatment and ANOVA tests for significance of treatment effects on transformed [$\log_{10}$(1 + individuals per 1000 m transect)] encounter rates for the ten most frequently encountered species.

Species	N[a]	Burned	Grazed	Hayed	Unburned	ANOVA result
Upland Sandpiper	142[b]	6.8 ± 1.51	4.2 ± 0.80	2.7 ± 0.69	2.1 ± 0.62	F = 5.22, df = 3 and 56, P = 0.003
Mourning Dove	58	1.4 ± 0.73	0.6 ± 0.39	0.4 ± 0.26	4.0 ± 1.06	F = 5.94, df = 3 and 56, P = 0.001
Eastern Kingbird	86	2.9 ± 0.41	2.1 ± 0.60	2.8 ± 0.53	1.8 ± 0.44	F = 1.61, df = 3 and 56, P = 0.20
Bell's Vireo	35	0	0	2.6 ± 0.71	1.3 ± 0.61	F = 10.01, df = 3 and 56, P < 0.001
Dickcissel	395[c]	10.3 ± 1.25	8.1 ± 1.31	9.2 ± 1.44	16.2 ± 1.41	F = 7.01, df = 3 and 56, P < 0.001[g]
Grasshopper Sparrow	340[d]	4.6 ± 1.01	12.3 ± 1.06	13.4 ± 1.38	7.4 ± 0.65	F = 15.53, df = 3 and 56, P < 0.001[g]
Henslow's Sparrow	26[e]	0	0.6 ± 0.35	0	2.3 ± 0.58	F = 16.31, df = 3 and 56, P < 0.001
Red-winged Blackbird	69	4.8 ± 2.82	0.2 ± 0.22	1.2 ± 0.78	1.4 ± 1.14	F = 1.89, df = 3 and 56, P = 0.14
Eastern Meadowlark	415[f]	6.3 ± 0.75	14.2 ± 1.49	11.9 ± 0.90	13.7 ± 1.31	F = 13.07, df = 3 and 56, P < 0.001
Brown-headed Cowbird	137	3.3 ± 1.26	4.4 ± 1.21	1.4 ± 0.56	6.0 ± 1.57	F = 2.88, df = 3 and 56, P = 0.04

[a] All detections within 80 m (unless otherwise indicated).
[b] All detections on ground or in flight within 200 m.
[c] Singing males within 150 m.
[d] Singing males within 100 m.
[e] Singing males within 130 m.
[f] All detections within 200 m.
[g] ANOVA performed on untransformed encounter rates because of their superior homogeneity of variances.

TABLE 4.21. Vegetation measures according to treatment ($\bar{x}$ ± 1 SE, n = 15) and ANOVA tests for significant differences. Means within each vegetation category sharing a superscript letter are significantly different (P < 0.05).

	Management treatment type				
	Burned	Grazed	Hayed	Unburned	ANOVA result
	Maximum height (cm)				
Grass	52.1 ± 1.75^{a}	55.7 ± 1.68^{b}	47.7 ± 1.37^{bc}	59.2 ± 1.08^{ac}	F = 10.86, df = 3 and 56, P < 0.001
Forbs	47.3 ± 2.36^{a}	51.4 ± 2.11^{b}	50.1 ± 1.29^{c}	60.7 ± 1.20^{abc}	F = 9.92, df = 3 and 56, P < 0.001
Litter	0.3 ± 0.14^{ab}	9.4 ± 1.05^{a}	6.5 ± 0.42^{b}	12.5 ± 1.21^{ab}	F = 39.42, df = 3 and 56, P < 0.001
Thatch	38.1 ± 4.41^{a}	74.0 ± 2.49^{ab}	42.9 ± 2.93^{b}	93.0 ± 3.20^{ab}	F = 61.02, df = 3 and 56, P < 0.001
	Density (number of contacts with a vertical 4 mm-wide rod)				
Grass < 20 cm	3.9 ± 0.34^{a}	3.2 ± 0.30	3.5 ± 0.33	2.4 ± 0.21^{b}	F = 4.33, df = 3 and 56, P = 0.008
Grass > 20 cm	1.8 ± 0.21^{a}	2.8 ± 0.30^{b}	2.6 ± 0.38^{c}	5.1 ± 0.39^{abc}	F = 18.49, df = 3 and 56, P < 0.001
Forbs < 20 cm	0.4 ± 0.09	0.3 ± 0.06	0.3 ± 0.08	0.4 ± 0.08	F = 0.80, df = 3 and 56, P = 0.50
Forbs > 20 cm	0.3 ± 0.09^{a}	0.3 ± 0.09^{b}	0.3 ± 0.09^{c}	0.9 ± 0.12^{abc}	F = 9.56, df = 3 and 56, P < 0.001
Litter < 20 cm	1.5 ± 0.27^{ab}	9.4 ± 0.58^{a}	8.1 ± 0.42^{b}	10.6 ± 0.51^{b}	F = 77.79, df = 3 and 56, P < 0.001
Litter > 20 cm	0.2 ± 0.08^{ab}	1.3 ± 0.27^{ac}	0.4 ± 0.09^{cd}	1.9 ± 0.30^{bd}	F = 14.61, df = 3 and 56, P < 0.001

TABLE 4.22. Presence distribution by transect and according to treatment of all 36 bird species encountered during transect surveys.

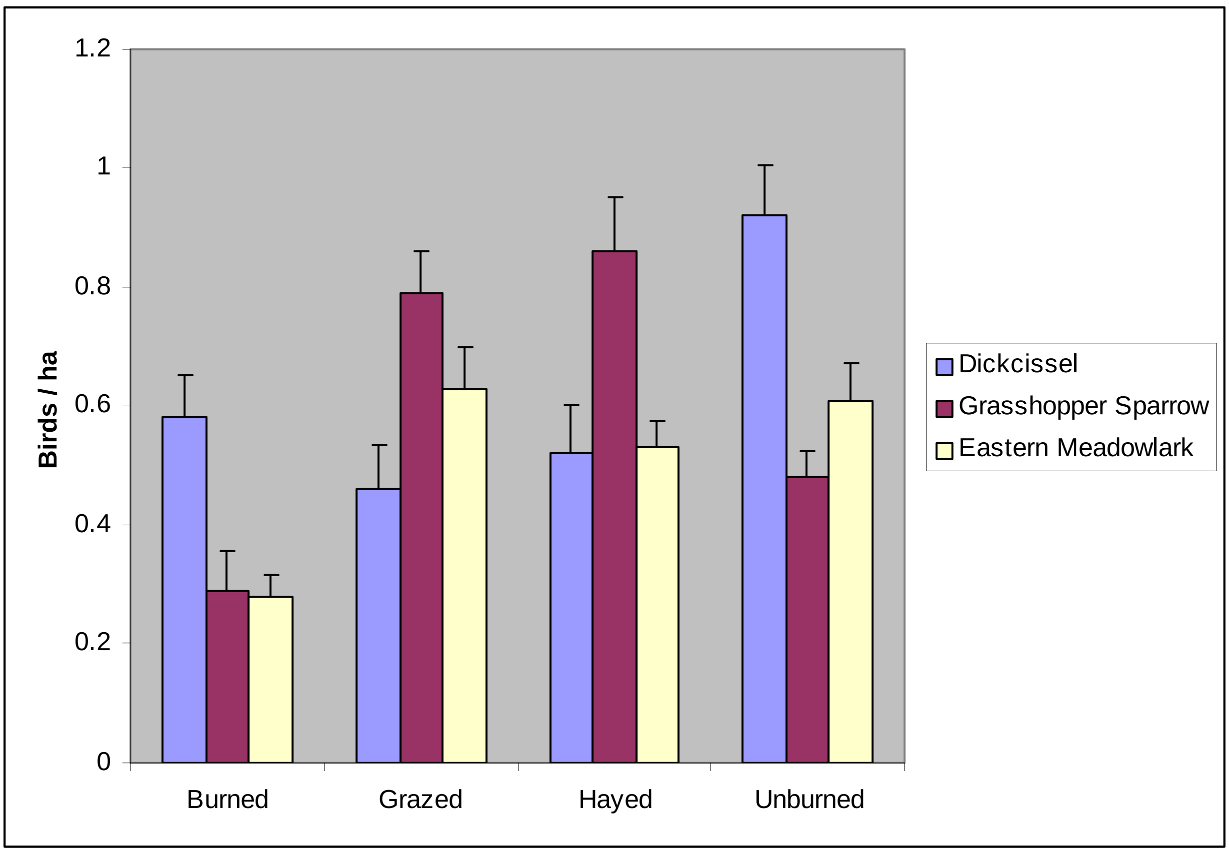
Species	Detections [a]	Number of transects, by treatment, in which detected			
		Burned	Grazed	Hayed	Unburned
Canada Goose	2	1			
Ring-necked Pheasant	6	2		1	3
Greater Prairie-Chicken	19	4	3	3	
Wild Turkey	1			1	
Northern Bobwhite	3	1		1	
Cooper's Hawk	1		1		
Killdeer	3		1	1	
Upland Sandpiper	142[b]	15	14	10	9
Mourning Dove	58	5	2	3	10
Common Nighthawk	13	4	1	4	2
Red-bellied Woodpecker	2		1		
Northern Flicker	6	2	2		
Eastern Phoebe	1	1			
Eastern Kingbird	86	14	9	12	9
Scissor-tailed Flycatcher	4			1	1
Loggerhead Shrike	3	1			1
Bell's Vireo	35			10	5
Rough-winged Swallow	1	1			
Barn Swallow	2	1			
House Wren	5		1	2	1
Gray Catbird	13			5	4
Brown Thrasher	25	2	1	7	6
European Starling	1		1		
Yellow Warbler	10		1	3	3
Common Yellowthroat	15	1		4	6
Dickcissel	395[c]	15	15	14	15
Grasshopper Sparrow	340[d]	12	15	15	15
Henslow's Sparrow	26[e]		3		11
Red-winged Blackbird	69	6	1	3	2
Eastern Meadowlark	415[f]	15	15	15	15
Western Meadowlark	5		3		
Great-tailed Grackle	8	1			
Brown-headed Cowbird	137	7	12	6	11
Orchard Oriole	8	3	1		2

Baltimore Oriole	8	1	1	3	
American Goldfinch	3			1	1

[a] All individuals detected within 80 m, unless otherwise indicated.
[b] All individuals on ground or in flight within 200 m.
[c] Singing males within 150 m.
[d] Singing males within 100 m.
[e] Singing males within 130 m.
[f] All individuals within 200 m.

shrub dweller, standing dead vegetation dependent

FIGURE 4.12. Densities of the three most commonly detected bird species on transects. Density values were calculated using DISTANCE and represent all individuals for Eastern Meadowlark and only singing males for Dickcissel and Grasshopper Sparrow.



CHAPTER 5. EVALUATION OF RANGE MANAGEMENT PRACTICES

William H. Busby, Kelly Kindscher, and Hillary Loring

5.1. INTRODUCTION

In 2003, staff of the Smoky Hill ANGR requested that the Kansas Biological Survey (KBS) convene a review of range management practices as part of the on-going natural resources study being conducted by KBS at the installation. The purpose of this review was to assess current range practices, evaluate range and habitat conditions, and suggest possible enhancements to current practices from the perspective of the maintenance and improvement of the long-term ecological condition of the mixed-grass prairie community and its component plant and wildlife species. The intended product was a general assessment of management practices and suggestions for possible enhancements to those practices.

The context and limitations of this review should be made clear. First, the scope of the review was restricted to evaluating the current cattle grazing and haying lease system. Major departures from the current system, such as replacing cattle with native grazers or replacing the current lease units with something quite different such as much larger grazing units, were not "on the table" for consideration. Such alternatives might offer the potential to restore the pre-settlement ecological conditions of the area by re-establishing a more natural grazing system and disturbance regime that could result in improved plant community quality and wildlife populations. Second, the time and resources put into this review were not extensive. The range tour was conducted on a single day so relatively few sites were visited and most had relatively high-quality range conditions. Given that no areas with a history of heavy grazing were visited, the group did not have a chance to see first hand the full variation in range conditions on the installation. However, several experts had visited Smoky Hill ANGR on previous occasions and were familiar with range conditions and practices in the recent past. Lastly, the effort invested by individuals was modest, and no attempt was made to reach consensus on recommended future directions in practices. The level of agreement by tour members on issues was not assessed although this report tries to convey a sense of the level of support for various ideas and comments. Experts may have had different or even conflicting views on certain topics and this should be borne in mind.

As a consequence of the nature of the review process, this report is intended not as a comprehensive examination of range management practices but rather a step in a continuing process of their periodic evaluation. It is intended to stimulate thought about whether current practices are leading to desired range conditions and to provide general suggestions for improvements in land management practices. The observations and ideas presented here come from recognized experts in range management and biodiversity conservation, but they do not necessarily represent a consensus opinion on the best direction for future management adjustments. These ideas are offered to installation staff as suggestions for additional consideration, not as definitive steps that need to be applied strictly. On-site resource management staff are most familiar with the day-to-day realities of the operating environment at Smoky Hill ANGR and can best evaluate how to implement any desired changes in management practices in a practical fashion. Installation staff are encouraged to follow up on the ideas presented here by seeking additional input from range experts. In this sense, this effort should stimulate re-evaluation and adaptive management that will result in continued progress toward enhancing the ecological condition of lands at Smoky Hill ANGR.

5.2. RANGE TOUR NOTES (compiled by William H. Busby)

5.2.1 Participants and Schedule

A range tour of Smoky Hill ANGR was conducted September 19, 2005. Range management and ecology experts participating in this review were:

Dr. David Engle, Iowa State University, Ames, IA
Dr. Walter Fick, Kansas State University, Manhattan, KS
David Kraft, U.S. Department of Agriculture, Emporia, KS
Jim Minnerath, U.S. Fish and Wildlife Service, Hartford, KS
Rob Penner, The Nature Conservancy, Hoisington, KS
Dwayne Rice, U.S. Department of Agriculture, Ellsworth, KS
Mike Rich, U.S. Fish and Wildlife Service, Manhattan, KS

Additional participants were Galen Wiens and Mike Hagen, Smoky Hill ANGR, and Kelly Kindscher, Bill Busby, and Hillary Loring, KBS. Dave Engle, who is currently conducting research on the installation, was not able to attend the tour but his comments were solicited afterwards by correspondence. Tour members were selected for their expertise in range ecology and management and familiarity with the Smoky Hills region.

5.2.2. Current Range Practices

Galen Wiens provided a summary of current range management practices on the installation. Areas under grazing leases are shown in Figure 2.1. Pastures are mostly about one square mile in size and are leased on a 5-year competitive basis. Bids recently have been about $22/acre. David Kraft commented that this rate would be on the high end for the Flint Hills. The grazing season is 1 May to 31 October, except for double stocked pasture which is grazed 1 May to about 30 July. Stocking rate is 1000 lbs per 7 acres.

Hay bids are also on a 5-year lease. Prices recently have been $4-12/acre. The hay cutting season is 1 July to 1 August.

Controlled burns are conducted on an as-needed basis. Pastures that would benefit from fire are burned when conditions are suitable (average to good moisture, etc.). In 2005, eight sections were burned. Few or no controlled burns are conducted when conditions are drier than normal.

Weed control is the responsibility of lessees. Contracts may be terminated when weed control is inadequate, but this practice is difficult to enforce. The process for getting permitted for weed control involves several steps (register with Galen, register with county, etc.). Some operators do a good job of weed control; others do not. A temporary employee maps the locations of weed populations every year. Problem weed areas are identified and aerially sprayed on about November 1 each year by a U.S. Air Force spray team out of Youngstown, Ohio. Using a C130 tanker plane with high-tech spray equipment the team flies at low elevation (100 feet) and applies 10 oz Tordon/acre in swaths about 300 feet wide.

5.2.3. Discussion of Practices

Weed Control. Weed control was discussed in some detail. Range experts were hesitant to say much before seeing the scale of the problem. No sites with musk-thistle or other noxious weeds were visited so tour members did not get to see the severity of the weed problem. However, several participants had visited the installation previously and were familiar with the situation. There was some skepticism about how big the weed problem really is. Jim Minnerath voiced concerns about the negative effects of broadcast spraying on wildlife through a negative effect on forbs. Walter Fick pointed out that spraying in late fall would limit the effect on non-target forbs. In response to a question regarding who was driving the concern about weeds, Galen responded that someone must be complaining, probably a neighbor, because the county weed agents were always on them. Galen said their first priority was to control weeds along the exterior properties so that weeds would be less visible to neighbors.

Stocking Rate. Stocking rate is considered moderate and wasn't discussed much by the group. This lack of discussion may indicate that tour participants thought the stocking rate was appropriate. Alternatively, people may not have seen enough pastures and felt they knew enough about the area to comment. The idea of adjusting stocking rates according to soils or grass productivity was discussed. Dwayne Rice suggested that stocking rates should be determined on a pasture by pasture basis according to range sites. He said the loamy upland and sandy upland sites would be in the 0.8 AUM per acre range and require a few more acres than the loamy lowland-dominated pastures. He offered to assist with evaluation of range sites and recommendations for stocking rates by pasture.

Mixed Management. Dwayne Rice and Jim Minnerath brought up the idea of mixed management. Dwayne and David Kraft said that doing the same thing every year is not the best approach for managing rangelands. Consistency in management may allow species adapted to one set of conditions to flourish while species adapted to other conditions may decline. They suggested mixing grazing intensities and incorporating rest periods. One example of this type of management would be to apply standard grazing rates the first four years of the lease, then have one year of double-stocking all season, then two years of rest. Various combinations of these alternatives could be tried. Jim mentioned patch burning, but there wasn't much discussion of this at the meeting. After the meeting, Dwayne suggested consideration of patch burning as a rotational grazing system without fencing. This type of management technique has been used in Oklahoma at a couple of different sites with favorable results.

Occasionally excluding a pasture from the bid process for a year or two as needed to accumulate fuel, rest, etc., also was discussed. A rotation between two pastures could be initiated where a lease would include two similarly sized pastures in one lease and the animals moved every 30 days to the second pasture.

Haying. Galen discussed how hay leases were initially established at the northern edges of the Impact Area. These areas were formerly being grazed, but because of training near these areas, there were concerns about safety. Allowing agricultural activity for a couple weeks a year (hay harvest) was suitable for the area, but pasturing cows and allowing people to visit the areas all growing season would have been problematic.

The timing of hay harvest was another topic of discussion. The best time for haying in terms of hay quality and maintaining prairie condition is the first half of July although the entire month of July generally is suitable. Hay quality declines sharply in August, and cutting this late in the season allows less time for regrowth. Tour members stated that experience has shown that the timing of haying would not be a problem for about the first five years, but consistently late haying for 10 or more years would have a negative effect on productivity. Dwayne and David asked if Smoky Hill ANGR had monitored soil fertility in hayed areas to see if it was showing declines. The benefits of occasional burning to control woody invasion around riparian areas was another topic of discussion. To control smooth sumac, two consecutive burns would be needed. Dwayne mentioned that haying could be used to control sumac in the floodplain (western part of the Impact Area) by burning the area twice and then cutting it for hay for a few years.

Burning. Jim suggested that burns be used creatively as a management tool. Allowing rest before a controlled burn would allow fuel to accumulate resulting in more complete burns. David recommended burning approximately one third of the property each year.

Timing of Grazing Season. David suggested that where early season double-stocking (ESDS) is practiced, the grazing period be moved up to 15 April from 1 May in pastures that were not burned. In the Flint Hills, burning has been shown to increase pasture productivity for livestock, and without burning it is hard to show the same gains. One way to get a slight increase in gains is to start the grazing season earlier to take advantage of cool season plants. David and Dwayne also talked about the risk of ESDS in dry years, which can result in a pasture being grazed out, and they suggested using a 15 April to 15 July season as a general rule.

5.3. OVERVIEW OF RECOMMENDATIONS

The consensus of range tour members was that current management practices at Smoky Hill ANGR are generally sound. Most thought stocking rates, the grazing season, and the burn regime were appropriate for the site. Dave Engle, who was not on the tour, wrote that an important benefit of the current plan is its simplicity. He pointed out that given the complications of multiple lessees, regulatory issues, and political pressures, a simple plan would more likely be implemented successfully. He mentioned that the visiting range consultants from six years ago deemed the status quo quite acceptable in terms of vegetation and wildlife objectives.

While noting the generally good range practices at Smoky Hill ANGR, most tour members also felt there was room for improvement and suggested ideas to enhance range productivity, vegetation condition, and native plant and animal diversity. Most suggestions related to incorporating some form of mixed management. When the same practices are followed every year, over time a few species that are well adapted to the conditions resulting from those practices will benefit. Practices that favor a few species are likely to decrease biological diversity. Varying grazing intensity and seasonality will favor a wider range of native species and thus promote diversity. The same applies to the frequency, seasonality, and intensity of fire. The goal is to imitate the natural disturbance regime of pre-settlement conditions. Fire and native grazers exerted strong influences on the vegetation. While the details of burning and grazing patterns during pre-settlement times in the mixed-grass prairie are not well understood it can be assumed that fires occurred at varying times, frequencies, and intervals, and that the density and behavior of native grazers varied seasonally and from year to year. By introducing more variation into management practices, a wider array of native species will be favored, fostering enhanced diversity.

Approaches for introducing mixed management are many. The following approaches were suggested by members of the range team:

1) Patch burn grazing. This could be employed in any number of ways: burning part of a single pasture, or implementing a patch burn grazing plan on 2+ pastures. One-third of the unit could be burned each year, or a more random design could be used.
2) Variation in grazing intensity within a pasture among years. Stocking rate could be increased some years and decreased others.
3) Movement of cattle among pastures within a grazing season; for example, move (double-stocked) cattle between two pastures every 30 days.
4) Periodically rest (no grazing or haying) pastures. This could be written into a lease agreement, or pastures could be rested between grazing leases.

One advantage of the current system is that three different grassland management practices are used: grazing, haying, and resting. This creates a mosaic of conditions that favor a diversity of plant and animal species. In addition, mobile wildlife species can move among the management treatments to suit their habitat needs (for example, birds such as prairie chicken requiring different grass structure for feeding vs. roosting). Furthermore, the varying burn patterns from year to year, especially in the Impact Area, create heterogeneity that has additional benefits for plant and animal diversity. In a sense, these different practices (grazed, hayed, and rested) are a form of mixed management at the scale of the entire installation. However, at the scale of the individual unit, management practices are constant over time, and the unit does not experience the benefits of mixed management. Application of the same practices every year on a unit is not as beneficial as varying the practices from year to year and over time, habitat conditions may become more uniform and diversity may decline. The fact that different land use practices are used in different parts of the property results in increased heterogeneity across the installation as a whole, but does nothing to enhance heterogeneity within a management unit.

One overriding concern expressed by several members of the range team was broadcast herbicide application. This practice was strongly discouraged because of the threat of irreversible damage to vegetation composition. The team did not have the opportunity to evaluate first hand the degree to which musk-thistle is a problem on the installation, but regardless of the actual or perceived severity of infestation, several team members felt that broadcast herbicide application was not a good solution.

Another topic mentioned by several members of the range team was the risk of erosion on tilled firebreaks. This concern has been lessened by recent improvements in firebreak design that reduce the amount of tillage required by burning the area between two narrow tilled bands. Team members were complimentary about this improved practice, but noted that erosion remains an issue, particularly on steeper slopes.

Concern was expressed about woody invasion in some areas visited during the range tour, particularly in hayed areas and in riparian zones. In hay leases, areas that are not regularly hayed due to ravines, rocky areas, or rough terrain, become invaded by woody vegetation over time. In riparian zones, woody vegetation develops fairly quickly without regular burning or other disturbance. Greater use of fire to control woody vegetation should be considered in both these areas. In uplands, the presence of small, scattered brushy thickets is not a major concern, but as these areas naturally expand and undergo succession and are invaded by trees, they become increasingly problematic. In riparian zones, some woody development is natural, especially along larger streams. From a range management perspective, control of woody riparian vegetation is not a priority except where woody vegetation continues to expand into significant portions of the floodplain. An example is in the Spring Creek floodplain within the Impact Area, where several range team members noticed the extensive coverage of sumac and suggested methods to limit its dominance.

Recommended Next Steps

As explained in the chapter introduction, the purpose of this review was to provide input on current range management practices from the perspective of maintaining and restoring native prairie vegetation and wildlife. Many ideas and recommendations for improved practices have been offered. However, this review was limited in scope: it consisting of a one-day tour and did not permit a thorough investigation of range conditions. In addition, management constraints imposed by the military training mission and by the grazing lease system create a unique situation to which any range practices must be adapted. This operational environment needs to be fully considered in any future modifications of range management operation. It is recommended that ANG natural resource staff take the following steps over the next few years:

- Review this document.
- Evaluate suggestions and recommendations that might be workable at Smoky Hill ANGR.
- Gather more information through various sources including additional consultation with range experts.
- Develop a plan for enhancing range practices.
- Implement the plan.
- Monitor results.

- Arrange for expert review of new practices and their effect on prairie vegetation and wildlife.

5.4. POST-TOUR COMMENTS FROM EVALUATION TEAM MEMBERS

Written comments received after the tour by individual tour participants are copied below. These comments were incorporated into Section 5.3 (Overview of Recommendations) and supplement information exchanged during the range tour.

Jim Minnerath 9/20/05:

If I had to pick one thing that I feel really needs to be done, it would be to park the C-130 for good and do away with all aerial application of herbicide. As you well know, I can only think in terms of the plant community when working on resource issues, at least that is always my baseline. To my way of thinking, protection of the plant diversity is key to promoting everything else.

I did feel the place looked very good and I do commend Galen on the present management.

Anything he can do to diversify the grazing systems, fire, rest, haying or any other activity would probably all lead to an increase in heterogeneity of the system and improve things for a more diverse assemblage of species.

David Kraft 10/11/05:

Like we discussed in Wichita, I find myself possibly over-analyzing the situation sometimes, due to comments we have made in the past. I realize that some of those suggestions may not be in the power of the manager to apply. I think that has improved with current management. Overall, I felt the areas we looked at certainly reflect some positive changes. The change in the firebreak is a good move. We have had concerns for quite some time in the amount of erosion that was occurring in some of these areas. It is not completely solved but a good change. I also realize they have to do something to minimize the risk of wildfire as much as possible.

The other comments I would have would be concerning the amount of prescribed burning they are applying. I think the approach of burning it in segments with approximately a third being burned each year is a good approach to management in that area of the state. It is no doubt a good move for upland bird populations and meets the needs of long-term management. The one suggestion I would have to add to this would be on the years where prescribed burning isn't used, is to consider allowing earlier entry to grazing to utilize cool season or undesirable species such as annual bromes and bluegrass. I think that part of the problem with the short season leases is that the size and number of cattle present on these pastures from July 15-30 are having a considerably larger impact than realized. When you consider that the cattle are considerably larger at the end of the grazing period, they are actually consuming a great deal more forage than they did at the beginning, and it is at a time when the desirable species are becoming very vulnerable to overuse and long-term impacts. On all short season stocking or grazing systems I *would strictly enforce a July 15 pullout. I think there is more flexibility in the front of the use period than on the end.*

Please let me know if I have confused any of the issues or failed to address the concerns which were brought before us that day.

Thanks!

<u>Dwayne Rice 10/17/05:</u>

Intended to get a report to you but this may have saved us both some time. Attached are my additions and comments to your notes. If you have any questions send me an email or give me a call.

[Note: All Dwayne's comments were incorporated into the range notes document. WHB]

<u>Rob Penner 10/19/05:</u>

It seemed like the Smoky Hill range had a lot of constrictions that limited what they could do differently. Overall the grassland conditions looked pretty good. Not the best wildlife habitat, but not too bad considering they have had to graze the area for funding. I listened to the suggestions that were presented during the tour and would have to say that any suggestions that related to implementing some type of change to the current system should be strongly considered. I am strongly in favor of inserting a rest period to the pastures as often as the grazing program will allow. Rest will improve the overall condition of the plant community while also improving wildlife habitat conditions. Another way to provide variability to the grazing system is to vary to stocking rates within the pastures. For example, using the current stocking rate in a given pasture, one year reduce the stocking rate a given percentage, then the next year, increase the stocking rate above the base rate by the same percentage it was reduced the year before. Then return to base stocking rate the third year. This can be done using one pasture or using a three pasture rotation in which one pasture is at the base stocking rate, one is at a lower stocking rate and the third is at a higher stocking rate. This results in variability in the pastures while still maintaining the same income. The key to this is to make sure the base stocking rate is not too high in the first place.

Patch burning could be desirable, but may not be easily implemented. A rotational burning plan should be considered or perhaps a random system in which all the burn units are identified and then a roll of the dice determines which units are burned in a given season. In this system some units might be burned a couple of times in a row, while others my not be burned for a number of years. This results in great wildlife habitat conditions, but might not be suitable for the site considering they seem to be tied down to the grazing program and also have areas that need special attention, such as weedy areas and woody areas.

<u>Dave Engle 11/02/05:</u>

Thank you for including me in the discussion and asking for my input.

The manager's life is a lot easier if he avoids the tangle of paperwork and the local political pressure that would escalate should he complicate life for the stockmen. He has good reason to avoid change even though he recognizes the ecological benefit of some other management approaches.

Simplicity is always a plus in management because a simple plan is more likely to succeed.

In the analysis of the visiting consultants 6 years ago or so, the status quo was actually deemed quite acceptable.

Several reasons for this:
1) They were meeting their vegetation and wildlife objectives.
2) No wildlife species were limited by habitat constraints, and in fact, prairie chicken populations were stable.
3) Current variation in vegetation structure and composition created desirable habitat for most, if not all, wildlife species.
4) No large or mounting problems with exotic plants.
5) Continuous grazing with moderate stocking rate mixed with fire and haying over the entire installation provided for a diversity of plant and animal life consistent with historical reference conditions. Patch burning might be an alternative on the grazing areas, but it might also be unworkable with a large number of different grazing contracts. [Would Galen consider working with one or two grazing lessees to implement?]

Several items should be given highest priority because they usually lead to irreversible change in vegetation composition. 1) Things to avoid: broadcast herbicide application (for either weed or brush control) and tillage, to include increasing the width and number of fire breaks. 2) Vigilance for exotic plant invasions (especially sericea lespedeza and leafy spurge) and rapid intervention (spot application of herbicide or mechanical removal of invading populations).

I believe Galen is managing in this mode, but it wouldn't hurt to revisit these over-arching priorities so that others in the command chain would understand. The other issues, grazing and haying as currently practiced, are of no significant negative impact, in my opinion.

This is my big-picture perspective, and some smaller issues, such as increasing population of sumac, might remain. If monitoring data suggest that these are major concerns, then perhaps they should be addressed, but I doubt they are major issues. Galen is concerned with sumac, possibly because of complaints from grazing lessees. I don't see sumac as an issue of concern. In fact, as a native shrub, the species should not be a target of control.

Hope these comments help. Thanks again for asking for my input.

CHAPTER 6: PREPARATION OF RECOMMENDATIONS AND ACTION PLAN FOR CONTROL AND ABATEMENT OF INVASIVE AND NON-NATIVE SPECIES

Craig C. Freeman and William H. Busby

6.1. BACKGROUND

In November 2005, the Kansas Biological Survey signed a modification to its contract to study the natural features of the Smoky Hill ANGR (DAM17-02-2-0043). The modification called for KBS to prepare recommendations and an action plan for control and abatement of invasive and non-native species at the Smoky HillANGR. This chapter lists each of the tasks identified in the contract modification and identifies where in this document information about that task may be found.

6.1.1. Study Objectives

The Statement of Work for the Preparation of Recommendations and Action Plan for Control and Abatement of Invasive and Non-native Species lists 10 tasks to be carried out by KBS: 1) background research, 2) analyze and evaluate database, 3) identify data gaps, 4) methodology development, 5) classification of vegetation community types, 6) field verification of community mapping units, 7) delineate the boundaries of critical habitat and stands of non-native plants, 8) conduct qualitative surveys for the presence of non-native and invasive species, 9) integrate updated plant community mapping into current GIS database, and 10) prepare a report of recommendations and action plan for control and abatement of invasive and non-native species.

Tasks 1—9 were carried out as part of, or in conjunction with, other activities conducted by KBS staff in their investigations of the natural features of Smoky Hill ANGR. Activities pertaining to Tasks 1—9 are enumerated below and referenced in earlier chapters in this document rather than repeating that information here. Task 10 is integrative – drawing together information from various chapters and research activities to develop the action plan for control and abatement of invasive and non-native species. The action plan is presented in Appendix G. We discuss the tasks below in the order in which they appear in the Statement of Work.

6.2. TASKS

6.2.1. Background Research

"In coordination with personnel at Smoky Hill ANGR, KBS shall develop a summary of existing, species-specific information necessary for specific recommendations and action plan."

On 22 February 2006, William Busby and Craig Freeman met with Stephen Covell and Smoky Hill ANGR staff to discuss invasive species work and related issues of concern on the installation. In March 2006, William Busby talked to Glenn Salsbury, Entomologist, Kansas Department of Agriculture, about potential invasive or non-native invertebrate pests in north-central Kansas. From March—May, KBS staff accumulated published and unpublished literature, and data concerning potentially invasive and non-native species that might cause management problems on Smoky Hill ANGR. Legal mandates and directives for management of invasive species were identified. Included among the documents gathered were the draft Kansas Terrestrial Invasive Species Management Plan and final Kansas Aquatic Nuisance Species Management Plan, both prepared by Kansas Department of Wildlife and Parks.

6.2.2. Analyze and Evaluate Database

"KBS will identify, analyze, and evaluate existing relevant information for detail and confidence levels of data presented as they pertain to preparation of specific recommendations and action plan."

Analysis and evaluation of relevant, existing data were carried out as part of planning efforts for survey and inventory work. This information is summarized in Chapters 2, 3, and 4. Estimates of invasiveness for all non-native plant species are presented in Appendix B; data are summarized in Chapter 3.

6.2.3. Identify Data Gaps

"KBS will identify and fill, as related to the scope of work for this project, data gaps in the existing information that are required for preparation of specific recommendations and action plan, including identifying special studies needed to fill data gaps."

Identification of data gaps was carried out as part of the planning effort for survey and inventory work, which is summarized in Chapters 2, 3, and 4.

6.2.4. Methodology Development

"KBS will develop a methodology for preparing the specific recommendations and action plan."

Standardized survey protocols for gathering weed data were used to gather information about musk-thistle, Russian olive, and sericea lespedeza on many management units on the installation. These protocols, which are described in Chapter 3, can be used for future survey and monitoring efforts in furtherance of the installation's invasive management plan. Vegetation conditions were assessed using cover estimates from vegetation plots, Floristic Quality Assessment, and the Shannon Diversity Index (Chapter 2). Survey protocols for native and non-native animals are described in Chapter 4.

6.2.5. Classification of Vegetative Community Types

"KBS will review any vegetation mapping accomplished for the INRMP, coordinate with other institutions and agencies having specialized knowledge or biological survey results from Smoky Hill ANGR."

The plant communities and landscape features of Smoky Hill ANGR are described in detail in Chapter 2, and the primary plant communities of the installation are mapped in Figure 2.7. Three natural/near-natural plant communities were identified and mapped: Dakota Hills Tallgrass Prairie (*Andropogon gerardii-Panicum virgatum-Schizachyrium scoparium*), Ash-Elm-Hackberry (*Fraxinus-Ulmus-Celtis*) Floodplain Forest, and Dakota Sandstone Sparse Vegetation. Eight semi-natural/altered plant communities were identified and mapped: Go-back Land/Tallgrass Prairie, Cultivated Fields, Windbreaks and Hedgerows, Ponds, Firebreaks, Developed Areas, Former Farmsteads, and Military Practice Disturbance.

6.2.6. Field Verify Plant Community Mapping Units

"KBS will verify remote sensing identification of included stands of non-native vegetation during field reconnaissance, including groundtruthing of all cover types."

Field and laboratory methods used to identify, classify, and map natural/near natural plant communities and semi-natural/altered plant communities are described in Chapter 2. This work included an analysis of the land use history of the installation.

6.2.7. Delineate Boundaries of Critical Habitat and Stands of Non-Native Plants

"KBS will identify and delineate all habitat deemed critical for the survival of sensitive species at Smoky Hill ANGR and report them as themes to supplement the current GIS database. Also, KBS will identify and delineate all stands of non-native vegetation, either monospecific or multi-species, dominated by non-native plants."

Locations of sensitive plant and animal species are described in Chapters 3 and 4, respectively. GIS coverages for rare species were provided to Smoky Hill ANGR staff. Field and laboratory methods used to identify, classify, and map semi-natural/altered plant communities are described in Chapter 2.

6.2.8. Conduct Qualitative Surveys for the Presence of Non-native and Invasive Species

"KBS will describe the presence of invasive and non-native species within the installation, focusing on plants, insects, rodents, birds, and other fauna. The extent of invasive and non-native plant cover will be determined initially by review of aerial photos, supplemented by groundtruthing."

One hundred fourteen non-native species of plants and six non-native species of animals were identified during floristic (Chapter 3) and faunistic (Chapter 4) surveys as occurring or potentially occurring on Smoky Hill ANGR. These species, scored by occurrence in each of the primary plant communities on the installation, are listed in Appendix G. The species × plant community matrix was populated based on field observations on Smoky Hill ANGR and from similar habitats in Saline and adjacent central Kansas counties. For the plants only, potential invasiveness in Kansas has been estimated (see discussion below).

Surveys for certain invasive, non-native plant species, including musk-thistle, Russian olive, and sericea lespedeza are described in Chapter 3. Qualitative estimates of the abundance of other invasive, non-native plant species also were made and are summarized in Appendix G. Surveys for exotic animals are described in Chapter 4, and a general review and assessment of invasive, non-native animal species appears in Appendix G. Surveys for semi-natural/altered plant communities are described in Chapter 2. A complete enumeration of GIS database layers that describe invasive and non-native species and communities appears in Appendix E; these GIS layers have been provided to Smoky Hill ANGR land managers.

6.2.9. Integrate Updated Plant Community Mapping into Current ANG GIS Database

"KBS will coordinate with the Smoky Hill ANGR Land Manager to integrate updated plant community maps into the current GIS database in the appropriate projections."

KBS researchers coordinated with Smoky Hill ANGR land managers from 2005—2006 to develop GIS coverages of plant communities. A complete enumeration of GIS database layers supplied to Smoky Hill ANGR land managers appears in Appendix E.

6.2.10. Prepare a Report of Recommendations and Action Plan for Control and Abatement of Invasive and Non-native Species

"KBS will identify invasive and non-native species through methods approved by NGB/A7CV and Kansas ANG POCs. KBS will prepare a report that quantifies the area of different alliances present, summarizes nuisance wildlife with potential to exist within those alliances, and provide an inventory with distribution maps of invasive and non-native species determined to be present. The report will present management actions consistent with the goals and objectives of the INRMP. The report will contain life history information for each invasive and non-native species of concern, including methods of control. The plan will include a 5-year seasonal calendar, in tabular form, of installation landscape management activities to control and prevent non-native and invasive species."

An action plan for the control and abatement of invasive and non-native species is presented in Appendix G.

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Appendix A.1. Average percent cover for species found in grassland habitats. Note vegetation layers overlap so plant cover can total more than 100%.

Scientific Name	Common Name	CoC Value	Average Percent Cover Impact Area	Average Percent Cover Hay Meadows	Average Percent Cover Pastures
Acalypha monococca	slender copperleaf	4	0.00	0.00	0.01
Achillea millefolium	western yarrow	1	0.35	0.88	0.39
Agalinis aspera	tall false foxglove	7	0.23	0.00	0.03
Agrostis hyemalis	winter bentgrass	2	0.01	0.04	0.14
Allium drummondii	Drummond's wild onion	6	0.06	0.06	0.00
Amaranthus retroflexus	rough pigweed	*	0.01	0.00	0.00
Ambrosia artemisiifolia	common ragweed	0	0.00	0.04	0.04
Ambrosia psilostachya	western ragweed	3	3.42	0.54	8.89
Ambrosia trifida	giant ragweed	0	0.02	0.04	0.01
Amorpha canescens	lead plant	7	2.32	1.44	0.31
Amphiachyris dracunculoides	annual broomweed	2	0.00	0.00	0.02
Andropogon gerardii	big bluestem	4	30.18	38.46	17.04
Andropogon virginicus	broomsedge bluestem	0	0.00	0.00	0.02
Androsace occidentalis	western rockjasmine	0	0.00	0.00	0.01
Androstephium caeruleum	blue funnel lily	7	0.01	0.00	0.00
Anemone canadensis	meadow anemone	6	0.05	0.00	0.01
Anemone caroliniana	Carolina anemone	5	0.05	0.02	0.01
Antennaria neglecta	field pussytoes	2	0.56	0.50	0.53
Apocynum cannabinum	hemp dogbane	0	0.00	0.02	0.00
Argemone polyanthemos	prickly poppy	3	0.00	0.00	0.01
Aristida oligantha	prairie threeawn	0	0.01	0.00	0.13
Aristida purpurea	Fendler's threeawn	5	0.19	0.00	0.15
Artemisia ludoviciana	Louisiana sagewort	2	0.68	2.63	1.87
Asclepias stenophylla	narrowleaf milkweed	7	0.09	0.31	0.14
Asclepias verticillata	whorled milkweed	1	0.15	0.15	0.07
Asclepias viridiflora	green-flowered milkweed	6	0.00	1.23	0.02
Asclepias viridis	green milkweed	1	0.07	0.44	0.32
Astragalus crassicarpus	common ground plum	7	0.02	0.15	0.03
Baptisia australis	blue false indigo	6	0.03	0.06	0.02
Bothriochloa laguroides	silver bluestem	1	0.00	0.00	1.92
Bouteloua curtipendula	side-oats grama	5	10.05	0.90	5.05
Bouteloua gracilis	blue grama	5	7.33	0.48	3.64
Bouteloua hirsuta	hairy grama	6	0.67	0.00	0.52
Brickelia eupatorioides	corymbulose false boneset	2	0.30	0.25	0.15
Bromus inermis	smooth brome	*	0.00	0.25	0.04
Bromus japonicus	Japanese Brome	*	0.08	5.35	10.77
Buchloe dactyloides	buffalograss	3	0.36	0.35	0.65
Callirhoe alcaeoides	pale poppy mallow	6	0.05	0.21	0.14

Scientific Name	Common Name	CoC Value	Average Percent Cover Impact Area	Average Percent Cover Hay Meadows	Average Percent Cover Pastures
Callirhoe involucrata	purple poppy mallow	1	0.08	0.25	0.18
Calylophus serrulatus	plains yellow evening primrose	5	0.25	0.52	0.12
Carduus nutans	musk-thistle	*	0.00	0.02	0.05
Carex bicknellii	Bicknell's sedge	2	0.00	0.02	0.02
Carex brevior	straw sedge	5	0.00	0.02	0.28
Carex bushii	Bush's sedge	4	0.00	0.52	0.14
Carex gravida	heavy sedge	4	0.00	0.10	0.15
Carex inops	long-stolon sedge	8	0.19	0.06	0.06
Carex muhlenbergii	southern sedge	2	0.07	0.13	0.02
Carex sp.	sedge		0.07	0.00	0.11
Cassia chamaecrista	showy partridge pea	2	0.02	0.00	0.00
Cenchrus longispinus	longspine sandbur	0	0.00	0.00	0.01
Cerastium brachypodum	shortstalk cerastium	2	0.01	0.02	0.01
Chamaesyce glyptosperma	ridge-seeded spurge	0	0.06	0.00	0.02
Chamaesyce maculata	spotted spurge	0	0.00	0.02	0.27
Chamaesyce nutans	eyebane	0	0.02	0.02	0.01
Chloris verticillata	windmillgrass	0	0.02	0.02	0.16
Chrysopsis villosa	rough goldenaster	4	0.00	0.00	0.01
Cirsium altissimum	tall thistle	2	0.02	0.10	0.06
Cirsium ochrocentrum	yellowspine thistle	4	0.01	0.00	0.03
Cirsium undulatum	wavyleaf thistle	4	0.30	0.50	0.40
Cirsium vulgare	bull thistle	*	0.00	0.00	0.01
Comandra umbellata	pale bastard toadflax	6	0.01	0.00	0.00
Commelina erecta	erect dayflower	4	0.00	0.02	0.00
Convolvulus arvensis	field bindweed	*	0.00	0.00	0.01
Conyza canadensis	Canada horseweed	0	0.50	0.10	0.29
Cornus drummondii	roughleaf dogwood	1	0.00	0.00	0.02
Coryphantha vivipara	coryphantha	6	0.01	0.00	0.00
Croton capitatus	woolly croton	1	0.05	0.00	0.05
Croton glandulosus	tropic croton	1	0.01	0.00	0.00
Croton monanthogynus	one-seeded croton	1	0.01	0.02	0.02
Croton texensis	Texas croton	1	0.05	0.02	0.04
Cyperus esculentus	yellow nutsedge	0	0.00	0.00	0.01
Cyperus lupulinus	flatsedge	3	0.10	0.21	0.10
Cyperus schweinitzii	Schweinitz' flatsedge	6	0.00	0.02	0.00
Dalea candida	western prairie clover	7	0.33	0.33	0.05
Dalea enneandra	nineanther dalea	5	0.02	0.00	0.01
Dalea purpurea	purple prairie clover	7	0.27	0.15	0.08
Delphinium virescens	plains larkspur	6	0.01	0.06	0.00
Desmanthus illinoensis	Illinois bundleflower	2	0.07	0.02	0.03
Desmodium illinoense	Illinois tickclover	5	0.01	0.06	0.01

Scientific Name	Common Name	CoC Value	Average Percent Cover Impact Area	Average Percent Cover Hay Meadows	Average Percent Cover Pastures
Dianthus armeria	Deptford pink	*	0.00	0.13	0.03
Dichanthelium acuminatum	pointed dichanthelium	3	0.00	0.10	0.05
Dichanthelium oligosanthes	Scribner's dichanthelium	4	1.68	0.83	0.82
Dichanthelium sphaerocarpon	roundseed dichanthelium	5	0.00	0.02	0.00
Digitaria cognata	fall witchgrass	3	0.09	0.29	0.58
Draba brachycarpa	shortpod draba	1	0.00	0.06	0.03
Draba reptans	white whitlowwort	2	0.02	0.06	0.02
Echinacea angustifolia	narrowleaf purple coneflower	6	0.16	0.10	0.06
Elaeagnus angustifolia	Russian olive	*	0.00	0.02	0.00
Eleocharis palustris	spikerush	6	0.00	0.04	0.00
Elymus canadensis	Canada wildrye	5	0.11	0.25	0.35
Elymus virginicus	Virginia wildrye	3	0.00	0.00	0.01
Equisetum laevigatum	smooth scouring-rush	3	0.01	0.00	0.01
Eragrostis spectabilis	purple lovegrass	3	0.58	0.00	0.31
Erigeron strigosus	daisy fleabane	4	0.76	10.17	0.46
Euphorbia davidii	David's spurge	0	0.00	0.00	0.01
Euphorbia marginata	snow-on-the-mountain	0	0.06	0.02	0.31
Euphorbia spathulata	spurge	0	0.03	0.15	0.06
Evolvulus nuttallianus	Nuttall's evolvulus	6	0.07	0.06	0.01
Fimbristylis puberula	hairy fimbristylis	8	0.01	0.15	0.02
Fraxinus pennsylvanica	green ash	0	0.00	0.00	0.01
Gaura coccinea	scarlet gaura	4	0.00	0.02	0.02
Gaura mollis	velvety gaura	1	0.00	0.00	0.12
Gaura villosa	hairy gaura	5	0.00	0.02	0.00
Geranium carolinianum	Carolina cranesbill	0	0.02	0.17	0.08
Gleditsia triacanthos	honey locust	0	0.00	0.00	0.04
Glycyrrhiza lepidota	wild licorice	3	0.00	0.00	0.01
Grindelia ciliata	wax goldenweed	1	0.06	0.04	0.00
Grindelia squarrosa	curlytop gumweed	0	0.02	0.00	0.01
Hedeoma hispidum	rough false pennyroyal	1	0.18	0.35	0.26
Hedyotis crassifolia	small bluets	1	0.00	0.04	0.00
Helianthus annuus	common sunflower	0	0.22	0.00	0.00
Helianthus pauciflorus	stiff sunflower	5	0.05	0.04	0.02
Hesperostipa spartea	porcupinegrass	8	1.02	2.44	0.09
Heterotheca subaxillaris	camphorweed	2	0.00	0.02	0.02
Hibiscus trionum	flower-of-an-hour	*	0.00	0.00	0.01
Hieracium longipilum	longbeard hawkweed	5	0.00	0.31	0.04
Hordeum pusillum	little barley	0	0.00	0.00	0.03
Hymenopappus scabioseus	flattop hymenopappus	4	0.02	0.19	0.10
Hypericum perforatum	common St. John's-wort	*	0.00	0.13	0.05
Juncus dudleyi	Dudley's rush	3	0.00	0.00	0.01

Scientific Name	Common Name	CoC Value	Average Percent Cover Impact Area	Average Percent Cover Hay Meadows	Average Percent Cover Pastures
Juncus interior	inland rush	2	0.03	0.02	0.09
Juncus tenuis	path rush	0	0.07	0.08	0.07
Juniperus virginiana	red cedar	1	0.00	0.00	0.02
Koeleria macrantha	Junegrass	6	3.10	1.21	0.53
Lactuca ludoviciana	Louisiana lettuce	2	0.00	0.08	0.00
Lactuca saligna	willowleaf lettuce	3	0.00	0.00	0.02
Lactuca serriola	prickly lettuce	*	0.02	0.06	0.05
Lepidium densiflorum	peppergrass	0	0.28	0.40	0.19
Lespedeza capitata	round-head lespedeza	6	0.17	0.04	0.01
Liatris punctata	dotted gayfeather	5	0.48	0.15	0.18
Liatris squarrosa	smooth gayfeather	7	0.03	0.00	0.01
Linum rigidum	stiffstem flax	7	0.00	0.00	0.01
Linum sulcatum	grooved flax	6	0.47	1.42	0.41
Lithospermum incisum	narrowleaf gromwell	5	0.18	0.35	0.16
Lomatium foeniculaceum	carrotleaf lomatium	6	0.02	0.02	0.01
Lotus unifoliolatus	prairie trefoil	3	0.18	0.06	0.08
Machaeranthera pinnatifida	southern ironplant goldenweed	3	0.05	0.00	0.01
Maclura pomifera	Osage orange	*	0.00	0.00	0.06
Medicago lupulina	black medick	*	0.00	0.00	0.02
Melilotus albus	white sweet clover	*	0.00	0.02	0.00
Melilotus officinalis	yellow sweet clover	*	0.02	0.04	0.02
Mimosa quadrivalvis	sensitive briar	6	1.32	0.48	0.29
Mirabilis linearis	narrowleaf four-o'clock	5	0.02	0.02	0.01
Mollugo verticillata	carpetweed	*	0.01	0.00	0.00
Muhlenbergia cuspidata	plains muhly	5	0.18	0.08	0.06
Muhlenbergia sobolifera	rock muhly	5	0.07	0.00	0.26
Myosotis verna	Virginia forget-me-not	2	0.00	0.02	0.00
Oenothera laciniata	cutleaf evening primrose	0	0.01	0.02	0.00
Oenothera villosa	common evening primrose	0	0.09	0.02	0.01
Opuntia macrorhiza	bigroot prickly pear	3	0.00	0.04	0.01
Oxalis dillenii	green wood sorrel	0	0.22	0.46	0.36
Oxalis violacea	violet wood sorrel	4	0.09	0.02	0.02
Packera plattensis	plains groundsel	5	0.07	0.04	0.04
Panicum capillare	witchgrass	0	0.05	0.00	0.00
Panicum virgatum	switchgrass	4	3.03	0.73	1.62
Paronychia jamesii	James' nailwort	6	0.05	0.00	0.01
Pascopyrum smithii	western wheatgrass	2	3.41	0.08	1.08
Paspalum setaceum	sand paspalum	2	0.00	0.06	0.03
Pediomelum esculentum	prairie turnip	7	0.05	0.04	0.14
Penstemon cobaea	cobaea beardtongue	5	0.03	0.04	0.02
Penstemon tubaeflorus	tube beardtongue	3	0.01	1.38	0.00

Scientific Name	Common Name	CoC Value	Average Percent Cover Impact Area	Average Percent Cover Hay Meadows	Average Percent Cover Pastures
Persicaria bicomis	longstyle smartweed	1	0.01	0.00	0.01
Physalis heterophylla	clammy groundcherry	4	0.03	0.08	0.02
Physalis longifolia	common groundcherry	2	0.02	0.04	0.02
Physalis virginiana	smooth Virginia groundcherry	6	0.00	0.00	0.01
Plantago patagonica	woolly plantain	1	0.16	0.85	0.15
Plantago virginica	pale-seeded plantain	1	0.17	0.42	0.29
Poa pratensis	Kentucky bluegrass	*	0.25	1.00	6.86
Polygala verticillata	whorled milkwort	3	0.02	0.27	0.12
Polygonum tenue	slender knowtweed	6	0.02	0.00	0.01
Potentilla recta	sulfur cinquefoil	*	0.01	0.19	0.05
Prunus americana	wild plum	3	0.00	0.00	0.02
Prunus virginiana	choke cherry	2	0.00	0.02	0.00
Pseudognaphalium obtusifolium	fragrant cudweed	0	0.01	0.00	0.10
Psoralidium tenuiflorum	many-flowered scurfpea	3	0.41	4.79	2.16
Pyrrhopappus carolinianus	Carolina false dandelion	1	0.00	0.02	0.00
Pyrrhopappus grandiflorus	tuberous false dandelion	4	0.01	0.00	0.00
Ratibida columnifera	yellow prairie coneflower	4	0.11	0.29	0.16
Rhus aromatica	aromatic sumac	3	0.00	0.00	0.01
Rosa arkansana	prairie wild rose	4	0.00	0.00	0.01
Rubus flagellaris	American dewberry	5	0.00	0.00	0.01
Rudbeckia hirta	black-eyed Susan	2	0.00	4.50	0.04
Ruellia humilis	fringeleaf ruellia	3	0.26	0.25	0.19
Rumex crispus	curly dock	*	0.00	0.00	0.02
Salvia azurea	blue sage	4	0.33	0.69	0.16
Schedonnardus paniculatus	tumblegrass	3	0.05	0.00	0.05
Schizachyrium scoparium	little bluestem	5	36.73	56.04	33.44
Scutellaria parvula	southern small skullcap	5	0.01	0.00	0.00
Setaria geniculata	knotroot bristlegrass	3	0.00	0.00	0.19
Silene antirrhina	sleepy catchfly	0	0.14	0.29	0.06
Sisyrinchium campestre	prairie blue-eyed grass	6	0.00	0.04	0.01
Solanum carolinense	Carolina horse nettle	1	0.01	0.02	0.01
Solanum rostratum	buffalo bur	0	0.05	0.00	0.06
Solidago canadensis	rough Canada goldenrod	2	0.01	0.02	0.03
Solidago missouriensis	Missouri goldenrod	5	0.66	0.56	0.41
Solidago mollis	ashy goldenrod	5	0.47	0.06	0.17
Solidago nemoralis	gray goldenrod	2	0.05	0.02	0.16
Solidago petiolaris	downy goldenrod	7	0.02	0.00	0.02
Solidago rigida	stiff goldenrod	3	0.14	0.04	0.11
Solidago speciosa	noble goldenrod	7	0.02	0.00	0.01
Sorghastrum nutans	Indiangrass	5	3.93	8.25	7.76
Spermolepis inermis	Red River scaleseed	3	0.55	0.46	0.10

Scientific Name	Common Name	CoC Value	Average Percent Cover Impact Area	Average Percent Cover Hay Meadows	Average Percent Cover Pastures
Sphenopholis obtusata	prairie wedgegrass	4	0.00	0.00	0.02
Spiranthes vernalis	upland ladies'-tresses	5	0.00	0.00	0.01
Sporobolus compositus	rough dropseed	3	3.91	7.77	21.06
Sporobolus cryptandrus	sand dropseed	0	0.09	0.10	0.65
Sporobolus vaginiflorus	povertygrass	0	0.00	0.00	0.06
Stellaria media	chickweed	*	0.00	0.02	0.01
Stenaria nigricans	narrowleaf bluets	5	0.05	0.00	0.00
Strophostyles leiosperma	slick-seed bean	3	0.01	0.13	0.11
Symphoricarpos orbiculatus	buckbrush	1	0.01	0.10	0.16
Symphyotrichum ericoides	heath aster	5	5.20	1.21	0.88
Symphyotrichum falcatum	western prairie aster	3	0.02	0.02	0.09
Symphyotrichum lanceolatum	aster	3	0.01	0.00	0.01
Symphyotrichum oblongifolium	aromatic aster	5	0.45	0.58	0.28
Symphyotrichum sericeum	silky aster	8	0.16	0.08	0.09
Taraxacum officinale	common dandelion	*	0.00	0.00	0.04
Teucrium canadense	American germander	1	0.00	0.00	0.01
Thelesperma megapotamicum	Missouri River greenthread	4	0.06	0.04	0.01
Tradescantia occidentalis	prairie spiderwort	5	0.05	0.19	0.01
Tradescantia tharpii	Tharp's spiderwort	7	0.01	0.00	0.00
Tragia betonicifolia	nettleleaf noseburn	5	0.00	0.02	0.01
Tragopogon dubius	goat's beard	*	0.00	0.44	0.04
Tridens flavus	purpletop	1	0.01	0.08	0.06
Triodanis leptocarpa	slimpod Venus' looking glass	3	0.05	0.04	0.03
Triodanis perfoliata	Venus' looking glass	4	0.33	0.27	0.08
Ulmus rubra	slippery elm	3	0.02	0.04	0.01
Verbena bracteata	prostrate verbena	0	0.00	0.00	0.01
Verbena stricta	woolly verbena	1	0.00	0.02	0.04
Vernonia baldwinii	common ironweed	2	0.08	0.23	0.39
Veronica peregrina	purslane speedwell	0	0.00	0.02	0.00
Vicia americana	American vetch	7	0.00	0.00	0.01
Viola bicolor	Johnny-jump-up	0	0.00	0.00	0.01
Vulpia octoflora	sixweeks fescue	5	0.05	0.27	0.04
Yucca glauca	small soapweed	4	0.00	0.04	0.00
Bare ground			6.28	1.94	4.50
Average total cover per plot			**140.41**	**174.69**	**147.65**

Appendix A.2. Average percent cover for species found in riparian plots. Note vegetation layers overlap so plant cover can total more than 100%.

Scientific Name	Common Name	CoC Value	Average percent cover per species
Acalypha rhomboidea	rhombic copperleaf	1	0.80
Acer negundo	common boxelder	1	0.20
Ambrosia trifida	giant ragweed	0	0.10
Bidens bipinnatus	Spanish needles	0	0.10
Carex amphibola	narrowleaf sedge	3	1.30
Carex sp.	sedge		2.50
Celtis occidentalis	common hackberry	1	6.90
Chenopodium album	lamb's-quarters	0	0.10
Chenopodium simplex	maple-leaved goosefoot	2	0.20
Chenopodium standleyanum	Standley's goosefoot	3	0.20
Cirsium altissimum	tall thistle	2	0.20
Commelina communis	common dayflower	*	0.10
Cornus drummondii	roughleaf dogwood	1	1.50
Elymus virginicus	Virginia wildrye	3	33.90
Euphorbia davidii	western toothed spurge	0	0.30
Fallopia scandens	climbing false buckwheat	0	0.10
Fraxinus pennsylvanica	green ash	0	13.50
Geum canadense	white avens	1	2.60
Gleditsia triacanthos	honey locust	0	0.60
Gymnocladus dioica	Kentucky coffee-tree	4	0.90
Hackelia virginiana	Virginia stickseed	3	0.30
Juglans nigra	black walnut	3	30.50
Lactuca canadensis	Canada lettuce	2	0.10
Leersia virginica	whitegrass	3	5.20
Maclura pomifera	Osage orange	*	1.60
Morus rubra	red mulberry	5	5.00
Muhlenbergia bushii	Bush's muhly	4	21.30
Muhlenbergia sobolifera	rock muhly	5	4.00
Parietaria pensylvanica	Pennsylvania pellitory	0	0.20
Phytolacca americana	pokeweed	0	0.20
Populus deltoides	plains cottonwood	0	4.00
Prunus virginiana	choke cherry	2	0.10
Ribes missouriense	Missouri gooseberry	3	0.40
Ribes odoratum	golden current	5	0.10
Sanicula canadensis	Canada sanicle	2	0.30
Smilax amnoides	bristly greenbrier	2	0.10
Symphoricarpos orbiculatus	buckbrush	1	23.40
Symphyotrichum lanceolatum	white panicled	3	0.10
Teucrium canadense	northern germander	1	0.20
Torilis arvensis	hedge parsley	*	0.70

Scientific Name	Common Name	CoC Value	Average percent cover per species
Toxicodendron radicans	common poison ivy	0	0.90
Tridens flavus	purpletop	1	0.10
Ulmus americana	American elm	2	3.00
Ulmus rubra	slippery elm	3	10.80
Urtica dioica	stinging nettle	1	3.90
Verbascum thapsus	woolly mullein	*	0.10
Verbena urticifolia	white verbena	2	0.20
Vernonia baldwinii	common ironweed	2	0.10
Viola sororia	downy blue violet	2	0.10
Vitis riparia	riverbank grape	2	0.20
Bare ground			9.80
Average total cover per plot			**193.10**

Appendix B. Vascular plants documented in Saline County and on Smoky Hill ANGR based on vouchers in the R. L. McGregor Herbarium, University of Kansas. Status codes: r = documented on Smoky Hill ANGR; s = documented in Saline County but not on Smoky Hill ANGR. U.S. Fish and Wildlife Service Region 5 Wetland Indicator Status (Wetland Indicator Status): OBL = obligate wetland species; FACW = facultative wetland species; FAC = facultative (upland or wetland) species; FACU = facultative upland species; UPL = upland species; NI = insufficient information to determine status; NS = no status (no agreement, thought not to occur in region, or not examined). Longevity codes are: A = annual; B = biennial; P = perennial. Raunkiaer life form codes (Habit): C = chamaeophyte (low shrubs and cushion plants with buds exposed above ground but below 0.25 m); G = geophyte/cryptophyte (plants with rhizomes, tubers, or bulbs located well below the surface of the soil); He = helophytes (water or swamp plants protruding above the water surface but with submerged winter buds); Hm = hemicryptophyte (perennial and biennial herbs and graminoids with buds located at or near surface of soil); Hy = hydrophytes (submerged or floating aquatic plants with winter buds at the bottom); N = nanophanerophytes (woody plants with winter buds 0.10—0.25 m above ground); P = phanerophyte (trees and tall shrubs with buds >0.25 m above ground); T = therophyte (annual plants that survive unfavorable periods as seeds). Definitions for state ranks (S-Rank), coefficients of conservatism (CoC), and alien status (Alien Status) are provided in Chapter 6.

Status	Family	Scientific Name	Common Name	S-Rank	CoC	Wetland Indicator Status	Alien Status	Longevity	Habit
r	Acanthaceae	Ruellia humilis Nutt.	fringe-leaf ruellia	S4	3	FACU	0	P	Hm
r	Aceraceae	Acer negundo L. var. negundo	boxelder	S3	1	FAC	0	P	P
r	Agavaceae	Yucca glauca Nutt.	small soapweed	S5	4	NS	0	P	C
r	Alismataceae	Echinodorus berteroi (Spreng.) Fassett	upright burhead	S5	4	OBL	0	AP	He
r	Alismataceae	Sagittaria ambigua J.G. Sm.	Kansas arrowhead	S2	8	OBL	0	P	He
r	Alismataceae	1. Sagittaria brevirostra Mack. & Bush	short-beak arrowhead	S3	4	OBL	0	P	He
s	Alismataceae	2. Sagittaria latifolia Willd.	broad-leaf arrowhead	S4	4	OBL	0	P	He
s	Amaranthaceae	3. Amaranthus albus L.	tumbleweed amaranth	S5	0	FACU	0	A	T
r	Amaranthaceae	4. Amaranthus blitoides S. Watson	prostrate pigweed	S5	0	FACW	0	A	T
r	Amaranthaceae	5. Amaranthus palmeri S. Watson	Palmer's pigweed	S5	0	FACU	0	A	T
r	Amaranthaceae	Amaranthus retroflexus L.	rough pigweed	S5	0	FACU	0	A	T
r	Amaranthaceae	Amaranthus tuberculatus (Moq.) J.D. Sauer	tall water-hemp	S5	0	OBL	0	A	T
s	Amaranthaceae	Froelichia floridana (Nutt.) Moq.	field snake-cotton	S3	3	NS	0	A	T
r	Amaranthaceae	Froelichia gracilis (Hook.) Moq.	slender snake-cotton	S4	3	NS	0	A	T
r	Anacardiaceae	Rhus glabra L.	smooth sumac	S5	1	NS	0	P	P
r	Anacardiaceae	Toxicodendron radicans (L.) Kuntze subsp. negundo (Greene) Gillis	poison-ivy	S5	0	FACU	0	P	P
s	Apiaceae	Berula erecta (Huds.) Coville var. incisa (Torr.) Cronquist	cut-leaf water-parsnip	S3	6	OBL	0	P	He
s	Apiaceae	Chaerophyllum procumbens (L.) Crantz var. procumbens	spreading chervil	S4	0	FAC	0	A	T
r	Apiaceae	Conium maculatum L.	poison-hemlock	SE	*	FACW	3	B	He
s	Apiaceae	Eryngium leavenworthii Torr. & A. Gray	Leavenworth's eryngo	S4	3	NS	0	A	T
r	Apiaceae	Lomatium foeniculaceum (Torr. & A. Gray) Cronquist var. daucifolium (Torr. & A. Gray) Cronquist	fennel-leaf desert-parsley	S5	6	NS	0	P	G

Status	Family	Scientific Name	Common Name	S-Rank	CoC	Wetland Indicator Status	Alien Status	Longevity	Habit
s	Apiaceae	Lomatium orientale J.M. Coult. & Rose	eastern desert-parsley	S3	8	NS	0	P	G
s	Apiaceae	Pastinaca sativa L.	garden parsnip	SE	*	NS	3	B	Hm
s	Apiaceae	Sanicula canadensis L. var. canadensis	Canadian sanicle	S5	2	NI	0	B	Hm
r	Apiaceae	Spermolepis inermis (Nutt. ex DC.) Mathias & Constance	spreading scaleseed	S5	3	NS	0	A	T
r	Apiaceae	Torilis arvensis (Huds.) Link	field hedge-parsley	SE	*	NS	3	A	T
r	Apocynaceae	Apocynum cannabinum L.	hemp dogbane	S5	0	FAC	0	P	G
s	Apocynaceae	Vinca minor L.	common periwinkle	SE	*	NS	3	P	C
r	Asclepiadaceae	Asclepias amplexicaulis Sm.	blunt-leaf milkweed	S3	7	NS	0	P	G
s	Asclepiadaceae	Asclepias arenaria Torr.	sand milkweed	S3	7	NS	0	P	G
s	Asclepiadaceae	Asclepias incarnata L. subsp. incarnata	swamp milkweed	S5	4	OBL	0	P	Hm
r	Asclepiadaceae	Asclepias lanuginosa Nutt.	woolly milkweed	S1	9	NS	0	P	G
s	Asclepiadaceae	Asclepias pumila (A. Gray) Vail	plains milkweed	S4	2	NS	0	P	G
r	Asclepiadaceae	Asclepias speciosa Torr.	showy milkweed	S5	2	FAC	0	P	G
r	Asclepiadaceae	Asclepias stenophylla A. Gray	narrow-leaf milkweed	S5	7	NS	0	P	Hm
s	Asclepiadaceae	Asclepias sullivantii Engelm. ex A. Gray	smooth milkweed	S4	5	NS	0	P	G
r	Asclepiadaceae	Asclepias syriaca L.	common milkweed	S5	1	NS	0	P	G
r	Asclepiadaceae	Asclepias tuberosa L. subsp. interior Woodson	butterfly milkweed	S5	6	NS	0	P	G/Hm
r	Asclepiadaceae	Asclepias verticillata L.	whorled milkweed	S5	1	NS	0	P	G
r	Asclepiadaceae	Asclepias viridiflora Raf.	green milkweed	S5	6	NS	0	P	Hm
r	Asclepiadaceae	Asclepias viridis Walter	spider milkweed	S5	1	NS	0	P	G
s	Asclepiadaceae	Cynanchum leave (Michx.) Pers.	smooth swallow-wort	S5	0	FAC	0	P	Hm
r	Asteraceae	Achillea millefolium L. subsp. lanulosa	western yarrow	S5	1	FACU	0	P	C
s	Asteraceae	Ageratina altissima (L.) R.M. King & H. Rob.var. altissima	tall snakeroot	S5	1	NI	0	P	Hm
r	Asteraceae	Ambrosia artemisiifolia L.	common ragweed	S5	0	FACU	0	A	T
r	Asteraceae	Ambrosia psilostachya DC.	western ragweed	S5	3	FAC	0	P	G
r	Asteraceae	Ambrosia trifida L.	giant ragweed	S5	0	FACW	0	A	T
r	Asteraceae	Amphiachyris dracunculoides (DC.) Nutt.	prairie broomweed	S5	2	NS	0	A	T
s	Asteraceae	Antennaria neglecta Greene	field pussy's-toes	S5	2	NS	0	P	C
s	Asteraceae	Artemisia campestris L. subsp. caudata (Michx.) H.M. Hall & Clem.	western sagewort	S2	5	NS	0	B	C
s	Asteraceae	Artemisia dracunculus L.	silky wormwood	S2	4	NS	0	P	G
r	Asteraceae	Artemisia ludoviciana Nutt. var. ludoviciana	Louisiana sagewort	S5	2	FACU-	0	P	C
s	Asteraceae	Artemisia ludoviciana Nutt. var. mexicana	Louisiana sagewort	S5	2	FACU-	0	P	C
s	Asteraceae	Berlandiera texana DC.	Texas berlandiera	S3	6	NS	0	P	Hm
r	Asteraceae	Bidens bipinnatus L.	Spanish needles	S5	0	NS	0	A	T
r	Asteraceae	Brickellia eupatorioides (Torr. & A. Gray) Shinners var. corymbulosa (Torr. & A. Gray) Shinners	eastern brickellbush	S5	2	NS	0	P	Hm
r	Asteraceae	Carduus nutans L.	musk-thistle	SE	*	NS	4	B	Hm
s	Asteraceae	Centaurea cyanus L.	bachelor's-button	SE	*	NS	2	A	T
r	Asteraceae	Cirsium altissimum (L.) Spreng.	tall thistle	S5	2	NS	0	B	Hm

Status	Family	Scientific Name	Common Name	S-Rank	CoC	Wetland Indicator Status	Alien Status	Longevity	Habit
r	Asteraceae	Cirsium undulatum (Nutt.) Spreng. var. undulatum	wavy-leaf thistle	S5	4	FACU	0	P	Hm
r	Asteraceae	Cirsium vulgare (Savi) Ten.	bull thistle	SE	*	UPL	3	B	Hm
r	Asteraceae	Conyza canadensis (L.) Cronquist	tall horseweed	S5	0	FACU-	0	A	T
s	Asteraceae	Conyza ramosissima Cronquist	spreading horseweed	S4	0	NS	0	A	T
s	Asteraceae	Coreopsis grandiflora Hogg var. harveyana (A. Gray) Sherff	big-flower coreopsis	S4	8	NS	0	P	Hm
r	Asteraceae	Coreopsis tinctoria Nutt. var. tinctoria	plains coreopsis	S5	1	FAC	0	A	T
r	Asteraceae	Croptilon hookerianum (Torr. & A. Gray) House var. validum (Rydb.) E.B. Sm.	Hooker's scratch daisy	S4	3	NS	0	A	T
s	Asteraceae	Cyclachaena xanthifolia (Nutt.) Fresen.	bur-weed marshelder	S4	0	FAC	0	A	T
r	Asteraceae	Dyssodia papposa (Vent.) Hitchc.	prairie fetid-marigold	S5	0	NS	0	A	T
r	Asteraceae	Echinacea angustifolia DC.	black-Sampson purple-coneflower	S5	6	NS	0	P	Hm
r	Asteraceae	Echinacea pallida (Nutt.) Nutt.	pale purple-coneflower	S5	7	NS	0	P	Hm
r	Asteraceae	Eclipta prostrata (L.) L.	yerba de tajo	S5	3	FACW	0	A	T
r	Asteraceae	Erechtites hieracifolius (L.) Raf. ex DC. var. hieracifolius	American burnweed	S3	1	FAC	0	A	T
r	Asteraceae	Erigeron strigosus Muhl. ex Willd. var. strigosus	daisy fleabane	S5	4	FAC	0	AB	Hm/T
s	Asteraceae	Eupatorium altissimum L.	tall joe-pye-weed	S5	2	NS	0	P	Hm
s	Asteraceae	Eupatorium perfoliatum L.	clasping-leaf joe-pye-weed	S3	5	OBL	0	P	Hm
r	Asteraceae	Euthamia gymnospermoides Greene	sticky euthamia	S4	3	FACW	0	P	G
s	Asteraceae	Gamochaeta purpurea (L.) Cabrera	purple everlasting	S3	4	UPL	0	AB	Hm/T
r	Asteraceae	Grindelia ciliata (Nutt.) Spreng.	wax gumweed	S5	1	UPL	0	A	T
s	Asteraceae	Grindelia squarrosa (Pursh) Dunal var. squarrosa	curly-cup gumweed	S5	0	FACU-	0	BP	Hm
r	Asteraceae	Gutierrezia sarothrae (Pursh) Britton & Rusby	broom snakeweed	S5	3	NS	0	P	P
s	Asteraceae	Helianthus ×laetiflorus Pers.	showy sunflower	S2	hybrid	NS	0	P	G
r	Asteraceae	Helianthus annuus L.	common sunflower	S5	0	FACU	0	A	T
r	Asteraceae	Helianthus maximilianii Schrad.	Maximilian's sunflower	S5	3	NS	0	P	G
r	Asteraceae	Helianthus mollis Lam.	ashy sunflower	S4	7	NS	0	P	G
r	Asteraceae	Helianthus pauciflorus Nutt. var. pauciflorus	stiff sunflower	S5	5	NS	0	P	G
r	Asteraceae	Helianthus petiolaris Nutt. var. petiolaris	plains sunflower	S5	1	NS	0	A	T
r	Asteraceae	Helianthus tuberosus L.	Jerusalem-artichoke sunflower	S5	2	FAC	0	P	G
r	Asteraceae	Heterotheca stenophylla (A. Gray) Shinners var. angustifolia (Rydb.) Semple	narrow-leaf golden-aster	S3	4	NS	0	P	Hm
s	Asteraceae	Heterotheca stenophylla (A. Gray) Shinners var. stenophylla	narrow-leaf golden-aster	S5	4	NS	0	P	Hm
r	Asteraceae	Heterotheca subaxillaris (Lam.) Britton & Rusby subsp. latifolia (Buckley) Semple	broad-leaf golden-aster	S5	2	FACU	0	A	T
r	Asteraceae	Hieracium longipilum Torr. ex Hook.	long-beard hawkweed	S4	5	FACU	0	P	Hm
r	Asteraceae	Hymenopappus scabiosaeus (Torr. & A. Gray) B.L. Turner var. corymbosus (Torr. & A. Gray) B.L. Turner	flat-top woolly-white	S4	4	NS	0	B	Hm

Status	Family	Scientific Name	Common Name	S-Rank	CoC	Wetland Indicator Status	Alien Status	Longevity	Habit
r	Asteraceae	Iva annua L.	annual sumpweed	S5	0	FAC	0	A	T
s	Asteraceae	Krigia cespitosa (Raf.) K.L. Chambers subsp. cespitosa	weedy dwarf-dandelion	S4	4	FACU	0	A	T
s	Asteraceae	Lactuca ludoviciana (Nutt.) Riddell	western lettuce	S5	3	FAC	0	B	Hm
s	Asteraceae	Lactuca oblongifolia Nutt.	chicory lettuce	S4	4	NS	0	P	G
r	Asteraceae	Lactuca saligna L.	willow-leaf lettuce	SE	*	FACU+	3	AB	Hm/T
s	Asteraceae	Lactuca serriola L.	prickly lettuce	SE	*	FAC	3	AB	Hm/T
s	Asteraceae	Leucanthemum vulgare Lam.	common ox-eye daisy	SE	*	NS	3	P	Hm
r	Asteraceae	Liatris punctata Hook.	western dotted gayfeather	S5	5	NS	0	P	G
r	Asteraceae	Liatris squarrosa (L.) Michx. var. glabrata (Rydb.) F.C. Gates	plains gayfeather	S3	7	NS	0	P	G
s	Asteraceae	Lygodesmia juncea (Pursh) D. Don ex Hook.	rush skeleton-weed	S5	3	NS	0	P	G
r	Asteraceae	Machaeranthera pinnatifida (Hook.) Shinners var. glaberrima (Rydb.) B.L. Turner & R.L. Hartm.	cut-leaf tansy-aster	S4	4	NS	0	P	Hm
s	Asteraceae	Nothocalais cuspidata (Pursh) Greene	wavy-leaf false-dandelion	S3	7	NS	0	P	Hm
r	Asteraceae	Packera plattensis (Nutt.) W.A. Weber & Á. Löve	prairie ragwort	S5	5	FACU	0	P	Hm
s	Asteraceae	Plectocephalus americanus (Nutt.) D. Don	American basket-flower	S1	3	NS	0	A	T
r	Asteraceae	Pluchea odorata (L.) Cass. var. odorata	purple marsh-fleabane	S3	2	NS	0	A	T
r	Asteraceae	Pseudognaphalium obtusifolium (L.) Hilliard & B.L. Burtt	fragrant false-cudweed	S4	0	NS	0	A	T
s	Asteraceae	Pyrrhopappus carolinianus (Walter) DC.	Carolina false-dandelion	S4	1	NS	0	AB	Hm/T
r	Asteraceae	Pyrrhopappus grandiflorus (Nutt.) Nutt.	tuberous false-dandelion	S3	4	NS	0	P	G
r	Asteraceae	Ratibida columnifera (Nutt.) Wooton & Standl.	upright prairie-coneflower	S5	4	NS	0	P	Hm
r	Asteraceae	Rudbeckia hirta L. var. pulcherrima Farw.	black-eyed-Susan	S4	2	FACU	0	ABP	Hm/T
r	Asteraceae	Silphium integrifoium Nutt. var. leave	showy rosinweed	S5	3	NS	0	P	Hm
s	Asteraceae	Silphium laciniatum L.	compassplant	S5	4	NS	0	P	Hm
r	Asteraceae	Solidago altissima L. var. altissima	Canadian goldenrod	S5	1	FACU	0	P	G
s	Asteraceae	Solidago canadensis L. var. hargeri Fernald	Canadian goldenrod	S3	2	FACU	0	P	G
r	Asteraceae	Solidago gigantea Aiton	late goldenrod	S5	3	FACW	0	P	G
r	Asteraceae	Solidago missouriensis Nutt.	Missouri goldenrod	S5	5	NS	0	P	G
r	Asteraceae	Solidago mollis Bartl. var. mollis	ashy goldenrod	S4	5	NS	0	P	G
r	Asteraceae	Solidago nemoralis Ation subsp. decemiflora (DC.) Brammall	gray goldenrod	S3	2	NS	0	P	Hm
r	Asteraceae	Solidago rigida L. var. rigida	stiff goldenrod	S4	3	FACU	0	P	Hm
r	Asteraceae	Sonchus asper (L.) Hill	prickly sow-thistle	SE	*	FACW	2	A	T
r	Asteraceae	Symphyotrichum ericoides (L.) G.L. Nesom var. ericoides	heath aster	S5	5	FACU	0	P	G
r	Asteraceae	Symphyotrichum falcatum (Lindl.) var. commutatum (Torr. & A. Gray) G.L. Nesom	western heath aster	S5	3	FAC	0	P	Hm
s	Asteraceae	Symphyotrichum lanceolatum (Willd.) G.L. Nesom var. lanceolatum	lance-leaf aster	S4	3	FACW	0	P	G
r	Asteraceae	Symphyotrichum lanceolatum (Willd.) G.L. Nesom var. latifolium ((Semple & Chmiel.) G.L. Nesom	lance-leaf aster	S4	3	FACW	0	P	G

Status	Family	Scientific Name	Common Name	S-Rank	CoC	Wetland Indicator Status	Alien Status	Longevity	Habit
r	Asteraceae	Symphyotrichum oblongifolium (Nutt.) G.L. Nesom	aromatic aster	S5	5	NS	0	P	G
r	Asteraceae	Symphyotrichum sericeum (Vent.) G.L. Nesom	silky aster	S5	8	NS	0	P	Hm
r	Asteraceae	Symphyotrichum subulatum (Michx.) G.L. Nesom var. ligulatum (Shinners) S.D. Sundb.	saltmarsh aster	S5	0	OBL	0	A	T
r	Asteraceae	Taraxacum erythrospermum Andrz. ex Besser	red-seed dandelion	SE	*	NS	3	P	Hm
r	Asteraceae	Taraxacum officinale F.H. Wigg.	common dandelion	SE	*	FACU	3	P	Hm
r	Asteraceae	Thelesperma megapotamicum (Spreng.) Kuntze var. megapotanicum	Rio Grande greenthread	S5	4	NS	0	P	Hm
r	Asteraceae	Tragopogon dubius Scop.	western salsify	SE	*	NS	3	BP	Hm
r	Asteraceae	Vernonia baldwinii Torr. subsp. interior (Small) W.Z. Faust	western ironweed	S5	2	FAC-	0	P	Hm
r	Asteraceae	Xanthium strumarium L.	common cocklebur	S5	4	NS	0	P	Hm
r	Bignoniaceae	Catalpa speciosa Warder	northern catalpa	SE	*	FACU	3	P	P
r	Boraginaceae	Hackelia virginiana (L.) I.M. Johnst.	Virginia bracted-stickseed	S3	3	FACU	0	B	Hm
s	Boraginaceae	Lithospermum caroliniense (Walter ex J.F. Gmel.) MacMill.	Carolina gromwell	S3	6	NS	0	P	Hm
r	Boraginaceae	Lithospermum incisum Lehm.	plains gromwell	S5	5	NS	0	P	Hm
r	Boraginaceae	Myosotis verna Nutt.	spring forget-me-not	S3	2	FAC-	0	A	T
r	Boraginaceae	Onosmodium bejariense (Mack.) B.L. Turner var. occidentale (Mack.) B.L. Turner	western marbleseed	S5	4	NS	0	P	Hm
s	Brassicaceae	Barbarea vulgaris W.T. Aiton	bitter wintercress	SE	*	FAC	3	B	Hm
r	Brassicaceae	Camelina microcarpa Andrz. ex DC.	little-pod false-flax	SE	*	NS	3	A	T
r	Brassicaceae	Capsella bursa-pastoris (L.) Medik.	common shepherd's-purse	SE	*	FACU	3	A	T
s	Brassicaceae	Cardamine parviflora L. var. arenicola (Britton) O.E. Schulz	small-flower bittercress	S3	2	FAC	0	AB	Hm/T
r	Brassicaceae	Chorispora tenella (Pall.) DC.	blue-mustard	SE	*	NS	3	A	T
s	Brassicaceae	Conringia orientalis (L.) Dumort.	treacle hare's-ear	SE	*	NS	2	A	T
r	Brassicaceae	Descurainia pinnata (Walter) Britton subsp. brachycarpa (Richardson) Detling	pinnate tansy-mustard	S5	1	NS	0	A	T
r	Brassicaceae	Descurainia pinnata (Walter) Britton subsp. halictorum (Cockerell) Detling	pinnate tansy-mustard	S3	1	NS	0	A	T
r	Brassicaceae	Descurainia Sophia (L.) Webb ex Prantl	flix-weed tansy-mustard	SE	*	NS	3	A	T
r	Brassicaceae	Draba brachycarpa Nutt.	short-pod draba	S4	1	NS	0	A	T
r	Brassicaceae	Draba reptans (Lam.) Fern.	white whitlow-wort	S5	2	NS	0	A	T
r	Brassicaceae	Erysimum repandum L.	bushy wallflower	SE	*	NS	3	A	T
s	Brassicaceae	Hesperis matronalis L.	dame's rocket	SE	*	NS	3	BP	Hm
r	Brassicaceae	Lepidium densiflorum Schrad. var. densiflorum	prairie pepper-grass	S5	0	NS	0	AB	Hm/T
r	Brassicaceae	Lepidium oblongum Small. var. oblongum	oblong pepper-grass	S4	0	NS	0	AB	Hm
s	Brassicaceae	Lepidium virginicum L. var. virginicum	Virginia pepper-grass	S4	0	FACU	0	AB	Hm/T
s	Brassicaceae	Microthlaspi perfoliatum (L.) F.K. Mey.	perfoliate-pennycress	SE	*	NS	3	A	T
r	Brassicaceae	Nasturtium officinale R. Br.	common watercress	SE	*	OBL	3	AP	He/T
s	Brassicaceae	Rorippa palustris (L.) Besser subsp. fernaldiana (Butters & Abbe) Jonsell var. fernaldiana	bog yellowcress	S3	2	OBL	0	ABP	Hm/T

Status	Family	Scientific Name	Common Name	S-Rank	CoC	Wetland Indicator Status	Alien Status	Longevity	Habit
r	Brassicaceae	Rorippa sessiliflora (Nutt.) Hitchc.	stalkless yellowcress	S4	1	OBL	0	AB	Hm
s	Brassicaceae	Rorippa sinuata (Nutt.) Hitchc.	spreading yellowcress	S5	3	FACW	0	P	G
s	Brassicaceae	Sibara virginica (L.) Rollins	Virginia rockcress	S3	0	NI	0	B	Hm
s	Brassicaceae	Sisymbrium officinale (L.) Scop.	common hedge-mustard	SE	*	NS	3	A	T
r	Brassicaceae	Thlaspi arvense L.	field pennycress	SE	*	NI	3	A	T
r	Cactaceae	Coryphantha missouriensis (Sweet) Britt. & Rose var. missouriensis	Missouri River coryphantha	S3	7	NS	0	P	Hm
s	Cactaceae	Coryphantha vivipara (Nutt.) Britt. & Rose var. vivipara	pin-cushion coryphantha	S3	6	NS	0	P	Hm
r	Cactaceae	Opuntia macrorhiza Engelm. var. macrorhiza	big-root pricklypear	S5	3	NS	0	P	C
r	Callitrichaceae	Callitriche heterophylla Pursh var. heterophylla	large water-starwort	S3	7	OBL	0	P	Hy
s	Campanulaceae	Lobelia cardinalis L.	cardinal-flower	S5	6	OBL	0	P	Hm
s	Campanulaceae	Lobelia siphilitica L. var. siphilitica	great lobelia	S5	4	OBL	0	P	Hm
r	Campanulaceae	Triodanis leptocarpa (Nutt.) Nieuwl.	slender-fruit Venus'-looking-glass	S5	3	NS	0	A	T
r	Campanulaceae	Triodanis perfoliata (L.) Nieuwl.	clasping-leaf Venus'-looking-glass	S5	2	FAC	0	A	T
r	Cannabaceae	Cannabis sativa L.	hemp	SE	*	FACU-	3	A	T
r	Caprifoliaceae	Sambucus canadensis L.	American honeysuckle	S5	2	FAC	0	P	P
r	Caprifoliaceae	Symphoricarpos orbiculatus Moench	buckbrush	S5	1	FACU-	0	P	P
r	Caryophyllaceae	Arenaria serpyllifolia L. var. serpyllifolia	thyme-leaf sandwort	SE	*	FAC	3	A	T
r	Caryophyllaceae	Cerastium brachypodum (Engelm. ex A. Gray) B.L. Rob.	short-stalk mouse's-ear-chickweed	S4	2	FACU	0	A	T
s	Caryophyllaceae	Cerastium fontanum Baumg. subsp. vulgare (Hartm.) Greuter & Burdet	common mouse's-ear-chickweed	SE	*	FACU	3	P	C
r	Caryophyllaceae	Dianthus armeria L.	Deptford pink	SE	*	NS	3	A	T
s	Caryophyllaceae	Holosteum umbellatum L. subsp. umbellatum	jagged-chickweed	SE	*	NS	3	A	T
r	Caryophyllaceae	Paronychia jamesii Torr. & A. Gray	James' nailwort	S5	6	NS	0	P	Hm
s	Caryophyllaceae	Saponaria officinalis L.	bouncingbet	SE	*	FACU	2	P	Hm
r	Caryophyllaceae	Silene antirrhina L.	sleep catchfly	S5	0	NS	0	A	T
s	Caryophyllaceae	Silene latifolia Poir. subsp. alba (Mill.) Greuter & Burdet	cowbell catchfly	SE	*	NS	2	P	Hm
s	Caryophyllaceae	Stellaria media (L.) Vill.	common chickweed	SE	*	NS	3	A	T
r	Caryophyllaceae	Stellaria pallida (Dumort.) Crép.	pale chickweed	SE	*	NS	3	A	T
s	Ceratophyllaceae	Ceratophyllum demersum L.	common hornwort	S4	3	OBL	0	P	Hy
r	Chenopodiaceae	Chenopodium album L.	lamb's-quarters goosefat	S3	0	FAC	0	A	T
r	Chenopodiaceae	Chenopodium berlandieri Moq. var. zschackii (Murray) Murray ex Asch.	pit-seed goosefoot	S4	0	NS	0	A	T
s	Chenopodiaceae	Chenopodium missouriense Aellen	Missouri goosefoot	S3	2	NS	0	A	T
r	Chenopodiaceae	Chenopodium pratericola Rydb.	field goosefoot	S5	3	NI	0	A	T
r	Chenopodiaceae	Chenopodium simplex (Torr.) Raf.	maple-leaf goosefoot	S4	2	NS	0	A	T
r	Chenopodiaceae	Chenopodium standleyanum Aellen	Standley's goosefoot	S3	3	NS	0	A	T
r	Chenopodiaceae	Kochia scoparia (L.) Schrad.	broom kochia	SE	*	FACU	3	A	T

Status	Family	Scientific Name	Common Name	S-Rank	CoC	Wetland Indicator Status	Alien Status	Longevity	Habit
r	Chenopodiaceae	Monolepis nuttalliana (Schult.) Greene	Nuttall's poverty-weed	S4	0	FACW	0	A	T
r	Clusiaceae	Hypericum perforatum L.	common St. John's-wort	SE	*	NS	3	P	Hm
s	Commelinaceae	Commelina erecta L. var. angustifolia (Michx.) Fernald	erect dayflower	S4	4	NS	0	P	Hm
r	Commelinaceae	Commelina erecta L. var. erecta	erect dayflower	S3	4	NS	0	P	Hm
r	Commelinaceae	Tradescantia bracteata Small	bracted spiderwort	S5	5	FAC	0	P	Hm
r	Commelinaceae	Tradescantia occidentalis (Britton) Smyth & L. Smyth var. occidentalis	western spiderwort	S5	5	NS	0	P	Hm
r	Commelinaceae	Tradescantia ohiensis Raf.	Ohio spiderwort	S5	5	FACU	0	P	Hm
r	Commelinaceae	Tradescantia tharpii E.S. Anderson & Woodson	Tharp's spiderwort	S3	7	NS	0	P	Hm
r	Convolvulaceae	Calystegia macounii (Greene) Brummitt	Macoun's hedge-bindweed	S3	6	NS	0	P	G
r	Convolvulaceae	Calystegia sepium (L.) R. Br. var. angulata Brummitt	common hedge-bindweed	S5	0	FAC	0	P	G
s	Convolvulaceae	Calystegia silvatica (Kit.) Griseb. subsp. fraternifolia (Mack. & Bush) Brummitt	woodland hedge-bindweed	S3	1	NS	0	P	G
r	Convolvulaceae	Convolvulus arvensis L.	field bindweed	SE	*	NS	4	P	G
s	Convolvulaceae	Evolvulus nuttallianus Schult.	Nuttall's evolvulus	S5	6	NS	0	P	Hm
s	Convolvulaceae	Ipomoea coccinea L.	scarlet morning-glory	SE	*	FACU	2	A	T
r	Convolvulaceae	Ipomoea hederacea Jacq.	ivy-leaf morning-glory	SE	*	FACU	3	A	T
s	Convolvulaceae	Ipomoea lacunosa L.	white morning-glory	S3	0	FACW-	0	A	T
r	Convolvulaceae	Ipomoea leptophylla Torr.	bush morning-glory	S5	5	NS	0	P	Hm
r	Cornaceae	Cornus drummondii C.A. Mey.	rough-leaf dogwood	S5	1	FAC	0	P	P
r	Cucurbitaceae	Cucurbita foetidissima Kunth	buffalo gourd	S5	0	NS	0	P	Hm
r	Cucurbitaceae	Sicyos angulatus L.	wall bur-cucumber	S5	2	FAC	0	A	T
r	Cupressaceae	Juniperus virginiana L. var. virginiana	eastern red-cedar	S5	1	FACU-	0	P	P
s	Cyperaceae	Bolboschoenus maritimus (L.) Palla subsp. paludosus (A. Nelson) T. Koyama	saltmarsh tuberous-bulrush	S4	4	NI	0	P	He
r	Cyperaceae	Carex aggregata Mack.	cluster sedge	S3	6	NS	0	P	Hm
r	Cyperaceae	Carex austrina Mack.	southern sedge	S5	2	NS	0	P	Hm
r	Cyperaceae	Carex blanda Dewey	woodland sedge	S5	1	FAC	0	P	Hm
r	Cyperaceae	Carex brachyglossa Mack.	yellow-fruit sedge	S5	5	FAC+	0	P	He
r	Cyperaceae	Carex brevior (Dewey) Mack. ex Lunell	short-beak sedge	S5	5	FAC	0	P	Hm
r	Cyperaceae	Carex bushii Mack.	Bush's sedge	S5	4	FAC	0	P	Hm
s	Cyperaceae	Carex davisii Schwein. & Torr.	Davis' sedge	S5	4	FACU	0	P	Hm
r	Cyperaceae	Carex gravida L.H. Bailey	heavy sedge	S5	4	NS	0	P	Hm
r	Cyperaceae	Carex grisea Wahlenb.	narrow-leaf sedge	S5	3	NS	0	P	Hm
r	Cyperaceae	Carex inops L.H. Bailey subsp. heliophila (Mack.) Crins	sun sedge	S3	8	NS	0	P	Hm
r	Cyperaceae	Carex laeviconica Dewey	smooth-cone sedge	S3	8	OBL	0	P	He
r	Cyperaceae	Carex lupulina Muhl. ex Willd.	hop sedge	S3	6	FACW+	0	P	Hm
s	Cyperaceae	Carex molesta Mack. ex Bright	pest sedge	S3	4	FAC	0	P	Hm
r	Cyperaceae	Carex pellita Muhl. ex Willd.	woolly sedge	S5	5	OBL	0	P	He
s	Cyperaceae	Carex umbellata Schkuhr ex Willd.	low sedge	S3	7	NS	0	P	Hm

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r	Cyperaceae	Carex vulpinoidea Michx.	fox sedge	S5	3	OBL	0	P	He
s	Cyperaceae	Cyperus ×mesochorus Geise	intermediate flat-sedge	S3	hybrid	NS	0	P	Hm
s	Cyperaceae	Cyperus acuminatus Torr. & Hook.	tape-leaf flat-sedge	S5	0	OBL	0	A	T
s	Cyperaceae	Cyperus bipartitus Torr.	brook flat-sedge	S3	4	NS	0	A	T
r	Cyperaceae	Cyperus erythrorhizos Muhl.	red-root flat-sedge	S3	4	OBL	0	A	T
r	Cyperaceae	Cyperus esculentus L.	yellow nut-sedge	S5	0	FACW	0	P	G
r	Cyperaceae	Cyperus lupulinus (Spreng.) Marcks subsp. lupulinus	slender-stem flat-sedge	S5	3	FACU	0	P	Hm
r	Cyperaceae	Cyperus odoratus L.	slender flat-sedge	S5	3	FACW	0	A	T
r	Cyperaceae	Cyperus schweinitzii Torr.	Schweinitz's flat-sedge	S3	6	FACU	0	P	Hm
r	Cyperaceae	Cyperus setigerus Torr. & Hook.	bristle flat-sedge	S4	7	FAC	0	P	Hm
r	Cyperaceae	Eleocharis coloradoensis (Britton) Gilly	Colorado spike-rush	S2	4	NS	0	P	He
r	Cyperaceae	Eleocharis compressa Sull. var. acutisquamata (Buckley) S.G. Sm.	flat-stem spike-rush	S3	6	FACW	0	P	He
r	Cyperaceae	Eleocharis engelmannii Steud.	Engelmann's spike-rush	S3	4	NS	0	A	T
r	Cyperaceae	Eleocharis erythropoda Steud.	bald spike-rush	S3	4	OBL	0	P	He
r	Cyperaceae	Eleocharis macrostachya Britton	large-spike spike-rush	S4	3	OBL	0	P	He
s	Cyperaceae	Eleocharis obtusa (Willd.) Schult.	blunt spike-rush	S4	3	OBL	0	A	T
s	Cyperaceae	Fimbristylis puberula (MIchx.) Vahl var. puberula	hairy fimbry	S5	8	OBL	0	P	Hm
r	Cyperaceae	Fimbristylis vahlii (Lam.) Link	Vahl's fimbry	S2	5	FACW	0	A	T
s	Cyperaceae	Schoenoplectus heterochaetus (Chase) Soják	slender twine-bulrush	S1	6	OBL	0	P	He
r	Cyperaceae	Schoenoplectus pungens (Vahl) Palla var. longispicatus	common threesquare twine-bulrush	S5	3	OBL	0	P	He
r	Cyperaceae	Schoenoplectus tabernaemontani (C.C. Gmel.) Palla	soft-stem twine-bulrush	S5	4	OBL	0	P	He
r	Cyperaceae	Scirpus georgianus R.M. Harper	Georgia bulrush	S3	4	NI	0	P	He
s	Cyperaceae	Scirpus pendulus Muhl.	drooping bulrush	S5	3	OBL	0	P	He
s	Dryopteridaceae	Cystopteris tennesseensis Shaver	Tennessee bladder fern	S4	6	NS	0	P	Hm
s	Dryopteridaceae	Onoclea sensibilis L.	sensitive fern	S3	6	FACW	0	P	G
s	Dryopteridaceae	Woodsia obtusa (Spreng.) Torr. subsp. obtusa	blunt-lobe cliff fern	S4	6	NS	0	P	Hm
r	Elaeagnaceae	Elaeagnus angustifolia L.	Russian-olive	SE	*	FAC	4	P	P
s	Elatinaceae	Bergia texana (Hook.) Seub. ex Walp.	Texas bergia	S2	2	OBL	0	A	T
s	Equisetaceae	Equisetum ×ferrissii Clute	intermediate scouring-rush	S4	hybrid	FAC	0	P	G
r	Equisetaceae	Equisetum laevigatum A. Braun	smooth scouring-rush	S5	3	FACW	0	P	Hm
r	Euphorbiaceae	Acalypha monococca (Engelm. ex A. Gray) Lill. W. Mill. & Gandhi	slender copperleaf	S3	4	NS	0	A	T
r	Euphorbiaceae	Acalypha ostryifolia Riddell	rough-pod copperleaf	S4	0	NS	0	A	T
r	Euphorbiaceae	Acalypha rhomboidea Raf.	rhombic copperleaf	S4	1	FACU-	0	A	T
r	Euphorbiaceae	Acalypha virginica L.	Virginia copperleaf	S4	0	FACU-	0	A	T
r	Euphorbiaceae	Chamaesyce glyptosperma (Engelm.) Small	ridge-seed mat-spurge	S5	0	NS	0	A	T
r	Euphorbiaceae	Chamaesyce maculate (L.) Small	spotted mat-spurge	S5	0	FACU-	0	A	T
r	Euphorbiaceae	Chamaesyce nutans (Lag.) Small	eyebane	S5	0	FACU-	0	A	T
r	Euphorbiaceae	Chamaesyce serpens (Kunth) Small	round-leaf mat-spurge	S5	0	NS	0	A	T

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s	Euphorbiaceae	Chamaesyce stictospora (Engelm.) Small	slim-seed mat-spurge	S5	0	NS	0	A	T
r	Euphorbiaceae	Croton capitatus Michx. var. capitatus	woolly croton	S4	1	NS	0	A	T
r	Euphorbiaceae	Croton glandulosus L. var. septentrionalis Müll. Arg.	tropic croton	S4	1	NS	0	A	T
s	Euphorbiaceae	Croton monanthogynus Michx.	one-seed croton	S5	1	NS	0	A	T
r	Euphorbiaceae	Croton texensis (Klotzsch) Müll. Arg.	Texas croton	S5	1	NS	0	A	T
s	Euphorbiaceae	Euphorbia cyathophora Murray	painted spurge	S5	3	NS	0	A	T
r	Euphorbiaceae	Euphorbia davidii Subils	western toothed spurge	S5	0	NS	0	A	T
s	Euphorbiaceae	Euphorbia hexagona Nutt. ex Spreng.	six-angle spurge	S5	2	NS	0	A	T
r	Euphorbiaceae	Euphorbia marginata Pursh	snow-on-the-mountain	S5	0	FACU	0	A	T
r	Euphorbiaceae	Euphorbia spathulata Lam.	warty spurge	S5	5	FACU	0	A	T
r	Euphorbiaceae	Tragia betonicifolia Nutt.	betony noseburn	S4	5	NS	0	P	Hm
r	Fabaceae	Amorpha canescens Pursh	leadplant	S5	7	NS	0	P	P
r	Fabaceae	Amorpha fruticosa L.	bush wild-indigo	S5	6	OBL	0	P	P
r	Fabaceae	Astragalus crassicarpus Nutt. var. crassicarpus	ground-plum milk-vetch	S5	7	NS	0	P	Hm
s	Fabaceae	Astragalus lotiflorus Hook.	lotus milk-vetch	S5	4	NS	0	P	Hm
r	Fabaceae	Astragalus plattensis Nutt.	Platte River milk-vetch	S4	7	NS	0	P	Hm
s	Fabaceae	Baptisia ×bicolor Greenm. & Larisey	bicolor wild-indigo	S2	hybrid	NS	0	P	Hm
r	Fabaceae	Baptisia australis (L.) R. Br. var. minor (Lehm.) Fernald	blue wild-indigo	S5	6	NS	0	P	Hm
s	Fabaceae	Baptisia bracteata Muhl. ex Elliott var. leucophaea (Nutt.) Gartesz & Gandhi	plains wild-indigo	S5	6	NS	0	P	Hm
r	Fabaceae	Chamaecrista fasciculata (Michx.) Greene	showy partridgepea	S5	2	FACU	0	A	T
s	Fabaceae	Crotalaria sagittalis L.	arrow rattlebox	S4	4	NS	0	A	T
s	Fabaceae	Dalea aurea Nutt. ex Pursh	golden prairie-clover	S5	5	NS	0	P	Hm
r	Fabaceae	Dalea candida Michx. var. candida	white prairie-clover	S5	7	NS	0	P	Hm
r	Fabaceae	Dalea enneandra Nutt.	nine-anther prairie-clover	S5	5	NS	0	P	Hm
r	Fabaceae	Dalea purpurea Vent. var. purpurea	purple prairie-clover	S5	7	NS	0	P	Hm
r	Fabaceae	Desmanthus illinoensis (Michx.) MacMill. ex B.L. Rob. & Fernald	Illinois bundle-flower	S5	2	FACU	0	P	Hm
r	Fabaceae	Desmodium illinoense A. Gray	Illinois tick-clover	S4	5	NS	0	P	Hm
r	Fabaceae	Gleditsia triacanthos L.	common honey-locust	S5	0	FAC	0	P	P
r	Fabaceae	Glycyrrhiza lepidota Pursh	American licorice	S5	3	FACU	0	P	G
r	Fabaceae	Gymnocladus dioica (L.) K. Koch	Kentucky coffeetree	S4	4	NS	0	P	P
r	Fabaceae	Lespedeza capitata Michx.	round-head bush-clover	S5	6	NS	0	P	Hm
r	Fabaceae	Lespedeza cuneata (Dum. Cours.) G. Don	sericea bush-clover	SE	*	NI	4	P	Hm
s	Fabaceae	Lotus tenuis Waldst. & Kit. ex Willd.	narrow-leaf trefoil	SE	*	NS	2	P	Hm
r	Fabaceae	Lotus unifoliolatus (Hook.) Benth. var. unifoliatus	prairie trefoil	S3	3	NS	0	A	T
r	Fabaceae	Medicago lupulina L.	black medic	SE	*	FAC	3	AP	Hm/T
s	Fabaceae	Medicago minima (L.) Bartal.	little medic	SE	*	NS	3	A	T
r	Fabaceae	Melilotus albus Medik.	white sweet-clover	SE	*	FACU	3	AB	Hm/T
r	Fabaceae	Melilotus officinalis (L.) Pall.	yellow sweet-clover	SE	*	FACU	3	AB	Hm/T
r	Fabaceae	Mimosa quadrivalvis L. var. nuttallii (DC.) L.S.	cat-claw mimosa	S5	6	NS	0	P	Hm

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		Beard ex Barneby							
r	Fabaceae	Pediomelum argophyllum (Pursh) J.W. Grimes	silver-leaf scurf-pea	S5	8	NS	0	P	Hm
s	Fabaceae	Pediomelum digitatum (Nutt.) Isely var. digitatum	palm-leaf scurf-pea	S3	7	NS	0	P	G
r	Fabaceae	Pediomelum esculentum (Pursh) Rydb.	bread-root scurf-pea	S5	7	NS	0	P	G
r	Fabaceae	Psoralidium tenuiflorum (Pursh) Rydb.	narrow-leaf scurf-pea	S5	3	NS	0	P	G
r	Fabaceae	Robinia pseudoacacia L.	black locust	S5	0	NS	0	P	P
r	Fabaceae	Securigera varia L.	common crown-vetch	SE	*	NS	4	P	Hm
r	Fabaceae	Senna marilandica (L.) Link	Maryland senna	S3	3	FAC	0	P	Hm
s	Fabaceae	Sophora nuttalliana B.L. Turner	silky sophora	S4	5	NS	0	P	G
r	Fabaceae	Strophostyles leiosperma (Torr. & A. Gray) Piper	slick-seed wildbean	S5	3	NS	0	A	T
r	Fabaceae	Tephrosia virginiana (L.) Pers.	Virginia hoary-pea	S4	7	NS	0	P	G
s	Fabaceae	Trifolium campestre Schreb.	low hop clover	SE	*	NS	3	A	T
r	Fabaceae	Trifolium repens L.	white clover	SE	*	FACU	2	P	C/Hm
r	Fabaceae	Vicia americana Hook. var. americana	American vetch	S2	7	NI	0	P	Hm
s	Fabaceae	Vicia americana Hook. var. minor Hook.	American vetch	S4	7	NI	0	P	Hm
s	Fabaceae	Vicia villosa Roth subsp. varia (Host) Corb.	hairy vetch	SE	*	NS	3	ABP	Hm/T
r	Fabaceae	Vicia villosa Roth subsp. villosa	hairy vetch	SE	*	NS	3	ABP	Hm/T
r	Fagaceae	Quercus macrocarpa Michx.	bur oak	S5	4	FACU	0	P	P
r	Fumariaceae	Corydalis curvisiliqua Engelm. subsp. grandibracteata (Fedde) G.B. Ownbey	big-bract fumewort	S4	3	NS	0	A	T
s	Fumariaceae	Corydalis micrantha (Engelm. ex A. Gray) A. Gray subsp. micrantha	slender fumewort	S5	0	NS	0	A	T
r	Geraniaceae	Geranium carolinianum L.	Carolina crane's-bill	S5	0	NS	0	A	T
r	Geraniaceae	Geranium pusillum L.	small crane's-bill	SE	*	NS	2	A	T
r	Grossulariaceae	Ribes missouriense Nutt.	Missouri gooseberry	S5	3	NS	0	P	P
r	Grossulariaceae	Ribes odoratum H. Wendl.	buffalo currant	S5	5	FAC	0	P	P
r	Hydrocharitaceae	Najas guadalupensis (Spreng.) Magnus subsp. guadalupensis	common naiad	S5	1	OBL	0	A	T
r	Hydrophyllaceae	Ellisia nyctelea (L.) L.	water-pod	S5	0	FAC	0	A	T
r	Iridaceae	Sisyrinchium campestre E.P. Bicknell	prairie blue-eyed-grass	S5	6	NS	0	P	Hm
s	Isoetaceae	Isoetes melanopoda J. Gay & Durieu	black-foot quillwort	S1	8	OBL	0	P	G
r	Juglandaceae	Juglans nigra L.	black walnut	S5	3	FACU	0	P	P
s	Juncaceae	Juncus acuminatus Michx.	taper-leaf rush	S3	5	OBL	0	P	Hm
s	Juncaceae	Juncus brachyphyllus Wiegand	small-head rush	S3	8	NS	0	P	Hm
r	Juncaceae	Juncus diffusissimus Buckley	slim-pod rush	S3	5	FACW+	0	P	Hm
s	Juncaceae	Juncus dudleyi Wiegand	Dudley's rush	S5	3	FAC	0	P	Hm
r	Juncaceae	Juncus interior Wiegand	inland rush	S5	2	FAC	0	P	Hm
s	Juncaceae	Juncus marginatus Rostk.	grass-leaf rush	S3	5	FACW	0	P	G
s	Juncaceae	Juncus tenuis Willd.	path rush	S5	0	FAC	0	P	Hm
r	Juncaceae	Juncus torreyi Coville	Torrey's rush	S5	2	FACW	0	P	G
s	Lamiaceae	Glechoma hederacea L.	gill-over-the-ground	SE	*	FACU	2	P	Hm
r	Lamiaceae	Hedeoma hispida Pursh	rough false-penny-royal	S5	1	NS	0	A	T
r	Lamiaceae	Lamium amplexicaule L. var. amplexicaule	hen-bit dead-nettle	SE	*	NS	3	A	T

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r	Lamiaceae	Lycopus americanus Muhl. ex W.P.C. Barton	American water-horehound	S5	3	OBL	0	P	G
r	Lamiaceae	Marrubium vulgare L.	common horehound	SE	*	FAC	2	P	G
s	Lamiaceae	Monarda citriodora Cerv. ex Lag. subsp. citriodora var. citriodora	lemon bee-balm	S5	4	NS	0	AB	Hm/T
r	Lamiaceae	Monarda fistulosa L. var. fistulosa	wild bergamot bee-balm	S5	3	FACU-	0	P	G
s	Lamiaceae	Monarda punctata L. var. occidentalis (Epling) E.J. Palmer & Steyerm.	spotted bee-balm	S4	5	NS	0	ABP	Hm/T
r	Lamiaceae	Nepeta cataria L.	common catnip	SE	*	FACU	2	P	G
s	Lamiaceae	Prunella vulgaris L.	common selfheal	SE	*	FAC	3	P	G
r	Lamiaceae	Salvia azurea Michx. ex Lam.	blue sage	S5	4	NS	0	P	Hm
r	Lamiaceae	Salvia reflexa Hornem.	lance-leaf sage	S5	1	NS	0	A	T
r	Lamiaceae	Scutellaria parvula Michx. var. australis Fassett	southern small skullcap	S4	5	FACU	0	P	G
r	Lamiaceae	Teucrium canadense L. var. canadense	American germander	S5	1	FACW	0	P	G
s	Lemnaceae	Lemna aequinoctialis Welw.	equinox duckweed	S3	7	OBL	0	P	Hy
r	Lemnaceae	Lemna minor L.	lesser duckweed	S5	3	OBL	0	P	Hy
r	Liliaceae	Allium canadense L. var. fraseri Ownbey	Canadian onion	S4	5	FACU	0	P	G
s	Liliaceae	Allium cepa L.	cultivated onion	SE	*	NS	1	P	G
s	Liliaceae	Allium drummondii Regel	Drummond's onion	S5	6	NS	0	P	G
s	Liliaceae	Allium vineale L.	field garlic	SE	*	FACU	3	P	G
r	Liliaceae	Androstephium coeruleum (Scheele) Greene	blue funnel-lily	S3	7	NS	0	P	G
r	Liliaceae	Asparagus officinalis L.	garden asparagus	SE	*	FACU-	3	P	G
s	Liliaceae	Muscari botryoides (L.) Mill.	common grape-hyacinth	SE	*	NS	2	P	G
s	Liliaceae	Polygonatum biflorum (Walter) Elliott	small Solomon's seal	S5	5	NS	0	P	G
s	Liliaceae	Toxicoscordion nuttallii (A. Gray ex S. Watson) Rydb.	Nuttall's death-camas	S3	5	NS	0	P	G
r	Linaceae	Linum compactum A. Nelson	compact flax	S3	6	NS	0	A	T
r	Linaceae	Linum sulcatum Riddell var. sulcatum	grooved flax	S5	6	NS	0	A	T
s	Loasaceae	Mentzelia oligosperma Nutt. ex Sims	stick-leaf	S5	4	NS	0	P	Hm
r	Lythraceae	Ammannia coccinea Rottb.	purple toothcup	S5	2	OBL	0	A	T
r	Lythraceae	Ammannia robusta Heer & Regel	stout toothcup	S5	2	NS	0	A	T
s	Lythraceae	Didiplis diandra (Nutt. ex DC.) A.W. Wood	common water-purslane	S2	7	OBL	0	A	T
r	Lythraceae	Lythrum californicum Torr. & A. Gray	California loosestrife	S4	4	OBL	0	P	He/Hm
r	Malvaceae	Abutilon theophrasti Medik.	common velvetleaf	SE	*	NS	2	A	T
r	Malvaceae	Callirhoë alcaeoides (Michx.) A. Gray	pale poppy-mallow	S5	6	NS	0	P	Hm
r	Malvaceae	Callirhoë involucrata (Torr. & A. Gray) A. Gray var. involucrata	purple poppy-mallow	S5	1	NS	0	P	Hm
r	Malvaceae	Hibiscus trionum L.	flower-of-an-hour	SE	*	NS	3	A	T
s	Malvaceae	Malva neglecta Wallr.	common mallow	SE	*	NS	3	AP	Hm/T
r	Malvaceae	Sphaeralcea coccinea (Nutt.) Rydb. var. coccinea	scarlet globe-mallow	S5	3	NS	0	P	Hm
s	Marsileaceae	Marsilea vestita Hook. & Grev. subsp. vestita	western water-clover	S5	4	OBL	0	P	He
r	Menispermaceae	Menispermum canadense L.	Canadian moonseed	S4	4	NI	0	P	P
r	Molluginaceae	Mollugo verticillata L.	green carpetweed	SE	*	FAC	3	A	T

Status	Family	Scientific Name	Common Name	S-Rank	CoC	Wetland Indicator Status	Alien Status	Longevity	Habit
r	Moraceae	Maclura pomifera (Raf.) C.K. Schneid.	Osage-orange	SE	*	UPL	3	P	P
r	Moraceae	Morus alba L.	white mulberry	SE	*	FAC	3	P	P
s	Nyctaginaceae	Mirabilis albida (Walter) Heimerl	white four-o'clock	S4	5	NS	0	P	Hm
s	Nyctaginaceae	Mirabilis carletonii (Heimerl ex Standl.) Standl.	Carleton's four-o'clock	S2	7	NS	0	P	Hm
r	Nyctaginaceae	Mirabilis linearis (Pursh) Heimerl var. linearis	narrow-leaf four-o'clock	S5	5	NS	0	P	Hm
r	Nyctaginaceae	Mirabilis nyctaginea (Michx.) MacMill.	wild four-o'clock	S5	0	UPL	0	P	Hm
r	Oleaceae	Fraxinus pennsylvanica Marshall	green ash	S5	0	FACW	0	P	P
r	Onagraceae	Calylophus serrulatus (Nutt.) P.H. Raven	plains yellow evening-primrose	S5	5	NS	0	P	Hm
r	Onagraceae	Gaura coccinea Pursh	scarlet butterfly-weed	S5	4	NS	0	P	Hm
r	Onagraceae	Gaura mollis E. James	velvet butterfly-weed	S5	1	NI	0	A	T
s	Onagraceae	Ludwigia alternifolia L.	bushy seedbox	S4	5	OBL	0	P	He/Hy
r	Onagraceae	Ludwigia peploides (Kuntze) P.H. Raven subsp. glabrescens (Kuntze) P.H. Raven	floating seedbox	S5	3	OBL	0	P	He/Hy
s	Onagraceae	Oenothera grandis (Britton) Smyth	large-flower cut-leaf evening-primrose	S4	4	NS	0	A	T
r	Onagraceae	Oenothera laciniata Hill	cut-leaf evening-primrose	S5	0	FACU-	0	A	T
s	Onagraceae	Oenothera macrocarpa Nutt. subsp. fremontii (S. Watson) W.L. Wagner	Fremont's evening-primrose	S3	7	NS	0	P	Hm
s	Onagraceae	Oenothera rhombipetala Nutt.	four-point evening-primrose	S3	4	FACU	0	A	T
s	Onagraceae	Oenothera speciosa Nutt.	showy white evening-primrose	S4	2	NS	0	P	Hm
s	Onagraceae	Oenothera triloba Nutt.	stemless evening-primrose	S3	3	NS	0	A	T
r	Onagraceae	Oenothera villosa Thunb. subsp. villosa	hairy evening-primrose	S4	0	FAC	0	B	Hm
s	Onagraceae	Stenosiphon linifolius (Nutt.) Heynh.	stenosiphon	S5	6	NS	0	B	Hm
r	Oxalidaceae	Oxalis dillenii Jacq. subsp. dillenii	gray-green wood-sorrel	S5	0	NS	0	P	C/T
r	Oxalidaceae	Oxalis violacea L.	violet wood-sorrel	S5	4	NS	0	P	G
r	Papaveraceae	Argemone polyanthemos (Fedde) G.B. Ownbey	plains prickly-poppy	S5	3	NS	0	AB	Hm/T
r	Pedaliaceae	Proboscidea louisianica (Mill.) Thell.	common devil's-claw	S5	0	FACU	0	A	T
s	Penthoraceae	Penthorum sedoides L.	ditch-stonecrop	S4	3	OBL	0	P	Hm
r	Phytolaccaceae	Phytolacca americana L. var. americana	American pokeweed	S5	0	FAC	0	P	Hm
s	Plantaginaceae	Plantago elongata Pursh subsp. elongata	slender plantain	S2	3	FAC	0	A	T
r	Plantaginaceae	Plantago patagonica Jacq. var. patagonica	woolly plantain	S5	1	NS	0	ABP	Hm/T
r	Plantaginaceae	Plantago patagonica Jacq. var. spinulosa (Decne.) A. Gray	bristle-bract plantain	S4	1	NS	0	ABP	Hm/T
r	Plantaginaceae	Plantago virginica L.	pale-seed plantain	S5	1	FACU	0	A	T
r	Poaceae	Aegilops cylindrical Host	jointed goat grass	SE	*	NS	3	A	T
r	Poaceae	Agrostis hyemalis (Walter) Britton et al.	winter bent grass	S5	2	FACU	0	P	Hm
r	Poaceae	Alopecurus carolinianus Walter	Carolina foxtail	S3	0	FACW	0	A	T
r	Poaceae	Andropogon gerardii Vitman	big bluestem	S5	4	FAC-	0	P	Hm
r	Poaceae	Aristida basiramea Engelm. ex Vasey	fork-tip threeawn	S3	4	NS	0	A	T
s	Poaceae	Aristida desmantha Trin. & Rupr.	curly threeawn	S1	6	NS	0	A	T

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s	Poaceae	Aristida dichotoma Michx. var. curtissii A. Gray ex S. Watson & J.M. Coult.	church-mouse threeawn	S3	4	FACU	0	A	T
r	Poaceae	Aristida oligantha Michx.	old-field threeawn	S5	0	NS	0	A	T
s	Poaceae	Aristida purpurascens Poir. var. purpurascens	arrow-feather threeawn	S3	7	NS	0	P	Hm
s	Poaceae	Aristida purpurea Nutt. var. longiseta (Steud.) Vasey	purple threeawn	S5	5	NS	0	P	Hm
r	Poaceae	Aristida purpurea Nutt. var. purpurea	purple threeawn	S3	5	NS	0	P	Hm
r	Poaceae	Bothriochloa bladhii (Retz.) S.T. Blake	Caucasian bluestem	SE	*	NI	4	P	Hm
r	Poaceae	Bothriochloa laguroides (DC.) Herter subsp. torreyana (Steud.) Allred & Gould	silver bluestem	S5	1	NS	0	P	Hm
r	Poaceae	Bouteloua curtipendula (Michx.) Torr. var. curtipendula	side-oats grama	S5	5	NS	0	P	Hm
r	Poaceae	Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths	blue grama	S5	5	NS	0	P	Hm
r	Poaceae	Bouteloua hirsuta Lag. var. hirsuta	hairy grama	S5	6	NS	0	P	Hm
r	Poaceae	Bromus inermis L.	smooth brome	SE	*	FACU	4	P	Hm
r	Poaceae	Bromus japonicus Thunb.	Japanese brome	SE	*	FACU	4	A	T
s	Poaceae	Bromus secalinus L.	rye brome	SE	*	NS	2	A	T
r	Poaceae	Bromus tectorum L.	downy brome	SE	*	NS	4	A	T
r	Poaceae	Buchloë dactyloides (Nutt.) Engelm.	buffalo grass	S5	3	FACU	0	P	Hm
r	Poaceae	Cenchrus longispinus (Hack.) Fernald	field sandbur	S5	0	NS	0	A	T
s	Poaceae	Chasmanthium latifolium (Michx.) H.O. Yates	broad-leaf wood-oat	S4	4	FAC	0	P	Hm
r	Poaceae	Cynodon dactylon (L.) Pers. var. dactylon	common bermuda grass	SE	*	FACU	3	P	Hm
s	Poaceae	Dichanthelium acuminatum (Sw.) Gould & C.A. Clark subsp. fasciculatum (Torr.) Freckmann	pointed dichanthelium	S4	3	FAC	0	P	Hm
r	Poaceae	Dichanthelium oligosanthes (Schult.) Gould subsp. scribnerianum (Nash) Freckmann & Lelong	Scribner's dichanthelium	S5	4	FACU	0	P	Hm
s	Poaceae	Dichanthelium perlongum (Nash) Freckmann	long-stalk dichanthelium	S3	7	NS	0	P	Hm
s	Poaceae	Digitaria ciliaris (Retz.) Koeler var. ciliaris	southern crab grass	SE	*	NS	3	A	T
r	Poaceae	Digitaria cognata (Schult.) Pilg.	fall witch grass	S5	3	NS	0	P	Hm
s	Poaceae	Digitaria ischaemum (Schreb.) Muhl.	smooth crab grass	SE	*	NS	3	A	T
r	Poaceae	Digitaria sanguinalis (L.) Scop.	hairy crab grass	SE	*	FACU	3	A	T
s	Poaceae	Echinochloa crusgalli (L.) P. Beauv.	common barnyard grass	SE	*	FACW	3	A	T
r	Poaceae	Echinochloa muricata (P. Beauv.) Fernald var. microstachya Wiegand	rough barnyard grass	S5	0	OBL	0	A	T
s	Poaceae	Eleusine indica (L.) Gaertn.	Indian goose grass	SE	*	FACU	2	A	T
r	Poaceae	Elymus canadensis L. var. canadensis	Canadian wild-rye	S5	5	FACU	0	P	Hm
s	Poaceae	Elymus virginicus L. var. jejunus (Ramaley) Bush	Virginia wild-rye	S3	3	FAC	0	P	Hm
r	Poaceae	Elymus virginicus L. var. virginicus	Virginia wild-rye	S5	3	FAC	0	P	Hm
s	Poaceae	Eragrostis barrelieri Daveau	Mediterranean love grass	SE	*	NS	2	A	T
r	Poaceae	Eragrostis cilianensis (All.) Vignolo ex Janch.	stink grass	SE	*	FACU	3	A	T
r	Poaceae	Eragrostis curtipedicellata Buckley	gummy love grass	S2	3	NS	0	P	Hm
r	Poaceae	Eragrostis hypnoides (Lam.) Britton et al.	teal love grass	S3	3	FAC	0	A	T

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s	Poaceae	Eragrostis pectinacea (Michx.) Nees var. pectinacea	Carolina love grass	S5	0	FAC	0	A	T
r	Poaceae	Eragrostis spectabilis (Pursh) Steud.	purple love grass	S5	3	FACU	0	P	Hm
s	Poaceae	Eragrostis trichodes (Nutt.) A.W. Wood	sand love grass	S5	4	NS	0	P	Hm
r	Poaceae	Eriochloa contracta Hitchc.	prairie cup grass	S5	0	FACU	0	A	T
r	Poaceae	Hesperostipa spartea (Trin.) Barkworth	porcupine grass	S4	8	NS	0	P	Hm
r	Poaceae	Hordeum jubatum L. subsp. jubatum	fox-tail barley	S5	1	FACW	0	P	Hm
r	Poaceae	Hordeum pusillum Nutt.	little barley	S5	0	FAC	0	A	T
r	Poaceae	Koeleria macrantha (Ledeb.) Schult.	prairie June grass	S4	6	NS	0	P	Hm
s	Poaceae	Leersia oryzoides (L.) Sw. var. oryzoides	rice cut grass	S5	4	OBL	0	P	He
r	Poaceae	Leersia virginica Willd.	white grass	S5	3	FACW	0	P	He
r	Poaceae	Leptochloa fusca (Lam.) A. Gray subsp. fascicularis (Lam.) N. Snow	bearded sprangletop	S5	0	OBL	0	AP	Hm/T
s	Poaceae	Leptochloa panacea (Retz.) Ohwi subsp. mucronata (Michx.) R. Nowak	red sprangletop	S3	0	OBL	0	A	T
s	Poaceae	Lolium perenne Willd. var. aristatum Willd.	perennial rye grass	SE	*	FACU	2	P	Hm
s	Poaceae	Muhlenbergia asperifolia (Nees & Meyen ex Trin.) Parodi	alkali muhly	S3	4	FACW	0	P	Hm
r	Poaceae	Muhlenbergia bushii R.W. Pohl	Bush's muhly	S4	4	NS	0	P	Hm
r	Poaceae	Muhlenbergia cuspidata (Torr.) Rydb.	plains muhly	S3	5	NS	0	P	Hm
r	Poaceae	Muhlenbergia sobolifera (Muhl. ex Willd.) Trin.	rock muhly	S3	5	NS	0	P	Hm
s	Poaceae	Panicum capillare L. var. brevifolium Vasey ex Rydb. & Shear	common witch grass	S4	0	FAC	0	A	T
r	Poaceae	Panicum capillare L. var. capillare	common witch grass	S5	0	FAC	0	A	T
r	Poaceae	Panicum dichotomiflorum Michx. var. dichotomiflorum	fall panicum	S5	0	FAC	0	A	T
s	Poaceae	Panicum hillmanii Chase	Hillman's panicum	S1	5	FAC-	0	A	T
s	Poaceae	Panicum miliaceum L. subsp. miliaceum	Broom-corn millet	SE	*	NS	1	A	T
r	Poaceae	Panicum virgatum L. var. virgatum	switch grass	S5	4	FAC	0	P	Hm
r	Poaceae	Pascopyrum smithii (Rydb.) Á. Löve	western wheat grass	S5	2	FACU	0	P	Hm
r	Poaceae	Paspalum setaceum Michx. var. stramineum (Nash) D.J. Banks	thin paspalum	S5	2	FAC	0	P	Hm
r	Poaceae	Phalaris arundinacea L.	reed canary grass	S4	0	FACW+	0	P	He/Hm
r	Poaceae	Phragmites australis (Cav.) Trin. ex Steud.	common reed	S3	2	FACW	0	P	He
s	Poaceae	Poa arida Vasey	plains blue grass	S4	5	FAC	0	P	Hm
s	Poaceae	Poa bulbosa L.	bulbous blue grass	SE	*	NS	2	P	Hm
r	Poaceae	Poa pratensis L.	Kentucky blue grass	SE	*	FACU	3	P	Hm
r	Poaceae	Schedonnardus paniculatus (Nutt.) Trel.	tumble grass	S5	3	NS	0	P	Hm
r	Poaceae	Schedonorus arundinaceus (Schreb.) Dumort.	tall mountain-fescue	SE	*	FACU	3	P	C/Hm
r	Poaceae	Schizachyrium scoparium (Michx.) Nash subsp. scoparium	little bluestem	S5	5	FACU	0	P	Hm
s	Poaceae	Setaria faberi R.A.W. Herm.	Chinese bristle grass	SE	*	NS	2	A	T
r	Poaceae	Setaria parviflora (Poir.) Kerguélen	knot-root bristle grass	S5	3	FAC	0	P	Hm

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r	Poaceae	Setaria pumila (Poir.) Roem. & Schult.	yellow bristle grass	SE	*	FAC	3	A	T
r	Poaceae	Setaria viridis (L.) P. Beauv. var. viridis	green bristle grass	SE	*	NS	3	A	T
r	Poaceae	Sorghastrum nutans (L.) Nash	yellow Indian grass	S5	5	FACU	0	P	Hm
s	Poaceae	Sorghum halepense (L.) Pers.	Johnson grass	SE	*	FACU	3	P	Hm
r	Poaceae	Spartina pectinata Link	prairie cord grass	S5	4	FACW	0	P	He
r	Poaceae	Sphenopholis obtusata (Michx.) Scribn.	prairie wedgescale	S4	4	FACW	0	AP	Hm/T
s	Poaceae	Sporobolus clandestinus (Biehler) Hitchc.	southeastern dropseed	S3	6	NS	0	P	Hm
r	Poaceae	Sporobolus compositus (Poir.) Merr. var. compositus	rough dropseed	S5	3	FACU	0	P	Hm
r	Poaceae	Sporobolus compositus (Poir.) Merr. var. drummondii (Trin.) Kartesz & Gandhi	meadow dropseed	S5	3	FACU	0	P	Hm
s	Poaceae	Sporobolus cryptandrus (Torr.) A. Gray	sand dropseed	S5	0	FACU-	0	P	Hm
s	Poaceae	Sporobolus neglectus Nash	puff-sheath dropseed	S5	1	NS	0	A	T
s	Poaceae	Sporobolus pyramidatus (Lam.) Hitchc.	whorled dropseed	S3	4	FAC	0	P	Hm
s	Poaceae	Sporobolus vaginiflorus (Torr. ex A. Gray) A.W. Wood	poverty dropseed	S5	0	FACU	0	A	T
r	Poaceae	Tridens flavus (L.) Hitchc. var. flavus	purpletop	S5	1	NS	0	P	Hm
r	Poaceae	Tripsacum dactyloides (L.) L. var. dactyloides	eastern gamma grass	S5	3	FAC	0	P	Hm
r	Poaceae	Triticum aestivum L.	bread wheat	SE	*	NS	1	A	T
r	Poaceae	Vulpia octoflora (Walter) Rydb. var. glauca (Nutt.) Fernald	six-weeks annual-fescue	S5	1	UPL	0	A	T
r	Polygalaceae	Polygala verticillata L.	whorled milkwort	S3	3	FAC-	0	A	T
s	Polygonaceae	Eriogonum annuum Nutt.	annual wild-buckwheat	S4	3	NS	0	A	T
s	Polygonaceae	Fallopia convolvulus (L.) A. Löve	dull-seed cornbind	SE	*	FACU	3	A	T
r	Polygonaceae	Fallopia scandens L.	hedge cornbind	S5	0	FACU	0	P	G
r	Polygonaceae	Persicaria amphibia (L.) S.F. Blake	swamp smartweed	S5	2	OBL	0	P	Hm
r	Polygonaceae	Persicaria bicornis (Raf.) Nieuwl.	pink smartweed	S5	1	FACW+	0	A	T
r	Polygonaceae	Persicaria lapathifolia (L.) Gray	pale smartweed	S5	2	OBL	0	A	T
s	Polygonaceae	Persicaria maculosa Gray	lady's-thumb smartweed	SE	*	OBL	3	A	T
s	Polygonaceae	Persicaria pensylvanica (L.) M. Gomez	Pennsylvania smartweed	S5	2	FACW+	0	A	T
r	Polygonaceae	Persicaria punctata (Elliott) Small	dotted smartweed	S5	3	OBL	0	P	G
r	Polygonaceae	Polygonum arenastrum Boreau	sand knotweed	SE	*	NS	3	A	T
r	Polygonaceae	Polygonum ramosissimum Michx. var. ramosissimum	bushy knotweed	S5	2	FAC	0	A	T
s	Polygonaceae	Polygonum tenue Michx.	pleat-leaf knotweed	S3	6	NS	0	A	T
r	Polygonaceae	Rumex altissimus A.W. Wood	pale dock	S5	0	FAC	0	P	Hm
r	Polygonaceae	Rumex crispus L.	curly dock	SE	*	FACW	3	P	Hm
s	Polygonaceae	Rumex patientia L.	patience dock	SE	*	NS	3	P	Hm
s	Portulacaceae	Claytonia virginica L.	Virginia springbeauty	S4	3	FACU	0	P	G
s	Portulacaceae	Phemeranthus calycinus (Engelm.) Kiger	rock-pink fameflower	S3	7	NS	0	P	G
s	Portulacaceae	Phemeranthus parviflorus (Nutt.) Kiger	prairie fameflower	S3	5	NS	0	P	G
s	Portulacaceae	Portulaca oleracea L.	common purslane	S4	0	FAC	0	A	T
s	Portulacaceae	Portulaca pilosa L.	hairy purslane	S3	3	NS	0	A	T

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s	Potamogetonaceae	Potamogeton diversifolius Raf.	water-thread pondweed	S3	4	OBL	0	P	Hy
r	Potamogetonaceae	Potamogeton foliosus Raf. subsp. foliosus	leafy pondweed	S4	5	OBL	0	P	Hy
r	Potamogetonaceae	Potamogeton nodosus Poir.	long-leaf pondweed	S4	4	OBL	0	P	Hy
r	Potamogetonaceae	Stuckenia pectinata L.	sago pondweed	S4	4	OBL	0	P	Hy
s	Primulaceae	Anagallis arvensis L.	scarlet pimpernel	SE	*	FAC	3	A	C/T
r	Primulaceae	Androsace occidentalis Pursh	western rock-jasmine	S5	0	FACU	0	A	T
s	Primulaceae	Lysimachia nummularia L.	moneywort	SE	*	OBL	3	P	C
r	Ranunculaceae	Anemone caroliniana Walter	Carolina anemone	S5	5	NS	0	P	G
r	Ranunculaceae	Delphinium carolinianum Walter subsp. virescens (Nutt.) R.E. Brooks	Carolina larkspur	S5	6	NS	0	P	Hm
r	Ranunculaceae	Ranunculus aquatilis L. var. diffusus With.	white water crowfoot	S3	7	OBL	0	P	Hy
r	Ranunculaceae	Ranunculus sceleratus L. var. sceleratus	cursed crowfoot	S5	0	OBL	0	A	T
s	Rosaceae	Agrimonia parviflora Aiton	small-flower agrimony	S3	4	FAC	0	P	Hm
r	Rosaceae	Geum canadense Jacq.	white avens	S5	1	FACU	0	P	Hm
r	Rosaceae	Potentilla recta L.	sulfur cinquefoil	SE	*	NS	3	P	Hm
r	Rosaceae	Prunus americana Marshall	American plum	S5	3	NS	0	P	P
r	Rosaceae	Prunus angustifolia Marshall	Chickasaw plum	S5	3	NS	0	P	P
r	Rosaceae	Prunus pumila (L.H. Bailey) Gleason var. besseyi (L.H. Bailey) Gleason	sand cherry	S3	7	NS	0	P	P
r	Rosaceae	Prunus virginiana L. var. virginiana	choke cherry	S5	2	FACU	0	P	P
r	Rosaceae	Rosa arkansana Porter ex Porter & J.M. Coult.	Arkansas rose	S5	4	NI	0	P	P
s	Rosaceae	Rosa blanda Aiton	smooth rose	S1	6	FACU	0	P	P
r	Rosaceae	Rosa multiflora Thunb.	multiflora rose	SE	*	NS	4	P	P
s	Rosaceae	Rubus flagellaris Willd.	American dewberry	S3	5	FACU-	0	P	C
s	Rosaceae	Rubus hancinianus L.H. Bailey	Hancin's dewberry	S2	4	NS	0	P	P
s	Rosaceae	Rubus mollior L.H. Bailey	soft blackberry	S1	4	NS	0	P	P
r	Rubiaceae	Cephalanthus occidentalis L.	common buttonbush	S5	4	OBL	0	P	P
r	Rubiaceae	Galium aparine L.	catch-weed bedstraw	S5	0	FACU	0	A	T
s	Rubiaceae	Sherardia arvensis L.	field-madder	SE	*	NS	2	A	T
r	Rubiaceae	Stenaria nigricans (Lam.) Terrell var. nigricans	narrow-leaf bluet	S5	5	NS	0	P	Hm
r	Salicaceae	Populus deltoides W. Bartram ex Marshall subsp. monilifera (Aiton) Eckenw.	plains cottonwood	S5	0	FAC	0	P	P
r	Salicaceae	Salix amygdaloides Andersson	peach-leaf willow	S5	3	FACW	0	P	P
r	Salicaceae	Salix exigua Nutt. subsp. interior (Rowlee) Cronquist	sandbar willow	S5	1	OBL	0	P	P
r	Salicaceae	Salix nigra Marshall	black willow	S5	2	OBL	0	P	P
r	Scrophulariaceae	Agalinis aspera (Douglas ex Benth.) Britton	rough agalinis	S4	7	FACU	0	A	T
s	Scrophulariaceae	Agalinis tenuifolia (Vahl) Raf.	narrow-leaf agalinis	S4	4	FACW	0	A	T
r	Scrophulariaceae	Bacopa rotundifolia (Michx.) Wettst.	round-leaf water-hyssop	S3	4	OBL	0	P	He/Hy
s	Scrophulariaceae	Castilleja sessiliflora Pursh	downy paintbrush	S4	7	NS	0	P	Hm
s	Scrophulariaceae	Gratiola neglecta Torr.	common hedge-hyssop	S2	4	OBL	0	A	T
s	Scrophulariaceae	Linaria dalmatica (L.) Mill. subsp. dalmatica	Dalmatian toadflax	SE	*	NS	1	P	Hm
r	Scrophulariaceae	Lindernia dubia (L.) Pennell var. anagallidea	false-pimpernel	S3	4	OBL	0	A	T

Status	Family	Scientific Name	Common Name	S-Rank	CoC	Wetland Indicator Status	Alien Status	Longevity	Habit
		(Michx.) Cooperr.							
r	Scrophulariaceae	Nuttallanthus texanus (Scheele) D.A. Sutton	Texas toad-flax	S3	3	NS	0	A	T
s	Scrophulariaceae	Penstemon buckleyi Pennell	Buckley beardtongue	S3	8	NS	0	P	Hm
r	Scrophulariaceae	Penstemon cobaea Nutt. var. cobaea	cobaea beardtongue	S5	5	NS	0	P	Hm
s	Scrophulariaceae	Penstemon grandiflorus Nutt.	shell-leaf beardtongue	S3	6	NS	0	P	Hm
r	Scrophulariaceae	Penstemon tubaeflorus Nutt.	tube beardtongue	S5	3	NS	0	P	Hm
r	Scrophulariaceae	Scrophularia lanceolata Pursh	lance-leaf figwort	S2	5	FAC	0	P	Hm
r	Scrophulariaceae	Verbascum blattaria L.	moth mullein	SE	*	NS	3	B	Hm
r	Scrophulariaceae	Verbascum thapsus L.	flannel mullein	SE	*	NS	3	B	Hm
r	Scrophulariaceae	Veronica arvensis L.	corn speedwell	SE	*	NI	3	A	T
s	Scrophulariaceae	Veronica peregrina L. subsp. peregrina	purslane speedwell	S3	0	OBL	0	A	T
r	Scrophulariaceae	Veronica peregrina L. subsp. xalapensis (Kunth) H. St. John & F.A. Warren	purslane speedwell	S5	0	OBL	0	A	T
s	Scrophulariaceae	Veronica polita Fr.	wayside speedwell	SE	*	NS	3	A	T
s	Scrophulariaceae	Veronica serpyllifolia L. subsp. humifusa (Dickson) Syme	thyme-leaf speedwell	SE	*	OBL	2	P	C
s	Scrophulariaceae	Veronica triphyllos L.	finger speedwell	SE	*	NS	2	A	T
r	Simaroubaceae	Ailanthus altissima (Mill.) Swingle	tree-of-heaven	SE	*	NI	2	P	P
s	Smilacaceae	Smilax lasioneura Hook.	Blue Ridge greenbrier	S3	3	NS	0	P	G
r	Smilacaceae	Smilax tamnoides L.	bristly greenbrier	S5	2	FAC	0	P	P
r	Solanaceae	Physalis heterophylla Nees	clammy ground-cherry	S5	4	NS	0	P	G
r	Solanaceae	Physalis longifolia Nutt. var. longifolia	long-leaf ground-cherry	S5	2	NS	0	P	G
s	Solanaceae	Physalis virginiana Mill.	Virginia ground-cherry	S3	6	NS	0	P	G
r	Solanaceae	Solanum carolinense L.	Carolina horse-nettle	S5	1	UPL	0	P	G
r	Solanaceae	Solanum elaeagnifolium Cav.	silver-leaf nightshade	S4	3	NS	0	P	G
r	Solanaceae	Solanum interius Rydb.	plains black nightshade	S4	2	FAC	0	AP	Hm/T
r	Solanaceae	Solanum ptychanthum Dunal	black nightshade	S5	1	FACU	0	A	T
r	Solanaceae	Solanum rostratum Dunal	buffalo-bur nightshade	S5	0	NS	0	A	T
s	Tamaricaceae	Tamarix ramosissima Ledeb.	salt-cedar	SE	*	FACW	4	P	P
r	Typhaceae	Typha angustifolia L.	narrow-leaf cat-tail	S5	0	OBL	0	P	He
r	Typhaceae	Typha domingensis Pers.	southern cat-tail	S4	1	OBL	0	P	He
s	Typhaceae	Typha latifolia L.	broad-leaf cat-tail	S5	1	OBL	0	P	He
r	Ulmaceae	Ulmus americana L.	American elm	S5	2	FAC	0	P	P
r	Ulmaceae	Ulmus pumila L.	Siberian elm	SE	*	NS	3	P	P
r	Urticaceae	Boehmeria cylindrical (L.) Sw.	small-spike false-nettle	S4	3	OBL	0	P	Hm
r	Urticaceae	Parietaria pensylvanica Muhl. ex Willd.	Pennsylvania pellitory	S5	0	FAC	0	A	T
r	Urticaceae	Urtica dioica L. subsp. gracilis (Aiton) Selander	American stinging nettle	S5	1	FACW	0	P	Hm
r	Verbenaceae	Glandularia bipinnatifida (Nutt.) Nutt. var. bipinnatifida	Dakota vervain	S4	4	NS	0	P	Hm
r	Verbenaceae	Phyla cuneifolia (Torr.) Greene	wedge-leaf fogfruit	S4	3	FAC	0	P	Hm
r	Verbenaceae	Phyla lanceolata (Michx.) Greene	northern fogfruit	S5	1	OBL	0	P	Hm
r	Verbenaceae	Verbena ×engelmannii Moldenke	Engelmann's vervain	S2	hybrid	NI	0	P	Hm
r	Verbenaceae	Verbena bracteata Lag. & Rodr.	prostrate vervain	S5	0	FACU	0	P	Hm

Status	Family	Scientific Name	Common Name	S-Rank	CoC	Wetland Indicator Status	Alien Status	Longevity	Habit
r	Verbenaceae	Verbena hastata L.	blue vervain	S4	4	FACW	0	P	Hm
r	Verbenaceae	Verbena ×rydbergii Moldenke	Rydberg's vervain	S3	hybrid	NI	0	P	Hm
r	Verbenaceae	Verbena stricta Vent.	hoary vervain	S5	1	NS	0	P	Hm
r	Verbenaceae	Verbena urticifolia L.	nettle-leaf vervain	S4	2	UPL	0	P	Hm
r	Violaceae	Viola bicolor Pursh	Johnny-jump-up	S5	0	FAC-	0	A	T
s	Violaceae	Viola sororia Willd. var. sororia	dowy blue violet	S3	2	FAC	0	P	Hm
s	Vitaceae	Parthenocissus quinquefolia (L.) Planch. var. quinquefolia	Virginia creeper	S5	1	FAC	0	P	P
r	Vitaceae	Vitis riparia Michx.	riverbank grape	S5	2	FAC	0	P	P
s	Zannichelliaceae	Zannichellia palustris L.	horned-pondweed	S5	2	OBL	0	P	Hy
s	Zygophyllaceae	Kallstroemia parviflora Norton	warty caltrop	S1	1	NS	0	A	T
r	Zygophyllaceae	Tribulus terrestris L.	speading puncturevine	SE	*	NS	3	A	T

Appendix C. Checklist of birds reported in Saline County (Otte 2006) and on Smoky Hill ANGR (bold) based on this study and Charlton et al. (2000). Status codes: r = documented on Smoky Hill ANGR; s = reported in Saline County but not on Smoky Hill ANGR. Seasonal occurrence (Spring (March – May), Summer (June—August), Fall (September—November), and Winter (December—February)) codes: C = common to abundant, U = uncommon, R = rare to occasional. Habitat codes: AQ = aquatic or wetland; GR = grassland or open habitats; WO = woodland, woodland edge, or other woody habitat; OT = other (aerial, urban, or habitat generalist).

Status	Family	Scientific Name	English name	Spring	Summer	Fall	Winter	Habitat
	ANATIDAE							
s		*Dendrocygna autumnalis*	Black-bellied Whistling Duck			R		AQ
s		*Anser albifrons*	Greater White-fronted Goose	U		U	R	AQ
r		*Chen caerulescens*	**Snow Goose**	R		U	R	AQ
s		*Chen rossii*	Ross's Goose	R		R	R	AQ
s		*BrAQntAQ hutchinsii*	Cackling Goose	U		U	U	AQ
r		*Branta canadensis*	**Canada Goose***	C	U	C	C	AQ
s		*Cygnus buccinator*	Trumpeter Swan				R	AQ
r		*Aix sponsa*	**Wood Duck***	U	R	U		AQ
r		*Anas strepera*	**Gadwall**	C		C	U	AQ
r		*Anas americana*	**American Wigeon**	U		U	R	AQ
s		*Anas rubribes*	American Black Duck			R	R	AQ
r		*Anas platyrhynchos*	**Mallard***	C	R	C	C	AQ
r		*Anas discors*	**Blue-winged Teal**	C	R	C		AQ
s		*Anas cyanoptera*	Cinnamon Teal	R		R		AQ
r		*Anas clypeata*	**Northern Shoveler**	C		C	R	AQ
r		*Anas acuta*	**Northern Pintail**	U		U	R	AQ
r		*Anas crecca*	**Green-winged Teal**	C		C	U	AQ
s		*Aythya valisineria*	Canvasback	R		R	R	AQ
r		*Aythya americana*	**Redhead**	U		U	R	AQ
r		*Aythya collaris*	**Ring-necked Duck**	U		U	R	AQ
r		*Aythya affinis*	**Lesser Scaup**	R		R		AQ
r		*Bucephala albeola*	**Bufflehead**	R		R	R	AQ
r		*Bucephala clangula*	**Common Goldeneye**	R		R	R	AQ
r		*Lophodytes cucullatus*	**Hooded Merganser**	R		R	R	AQ
s		*Mergus merganser*	Common Merganser	R		R	R	AQ
s		*Mergus serrator*	Red-breasted Merganser	R		R		AQ

Status	Family	Scientific Name	English name	Spring	Summer	Fall	Winter	Habitat
r		*Oxyura jamaicensis*	**Ruddy Duck**	U		U	R	AQ
	PHASIANIDAE							
r		*Phasianus colchicus*	**Ring-necked Pheasant***	C	C	C	C	GR
r		*Tympanuchus cupuido*	**Greater Prairie-Chicken***	C	C	C	C	GR
r		*Meleagris gallopavo*	**Wild Turkey***	C	C	C	C	WO
	ODONTOPHORIDAE							
r		*Colinus virginianus*	**Northern Bobwhite***	C	C	C	C	WO
	GAVIIDAE							
s		*Gavia immer*	Common Loon					AQ
	PODICIPEDIDAE							
r		*Podilymbus podiceps*	**Pied-billed Grebe**	U		U		AQ
s		*Podiceps auritus*	Horned Grebe	R		R		AQ
s		*Podiceps nigricollis*	Eared Grebe	R		R		AQ
s		*Aechmophorus occidentalis*	Western Grebe	R		R		AQ
	PELECANIDAE							
s		*Pelecanus erythrorhychnchos*	American White Pelican	R		R		AQ
	PHALACROCORACIDAE							
r		*Phalacrocorax auritus*	**Double-crested Cormorant**	U	R	U		AQ
	ARDEIDAE							
r		*Botaurus lentiginosus*	**American Bittern**	R		R		AQ
r		*Ixobrychus exilis*	**Least Bittern***	R	R	R		AQ
r		*Ardea herodias*	**Great Blue Heron***	C	C	C	U	AQ
r		*Ardea alba*	**Great Egret**	R	R	R		AQ
s		*Egretta thula*	Snowy Egret	R	R	R		AQ
s		*Egretta caerulea*	Little Blue Heron	R	R	R		AQ
r		*Bubulcus ibis*	**Cattle Egret**	U	U	U		AQ
r		*Butorides virescens*	**Green Heron***	U	C	U		AQ
s		*Nycticorax nycticorax*	Black-crowned Night-Heron	R	R	R		AQ
s		*Nyctanassa violacea*	Yellow-crowned Night-Heron	R	R	R		AQ
	THRESKIORNITHIDAE							
s		*Plegadis chihi*	White-faced Ibis	R		R		AQ
	CATHARTIDAE							
r		*Cathartes aura*	**Turkey Vulture***	U	U	U		OT

Status	Family	Scientific Name	English name	Spring	Summer	Fall	Winter	Habitat
	ACCIPITRIDAE							
s		*Pandion haliaetus*	Osprey	R		R		AQ
s		*Ictinia mississippiensis*	Mississippi Kite	R	R	R		WO
s		*Haliaeetus leucocephalus*	Bald Eagle				R	AQ
r		*Circus cyaneus*	**Northern Harrier**	U	R	U	U	GR
r		*Accipiter striatus*	**Sharp-shinned Hawk**	U		U	R	WO
r		*Accipiter cooperii*	**Cooper's Hawk***	U	U	U	U	WO
s		*Accipiter gentilis*	Northern Goshawk			R	R	WO
s		*Buteo platypterus*	Broad-winged Hawk	R		R		WO
r		*Buteo swainsoni*	**Swainson's Hawk**	R	R	R		GR
r		*Buteo jamaicensis*	**Red-tailed Hawk***	C	C	C	C	WO
s		*Buteo regalis*	Ferruginous Hawk				R	GR
r		*Buteo lagopus*	**Rough-legged Hawk**	U		U	R	GR
s		*Aquila chrysaetos*	Golden Eagle				R	GR
	FALCONIDAE							
r		*Falco sparverius*	**American Kestrel***	C	U	C	C	GR
s		*Falco columbrius*	Merlin	R		R	R	GR
r		*Falco peregrinus*	**Peregrine Falcon**	R	R	R	R	AQ
r		*Falco mexicanus*	**Prairie Falcon**	R		R	R	GR
	RALLIDAE							
s		*Rallus limicola*	Virginia Rail	R		R		AQ
r		*Porzana carolina*	**Sora**	R		R		AQ
r		*Fulica americana*	**American Coot**	U	R	U	R	AQ
	GRUIDAE							
r		*Grus candensis*	**Sandhill Crane**	R		R		AQ
s		*Grus americana*	Whooping Crane	R		R		AQ
	CHARADRIIDAE							
s		*Charadrius semipalmatus*	Semipalmated Plover	R		R		AQ
r		*Charadrius vociferus*	**Killdeer***	C	C	C	R	AQ
	RECURVIROSTRIDAE							
s		*Recurvirostra americana*	American Avocet	R		R		AQ
	SCOLOPACIDAE							
r		*Tringa melanoleuca*	**Greater Yellowlegs**	U	R	U		AQ

Status	Family	Scientific Name	English name	Spring	Summer	Fall	Winter	Habitat
r		*Tringa flavipes*	**Lesser Yellowlegs**	U	R	U		AQ
r		*Tringa solitaria*	**Solitary Sandpiper**	U	R	U		AQ
r		*Actitis macularia*	**Spotted Sandpiper**	U	R	U		AQ
r		*Bartramia longicauda*	**Upland Sandpiper***	C	C	C		GR
s		*Numenius americanus*	Long-billed Curlew	R	R			AQ
s		*Limosa haemastica*	Hudsonian Godwit	R		R		AQ
r		*Calidris pusilla*	**Semipalmated Sandpiper**	U		U		AQ
r		*Calidris minutilla*	**Least Sandpiper**	U		U		AQ
r		*Calidris fusicollis*	**White-rumped Sandpiper**	U	R			AQ
s		*Calidris bairdii*	Baird's Sandpiper	U		U		AQ
r		*Calidris melanotos*	**Pectoral Sandpiper**	R		R		AQ
s		*Tryngites subruficollis*	Buff-breasted Sandpiper	R		R		AQ
r		*Limnodromus scolopaceus*	**Long-billed Dowitcher**	R		R		AQ
r		*Gallinago delicata*	**Wilson's Snipe**	R		U		AQ
s		*Scolopax minor*	American Woodcock	R		R		WO
r		*Phalaropus tricolor*	**Wilson's Phalarope**	U	R	U		AQ
	LARIDAE							
r		*Larus pipixcan*	**Franklin's Gull**	C	R	C		AQ
r		*Larus delawarensis*	**Ring-billed Gull**	U		U	U	AQ
s		*Larus argentatus*	Herring Gull	R		R	R	AQ
r		*Sterna forsteri*	**Forster's Tern**	R	R	R		AQ
s		*Sterna antillarum*	Least Tern	R	R	R		AQ
s		*Chlidonias niger*	Black Tern	R	R	R		AQ
	COLUMBIDAE							
r		*Columba livia*	**Rock Pigeon**	U	U	U	U	OT
s		*Streptopelia decaocto*	Eurasian Collared-Dove	R	R	R	R	OT
r		*Zenaida macroura*	**Mourning Dove***	C	C	C	U	OT
s		*Columbina inca*	Inca Dove			R		OT
	CUCULIDAE							
r		*Coccyzus erythropthalmus*	**Black-billed Cuckoo**	R	R	R		WO
r		*Coccyzus americanus*	**Yellow-billed Cuckoo***	U	U	U		WO
	TYTONIDAE							
s		*Tyto alba*	Barn Owl	R	R	R	R	GR

Status	Family	Scientific Name	English name	Spring	Summer	Fall	Winter	Habitat
	STRIGIDAE							
r		*Megascops asio*	**Eastern Screech-Owl**	U	U	U	U	WO
r		*Bubo virginianus*	**Great Horned Owl***	U	U	U	U	WO
s		*Bubo scandiacus*	Snowy Owl				R	GR
r		*Athene cunicularia*	**Burrowing Owl**	R		R		GR
r		*Strix varia*	**Barred Owl***	R	R	R	R	WO
r		*Asio otus*	**Long-eared Owl**	R		R	R	WO
r		*Asio flammeus*	**Short-eared Owl**	U		U	R	GR
	CAPRIMULGIDAE							
r		*Chordeiles minor*	**Common Nighthawk***	C	C	C		GR
	APODIDAE							
r		*Chaetura pelagica*	**Chimney Swift***	U	U	U		OT
	TROCHILIDAE							
s		*Archilochus colubris*	Ruby-throated Hummingbird	R	R	R		WO
	ALCEDINIDAE							
r		*Ceryle alcyon*	**Belted Kingfisher**	R	R	R		AQ
	PICIDAE							
r		*Melanerpes erythrocephalus*	**Red-headed Woodpecker***	U	U	C	R	WO
r		*Melanerpes carolinus*	**Red-bellied Woodpecker***	U	U	U	U	WO
s		*Sphyrapicus varius*	Yellow-bellied Sapsucker				R	WO
r		*Picoides pubescens*	**Downy Woodpecker***	U	U	U	U	WO
r		*Picoides villosus*	**Hairy Woodpecker**	R	R	R	R	WO
r		*Colaptes auratus*	**Northern Flicker***	C	C	C	C	WO
	TYRANNIDAE							
r		*Contopus cooperi*	**Olive-sided Flycatcher**	R		R		WO
r		*Contopus virens*	**Eastern Wood-Pewee**	R	R	R		WO
r		*Empidonax alnorum*	**Alder Flycatcher**	R		R		WO
s		*Empidonax traillii*	Willow Flycatcher	R		R		WO
r		*Empidonax minimus*	**Least Flycatcher**	U	R	U		WO
r		*Sayornis phoebe*	**Eastern Phoebe***	U	U	U		WO
r		*Sayornis saya*	**Say's Phoebe**	R		R		GR
r		*Myiarchus crinitus*	**Great Crested Flycatcher***	U	U	U		WO
r		*Tyrannus verticalis*	**Western Kingbird***	U	U	U		GR

Status	Family	Scientific Name	English name	Spring	Summer	Fall	Winter	Habitat
r		*Tyrannus tyrannus*	**Eastern Kingbird***	C	C	C		GR
r		*Tyrannus forticatus*	**Scissor-tailed Flycatcher***	U	U	U		GR
	LANIIDAE							
r		*Lanius ludovicianus*	**Loggerhead Shrike***	U	U	U		GR
r		*Lanius excubitor*	**Northern Shrike**				R	GR
	VIREONIDAE							
r		*Vireo belli*	**Bell's Vireo***	U	U	U		WO
r		*Vireo solitarius*	**Blue-headed Vireo**	R		R		WO
r		*Vireo gilvus*	**Warbling Vireo***	C	C	C		WO
r		*Vireo olivaceus*	**Red-eyed Vireo***	U	U	U		WO
	CORVIDAE							
r		*Cyanocitta cristata*	**Blue Jay***	C	C	C	U	WO
r		*Pica hudsonia*	**Black-billed Magpie***	R	R	R	R	WO
r		*Corvus brachyrhynchos*	**American Crow***	C	C	C	U	WO
	ALAUDIDAE							
r		*Eremophila alpestris*	**Horned Lark***	U	U	U	U	GR
	HIRUNDINIDAE							
s		*Progne subis*	Purple Martin	R	R			OT
r		*Tachycineta bicolor*	**Tree Swallow**	R	R	R		AQ
r		*Stelgidopteryx serripennis*	**Northern Rough-winged Swallow***	C	C	U		OT
s		*Riparia riparia*	Bank Swallow	R	R			OT
r		*Petrochelidon pyrrhonota*	**Cliff Swallow***	U	U			OT
r		*Hirundo rustica*	**Barn Swallow***	C	C	C		OT
	PARIDAE							
r		*Poecile atricapillus*	**Black-capped Chickadee***	U	U	U	U	WO
r		*Baeolophus bicolor*	**Tufted Titmouse**	R	R	R	R	WO
	SITTIDAE							
s		*Sitta canadensis*	Red-breasted Nuthatch	R		R	R	WO
r		*Sitta carolinensis*	**White-breasted Nuthatch***	U	U	U	U	WO
	CERTHIIDAE							
s		*Certhia americana*	Brown Creeper	R		R	R	WO
	TROGLODYTIDAE							
s		*Salpinctes obsoletus*	Rock Wren	R	R	R		GR

Status	Family	Scientific Name	English name	Spring	Summer	Fall	Winter	Habitat
r		*Thryothorus ludovicianus*	**Carolina Wren***	R	R	R	R	WO
r		*Thryomanes bewickii*	**Bewick's Wren**	R	R	R	R	WO
r		*Troglodytes aedon*	**House Wren***	C	C	C		WO
s		*Troglodytes troglodytes*	Winter Wren			R	R	WO
s		*Cistothorus platensis*	Sedge Wren			R		GR
	REGULIDAE							
s		*Regulus satrapa*	Golden-crowned Kinglet	R		R	R	WO
r		*Regulus calendula*	**Ruby-crowned Kinglet**	U		U	R	WO
	SYLVIIDAE							
r		*Polioptila caerlea*	**Blue-gray Gnatcatcher***	R	R	R		WO
	TURDIDAE							
r		*Sialia sialis*	**Eastern Bluebird***	C	C	C	C	WO
s		*Sialia currucoides*	Mountain Bluebird			R	R	WO
s		*Myadestes townsendi*	Townsend's Solitaire			R	R	WO
r		*Catharus ustulatus*	**Swainson's Thrush**	U		U		WO
s		*Hylocichla mustelina*	Wood Thrush	R		R		WO
r		*Turdus migratorius*	**American Robin***	C	C	C	U	WO
	MIMIDAE							
r		*Dumetella carolinensis*	**Gray Catbird***	R	R	R		WO
r		*Mimus polyglottos*	**Northern Mockingbird***	U	U	U	U	WO
r		*Toxostoma rufum*	**Brown Thrasher***	C	C	C		WO
	STURNIDAE							
r		*Sturnus vulgaris*	**European Starling**	C	C	C	C	OT
	MOTACILLIDAE							
r		*Anthus rubescens*	**American Pipit**	R		R		GR
r		*Anthus spragueii*	**Sprague's Pipit**	R		R		GR
	BOMBYCILLIDAE							
s		*Bombycilla cedorum*	Cedar Waxwing	R	R	R	R	WO
	PARULIDAE							
r		*Vermivora peregrina*	**Tennessee Warbler**	R		R		WO
r		*Vermivora celata*	**Orange-crowned Warbler**	U		U		WO
r		*Vermivora ruficapilla*	**Nashville Warbler**	R		R		WO
s		*Parula americana*	Northern Parula	R		R		WO

Status	Family	Scientific Name	English name	Spring	Summer	Fall	Winter	Habitat
r		*Dendroica petechia*	**Yellow Warbler***	U	U	U		WO
s		*Dendroica pensylvanica*	Chestnut-sided Warbler	R		R		WO
s		*Dendroica magnolia*	Magnolia Warbler	R		R		WO
s		*Dendroica tigrina*	Cape May Warbler	R		R		WO
r		*Dendroica coronata*	**Yellow-rumped Warbler**	C		C	U	WO
s		*Dendroica virens*	Black-throated Green Warbler	R		R		WO
r		*Dendroica palmarum*	**Palm Warbler**	R		R		WO
s		*Dendroica castanea*	Bay-breasted Warbler	R		R		WO
r		*Dendroica striata*	**Blackpoll Warbler**	R		R		WO
r		*Mniotilta varia*	**Black-and-white Warbler**	R		R		WO
r		*Setophaga ruticilla*	**American Redstart**	U		U		WO
s		*Protonotaria citrea*	Prothonotary Warbler	R		R		WO
s		*Seiurus aurocapilla*	Ovenbird	R		R		WO
s		*Seiurus noveboracensis*	Northern Waterthrush	R		R		WO
r		*Geothlypis trichas*	**Common Yellowthroat***	U	U	U		GR
s		*Wilsonia cirtrina*	Hooded Warbler	R		R		WO
s		*Wilsonia pusilla*	Wilson’s Warbler	R		R		WO
r		*Icteria virens*	**Yellow-breasted Chat**	R	R	R		WO
	THRAUPIDAE							
s		*Piranga olivacea*	Scarlet Tanager	R		R		WO
	EMBERIZIDAE							
r		*Pipilo maculatus*	**Spotted Towhee**	R		R	RC	WO
s		*Pipilo erythrophthalmus*	Eastern Towhee	R		R		WO
r		*Spizella arborea*	**American Tree Sparrow**	C		C	C	WO
r		*Spizella passerina*	**Chipping Sparrow**	U		U		WO
r		*Spizella pallida*	**Clay-colored Sparrow**	U		U		WO
r		*Spizella pusilla*	**Field Sparrow***	U	U	U		WO
r		*Pooecetes gramineus*	**Vesper Sparrow**	U		U		GR
r		*Chondestes grammacus*	**Lark Sparrow***	U	U	U		GR
r		*Calamospiza melanocorys*	**Lark Bunting**	R				GR
r		*Passerculus sandwichensis*	**Savannah Sparrow**	U		U		GR
r		*Ammodramus savannarum*	**Grasshopper Sparrow***	C	C	C		GR
r		*Ammodramus henslowii*	**Henslow’s Sparrow***	R	R	R		GR

Status	Family	Scientific Name	English name	Spring	Summer	Fall	Winter	Habitat
r		*Ammodramus leconteii*	**Le Conte's Sparrow**	R		R		GR
s		*Passerella iliaca*	Fox Sparrow	R		R		WO
r		*Melospiza melodia*	**Song Sparrow**	U		U	U	WO
r		*Melospiza lincolnii*	**Lincoln's Sparrow**	R		R		WO
r		*Zonotrichia albicollis*	**White-throated Sparrow**	R		R		WO
r		*Zonotrichia querula*	**Harris's Sparrow**	U		U		WO
r		*Zonotrichia leucophrys*	**White-crowned Sparrow**	U		U		WO
r		*Junco hyemalis*	**Dark-eyed Junco**	C		C	C	WO
s		*Calcarius lapponicus*	Lapland Longspur	U		U	U	GR
s		*Calcarius pictus*	Smith's Longspur			R	R	GR
s		*Plectrophenax nivalis*	Snow Bunting				R	GR
	CARDINALIDAE							
r		*Cardinalis cardinalis*	**Northern Cardinal***	C	C	C	C	WO
r		*Pheucticus ludovicianus*	**Rose-breasted Grosbeak***	R	R			WO
s		*Pheucticus melanocephalus*	Black-headed Grosbeak	R				WO
r		*Passerina caerulea*	**Blue Grosbeak***	R	U	R		WO
s		*Passerina amoena*	Lazuli Bunting	R		R		WO
r		*Passerina cyanea*	**Indigo Bunting***	R	R	R		WO
s		*Passerina ciris*	Painted Bunting	R				WO
r		*Spiza americana*	**Dickcissel***	C	C	U		GR
	ICTERIDAE							
s		*Dolichonyx oryzivorus*	Bobolink	R				GR
r		*Agelaius phoeniceus*	**Red-winged Blackbird***	C	C	C	C	GR
r		*Sturnella magna*	**Eastern Meadowlark***	C	C	C	U	GR
r		*Sturnella neglecta*	**Western Meadowlark***	U	U	U	U	GR
r		*Xanthocephalus xanthocephalus*	**Yellow-headed Blackbird**	R		R		GR
s		*Euphagus carolinus*	Rusty Blackbird			R	R	WO
r		*Euphagus cyanocephalus*	**Brewer's Blackbird**	R		R	R	GR
r		*Quiscalus quiscula*	**Common Grackle***	U	U	U		OT
r		*Quiscalus mexicanus*	**Great-tailed Grackle**	R	R	R		OT
r		*Molothrus ater*	**Brown-headed Cowbird***	C	C	C	R	OT
r		*Icterus spurius*	**Orchard Oriole***	U	U	U		WO
r		*Icterus galbula*	**Baltimore Oriole***	C	C	C		WO

Status	Family	Scientific Name	English name	Spring	Summer	Fall	Winter	Habitat
	FRINGILLIDAE							
s		*Pinicola oryzivorus*	Pine Grosbeak				R	WO
s		*Carpodacus purpureus*	Purple Finch				R	WO
r		*Carpodacus mexicanus*	**House Finch***	R	R	R	R	OT
s		*Loxia curvirostra*	Red Crossbill			R	R	WO
s		*Carduelis pinus*	Pine Siskin	R			R	WO
r		*Carduelis tristus*	**American Goldfinch***	C	C	C	C	WO
s		*Coccothraustes vepertinus*	Evening Grosbeak				R	WO
r	PASSERIDAE							
		Passer domesticus	**House Sparrow***	U	U	U	U	OT

Appendix D. Results of breeding bird surveys conducted on Smoky Hill ANGR from 2003 to 2006. Each survey consists of thirty 3-minute stops along a standard driving route. See Section 7.3.3.2. for explanation of methods. Presented below are data for each survey by survey date: observer name, the number of stops where a species was detected, the total number of individuals detected, total number of species detected, and total number of birds of all species detected.

English Name	5/9/2003		6/6/2003		6/20/2003		5/27/2004		6/22/2004		6/6/2005		6/19/2005		6/8/2006		6/23/2006	
	Pittman		Pittman		Pittman		Pittman		Pittman		Pittman		Busby		Busby		Busby	
	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds
Total species/individuals	48	653	46	609	41	488	37	376	47	486	48	426	47	449	48	732	54	750
Wood Duck													2	6			1	2
Ring-necked Pheasant	17	25	15	26	6	7	13	17	18	19	21	25	15	19	16	18	9	12
Gr. Prairie-Chicken (leks/indiv)	15	25	8	13	1 ?		2 ?		0	0	2 ?		1 ?		6	16	3	6
Wild Turkey	4	6			1	5			4	4	4	4	3	3	7	9	1	4
Northern Bobwhite	6	9	17	30	11	13	5	6	12	14	15	23	14	17	20	40	23	36
Great Blue Heron			1	1					2	2	1	1	1	1			2	2
Green Heron															1	1		
Turkey Vulture	1	1																
Cooper's Hawk			1	1														
Red-tailed Hawk	1	1	2	2	1	1			1	2	2	2			4	4	4	4
American Kestrel			1	1	2	4			2	4	1	1			1	1		
Killdeer	7	8	7	14	6	9	7	10	6	9	4	5	2	2	3	6	6	6
Upland Sandpiper	20	48	20	75	22	82	12	22	22	44	13	27	22	36	17	39	22	54
Mourning Dove	17	84	21	72	19	53	19	38	20	56	19	36	22	53	22	117	28	117
Black-billed Cuckoo					1	1												
Yellow-billed Cuckoo			5	5			2	2	6	7	5	8	11	15	7	8	5	5
Eastern Screech-Owl									1	1								
Great Horned Owl			2	2											1	1	1	1
Barred Owl							1	1										
Common Nighthawk	3	6	11	17	18	29	6	9	7	12	5	6	11	18	18	25	12	27
Red-headed Woodpecker	4	4	1	1	1	1			2	3	1	1	2	2	2	2	3	3
Red-bellied Woodpecker	4	4	1	1	1	1			2	2	2	2	3	3	4	4	3	4
Downy Woodpecker			2	3					2	2	1	1					1	1
Hairy Woodpecker															1	1		
Northern Flicker	4	4	2	3	2	2	2	2	4	7	4	6	6	9	7	8	12	18
Eastern Phoebe	3	4	3	3	1	1	2	2	1	2	1	1	2	2			2	2
Great Crested Flycatcher	2	4	4	5	2	2	1	2			5	7	3	3	5	5	8	9
Western Kingbird	2	3					1	1					1	1	1	1		
Eastern Kingbird	16	21	11	14	8	11	12	16	11	17	11	19	8	11	12	13	8	10
Scissor-tailed Flycatcher	1	1	1	2			1	1	2	2	1	1	1	1			4	5

English Name	5/9/2003 Pittman		6/6/2003 Pittman		6/20/2003 Pittman		5/27/2004 Pittman		6/22/2004 Pittman		6/6/2005 Pittman		6/19/2005 Busby		6/8/2006 Busby		6/23/2006 Busby	
	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds
Loggerhead Shrike	2	2			1	1	1	2									2	2
Bell's Vireo	3	4					1	1	1	2					1	1	1	1
Warbling Vireo	2	2	3	5	1	1	4	6	2	3	2	2	2	2	1	1	3	4
Red-eyed Vireo			1	1	1	1	1	1	1	1							1	1
Blue Jay	10	19	4	6	1	2	4	9	5	7	6	10	7	10	5	12	2	3
American Crow	3	6	3	9	1	2			1	1	1	1			4	4	6	6
Purple Martin	4	5					1	1										
Tree Swallow													1	3				
Northern Rough-winged Swallow	1	2	1	2	3	4			2	2	2	2	3	5	3	5		
Cliff Swallow	1	1	1	1									1	1				
Barn Swallow	2	3	3	7	2	4	1	1	3	6	2	3	3	3			3	5
Black-capped Chickadee																	1	1
White-breasted Nuthatch									1	1	1	1	2	2	1	1		
Carolina Wren															1	2	1	1
House Wren	4	8	7	14	5	8	4	7	6	10	5	6	6	8	3	4	3	4
Eastern Bluebird	1	1	1	1					1	1	3	3	2	2	4	5	8	11
American Robin	2	2	1	2	1	3	1	1	1	1	1	1			1	1	2	2
Gray Catbird					1	1			1	1			1	1			1	1
Northern Mockingbird	10	11	5	5	4	5	2	2	11	12	2	2	1	1	5	8	4	4
Brown Thrasher	7	9	9	11	4	5	10	10	4	5	2	2	5	7	12	18	6	6
European Starling			1	6	2	9			6	11	2	5	4	8	2	12	1	6
Yellow Warbler											1	1			2	2	2	2
Common Yellowthroat	8	9	1	1	1	1	5	5	1	2	2	2	2	2	3	3	1	1
Chipping Sparrow	2	8																
Field Sparrow	1	1	1	1							1	1					1	1
Lark Sparrow	2	3					3	3			1	1	2	3	1	2	2	2
Grasshopper Sparrow	25	48	15	28	14	24	22	36	22	35	22	34	22	34	14	27	15	32
Henslow's Sparrow											2	4	2	3				
White-crowned Sparrow	1	1																
Northern Cardinal	2	3					5	6	2	2	3	3	2	3	3	4	3	5
Rose-breasted Grosbeak																	1	1
Blue Grosbeak																	1	1
Indigo Bunting	1	1					1	1	3	3	1	2	1	1	3	5	2	4
Dickcissel			25	89	26	72	26	76	27	63	24	54	27	55	28	93	26	70
Red-winged Blackbird	9	57	10	16	8	33	5	8	10	22	6	13	8	14	16	34	13	42
Eastern Meadowlark	27	93	27	64	25	56	22	39	24	54	24	53	26	47	27	110	28	123

English Name	5/9/2003 Pittman		6/6/2003 Pittman		6/20/2003 Pittman		5/27/2004 Pittman		6/22/2004 Pittman		6/6/2005 Pittman		6/19/2005 Busby		6/8/2006 Busby		6/23/2006 Busby	
	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds	# stops	# birds
Western Meadowlark	5	13	3	7	1	2	6	7	2	3	1	1	1	1	3	3	6	7
Yellow-headed Blackbird	1	15																
Common Grackle			1	2	3	6			1	1	2	2	1	1	1	1	1	2
Brown-headed Cowbird	16	41	13	30	7	16	11	16	11	17	13	32	11	19	13	28	19	44
Orchard Oriole	3	4	1	1	2	2			2	2	1	1	2	2	3	3	4	5
Baltimore Oriole	11	14	6	7	5	6	7	9	7	9	8	8	4	4	13	20	14	22
American Goldfinch	6	9	1	2	1	2							4	5	3	4		
House Sparrow																		

Appendix E. Data layers provided in ArcView GIS format.

These digital files were created as part of a five-year project examining the biological resources of the Smoky Hill ANGR in Saline and McPherson counties, Kansas. All files are in ArcView shapefile format in the UTM Zone 14, North American Datum 1983 projection.

A. CURRENT VEGETATION

1. **Plant_communities**: Plant communities and landscape features included in the community classification described in this report:

   Dakota Hills Tallgrass Prairie - digitized from 2001 aerial photography
   Ash-Elm-Hackberry Floodplain Forest - digitized from 2001 aerial photography
   Dakota Sandstone Sparse Vegetation - digitized from 2001 aerial photography
   Go-back Land/Tallgrass Prairie - clipped from "Former_crop_fields.shp" (see description below)
   Cultivated Fields - copied from shapefile received from staff at Smoky Hill ANGR
   Wind breaks and Hedgerows - digitized from 2001 aerial photography
   Ponds - clipped from soil survey data and edited to add ponds not present at time of soil survey. A 10-m buffer was added using the buffering routine in ArcView
   Firebreaks - shapefile received from staff at Smoky Hill ANGR
   Developed Areas - digitized from 2001 aerial photography
   Former Farmsteads - clipped from "Former_farmsteads.shp" (see description below)
   Military Practice Disturbance Areas - digitized from 2001 aerial photography

2. **Vegetation_plots**: All vegetation sampling plots on Smoky Hill ANGR and adjacent private property. Includes attribute indicating management type (pasture, hay, woods, impact). Point location data determined by GPS.

3. **Weed_points:** Point data of **Carduus** *nutans* and *Elaeagnus angustifolia* observations.

4. **Weed_polygons**: Polygon data of *Carduus nutans*, *Elaeagnus angustifolia*, and *Robinia pseudoacacia* observations.

B. HISTORIC VEGETATION

1. **1866_vegetation**: Historic vegetation of the Smoky Hill ANGR determined from Public Land Survey maps created in the period 1859—1866. Vegetation types are Dakota Hills Tallgrass Prairie and Ash-Elm-Hackberry Floodplain Forest. Vegetation types digitized as polygons from photocopies of original, hardcopy maps.

2. **Former_crop_fields**: Fields clearly identifiable as being under cultivation in 1938. Digitized from scanned and georeferenced 1938 aerial photography.

3. **Possible_crop_fields**: Fields possibly under cultivation in 1938 but for which there was some uncertainty as to whether they were under cultivation. Digitized from scanned and georeferenced 1938 aerial photography.
4. **Former_farmsteads**: Developed areas containing structures visible in 1938 aerial photography. Digitized from scanned and georeferenced 1938 aerial photography.

C. ANIMAL DATA

1. **Bird_point_locations**: Point locations of all rare bird species observations. Includes observations along study transects as well as opportunistic sightings.

2. **Bird_survey_route**: Driving route along which Breeding Bird Surveys were conducted.

3. **Bird_survey_transects**: Walking transects used in study of bird species responses to management treatments.

4. **Herp_points**: Point locations of all reptile and amphibian observations. Includes observations at sampling stations as well as opportunistic sightings.

5. **Herp_stations**: Point locations of drift fences and cover board clusters used for sampling reptile and amphibian populations. Includes brief description of habitat. A point within each unit was determined by GPS.

6. **Mammal_points**: Point locations of all mammal observations. Includes observations at sampling stations as well as opportunistic sightings.

7. **Mammal_stations**: Point locations of Sherman trap arrays, drift fences, and cover board clusters used for sampling small mammal populations. Includes brief description of habitat. A point within each unit was determined by GPS.

8. **Regal_fritillary**: Point locations of Regal Fritillary observations along bird survey transects.

Appendix F.1. Report on Land Use History.

A HIGH PRICE FOR PEACE: LAND USE HISTORY OF THE SMOKY HILL AIR NATIONAL GUARD RANGE, SALINE COUNTY, KANSAS

PREPARED FOR

AIR NATIONAL GUARD READINESS CENTER
3500 FETCHET AVENUE
ANDREWS AFB, MD 20762-5157

AND

SMOKY HILL AIR NATIONAL GUARD RANGE
8429 WEST FARRELLY ROAD
SALINA, KS 67401-9407
JUNE 15, 2007

SUBMITTED TO THE KANSAS BIOLOGICAL SURVEY

31 JANUARY 2007

PREPARED BY DALE E. NIMZ, PH.D.
1928 COUNTRYSIDE LANE
LAWRENCE, KS 66044

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A High Price for Peace in Saline County: Land Use History

Introduction

For more than one hundred farm families in southwest Saline County, life changed suddenly in May, 1942. On May 7, the Salina Journal reported that Major Daniel P. Caulkins, area engineer, was beginning to survey and plan for a U. S. army troop cantonment in that area. Although no official announcement had been made, tentative plans for the cantonment included a large area in southwest Saline County starting about a mile southwest of the U. S. army air base, then under construction two miles southwest of Salina.

The first reaction by landowners was defensive, but patriotism won out in just a few weeks. Approximately one hundred farmers in the Falun and Smolan communities met on May 11 and decided to ask that the army cantonment be moved to an area that would not affect so many churches and schools. On May 15 Senator Arthur Capper and Representative Frank Carlson took their protest to the Assistant Secretary of War. The petition asked that another site be selected for the cantonment because: approximately 50,000 acres of land will be required for the site; about 1,000 farm people will be compelled to move from their homes; and the move "will destroy the social life of several well-established communities, Falun, Smolan, Bavaria, Brookville, and others with well-established schools and churches." The petition concluded that the people were "willing to make every sacrifice necessary to win the war," but they felt that there was "ample and suitable space for a cantonment only a few miles west of the proposed site, which is thinly settled and where no community life would be affected."[1] This protest petition may have influenced the location of the military camp because the eventual boundaries avoided the small towns and most of the existing rural churches and schools.

Finally, the Journal reported on May 23 that the construction seemed virtually certain. Still without an official announcement, the general contract for the cantonment had been signed and heavy equipment was on the way from Camp Crowder, Missouri, to Smolan, Kansas. That report stated that the cantonment would affect 119 farm families in an area of approximately 72 square miles. The army acquired the tract according to the "war act" which gave the government the right to file condemnation proceedings in federal court to give the army immediate possession of the necessary land.[2] An official announcement of the cantonment construction finally came from the war department in Washington, D. C. on June 2.[3]

Despite the short-lived protest, most of the families cooperated with the abrupt removal. For example, John Gustafson, the first farmer to leave the area requisitioned by the United States government, concluded that "if there hadn't been a war this would not have been necessary. But there is and we didn't start it. The government needs this ground and I'll not stand in the way. After all we're all government, aren't we?"[4]

Less than one year later on January 6, 1943, Dr. Ernst Pihlblad reported to the Falun Lutheran Church, "the year of 1942 has proven itself the most trying in the history of our Church, and in fact of the west part of Saline County. The course of events has

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[1] "Two Angles in Salina's War Project," Salina Journal 12 May 1942, p. 1, col. 3; "Saline Protest In," Salina Journal 15 May 1942, p. 2, col. 5.
[2] "40 Million Cantonment Seems Sure," Salina Journal 23 May 1942, p. 1, col. 8.
[3] "Cantonment Assured by Washington," Salina Journal 2 June, 1942, p. 1, col. 1.
[4] "Cantonment Will Be Started Immediately," Salina Journal 7 May 1942, p. 1, col. 4; "Smolan Area Teeming, An Army Arrives," Salina Journal 25 May 1942, p. 1, col. 1.

driven many of our families from their homes." At the same time Pastor Pihlblad reaffirmed the patriotism that has supported the military mission in Saline County for more than sixty years. He said, "we have paid a high price however, without a whimper, realizing all the time that it is not too high a price for what we hope to buy, lasting peace under which we may keep alive the freedom and democracy which America has sought to maintain for its people."[5]

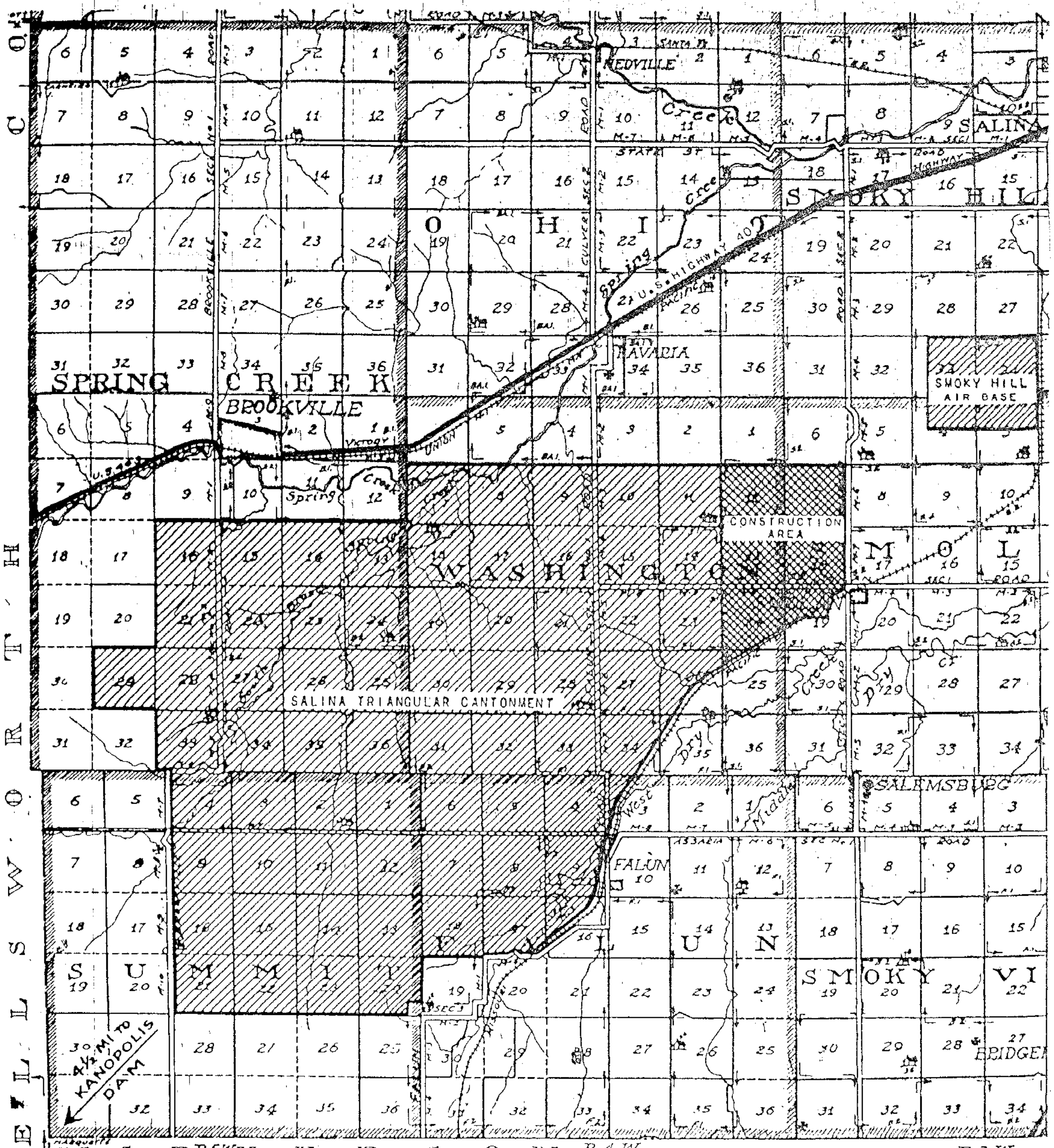
The War Department entered Saline County a few days earlier with the condemnation of 1,441 acres of land for the construction of a military air base. Confirmation of that seven-million-dollar project came from Congressman Frank Carlson, Senator Clyde Reed, and Senator Arthur Capper in an official announcement on April 29, 1942. After the end of World War II, the former army cantonment, Camp Phillips, served as an indispensable training site for the Smoky Hill Army Air base.

Camp Phillips (later the Smoky Hill Air National Guard Weapons Range) was carved out of four townships--Falun, Washington, South Spring Creek, and Summit. Military planners chose this site for several reasons--the central inland location, transportation infrastructure, and relatively inexpensive land. Southwest Saline County was far from the coasts and safe from the threat of invasion. The lightly settled land that was available provided a tract that was large enough for training infantry, artillery, and tank troops. Moreover, the site was served by a railroad line not far from the intersection of major east-west and north-south highways.[6]

[5] "The Camp Phillips Story," copy, Historical File, Smoky Hill Air National Guard Weapons Range, 1.
[6] In 1940 a "Guide to Salina," reported that "two great transcontinental highways join at Salina and excellent railroad facilities have made it an important distribution point," Federal Writers Project, (Salina, KS: Advertiser-Sun, 1940), 11.

THE SALINA JOURNAL, SATURDAY, JUNE 6, 1942

Thousands of Acres of Saline County Becomes a Defense Are



This map accurately shows the outlines of both the new army air base, now under construction two miles southwest of Salina and the new army ca west Saline county. The arrow in lower left hand corner shows the direction and distance to the big Smoky Hill dam. Condemnation proceedings on the entire ment area were filed in federal court at Topeka Friday by Paul L. Aylward, special U. S. district attorney, but so far the court has issued orders giving the sion only of the housing area just northwest of Smolan. The map was drawn according to legal descriptions shown on the actual court petition filed in Topek accurate at this stage. The Journal believes the people who live in southwest Saline county, some of whom have farmed the same land for more than 50 year know whether the boundaries of the reservation will include their farms. Because of this, and because the national press censor has ruled that court proceedings are privileged for publication, this map is being made public.

To fight a world war that began in 1941, the United States government changed the settlement pattern of Saline County. After the war ended, military planners held on the range because it was particularly useful for aerial gunnery and bombing training. Since the continuing military use has limited agricultural land use, important changes in the vitality and diversity of native plant and animal species have occurred. Compared to the rest of Kansas, these changes make the Range a valuable site for the study of biological change.

Major periods of change in land use history

This study identified four major periods in the land use history of the Smoky Hill Air National Guard Weapons Range defined by changes in the landscape. The first and longest period was the occupation by nomadic Native Americans from before 1500 to ca. 1860. The most significant change in ecological terms, was the second--the migration of European-Americans to central Kansas and the dramatic environmental change to a settled landscape. Southwest Saline County was occupied and settled by farmers and stockgrowers between 1870 and 1890.

Military training was the third major change in the land use history. When the U.S. military acquired this part of Saline County in 1942, the descendants of early settlers were moved out and their farms demolished. But the intensive use for military training and maneuvers only lasted from 1942 to 1944. Then in 1945 -1946, most of the military training structures were demolished or sold for salvage.

In the fourth period of land use since that time, the range has been reserved for gunnery and bombing training with relatively few personnel managing the facility. When the war ended, former residents hoped that the land in southwest Saline County would be returned to the previous owners and agricultural use. Although some of the land in the original cantonment was declared surplus and sold to private owners, most of the training camp remained a firing and bombing range. Today the Smoky Hill Weapons Range is a valuable training asset for the Kansas Air National Guard and other National Guard units in the region. Although the name and administration have changed over the years, the mission of the Smoky Hill Range has remained paramount--to provide combat capability for the nation and support to civil authority for the state of Kansas. From 1945 to 2006, military use of the range has varied in intensity, but the need for realistic training and the limitations on alternative training sites means that the Smoky Hill Air National Guard Weapons Range will be maintained as a training facility for the future.

Early Settlement, 1800-1854

What is now Saline County, Kansas, may have been visited by the Coronado expedition in 1541. Later, the French explorer and trader, Etienne Veniard de Bourgmont, traveled through central Kansas in 1724. Indian tribes living in the region during prehistoric times included the Wichita, Osage, Kansas, and Pawnee. Other tribes, such as the Cheyenne, Arapahoe, and Kiowa hunted in the area. The valleys of the Smoky Hill, Saline, and Solomon rivers were rich in wild game.

However, there were not large settlements of Native Americans in what is now southwest Saline County. This area is an upland that includes the headwaters of several low order streams. Only small sections of higher order streams are included in the Smoky Hill Weapons Range; these are parts of Ralston and Spring Creeks and a small section of the Smoky Hill River floodplain. This is an open prairie landscape of perennial grasses with some riparian timber along the streams flowing into the Smoky Hill River. The prairie nurtured a variety of native plant and animal species.

Periodically, the prairie was burned and grazed by bison herds. That landscape persisted from ca. 1500 to ca. 1860.

The American explorer, Zebulon Pike, crossed the Saline and Solomon rivers in 1806. Beginning in 1825, overland traders and travelers crossed the Great Plains on the Santa Fe Trail to the south and later after 1841 on the Oregon-California Trail to the north. Explorer John C. Fremont crossed Pike's route in 1848, probably two or three miles west of the present site of Salina.[7]

Permanent European-American settlement in Kansas Territory followed the signing of the Kansas-Nebraska Act May 30, 1854. Settlers trickled into the Saline River valley after the opening of a military road westward from Fort Riley (established 1852) to the Santa Fe Trail and Fort Larned. Other wagon roads linked with the military road.[8] When pioneer settler James Mead described the region, the valleys of the Saline, Solomon and Smoky Hill rivers for 100 miles west of Salina were "a land almost unknown." Mead remembered

> a land of timbered rivers, streams of pure water fed by springs in the Dakota sandstone, broad valleys, rolling hills covered with a velvety coat of sweet grass, sandstone cliffs sculptured by nature in the form of ruined castles; monoliths, cyclopean walls, with cedar canyons and sparkling springs.
>
> Over this entrancing land roamed countless numbers of buffalo, elk, and deer. Beaver built their dams and sported undisturbed in the rivers and streams. Glossy black turkeys were as common as chickens about a farmhouse. Eagles soared aloft, and thousands of ravens, a bird peculiar to the plains. There were prairie-chickens of two varieties; occasional flocks of quail, of the Texas variety; fox-squirrels in the oak timber; raccoons, porcupines, foxes, otter; the lynx, wildcat, and panther; badgers and prairie-dogs; and everywhere big gray wolves and the musical coyotes, subsisting on the weak or fallen and the hunter's waste. On every side was animal life, and no one to disturb the harmony of nature except the occasional roving bands of the red men of the wilderness … Such was the

[7] Louise Barry, "Kansas Before 1854: A Revised Annals," Kansas Historical Quarterly 31:2 (Summer, 1965), 190.

[8] Harry Hughes and Helen C. Dingler, From River Ferries to Interchanges: A Brief History of Saline County, Kansas, from the 1850s to the 1980s (Ellsworth, KS: Ellsworth Printing Company, 1988). 49.

> Saline country as I found it in 1859, then in its original condition of life and beauty.[9]

As a young man, Mead left Davenport, Iowa for Kansas Territory and crossed the Missouri River on May 23, 1859. He organized a party to explore and hunt buffalo on September 1. They followed the Santa Fe Trail to a ranch south of the big bend of the Smoky Hill River. Venturing northward to hunt, Mead crossed the Saline River. When he returned to the Saline River country the next summer, he found "a beautiful spot sheltered by timber near the north bluff, commanding a view five miles down the valley" where he and his companions built winter cabins, a stable, and corral known as Mead's ranch. In exploring the country, Mead rode down the river to the east fifteen or twenty miles and two miles southwest on the Smoky River to find a little town of a dozen or more houses called Salina. There he met Col. William A. Phillips, one of the town's founders, and Alexander Campbell who operated the store and post office.[10] At this time, the country surrounding Salina was mainly a buffalo range. Mead spent three years in the Saline River country.

Westward travel increased with the discovery of gold in the eastern Rocky Mountains in 1858. The Smoky Hill route to the Rockies followed the Smoky Hill River westward and this central route became the most well-known route to the gold fields. Hundreds of people traveled west to present-day eastern Colorado in this gold rush. As early as September, 1858, Kansas newspapers promoted the Smoky Hill route as the most direct from Leavenworth. By the next year, however, stories of suffering, starvation, and death on the relatively unexplored route diverted many gold-seekers to follow the Santa

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[9] James R. Mead, "The Saline River Country in 1859," Transactions, Kansas State Historical Society IX (1905-1906), 8-9.
[10] Mead, "Saline River Country in 1859," 11.

Fe Trail to the south or the Oregon Trail to the north to reach Colorado by a longer, but safer route.[11] To regain this traffic in 1860, Leavenworth boosters sponsored two expeditions to report on, mark, and improve the central route to Colorado. By 1861, the gold rush was over, but these expeditions led the Butterfield stage line to use the central road later and, eventually, the Kansas Pacific railroad built along the same route.[12]

In 1854 the first territorial legislature defined the Ninth Election District as all the area north of the Smoky Hill River and west of a line running north from the junction of the Smoky Hill with the Republican River near present day Junction City. The north boundary was the territorial border. The western boundary of the district and Kansas Territory extended to the mountain divide of present-day Colorado.[13]

In the first years of Kansas Territory, there were two unsuccessful attempts to establish settlements in what is now Saline County. In 1856 Preston B. Plumb and several others located a site known as Mariposa along the south side of the Smoky Hill River near the junction with the Saline River. Soon afterwards, the Buchanan Town Company was located near the mouth of the Solomon River. Eight cabins were built by pro-slavery settlers, but only one or two were occupied and only for a short time. Prairie fires and floods obliterated Mariposa and Buchanan with a few years.[14]

A permanent and more successful settlement became Salina, the county seat of Saline County. Salina was a western outpost in the territorial struggle over the issue of admitting slavery into Kansas Territory. In the spring of 1857, W. A. Phillips explored the unsettled western country looking for a town site. From Fort Riley, he followed the

[11] Calvin W. Gower, "The Pike's Peak Gold Rush and the Smoky Hill Route, 1859-1860," Kansas Historical Quarterly, 158-161.
[12] Gower, "Smoky Hill Route," 165-171.
[13] Hughes and Dingler, History of Saline County, 21.
[14] Hughes and Dingler, History of Saline County, 35.

Smoky Hill River to the Saline, crossed to the Solomon, followed the Republican and Kansas Rivers back to the site of Manhattan, then up the Blue to its forks where he came to the Military Road and reached site of Marysville. After this two week journey through north central Kansas, Phillips decided to locate on the Smoky Hill River. He returned in February, 1858 and began a town survey in March of the site that he named Salina. The survey continued at intervals until completed in March, 1862.

In February, 1859, the territorial legislature organized five counties west of the 6th principal meridian including Saline County. Saline was the westernmost organized county at that time. The first Board of County Commissioners met April 26 and took their oath of office April 27, 1860. There were only about a dozen families in the county before 1860 and these settlers were mostly located at the Salina town site. The first Salina post office was established in 1861.[15]

At the beginning of the settlement period in 1859, surveyors described the landscape in the General Land Office original survey notes. The federal General Land Office survey defined section and township lines within the county boundaries.[16] Sections that eventually were included in the Smoky Hill Air National Guard Weapons Range were surveyed in 1861 and 1864-1866. The four townships were surveyed from north to south and from east to west.

In the northeast part of what is now the Weapons Range, *Township 15South, Range 4West,* had two small creeks with some timber--Elm Creek in the northwest and another in the southeast. As the surveyor described,

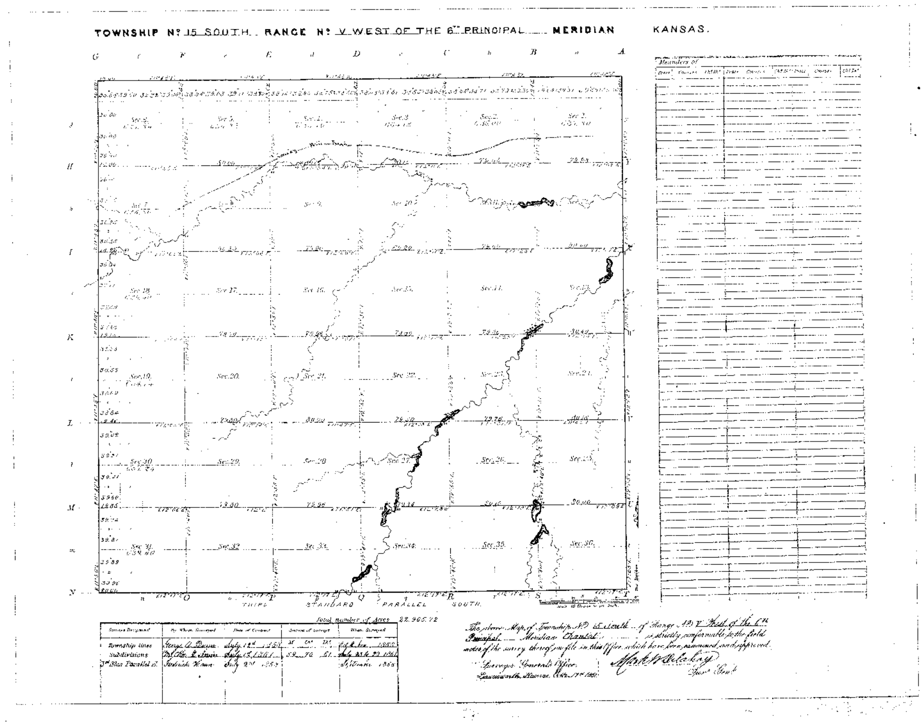
> The quality of land in this township is generally good. There is rich fine level bottom land on each side of Elm Creek. The same on dry creek.[sic] The other

[15] A. T. Andreas, History of the State of Kansas (Chicago, IL: A. T. Andreas, 1883), 698.
[16] Hughes and Dingler, History of Saline County, 3.

> portion of the township are [sic] high rolling prairie but little broken and well adapted for cultivation. Dry Creek runs through the S East portion of the township and has some scrubby scattering timber on each bank. Elm Creek in the N West corner of the township has some inferior growth of walnut elm willows on its either margin. There are many fine sandstone quarries along the south side of Elm Creek in the hills and some ledges of limestone.

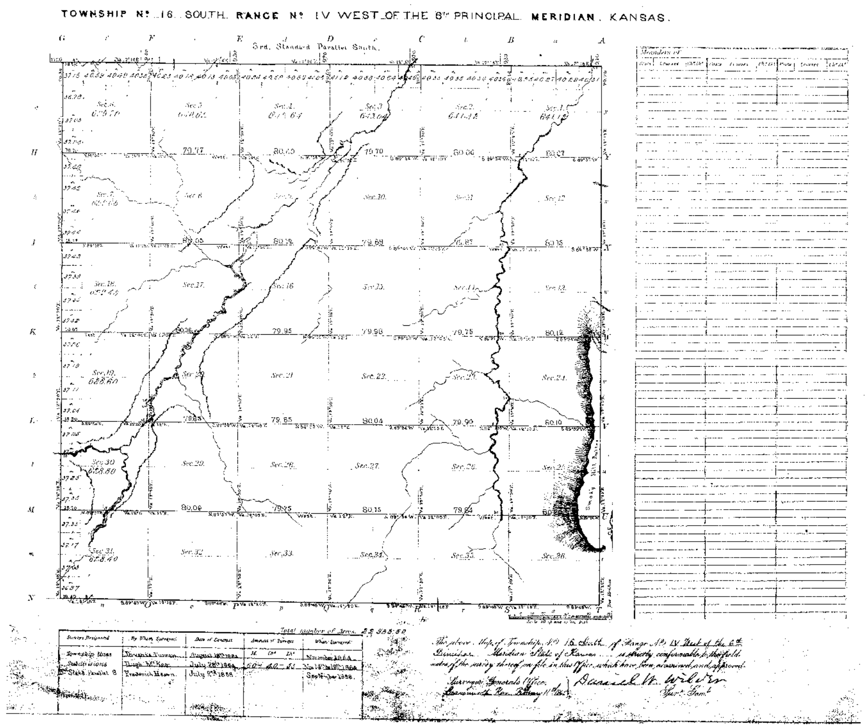
To the southeast, Spring Creek is located in the north part of *Township 15South, Range 5West* running east and west. The Smoky Hill Road ran along the north side of the creek and the surveyor commented that.

> The general quality of the land in this township does not come up to the common average. Along and on either side of Elm and Spring Creeks, there is some fine rich level bottom varying in width from one to two miles. The balance of the township is broken and stony. The soil is covered with Buffalo grass in the ravines varying from 2 to 10 chains in width. There is apparent good soil and new good grass.
>
> Elm Creek passes through this township in a N.E. direction and is about 60 links wide on an average but little water. The timber is of a very inferior quality and scattering along the banks. Spring Creek runs through the Northern portion of the township from west to east and unites with Elm Creek in the adjoining Township east. There is little or no timber on its banks. The water is clear and excellent being fed by springs from the bluffs. There are vast piles of sandrock dispersed thru the Township. There are excellent springs of good sandstone water throughout this Township one of particular note in Section 8 on the South side of Spring Creek. The Sandstone here presents a perpendicular front of some 100 feet. The front of which is carved with Indian characters and engraved with names on the stone. The timber on Spring Creek is so inferior it is scarcely worth mentioning. Some cottonwood Elm plumb [sic] cherry and grape vines. The road from Leavenworth to Smoky Hill Crossing passes through the Township nearly east and west.



In the southeast part of the Weapons Range, *Township 16South, Range 4West,* the surveyor described two small unnamed creeks--one running northeast and southwest and another in the east part ran north and south. The Smoky Hill Buttes were located on the east boundary of this township. The surveyor also rated the land as less desirable.

> The quality of the land in this township is below the common average in being mostly broken upland. Soil: 2nd and 3rd rate. There is some 1st rate bottom land on each side of the creek which runs from Section 31 to Section 3. There is some good 2nd rate land along the creek that runs from the South nearly North through the 2nd tier of sections. Timber is scarce and inferior in quality. Small, scrubby, cottonwood. elm. ash. walnut and willow.[sic] Sandstone and Lime stone are equally distributed through the Township in inexhaustible quantities. This township would not be suitable for farming, but would answer for grazing purposes.



The land in the southwest part of the Weapons Range, located in *Township 16South, Range 5West***,** was

> mostly broken except along the creek bottoms. The quality of the soil is nearly all first-rate. Vegetation grows luxuriantly; such as the grape, wildflowers, undergrowth and vines. It is well adapted to grazing. There are [sic] fine red and gray sandstone in every part of the township but little or no lime stone to be found.
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> The Township is watered by several small creeks running north into Clear Creek or South into Smoky Hill; their rise is about-10 feet-, as shown by the drift deposited on their banks. There is some timber along the creeks; Oak, Cottonwood, Ash, Willow and Box Elder. The Smoky Hill River is South and Smoky Hill Route is immediately North of this Township.[17]

According to the Kansas Board of Agriculture annual report published in 1874, the land in Saline County was classified as one-third fertile valley, one-third rolling tillable upland, and one-third "precipitous upland adaptable for livestock grazing." Valley land included that of the Smoky Hill River and its tributaries, the Saline and

[17] "Field Notes, General Description" (Book 28) Township 16-20South. Range 5West, 40.

Solomon rivers, and several creeks. Ninety-six per cent was prairie or grassland with only four per cent in forest. As noted in the original survey, most of the tree growth was concentrated on the banks of rivers and creeks.[18]

Settlement Land Use, 1870--1942

Explorers, traders, hunters, gold seekers, and early overland emigrants traveled across the area. Even though permanent settlers were few before 1865, the travelers who traversed the central Great Plains killed and drove away many of the large mammals. They also began to introduce new plant species that established near the ruts and trails and spread to the surrounding prairie. Later, Texas cowboys with their longhorn cattle moved through, but the herds moved further west by 1874.

After the end of the Civil War in 1865, European-Americans migrated to central Kansas and dramatically changed the prairie. These settlers constructed a network of farms, roads, and railroads that supported intensive agriculture and livestock grazing. Southwest Saline County was the least populated area of the county because the land was primarily grassland with relatively little arable land. As the 1884 Saline County Atlas described,

> on the outer edges of the county, especially on the west and north, the surface is quite broken with narrow valleys and hills alternately. The uplands are generally undulating and where not too rough have proved of excellent fertility, especially in wheat raising. A good deal of the high land, however, is only fit for grazing. And located in the county are some of the finest sheep and cattle ranch in the state.[19]

Settlement began to change the landscape. For example, the Atlas explained, "trees grow rapidly and where there is [sic] effective precautions against the ravages of prairie fires, the belts of native timber are constantly enlarging their area." During this

[18] Hughes and Dingler, History of Saline County, 4.
[19] "General Description," Edwards Atlas of Saline County (Philadelphia, PA: John P. Edwards, 1884), 8.

period, settlers invested a good deal of effort in "arboriculture" because of the "scarcity of timber and dearth of coal, and for wind breaks, and shade and ornamental trees. There is scarcely a farm without trees."[20] Along with the farms, the settlers established schools, churches, and towns throughout Saline County.

Because of the outbreak of the Civil War, immigration to Saline County paused after 1861 and the county population remained small until the first railroad, Union Pacific, Eastern Division, later named the Kansas Pacific, built through the area in 1867 on the way to Denver, Colorado. Early settlement ended when the first line was completed to Salina April 20, 1867. Passenger service west of Junction City began on May 6. This achievement connected Saline County to the developing railroad network and national economy.

Railroads transported many new settlers to the area and carried the products of the county to national and international markets. To finance the first railroad construction, the federal government granted almost half of the land in Saline County to the Kansas Pacific, including practically all of the odd-numbered sections. The railroad sold land to many of the early settlers.[21]

Salina incorporated as a city of the third class in 1870. The federal land office moved from Junction City to Salina in 1871. As central Kansas was settled, the Salina land office finally was consolidated with the Topeka office on December 31, 1892.[22] By 1871 Salina was flourishing, despite the fact that the Kansas Pacific platted the town of Brookville west of Salina as its division point in 1870. The company constructed a

[20] "General Description," Atlas of Saline County, 8.
[21] Hughes and Dingler, History of Saline County, 74.
[22] Frank W. Blackmar, ed., Kansas: A Cyclopedia of State History (Chicago, IL: Standard Publishing Company, 1912), 97-98.

roundhouse and shops, residences, stores, and hotels. Brookville boomed until the late 1880s when the railroad relocated the division point to Salina.[23]

During the 1880s, rapid population growth and economic prosperity stimulated the construction of a state railroad network. Three more railroads built through Saline County during this decade. The Missouri Pacific first entered the county in 1880 while extending a line from Holden, Missouri, through Paola and Ottawa, Kansas to the west. By the fall of 1886, citizens of Salina competed for the location of the railroad division headquarters and the machine shops of both the Union Pacific and Missouri Pacific railroads. The Missouri Pacific main line, a route of 540 miles across the plains from Ottawa to Pueblo, Colorado, was completed in December, 1887.[24]

In January 1890, there were four railroad lines (Union Pacific, Missouri Pacific, Atchison, Topeka, and Santa Fe, Rock Island and Pacific), operating twenty-eight passenger trains daily in and out of Salina. In the twentieth century, Salina was a major railroad junction served by the Union Pacific, Missouri Pacific, and a north-south branch line, the Salina Northern, operated by the Atchison, Topeka, and Santa Fe. Four major railroads continued to serve Saline County until after World War II. Passenger service to Salina ended in 1979.[25]

Population groups in southwest Saline County

After the Civil War, immigrants streamed into Kansas because the state was a place of opportunity. By 1884, the Saline County Atlas explained that

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[23] Salina, Kansas Centennial: Wagons to Wings, 1858-1958, n.p.; Hughes and Dingler, History of Saline County, 55-56.
[24] A. Bower Sageser, "Building the Main Line of the Missouri Pacific Through Kansas," Kansas Historical Quarterly 21 (Spring 1955), 327-330.
[25] Salina Journal, "Last Passenger Service," 2 April 1979; "A Rail Era to End," 16 February 1971; "Century-Old Tradition Fades," 29 April 1971.

> at least thirty percent of the population are Scandinavians, chiefly Swedes and occupying mostly the southern portion of the county; about five per cent are Germans, and about the same amount are Irish. The number of colored people would reach about one per cent. About nine per cent would, perhaps, include all other foreign elements as Scotch, English, French, and other nationalities.[26]

At this time when the fundamental settlement pattern was established, approximately fifty per cent of Saline county residents were immigrants and fifty per cent were native born Americans from every section of the United States.

Scandinavian-Americans were a significant group in southwest Saline County. Swedish settlers included direct immigrants and organized groups moving west from Chicago and Galesburg, Illinois. The First Swedish Agricultural Society was organized in Chicago in the spring of 1868 and the Galesburg Colonization Company was organized in the fall. The Agricultural Society bought a total of 16,000 acres in southern Saline and northern McPherson County from the Kansas Pacific Railroad. The Swedish-Americans also homesteaded on government sections alternating with the railroad land grants. Generally, their land was located east and southeast of the present-day Weapons Range. Friends and relatives of these settlers later emigrated and established the town of Lindsborg in McPherson County.[27]

Members of the Galesburg Company selected land northwest, west, and southwest of the area settled by the First Agricultural Company and more of their land was taken in 1942 by the U.S. government. Swedish Americans established the towns of Smolan and Falun east and southeast of the Smoky Hill Weapons Range. Falun was located west of the Smoky Hill Buttes. The Missouri Pacific Railroad built through the settlement in 1886. Falun High School was organized in 1915. Smolan, the largest of the Swedish-

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[26] Atlas of Saline County, 9
[27] Rev. Alfred Bergin, "The Swedish Settlements in Central Kansas," (1909), File, Salina Public Library, Kansas Collection, 1, 4-5.

American settlements, was established in 1886 as a post office and railroad depot. The Swedish Mission Church was founded in 1875 about one-and-a-half miles south of present-day Smolan. Smolan Rural High School was organized in 1919 and closed in 1950.

Other Swedish immigrants also established Assaria, Marquette, and Salemsborg. Salemsborg, three miles south of Smolan, was founded as a site for the Salemsborg Evangelical Lutheran church in 1869. Approximately fifty Swedish members of the Galesburg Company purchased land in the area and organized the Salemsborg church.[28] After condemnation for Camp Phillips took many of the farms in the vicinity in 1942, several area churches merged or were abandoned but the Salemsborg Lutheran church survived.

North of the Swedish emigrants, Germans settled in an area where Bavaria, another small town, was established. Ernst Hohneck, the founder of Bavaria, arrived in 1867 and established a post office that same year. By 1870 the population of Saline County had increased to 4,246 residents. Most were European-American, only six were African-American.[29]

Reportedly, the first African American settler in Saline County was Larry Lapsley who came from Kentucky in 1865 and lived in Liberty Township east of the Weapons Range. Several African-American families who settled southwest of Salina were a significant group in the early history of the area. More African-Americans came to central Kansas in the late 1870s. Some were part of the organized Exoduster movement

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[28] Hughes and Dingler, History of Saline County, 40, 42, 46. Emory K. Lindquist, Smoky Valley People: A History of Lindsborg, Kansas (Lindsborg, KS: Bethany College, 1953), 174-176; Devere E. Bloomberg, Heart and Heritage: Centennial Reflections, Falun Lutheran Church and Community, 1887-1987 (Falun, KS: Falun Centennial Committee, 1987).
[29] Hughes and Dingler, History of Saline County, 183.

to Kansas in 1879-1880. In this movement, thousands of African-Americans left the South because of the oppression and poverty that intensified at the end of Reconstruction. Several African American families settled in Summit Township, now included in the southwest part of the Smoky Hill Weapons Range. These families were located predominantly in the northeast quarter of Summit Township. Family names included Calloway, Clark, Green, Hurston, Maxey, Price, and Smith.[30]

The earliest arrivals to Summit Township were Thomas C. Price, his cousins, Ben and Willis (John Willis) Price, their wives, and Ben and Willis's sister. They arrived in1879 from Kentucky and appeared to be the African American settlers who owned the most land and stayed for the longest time. According to the 1880 census, Thomas Price was born in Virginia in 1850 and his wife, Maria, was born in Kentucky in 1857. Probably, both were born into slavery. Their one-year-old son, Willis, was born in Kentucky. Price received a federal patent for eighty acres in the west half of the southeast quarter of Section 14 in 1886. The Prices sold this property in 1896. They moved to an adjacent 160 acres acquired in 1894. Thomas Price farmed and raised stock until the Prices sold the property in 1905.

Thomas Price's cousins, Ben and John Willis Price, apparently lived in Salina until 1899 when they each received government patents for the southwest quarter of Section 12. Ben and his wife, Laura, bought the south half (80 acres) and John Willis and Ellen Price bought the north half. Later, John Willis Price increased his property to 240 acres in 1903 when he bought the adjacent southeast quarter of Section 11. In 1905 he sold an acre in the northeast quarter of this tract to School District 67. The District

[30] R. C. Goodwin & Associates, "Archival Research, Archeological Predictive Model, and Archeological Survey for the Smoky Hill Air National Guard Range, Saline County, Kansas," Prepared for the Air National Guard Readiness Center (June 2005), 56.

school moved to this location and served the children in the area, both African-American and white.[31]

John Willis Price sold the south half of his 160-acre parcel in Section 11 to one of his sons, Cleo Price, in 1917. In the 1920s, the rural African-Americans began leaving the land to find work and Cleo Price sold his land in 1924. John Willis Price sold the east half of his 80-acre property in Section 12 in 1926. Then he lost the remaining forty acres in Section 12 and the north half of his land in Section 11 in a sheriff's sale in 1935. John Willis Price probably is buried on a plot near where he lived. At the same time, Ben Price transferred his 80-acre parcel in Section 12, directly south of his brother's land, to his son, David Price, in 1936. David Price sold this parcel to the United States government on September 18, 1942 as part of the land acquisition for the Army training camp, Camp Phillips.[32]

Henry Green's gravesite probably is located on the Weapons Range. Green and his wife, Mary, arrived from Kentucky between 1880 and 1885 when they were first recorded in the Summit Township census. Henry and Mary had married in 1880 and had their first son, Tom, that year. According to the 1910 census, Henry Green had been born in Kentucky in 1824 and Mary had been born in West Virginia in 1845. Green first owned the northeast quarter of Section 10. He received a receipt for the land from the federal government in March, 1887, and a patent in May, 1888. Henry and Mary Green sold this tract in 1896. The 1884 Atlas showed John Green as the owner of this land with a structure on the east side of the property. John Green was Henry's brother and,

[31] R. C. Goodwin, "Archival Research and Archeological Survey for the Smoky Hill Air National Guard Range," 62.
[32] R. C. Goodwin, "Archival Research and Archeological Survey for the Smoky Hill Air National Guard Range," 62.

reportedly, the two homesteaded in Saline County together. The Greens bought a second tract, the southeast quarter of Section 12, in 1900. Henry was listed in the 1903 plat book as a farmer and stock raiser. A structure on the north side of the property was recorded indicating that this was the home where the Greens lived with their fifteen children (only 12 survived to become adults). Apparently, Green lost his land in 1917 because the land was sold at a sheriff's sale in 1920. The Greens moved to Salina.[33]

Recent archeological survey of the Weapons Range identified a site believed to be the Henry Green homestead with the remains of three structures and a concrete grave marker bearing his name and military unit located west of the structures. According to Green's gravestone, he served in the Civil War as a private in Company A of the 13th Regiment of the United States Colored Heavy Artillery. This regiment was organized at Camp Nelson, Kentucky, on June 23, 1864 and mustered out of service on November 18, 1865. However, documentary research proved that this property was owned by Henry and Frances Maxey and later the Hurstons, both African American families.[34]

Several other African American families lived in Summit Township in the late nineteenth and early twentieth century. Besides the Prices, Henry and Frances Maxey, their sons John and Robert, and two grandchildren were recorded in the 1880 census of Summit Township. Henry and Frances were born in Virginia, but their sons and grandchildren were born in Kentucky between 1870 and 1880. The 1884 plat show that M. Maxey owned 80 acres in the west half of the northwest quarter of Section 14 near Thomas Price's original tract. Later, William M. Smith, who appeared in the 1885

[33] R. C. Goodwin & Associates, "Archival Research and Archeological Survey for the Smoky Hill Air National Guard Range," 62-63.
[34] R. C. Goodwin & Associates, "Integrated Cultural Resources Management Plan," Volume 1 of 2 (June 2005), 37.

Kansas census of Summit Township, bought this land from the federal government in 1889 and received a patent in 1890. Smith lost this parcel in a sheriff's sale in 1891. That buyer then sold to another African American, James Hurston, who had married the sister of Ben and John Willis Price. Hurston was recorded as farming and stock raising on this parcel in 1903. But later in 1935, he also lost his land in a sheriff's sale, possibly because of the effects of drought and the Depression.

Another African American family, the Calloways, lived on a 160-acre tract in Section 14 east and adjacent to Hurston. William F. "Mitch" Calloway was listed in the 1885 census of Summit Township. He bought his land in 1904. Deed records indicated that the property passed to his wife and child after he either died or was committed to a mental institution and they sold in 1915.

The Clark family lived north of the other African Americans in Summit Township. Missouri native Joseph Clark received a patent in 1882 for 160 acres, the west half of the east half of Section 2. Clark increased his holding to 320 acres in 1894 when he acquired the southwest quarter of Section 2. The land passed to his sons J. Edward and John Clark after Joseph's death in the early twentieth century. In 1912 the two brothers sold their half-interests to each other so that John solely owned the southwest quarter of Section 2 and J. Edward owned the other quarter. John sold his land in 1923 and J. Edward lost his land in a sheriff's sale in 1933 or 1934.[35]

Settlement Pattern, 1890 and 1942

[35] This summary of the African-American settlers in Summit Township is based on a more extensive analysis in R. C. Goodwin & Associates, "Integrated Cultural Resources Management Plan," 63-64.

A recent cultural resource inventory of the Weapons Range identified forty-five historic archeological sites and twenty-two prehistoric sites.[36] Historic period sites located on the Smoky Hill Weapons Range date from the late nineteenth century through the mid-twentieth century. The Kansas Historic Preservation Office assigns higher archeological significance to sites that were occupied solely in the nineteenth century and homesteads known to have been occupied by African Americans. Archeological survey also identified sixteen bridges and two culverts attributed to the Works Progress Administration. In a systematic survey of the historic wells present on the Weapons Range completed in 1988, the Goodman Water Well Drilling Company identified 98 wells, cisterns, and springhead vaults within the Range. Some of these features may indicate previously undocumented homesteads since at least 46 were not associated with any of the known or mapped historic homestead sites.[37]

Information about the distribution and location of homestead sites in southwest Saline County indicated the settlement pattern established by 1890. This early settlement landscape was documented in the 1884 Edwards Atlas of Saline County. For example, Washington Township had some of the better land in southwest Saline County, but the township also had large areas of upland pasture. Not all the land in southwest Saline County had been settled by 1884. The Union Pacific Railroad retained 320-acre tracts in Section 19, Section 29, and Section 31. J. M. Danielson & Company owned the largest tract--Section 17 (640 acres). R. Sloan held 320 acres in Section 29 and F. Linn had 320 acres in Section 31. J. McHatton owned 240 acres in Section 19. Generally the other

[36] R. C. Goodwin & Associates, "Integrated Cultural Resources Management Plan," 32-36.
[37] R. C. Goodwin & Associates, "Archival Research, Archeological Predictive Model, and Archeological Survey for the Smoky Hill Air National Guard Range, Saline County, Kansas," 135.

sections in the township were subdivided into 160 and 80-acres farms. G. L. Richards was listed as a stock raiser and wool grower in this township.

The landholding pattern in Falun Township was similar. The Union Pacific Railroad had one large tract (480 acres) in Section 7 and the National Land Company had 320 acres in Section 5. Otherwise, the E. Washburn Sheep Farm in Section 6 and Levi Shaw's farm were the largest (320 acres). Other farms in the township were 160 and 80-acre tracts.

In Spring Creek Township, there were tracts of School Land in Section 16 and the remnants of Union Pacific Railroad land grants in Section 15, Section 21, Section 33, and Section 35. The size of land parcels varied greatly. For example, Mr. S. A. Shephard owned 1280 acres in Sections 20, 21, 28, and 29 but did not live on the tract. Mr. D. E. Tyler, who lived in Section 22, had 800 acres in Section 22 and Section 27. There were several 320 acre parcels and some 80 acre tracts, but other sections in the township (Section 16, 14, 13, 24, 25 and 36) were partitioned according the Homestead Act ideal of 160-acre family farms.

Summit Township in the southwest corner of Saline County was the most sparsely settled; much of this area was upland pasture. Again, the Union Pacific Railroad still owned 400 acres in Section 3 and 640 acres of Section 13. There were a few large landowners, particularly Carlin Brothers who owned 1280 acres in Section 9, Section 16, and Section 21. Mrs. Emma L. Brown owned 480 acres in Section 1 and Section 11 and Mr. T. J. Darrah owned 480 acres in Section 23. Several others owned 320 acres, but most landowners had 160-acre and 80-acre farms. Also in Summit Township, T. S.

Wolcott (80 acres) and Albert Gillingham (320 acres) were listed as farmers and wool growers.

Agriculture in Saline County

Most of the land in the Smoky Hill Weapons Range is grassland with relatively limited arable land. On these upland pastures, stockraising became an important industry. The first cattle in Kansas were brought to Kansas on the overland trails in the 1850s. Later, these cattle were bred with longhorn cattle driven north from Texas after the Civil War to begin the Kansas cattle industry.[38] The development of the railroad through Saline County in 1867 and later in the 1880s stimulated settlement, agricultural development, and stock-raising. For a few years in the 1870s, Brookville in northwest Saline County and Salina in the center served as cattle shipping points.

As more and more homesteaders claimed the land that had been used for open-range grazing, cattlemen began to manage their herds in fenced pastures. Livestock in Saline County included beef cattle, milk cows, hogs, and some sheep. Raising and feeding beef cattle was the major type of stock production. Residents of Saline County benefited from the growing beef industry that shipped livestock to packing plants in Kansas City and then in refrigerated railroad cars to the urban centers of the eastern United States.[39]

In the 1890s, the Kansas beef cattle industry became an industry based on ranches. The heaviest concentration of cattle was in the Flint Hills region in counties just east and south of Saline County. Better breeding and nutrition, fenced pastures and shelter, and improved transportation made the industry more efficient and productive.

[38] Charles L. Wood, The Kansas Beef Industry (Lawrence, KS: Regents Press of Kansas, 1980), xi.
[39] Andreas, History of the State of Kansas, 701.

The industry was important in Saline County and Kansas. Saline County's beef production ranked in the middle of the state's distribution during this period. In 1890 Saline County had between 20,000 and 32,500 head. In 1920 Saline County had fewer cattle, 20,000 to 25,000 head. In 1940 the county had 25,000 to 38,600 head. Not until 1975 did Saline County's share of cattle production decline in relation to the rest of the state.[40]

Agriculture, stockgrowing and related industries flourished in Saline County from the early settlement period to the mid-twentieth century. During the decades from about 1880 to 1940, agriculture sustained the greatest population on farms and in local communities. Wheat and corn were the most important crops and Salina became one of the milling centers of the state.

Before 1880, farming was mainly a subsistence activity in Saline County, but the construction of a railroad network enabled farmers to market their crops and agriculture became the foundation of the local economy. In 1870 there were 662 farms in Saline County, but most were less than fifty acres. Ninety farms were 50 to 99 acres, 19 were 100 to 499 acres and one was between 500 and 999 acres. Ten years later in 1880, there were 1,986 operating farms in Saline County. The size of farms had increased. A majority (1,295) were between 100 and 499 acres. The average farm size was 160 acres.[41] In 1875 Saline County farmers grew wheat on more than 30,000 acres, corn on 14,935 acres, and smaller amounts of several other crops.[42]

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[40] Wood, Kansas Beef Industry, 70-73.
[41] R. C. Goodwin, Draft "Cultural Resources Management Plan," 184. Cited Inter-University Consortium for Political and Social Research (2002), 1870, 1880.
[42] Hughes and Dingler, History of Saline County, 199-200.

By 1890 the number of farms grew to 1,856 and average farm size increased to 200 acres. Wheat and corn were the most important crops. The number of farms grew to 1,948 farms averaging 222.5 acres in 1900.[43] Although the early twentieth century from about 1900 to 1945 was a period of agricultural dominance in Kansas, the pattern of land use began to change in Saline County. By 1910 the number and average size of farms declined to 1,856. Despite an overall population increase, the number of farms in Saline County dropped to 1,804 in 1920. Mechanization of agriculture and the movement of the rural population to cities were the underlying causes of demographic change.

Since the railroad was the most important transportation mode in the late nineteenth century, state and county roads were not improved until the early twentieth century. By 1913, the "Golden Belt Road" ran east-west through Salina and Saline County. Known as the "Golden Belt" because the road traversed the wheat section of Kansas, boosters promoted this road as "the shortest, most picturesque and best motor route between Kansas and Colorado." In the 1930s, U.S. Highway 40 replaced the Golden Belt road. This highway paralleled the route of the Union Pacific Railroad which ran diagonally east-west through Saline County. The major north-south highway in Saline County was known as the Meridian Highway before it was designated U.S. 81. U. S. Highway 81 was considered the first international highway because it connected three countries, Canada, the United States, and Mexico.[44] By 1939 Salina benefited from its location at the junction of two great transcontinental highways--north-south U.S. 81 and east-west U.S. 40.

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[43] R. C. Goodwin, Draft "Cultural Resources Management Plan,", 188. Cited Inter-University Consortium for Political and Social Research.
[44] Hughes and Dingler, History of Saline County, 61-62.

Wheat production in central Kansas grew steadily and Salina became one of the milling centers of the state. By 1927 flour milling was the chief industry of Salina with five mills producing 10,000 barrels of flour a day. In 1929 the city's daily production of 10,500 barrels made it ninth in the nation for flour milling.[45] In the 1920s, an important new industry developed in Saline County in the 1920s when oil was discovered in the southern section of the county, east of the area now included in the Weapons Range.[46]

In 1936 a promotional article described Salina as a "Saline county metropolis" that controlled a vast region. Located at the center of one of the most outstanding hard wheat producing areas in the world, the reporter concluded that it was not surprising that the city had "achieved prominence in flour milling, being second in Kansas and sixth in the nation in volume of flour making." Salina had five large flour mills with a capacity of 10,000 barrels. The reporter estimated that some 400,000 persons from the rich agricultural regions surrounding Salina shopped in the city's 200 retail stores. Moreover,

> national jobbers and distributors have been quick to seize upon the advantageous position of Salina as an ideal point from which to supply that territory with their commodities, particularly of farm equipment and construction materials. Splendid transportation facilities have aided in bringing about this healthful economic condition.

Distribution was based on the transportation network since four railroads radiated in nine directions out of the city and many motor truck lines ran between Salina, Topeka, Kansas City, and Wichita.[47] Three years later, the WPA Guide to Salina, Kansas concluded that, "Salina is the trading, educational, and recreational center for a large area in the wheat belt." Wheat formed the base of the county economy with manufacturing in second place

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[45] R. C. Goodwin, Draft "Cultural Resources Management Plan," 189.
[46] Hughes and Dingler, History of Saline County, 142-143.
[47] "Salina--One of Kansas' Modern 'Cities of Cibola,'" Kansas Business (June 1936), 9, 16-17.

and wholesale distribution third. At that time, Salina had ten hotels, five tourist camps, five motion picture houses, and a population of 20,155.[48]

Along with other Americans, Kansans suffered from the bank closures, business failures, and unemployment following the financial crash of 1929. On the Great Plains, the effects of the economic depression were intensified by the drought that began in 1933. Farming practices that exacerbated the natural conditions caused by cyclical drought led to dust storms and intense "blizzards" of dust that blew as far as New York, Washington, Boston. By 1935 nearly nine million acres of land were abandoned. The drought continued until the end of the decade. Relief programs instituted by the New Deal administration of President Franklin D. Roosevelt helped put people back to work and produced many community improvements. The agencies leading this effort were the Federal Emergency Relief Administration, the Public Works Administration, and the Works Progress Administration. The WPA constructed a number of bridges in Saline County, including several bridges and culverts now included in the Smoky Hill Weapons Range.

As the Kansas Board of Agriculture reported, drought in 1937 was severe over the state. The year's supply of moisture was deficient in practically all parts of the state. The livestock inventory of the state was greatly reduced in 1936 because of dried-up pasture and the shortage of forage crops. The drought first struck in 1931 and the unfavorable crop years continued through 1938.[49] 1939 also had less than normal precipitation, but 1940 was more nearly normal in both temperature and precipitation. At this time the

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[48] Federal Writers' Project, Works Progress Administration, State of Kansas, A Guide to Salina, Kansas (Salina, KS: Advertiser-Sun, 1939), 5-11.
[49] Kansas Board of Agriculture, 31st Biennial Report 36 (1937-38) (Topeka, KS: Kansas State Printing Plant, 1942), 7-8.

Board of Agriculture promoted sorghum production, instead of corn, because of its ability to withstand dry weather.[50]

During the period from about 1915 to 1940, important changes in agricultural practices transformed the production of wheat in Kansas. The equipment used in 1915 consisted of "a moldboard plow or lister, disk and spike-tooth harrow, drill, binder or header, threshing separator, and enough horses or mules to furnish power."[51] After that time, horses and mules were replaced by tractors and the combined harvester-thresher. Many tools for tillage came in wide usage. As a result, the average harvest time per acre dropped from 3.4 hours in the western hard winter wheat section of the state and 4.7 hours in the eastern section in 1919 to 1.2 hours and 1.7 hours in 1936. In 1919, for example, five percent of farms in the western section and one percent in the eastern sector used combines. By 1936 ninety percent in the west and 80 percent in the east used combines.[52] Another major trend in wheat production was the improvement in varieties through plant breeding and the planting of pure seed to improve quality. New wheat varieties produced higher yields and test weights and had better milling qualities, stronger straw and greater resistance to the major plant diseases and insects.[53]

In this study, one of the goals was to compare the land use pattern in 1880 with land use in 1940 and summarize the dramatic change caused by the intrusion of Camp Phillips and the Gunnery Range. Wheat growing and stockraising were important components of the agricultural economy that persisted in Saline County even after the terrible effects of the dust storms and the economic Depression. In 1940 there were

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[50] Kansas Board of Agriculture, 32nd Biennial Report 37 (1939-40), 8-9.
[51] L. P. Reitz and E. G. Heyne, "Wheat Planting and Wheat Improvement in Kansas," Kansas State Board of Agriculture, 33rd Biennial Report (1941-1942), 169.
[52] Reitz and Heyne, "Wheat Planting and Wheat Improvement in Kansas," 169-170.
[53] Reitz and Heyne, "Wheat Planting and Wheat Improvement in Kansas," 207.

3,570 horses in the county and 23,590 cattle other than milk cows. Saline County had 169,000 acres of wheat, 10,400 acres of corn, 9,660 acres of sorghum and 125,000 acres in pastures (tame and prairie grass).[54]

Possibly because of wetter weather or the war effort, pasture acreage decreased to 98,951 acres in 1942. Winter wheat acreage was 119,000 (down from 177,500 in 1941). Corn was up to 18,090 acres from 7,290 in 1941 and sorghum acreage was 18,070 in 1942 (down from 21,440 acres in 1941).[55]

Township[56]	Population (1939)	Population (1940)	Population (1941)	Population (1942)	Assessed valuation Land (1940)	Assessed valuation Land (1942)
Falun	358	376	361	367	$695,100	
Spring Creek	342	297	310	304	$804,085	$583,220
Summit	98	96	91	82	$353,400	$188,630
Washington	289	291	276	276	$666,180	$176,960

Township	Population (1943)	Population (1944)	Population (1945)	Population (1946)	Assessed valuation Land (1944)	Assessed valuation Land (1946)
Falun	342	320	334	353	$554,280	$563,210
Spring Creek	199	174	147	175	$594,020	$625,670
Summit	22	24	27	23	$189,130	$197,440
Washington	85	85	86	101	$205,030	$315,020

[54] Kansas Board of Agriculture, 32nd Biennial Report (1939-1940), 444-445 553.
[55] Kansas Board of Agriculture, 33rd Biennial Report (1941-1942), 425, 536.
[56] Kansas Board of Agriculture, 32nd Biennial Report (1939-1940), 444; 33rd Biennial Report (1941-1942), 424.

Change in agriculture in these townships was documented by statistics recording the number and value of livestock in Saline County and the acres planted in wheat, corn, sorghum, and pasture. In the years between 1939 and 1946, there was a decline in horses and an increase in cattle. There was an increase in wheat production, but stable corn production, and a decline in sorghum production.

Saline County[57]	1939	1940	1941	1942	1943	1944	1945	1946
Horses	3,570	3,340	3,180	3,250	3,110	2,980	2,600	2,350
Cattle (other than milk cows)	23,590	25,320	28,550	31,960	31,960	35,750	33,570	31,080
Wheat (acres)	144,000	169,000	177,500	119,000	128,000	165,000	168,000	166,000
Corn (acres)	12,400	10,400	7,390	18,090	25,800	22,100	15,900	14,900
Sorghum (acres)	8,450	9,660	7,800	5,960	5,780	9,660	6,540	5,560
Pastures (tame & prairie grass)		125,000		98,951		113,301		144,385

Contrasting with the 1930s, the years from 1944 to 1947 were remarkable because agricultural production responded to the demand of war with record crops. In each of those years production steadily increased setting a record each year until the 1947 wheat crop, for example, estimated at 286,702,000 bushels, by far the largest in Kansas history.[58] In 1950 the number of farms dropped to 1,277. The largest group of farms was 260 to 499 acres, much larger than before World War II.

[57] Kansas Board of Agriculture, Biennial Reports, 1939-46.
[58] Kansas Board of Agriculture, 35th Biennial Report 40 (1945-46), 7-8; Kansas Board of Agriculture, 36th Biennial Report 41 (1947-48), 7.

Saline County remains one of the top twenty wheat producers in Kansas. Until the 1950s, Salina was a flour milling center but after that the industry moved eastward to be located nearer the major flour consuming areas of the country. In recent years, the county has developed a diverse economic base. By 1985 only three percent of the county's workers were employed in agriculture.[59]

Camp Phillips (Cantonment Salina)

World War II dramatically changed Saline County. First the construction of the Smoky Hill Army Air Base and then, the construction of Camp Phillips, stimulated a new era of economic expansion and population growth in the county and in Salina, the county seat. After Germany invaded Poland in 1939, the War Department realized that the armed forces were inadequate in case the United States entered a world war. More than a year before the Japanese surprise attack of December 7, 1941 on Pearl Harbor, the U.S. War Department began a search for potential training sites to provide the soldiers needed to win a world war. The war department began to plan for rapidly increasing military training capacity. In that plan, the estimated size of the army determined the number of 35,000-man training camps and air fields needed. The war plan called for dispersing these camps across the nation.[60] Camp Phillips in southwest Saline County became an infantry training cantonment.

Army engineers wrote a favorable report on the feasibility of the Saline County site in January, 1942. Early in April, 1942, Captain Paul M. Long, USACE, arrived in Saline County to make soil tests on the proposed site. On April 28, the government filed a condemnation suit to acquire 1,441 acres of land two miles southwest of Salina for an

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[59] R. C. Goodwin & Associates, "Archival Research and Archeological Survey for the Smoky Hill Air National Guard Range," 37.
[60] Royal Oakes, Camp Phillips: World War II Army Post (Bountiful, Utah: Self-published, 1986), 16, 19.

army air base. Just one week later the government began to survey an even larger site for a U.S. Army troop cantonment to be located southwest of the air base.[61] This was first known as "Cantonment Salina" in 1942 and called Camp Phillips after completion.

Saline County residents were surprised by the announcement that an Army training base would be established in central Kansas. With the acquisition of land for Camp Phillips beginning in May, 1942, Smolan, the nearest town and railhead, became the scene of feverish activity. For the next three years, the local railroad depot accommodated the arrival and departure of thousands of soldiers who were sent to Camp Phillips for training. The upheaval was a profound experience for local residents as the small town's population of about 100 grew to more than a thousand for this period.

Camp Phillips covered a total of 69 square miles or 44,090 acres; the main cantonment or building area was 3,200 acres or 5 square miles.[62] The army cantonment was located in the geographical center of the United States. In 1943 the camp's commanding officer, Colonel Howard J. Liston, described it as "located on the rolling Kansas plain country just 12 miles west of Salina, Kansas" where east to west Highway 40 bisects north to south Highway 81.[63] The chosen site was located just west of Smolan and extended twelve miles west.

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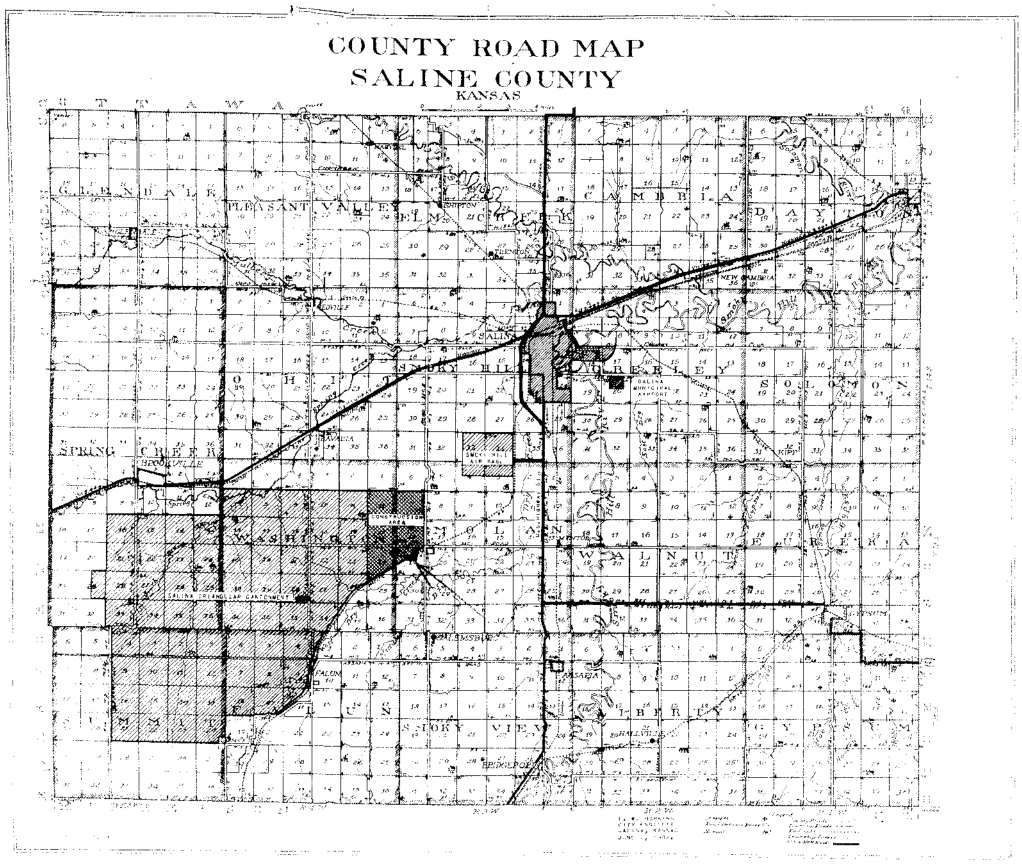
[61] Willis J. McClure, "No Bugles Will Blow, No Trumpets Will Sound" M. A. thesis, Emporia State University, (1983), 10.

[62] The cantonment area was described as "beginning at the northwest corner of the Smolan town site, thence due north two miles, thence three and a quarter miles due south to the north railway line of the Missouri Pacific railroad, thence in northeasterly direction along the north property line of the Missouri Pacific Railroad to the point of beginning." "Camp Phillips," typed manuscript, Camp Phillips file, Salina Public Library; Oakes, Camp Phillips, 30-31.

[63] Herald-American Pictorial Review 1 August 1943, Clippings file, Salina Public Library.



By the late nineteenth century, Saline County was subdivided into nineteen townships. Almost half of the area of Summit and Smoky View Townships was included in Camp Phillips. When the U.S. government acquired most of Summit Township in 1942, the remaining area was joined with Falun Township for official purposes. More than three-quarters of the land in Washington Township and one-fourth of Falun Township was included in Camp Phillips. These townships in western Saline County were the least populated in the county because of the large acreages of non-tillable grazing land.[64]

Camp Phillips had a short, busy life. The first post commander and the first troop train arrived on September 24, 1942 and the camp was deactivated in October, 1944.

[64] Huges and Dingler, History of Saline County, 31-32. Salina Journal "Guide, Two Townships," 2 May 1982, G52.

Construction of Camp Phillips began with a simple groundbreaking ceremony May 1, 1942. Construction of the air base began on May 5.[65] According to the government report of actual construction dates, preliminary surveying began May 12, 1942 and construction started May 29. Scheduled for completion by March 1, 1943, the project actually was completed December 31, 1942. The contractor officially turned over the camp to the Army Engineers on January 30, 1943.[66] A final revised progress report was completed February 15, 1943 and the Area Engineer issued a certificate of completion June 5, 1943.[67]

According to local newspaper reports, Congress appropriated $44,000,000 for land acquisition in Saline County and camp construction. However, the final Field Progress Report showed that the actual cost of construction was $19,744, 517 and the cost of land was $1,927,060.[68]

By the time of completion, the new Army camp in Saline County was named Camp Phillips. The War Department selected the name in honor of Colonel W.A. Phillips, who founded Salina and served in the Union Army during the Civil War.[69] News of the camp and training activities was published in a newspaper, Cantonment News, first issued on October 9, 1942 and renamed the Prairie Schooner on October 23, 1942 The final issue was published September 1, 1944.

Camp Phillips was a Theater of Operations type camp; the Army carried out basic training at older, established Army bases. The camp was designed to provide housing for 34,016 enlisted men and 2,011 officers as well as 1,726 hospital beds and a

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65 McClure, "No Bugles Will Blow," 11.
66 Oakes, Camp Phillips, 30.
67 Oakes, Camp Phillips, 91.
68 Oakes, Camp Phillips, 94.
69 Salina Journal 6 October 1946, Oakes, Camp Phillips, 98.

3,000-man internment camp. War Department architects planned 2,498 buildings, structures, and training facilities.[70] The architectural and engineering work for Camp Phillips was directed by Wyatt C. Hedrick, Fort Worth, Texas. W. B. Kellogg was the chief engineer. The army awarded a cost-plus contract May 4, 1942, to G. L. Tarlton, Inc. and MacDonald Construction Company, St. Louis, Missouri.[71] The same contractors who built Camp Crowder were directed to build Camp Phillips. The Camp Phillips contractors were Johnson Brothers, Peterson, Busboom and Rauh from Salina and B-W Construction Company from Chicago.

The first construction task was building a railroad spur to construction yards and warehouses one mile west of Smolan. Soon, the first ten of more than one hundred carloads of heavy construction equipment arrived from Camp Crowder, Missouri, on May 26, 1942. Twenty big trucks with construction equipment, supplies, and lumber also arrived at Smolan. Pre-fabricated buildings for construction field offices were shipped to the site.[72]

Construction crews of more than 10,000 laborers worked on the camp. First, they cleared the 3424-acre cantonment site of all hedge fences, trees, wire fences, and utility lines. Then they straightened and leveled all the waterways and drainage channels for camp drainage. All farm buildings were demolished, the salvage lumber was hauled to new building sites, and all scrap material was hauled away and burned. Existing water wells were blasted and filled. To provide material for the construction, contractors opened a rock quarry three miles north of Camp Phillips on the Schneider Brothers and Adolph Swanson farms. They opened a clay and gravel pit on the T. H. Terry farm one

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[70] Oakes, Camp Phillips, 28.
[71] Oakes, Camp Phillips, 32-33.
[72] "Camp Phillips," typed manuscript, Camp Phillips file #1, Salina Public Library.

mile northwest of Bavaria. Major construction also included spur railroad tracks from the main Missouri Pacific line to construction yards and warehouses.

The Army bombing range was located approximately five miles west of the cantonment area. A small arms and rifle practice range was located two-and-a-half miles west of Smolan (on the former August Carlson and C. O. Palmquist farms). A heavy artillery practice range was located three miles northwest of Smolan. Military planners selected isolated sites for storing ammunition. There was underground storage on a hilltop located on the former Louisa Drevets pasture and an ammunition depot on the former Ed Munson farm approximately four miles northwest of Smolan.[73]

Other features of Camp Phillips included military roads, utility lines, building sites, and a large sewage disposal plant in the southeast corner of the camp site. Water wells were drilled on the Smoky Hill River four miles southwest from 9th and Cloud Streets in Salina and a water filtering and pump station was constructed with all located in Walnut Township. The water pipeline extended from approximately six miles west from the pump station to a concrete storage reservoir on top of a hill approximately two miles north of Smolan. The reservoir was fed by four wells and pumps seven miles east of reservoir near the Smoky Hill River. With a capacity of 1,500,000 gallons, the reservoir was located on a high point at the north boundary of the base north of the hospital. A twenty-four-inch diameter water line provided water for Camp Phillips and the Air Field near Salina.[74]

The west side of the building cantonment housed a triangular division including three infantry regiments, an artillery regiment, and engineer, medical, and signal

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[73] "Camp Phillips," typed manuscript, Camp Phillips file #1, Salina Public Library.
[74] Oakes, Camp Phillips, 88.

detachments (approximately 18,000 troops). The east side housed non-divisional troops including tank battalions and tank destroyer battalions (approximately 15,000 troops).[75]

American troops were to have, after basic training, one full year of advanced military training (superior in battle and better chance of survival). Advanced training intended to give each soldier the actual experience of performing each activity on his own. Combat soldiers trained for weeks out on the Camp Phillips reservation.

> The narrow country roads on the reservation were used for long hikes. These hikes increased in length. They started at five mile lengths and continued to ten, fifteen, twenty, and twenty-five miles as the soldier's physical fitness developed with the rigorous training. The rolling Kansas prairie of the reservation, which had been wheat fields, was the site of many marches of long columns of GI soldiers with heavy packs on their backs.[76]

Also on the Camp Phillips reservation, there was a Nazi village replica where combat soldiers practiced an assault in a platoon training exercise using live ammunition. The reservation roads provided driver training courses for truck and other vehicle drivers. Some hills had intricate courses laid out which drivers had to negotiate safely.[77] By June, 1943, the United States was sending large numbers of trained troops to Europe, some as complete divisions, some as replacements.

All four divisions trained at Camp Phillips were assigned to the European theater and served with distinction in combat. The 94th Infantry Division arrived November 20, 1942; the 80th Infantry Division arrived September 10, 1943; the 79th Infantry Division arrived December 15, 1943; the 44th Infantry Division arrived April 19, 1944. The departure dates and destinations of the divisions leaving Camp Phillips were not

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[75] Oakes, Camp Phillips, 113.
[76] Oakes, Camp Phillips, 103-104, 109.
[77] Oakes, Camp Phillips, 110.

announced due to security restrictions. Troops equal to eight infantry divisions trained at Camp Phillips.[78] ***(See Unit Histories.)***

Equal numbers of non-divisional troops trained at Camp Phillips. Nineteen non-divisional units trained at Camp Phillips included combat units such as the 1113th Engineering Combat Group, 817th Tank Destroyer Battalion, 702nd Tank Battalion, 787th Tank Battalion, Headquarter 16th Armored Group. Other non-divisional units stationed at Camp Phillips included the 186th General Hospital, 250th Station Hospital, 249th Station Hospital, and 7th Guard Company. Support units included the 132nd Ordinance Company, 513th Quartermaster (Truck) Regiment, 405th Field Artillery Group, 743rd Sanitary Company, 291st Quartermaster Company (Refrigeration), 273rd Quartermaster Battalion as well as Military Police, Quartermaster, and Headquarters Detachments.[79]

End of Camp Phillips

On August 30, 1944, the War Department declared Camp Phillips one of many surplus training sites. Kansas Senator Arthur Capper commented that, "the war department has been closing military camps for several weeks. Salina is ninetieth declared surplus to the needs of the army out of a total of several hundred." Surplus camps were offered to other branches of government for use and if there were no responses, the war department then disposed of the property. After an exchange of telegrams with Kansas Senators Reed and Capper, Congressman Carlson suggested that the hospital at Camp Phillips, "which generally is admitted to be one of the best in the middle west, be taken over as a hospital for the Midwest area, and that the possibilities of

[78] Oakes, Camp Phillips, 114. See also handwritten note in "Salina--Camp Phillips#2," Salina Public Library.
[79] Oakes, Camp Phillips, 115-116.

making this a demobilization center be probed."[80] Others offered suggestions for continued use of the hospital facility.

The Army hospital at Camp Phillips was planned for casualties returning from the war front. When completed, the hospital was considered by army and government officials to be one of the best in the country. It was air conditioned, with modern plumbing and heating, protected against fire by sprinkling system. There were 132 buildings in the hospital complex.[81] The field hospital was located 1.5 miles northwest from Smolan on what had been the Simon Johnson and Carl Brax farms.[82]

The hospital at Camp Phillips had several phases of use and inactivity--first, a tract of 640 acres surrounding the 1,700-bed hospital was offered to the Veterans Administration in November, 1944 as a rehabilitation facility for disabled veterans. When this use was not pursued, the property was transferred to the Air Force in September, 1946. After the old hospital wards were converted to 220 apartments for Air Force personnel, these structures were known as Phillips Village and they continued in use until 1959. When the government determined in 1964 that agencies had no further use for them, these remaining buildings finally were demolished.[83]

Camp Phillips was officially deactivated on October 27, 1944, by an order from the Army Seventh Service Command Headquarters, Omaha, Nebraska. Few soldiers remained on the post and all in training were gone by November 15. Camp Phillips was turned over to the Army Engineers November 16, 1944.

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[80] "Camp Phillips To Be Closed," Salina Journal 30 August 1944, Camp Phillips clippings file IX, Salina Public Library.
[81] Oakes, Camp Phillips, 86.
[82] "Camp Phillips," typed manuscript, Camp Phillips file, Salina Public Library.
[83] Oakes, Camp Phillips, 130.

Camp Phillips also served as a prisoner of war camp for three thousand Germans and Italians. This internment camp was located one mile southwest of the cantonment area, surrounded by two high wire fences with four guard towers.[84] 350 prisoners of war remained in the camp in November, 1944.[85]

The War Department announced February 16, 1945, that 32,000 acres had been transferred from Camp Phillips to the Smoky Hill Air Base for use as a bombing range and air-to-ground gunnery range for B-29s stationed at the base. That decision ruined the dreams of local farmers who hoped to get back the land purchased by the government in early 1942.[86] The remaining tract included twelve firing ranges and an artillery impact area (also used by the Army Air Corps from Smoky Hill Air Base as a practice bombing range).[87]

Demolition of Camp Phillips began soon after June 23, 1945. As the Salina Journal announced, "bids were opened in Kansas City by the U.S. Army Engineers to dismantle three hundred buildings." The purpose of the contract was to recover usable building materials due to critical shortages. The demolition contract was awarded July 13, 1945, to the General Wrecking Company, St. Louis. The Army conducted a surplus hardware sale followed by a surplus equipment sale on August 16, 1945. Later, in June, 1946, the remaining surplus buildings were removed--some as entire buildings and some as separate panels.[88] In 1972 historian Willis McClure noted that the foundations of the Camp Phillips operations building, barracks, and main control tower remained. The

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[84] Smolan Historical Committee, Highlights of Smolan, Kansas History, 1886-1986 (Smolan Historical Committee, 1986), 13; Salina Journal 25 May 1942; Oakes, 88.
[85] Oakes, Camp Phillips, 122.
[86] McClure, "No Bugles Will Blow," 66, Salina Journal 16 February 1945; "Back to Farm Use," Salina Journal 13 April 1945, Camp Phillips clippings file X, Salina Public Library.
[87] Oakes, Camp Phillips, 129-130.
[88] Oakes, Camp Phillips, 126.

guard tower of the POW camp stood deserted in a field and abandoned bunkers remained near the main north entrance to the Air National Guard rifle range.[89]

[89] When Wills McClure served at the Smoky Hill Weapons Range in 1972, he encountered farmers who still recalled how the Army shoved owners off their land and left it dormant after purchasing the land for between $1 and $15 an acre. McClure, "No Bugles Will Blow," 14.

Impact of Camp Phillips on Saline County

To establish Camp Phillips, the United States War Department condemned and ordered the vacation of one hundred forty-three farmsteads. Construction started with only part of the necessary land purchased. Land owners were mostly cooperative and all of the land needed for the training camp eventually was purchased. However, more than one hundred residents of Falun, Smolan, Bavaria, and Brookville signed a petition on May 11 protesting the construction that they believed would wipe out four towns with their schools, churches, and homes. These residents argued that ample suitable land for the base existed a few miles west of the proposed site where no community life would be affected.[90] In fact, Camp Phillips was located adjacent to Smolan, but all the small towns remained and actually gained many temporary residents. Still the dispossession disrupted existing rural communities.

Several property owners insisted that the government go through condemnation proceedings. For example, the August Olson family lost most of their farm located on the west boundary of Camp Phillips. According to John Sjo, whose parents farmed the land for Olsen, his grandfather, the family lost 320 acres of pasture and the home place of 160 acres.

> Grandpa was one of the ones who strongly objected to giving up his land and particularly at the price offered… He forced the government to go through condemnation proceedings to take his land. He was paid a bit more, but I think being able to stand up to the government was more important to him than was the additional money.[91]

Beginning in May, 1942, officials of the Federal Land Bank appraised the land and awarded an average payment of \$22 to \$25 per acre, although some owners hoped for \$30 to \$35. The farmers and their tenants had to act quickly to move their belongings and to sell or move their livestock and farm equipment. Information for about 95 of the

[90] "Two Angles in Salina's War Project," Salina Journal 12 May 1942, p. 1, col. 3; "Saline Protest In," Salina Journal 15 May 1942, p. 2, col. 5; "Protest Air Base Plan," Kansas City Times 15 May 1942, Clipping file, Salina Public Library.
[91] John Sjo, Taking up the Reins: A Prairie Heritage (Manhattan, KS: John & Irma Sjo, 2000), 246.

137 relocated families indicated that approximately sixty percent moved to other farm sites in Saline, Dickinson, and McPherson counties. Others found new homes in nearby communities such as Brookville, Smolan, Salina, Abilene, and Lindsborg. In addition to individual farm families, five county schools were affected by the land acquisition.[92]

Members of the Smolan Historical Committee recalled that

> some farmers sought other land to buy but others left farming entirely. Residents were given little notice, often less than a month, to move. Wheat crops were left standing in the fields for the government to dispose of. Some wheat was harvested and sold, but other fields were burned along with houses that for many years had been home.

A few houses from the camp area were moved into Smolan. The Smolan Mission Church lost over 60% of its congregation and the Salemsborg Church also lost a large portion of their congregation when their farming members were forced to relocate.[93]

Loss of home and community meant more than a financial cost. As John Sjo concluded, "disbanding a community is a disheartening experience." Although almost all the young people reared in the rural communities were already leaving as soon as they finished high school, they still had a sense of home. When their families lost their land and the government removed all signs of previous habitation, that sense of "belonging to a piece of land was lost."[94]

Years later, the Smoky Hill Museum staff interviewed some displaced residents to collect information on the history of Camp Phillips for an exhibit entitled "Along the Burma Road: Planes, Tanks, and Tractors." Burma Road ran along the east boundary of Camp Phillips. When Verna Brax Smith remembered the change, "we had fifteen days

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[92] R.C. Goodwin & Associates, "Archival Research and Archeological Survey for the Smoky Hill Air National Guard Range," 36.
[93] Smolan Historical Committee, Highlights of Smolan, Kansas History, 1886-1986 (Smolan Historical Committee, 1986, 15.
[94] Sjo, Taking Up the Reins (2000), 193.

notice, we were devastated to think that we were going to have to move." She and her family had to leave land that had homesteaded by her mother's grandparents. "We were thinking that we were going to get a good wheat crop that spring, the wheat looked good. It was just beginning to head and with all this activity, people walking through it, tramping it down," the wheat was trampled by construction and vehicles. They also had to keep their cattle in the corrals and keep everything locked up so people wouldn't walk in and let the animals out. After the war, Verna and her husband Chuck Smith bought the tract where the house had stood, but the south end of the tract near the barracks area of Camp Phillips had concrete foundations remaining and could never be reclaimed.[95]

Sisters Helen and Ruby Johnson found out on May 5, 1942, that the government planned to take their land. The family had occupied the place for forty-two years. They had a sale on June 3--including everything on the farm and the buildings except for the house and barn--and moved to Salina June 8. "Everybody around there had to have sales too, you know, so the sale didn't go very good, because people had to move and didn't know where they were gonna move." The government gave the family "a real good price because ours was a modern house. It was a beautiful wheat crop that year but they wouldn't let us harvest it, they burned it off.[96]

Leo Anderson's family lived two miles west of Smolan and was one of the last families to move out. He recalled, "we thought we had to get out. There was no choice. This is it. You're gonna go. Nobody thought they got a fair price for it [their farms]. It was right before harvest, too. The wheat was actually ripe when they come in there and just tore it up. That made us feel bad too." Most of the Anderson land was used for

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[95] Interview with Verna Brax Smith and Chuck Smith by Mary Mattson, April 26, 1989.
[96] Interview with Helen and Ruby Johnson by Mary Mattson, April 26, 1989 Smoky Hill Museum.

Army buildings. Anderson, a farmer who bought his father's land after the war ended described, "The ground we bought back is a real mess now … The land wasn't worth much when I bought it back [because of the debris].[97]

Lois Larson's family found out on Mother's Day, 1942, that the government would build Camp Phillips. Because their land had changed hands two years earlier and all deeds and titles up-to-date, the Larsons were one of the first to sell to the government and a photo in the Salina Journal showed the exchange of a check. They moved all the buildings and left their farm in one month. After the war, they bought their former property from the government.

The influx of job seekers and new workers affected the surrounding rural communities. During the summer and fall of 1942, when contractors were busy, Lois Larson described that along Burma Road wherever somebody could drive into a field, "there were people camping and sleeping" anywhere they could put up a tent. Verna Brax Smith also remembered people living and sleeping in their cars all over the field south of the creek on her uncle's farm south of Smolan. At the time the graveled Burma Road was crowded and dangerous, "a real rough road."[98]

On the north side of the Range, the family of Tom Holmquist lost two sections of pasture to Camp Phillips. Without that pasture, Holmquist was unable to be a full time farmer in the post-war period. He also pointed out that before Camp Phillips, the creek pastures in the area were used for dairy and horses, but they are not used now. Holmquist concluded that most of the farms now included in the Weapons Range should have been

[97] Smoky Hill Museum, Salina, Kansas. Interview notes for exhibit "Along the Burma Road: Planes, Tanks, and Tractors," June 6--October 22, 1989.
[98] Interview with Lois Larson by Mary Mattson, April 24, 1989, 1-2, Smoky Hill Museum.

grassland and would have been consolidated into larger units of pasture and wheat fields even if the Weapons Range had not remained.[99]

On the west border of the Weapons Range, Lloyd Dauer now lives on land owned by his father when Camp Phillips was constructed. The family's neighbors to the east were August Olsen (previously mentioned by John Sjo) and his brother who lost their farms. Although nearby pasture leases were available to him, Mr. Dauer never leased any government land because the fences were not well maintained and the cattle often mixed on leased pastures. Raising cattle and wheat were the major sources of Dauer's farm income. He also noticed that in the present day, there is more wildlife in the area than before 1942--more coyotes, bobcats, turkeys, deer, and some prairie chicken.[100]

After World War II ended, the government gave some former property owners the opportunity to lease land that had been their farms. First in 1945, 19,000 acres were leased for farming and grazing. Later in 1946, 12,000 acres were declared surplus and sold to be used again for agriculture. This included a tier of sections (one mile wide and seven miles long) north of Camp Phillips and a tier of sections on the southeast side of the camp along the Missouri Pacific railroad tracks.[101] On April 13, 1945, government agents accepted bids representing $16,863.95 on 6,611 acres of surplus land in the Camp Phillips area. Of forty-six tracts in the total acreage, thirty-two tracts were leased. Twelve bids were rejected and two tracts were unbid. The Salina Journal reported that bids covering the entire surplus acreage would be accepted by evening. As reported, the return of the land to farming and grazing "brings back to one Saline county family its old

[99] Interview with Tom Holmquist by Dale Nimz, May 27, 2005.
[100] Interview with Lloyd Dauer by Dale Nimz, May 26, 2005.
[101] Oakes, 130-132.

family home, the Soderburg brothers of Lindsborg, who successfully bid for the 262-acre farm on which the buildings are still standing."[102]

More surplus land on the northern and eastern border of the Camp Phillips was offered for sale to the public by the government in 1948. According to an announcement by C.G. Shull, president of the Federal Land Bank of Wichita and regional director of surplus property disposal, more than 8,000 acres of the 8,302 acres which was offered early in 1948 was re-purchased by former owners and tenants for $370,200.[103] Later that year, county officials reported that tangible property in Saline County was valued at $3,304,704 more than in 1947. This substantial increase was a consequence of the government sale of land to private owners, a bustling housing boom, new business firms, and a boost in Saline County's population.[104]

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102 Salina Journal 13 April 1945.
103 "Ex-Owners Again in Camp Phillips," Salina Journal 13 April 1947. Only two tracts remained--one of 120 acres (former property of Mary Joyce, whose heirs failed to make an offer) and a one-and-a-half-acre which formerly belonged to School District No. 43.
104 "Return of Land in Phillips Area Boosts Valuation," Salina Journal 7 August 1948.

Smoky Hill Air Base (Schilling Air Base)

When the Japanese attacked Pearl Harbor on December 7, 1941, the United States Army had one hundred and fourteen air bases in operation with fourteen more planned. Soon airfields in Kansas were constructed near Salina, Topeka, Pratt, Walker, Herington, Great Bend, Liberal, Independence, Coffeyville, Dodge City, Garden City, and Winfield.[105] The Army Air Force consisted of the 1st--4th Air Forces which were dedicated to the training and defense of the continental United States and the 5th--15th and 20th Air Forces which served as combat air forces. Smoky Hill Air Base was administered by the Second Air Force with headquarters in Colorado Springs, Colorado, from its conception in April, 1942.

During World War II, Smoky Hill was distinguished as a B-29 training base and staging area for bombardment groups going overseas.[106] In 1941 the B-17 had just been introduced, the forerunner of other improved bombers such as the B-19 which later became the B-29. During World War II, the B-29 became the most important long-range heavy bomber in the Air Force. These heavy bombers required extensive facilities and long runways (10,000 feet).[107] Because of the long runways, the Smoky Hill air field was used as a staging area for heavy bombardment units going to overseas stations. B-29 units began to arrive in fall, 1943 and from that time on Smoky Hill was predominantly a B-29 training base.[108]

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[105] McClure, "No Bugles Will Blow," 7; KSHS staff, "The Battle of Kansas," 13:8 (November 1945), 481.
[106] McClure," No Bugles Will Blow," 15.
[107] "U.S. Army and Air Force Wings Over Kansas," Kansas Historical Quarterly 25:3 (Autumn 1959, 347-349.
[108] "U.S. Army and Air Force Wings Over Kansas," Kansas Historical Quarterly (Autumn, 1959), 25:3, 347-349. Women at the Smoky Hill base were organized on May 1, 1943, at the 755th WAAC Post Headquarters Company, see McClure, "No Bugles Will Blow," 35.

Smoky Hill began as "the Army Air Base at Salina." The base became Smoky Hill Army Air Field in December, 1942 and ended as Schilling Air Force Base in 1965.[109] The Army Air Force acquired approximately 2,600 acres of land in 1943 southwest of Salina. The Air Base was declared operational on December 23, 1942 and the name was changed from Salina Army Air Field to Smoky Hill Army Air Field. The first B-17 landed on September 24, 1942 at the site.[110] The first B-29 landed to refuel on July 19, 1943. The 58th Bomb Wing was the first B-29 equipped unit to go overseas. The 20th Bomber Command, organized and trained at Smoky Hill, was the first B-29 unit to bomb mainland Japan.[111] A smaller fleet of C-47 cargo planes was organized and operated from the base beginning in October, 1944.[112]

Several famous B-29 units stationed and trained at Smoky Hill Base. The 20th Bomber Command served in the China-Burma-India theater. The 21sth Bomber Command served from the Marianas to Japan. Other units that trained at Smoky Hill included the 58th Bombardment Wing, the 73d Bombardment Wing, and tactical groups--the 468th, the 499th, and the 39th Bombardment groups.

As the war went on, the new B-29 bombers replaced the B-17. General of the Army, H. H. Arnold, chief of the air force, arrived at Smoky Hill Airfield March 9, 1944 and demanded B-29s by April 15 for bombing Japan. He asked how many bombers could leave next day for India as ordered. Because of modifications, the answer was, none. Arnold exploded and issued a set of "impossible" orders insisting that the last B-29 Superfortresses must fly away April 15. Mechanics flew in and Boeing sent 600 civilians

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[109] Willis J. McClure, "No Bugles Will Blow," 2.
[110] Salina Advertiser-Sun 24 September 1942.
[111] Salina Journal 19 July 1943; Salina Advertiser-Sun 15 April 1948; Salina Journal 16 June 1944.
[112] Salina Journal 25 June 1945.

from Wichita. Men worked outside and as many hours as they could stand up. They met the deadline; the last B-29 left Smoky Hill Air Field April 15 and two months later the planes bombed the Japanese mainland.[113]

Strategic bombing of the home islands by B-29s was the Air Force's main strategy for pounding the Japanese into surrender. On June 15, 1944, forty-seven B-29 crews based in India attacked steel mills in the first B-29 strike against Japan. The Air Force carried out the first B-29 raid on Tokyo November 24. Early in 1945 the B-29 crews began night incendiary raids on Japan. From June to August, 1945, there were five fighting wings with a full strength of 1,000 bombers in action against Japan.[114]

On August 13, 1945, the mission of the Smoky Hill Air Base changed from preparing air crews for overseas duty to a CCTS mission (keeping plane crews together).[115] In a brief period after the war's end on September 1, 1945, the Smoky Hill Air Base was reorganized three times. The Second Air Force became the 15th in April, 1946. Smoky Hill was one of thirty-eight air fields in that division which included fields at Great Bend and Pratt before they were soon deactivated and declared surplus. When the Strategic Air Command was organized later in 1946, the 15th Air Force and Smoky Hill Air Base were included.[116] Postwar reorganization culminated in late 1947 with the designation of the 301st Bomb Wing as the main unit stationed at Smoky Hill. Three units were assigned to the Smoky Hill Base, the 301st, 97th, and 22nd. After transfer from SHAB, the latter two became full fledged wings.

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[113] KSHS staff, "The Battle of Kansas," Kansas Historical Quarterly 13:8 (November 1945), 482-483.
[114] Glines, Compact History of the United States Air Force, 201, 205; Gross, American Military Aviation, 132; Walter J. Boyne, Beyond the Wild Blue: A History of the United States Air Force, 1947-1997 (New York, NY: St. Martins Press, 1997), 369, 371.
[115] McClure, "No Bugles Will Blow," 22.
[116] McClure, "No Bugles Will Blow," 45; Salina Journal 18 April 1946.

Post-war bomb groups at Smoky Hill were designated as "Very Heavy." Primarily composed of B-29s, these groups had the potential to be part of a future nuclear bomber force. Although their missions were classified, post-war temporary duty assignments to Europe and Alaska probably indicated that the Smoky Hill groups did handle atomic bombs. In a post-war consolidation January 9, 1947, the 49th Combat Bombardment Wing (Very Heavy) was organized and assumed responsibility for operating Smoky Hill Air Base. That unit was replaced by the 301st Bombardment Wing November 5, 1947. Also, the 301st Air Refueling Squadron was activated and equipped with the KB-29 tanker which gave greater range to the other bombers.[117] Early in 1946, the Strategic Air Command, Tactical Air Command, and the Air Defense Command were activated.

During 1947, the Air Force was cut to 300,000 men and 10,000 planes. The National Security Act also established the Department of Defense and a separate Air Force.[118] With the establishment of an autonomous Air Force, the base became known as "Smoky Hill Air Force Base" (SHAFB) beginning on January 23, 1948.[119] When the Berlin Blockade began June 25, 1948, the Air Force mobilized C-47 transports to supply the city. The 22nd and 301st Bomb Groups from Smoky Hill Base were assigned to England during the winter of 1948-49 to participate in the Berlin Airlift.[120]

During World War II and for a few years afterwards, Smoky Hill Base had a segregation policy and Negro soldiers were confined to their own barracks area. Negroes

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[117] McClure, "No Bugles Will Blow," 47-49. For unit histories of Air Force units that trained at Smoky Hill (Schilling) Air Base, see appendix.
[118] Glines, Compact History of the United States Air Force, 288, 290.
[119] McClure, "No Bugles Will Blow," 55; Salina Journal 20 November 1947; Salina Journal 23 January 1948.
[120] McClure, "No Bugles Will Blow," 61.

of the 49th Aviation Squadron at Smoky Hill celebrated the first anniversary of their unit in August, 1945.[121] But the Air Force led the way when leaders announced a policy of racial integration April 26, 1948--the first service to do so--before President Harry Truman's executive order on equal opportunity in July, 1948.[122] In mid 1949, Air Force chief of staff General Hoyt Vanderberg ordered all bases to integrate. At Smoky Hill, Colonel Joe Kelly, 301st Bomb Wing Commander, held a meeting and ordered all units integrated "as soon as possible."[123]

Air Force representatives announced on August 28, 1949 that the Smoky Hill Base would be placed on caretaker status by the end of the year.[124] The 301st Bomb Wing moved to Barksdale AFB, Shreveport, LA, to be equipped with new B-47 jets.[125] In the competition for active status, the long runways gave Smoky Hill special value, but the base lacked permanent buildings. Perhaps a more important factor in the change was the lack of political clout. At a time when Democrats controlled Congress, Kansas had one new Republican Senator and one in poor health who were unable to protect the base in central Kansas. Smoky Hill Air Base was inactive from December 8, 1949 to August, 1951.[126]

For a time, local ambition was placated by the announcement late in 1949 that Salina was being considered as a site for the planned Air Force Academy. However, one hundred other sites were considered including eight in Kansas. The town and air base

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[121] McClure, "No Bugles Will Blow," 35.
[122] Boyne, Beyond the Wild Blue, 375.
[123] McClure, "No Bugles Will Blow," 80, Salina Journal 23 July 1949.
[124] McClure, "No Bugles Will Blow," 64.
[125] McClure, "No Bugles Will Blow," 112. Salina Journal 30 August 1949.
[126] McClure, "No Bugles Will Blow," 114, 118.

were surveyed on January 5, 1950 by a three-man team, but the Academy was located in Colorado Springs.[127]

In just a few months, however, the outbreak of the Korean War created a need for Smoky Hill Air Base. When North Korea invaded South Korea on June 25, 1950, United Nations forces fought back. Eventually, the conflict settled into a stalemate at the 38th Parallel and the opposing forces finally concluded a permanent cease-fire on July 26, 1953.

Early in 1951, local representatives questioned why the Air Force planned to build another air base at the Wichita Municipal Airport. Kansas politicians argued that the Smoky Hill Air Base should be put to use. They emphasized its potential value in the Korean War effort. Built to handle B-29s during the war, Smoky Hill was one of the largest fields in the country with runways two-and-a-half miles long and five hundred feet wide.[128]

To meet the need for training air crews for the war, Senator Andrew Schoppel announced on June 21, 1951 that the Smoky Hill Base would be reopened. He explained that 1,000 officers, 6,000 enlisted men, and 800 civilians would be assigned to the Smoky Hill Base. The mission would be combat training with medium and heavy bombers.[129] Smoky Hill re-opened August 2, 1951. The gunnery range was not ready but planes from Forbes AFB, Topeka, began using the range for practice as it was.[130]

Because more combat bombers were needed, the 310th Bomb Wing was reactivated at Forbes Air Base and later sent to Smoky Hill for training. The 40th Bomb

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[127] McClure, "No Bugles Will Blow," 120-121; Salina Journal 13 December 1949; 5 January 1950.
[128] "The Case of the Missing Kansas Air Base," Newsweek 12 February 1951, 19.
[129] McClure, "No Bugles Will Blow," 128; Salina Journal 21 June 1951.
[130] McClure, "No Bugles Will Blow,"129.

Wing also was assigned to Smoky Hill. By early 1952, construction was going full blast and Smoky Hill reopened in the spring as a Strategic Air Command bomber base. Although Salina had been an agricultural city for most of its history, with the return of the Air Force in 1952, "the prevention of war became its major industry."

The first B-29 (the same plane that occupied the base from 1944 to 1949) landed again at Smoky Hill Air Base on September 11, 1952. The Air Force expected to move B-47 bombers to the base by late 1952. Also, the first KC-97 four-engine propeller-driven refueling tanker landed November 14, 1951.[131] The 310th Wing arrived September 4, 1953 from Forbes Air Force Base. Each of the two bomb wings at Smoky Hill had 45 planes assigned to the base. These were B-47 medium bombers with three-man crews. The first B-47 arrived June 2, 1954.[132]

In 1956 SHAFB was one of 98 continental and 13 overseas air bases listed as "permanent." Several criteria supported this classification--the firm and continuing need for the base, exclusive Air Force or federal control of the base, clear government title to the land, and strong community support. SHAFB had particularly good community relations; the city sponsored "honor the uniform week" and the base hosted community open houses.[133] By this time, Smoky Hill was considered one of the top bases in the Strategic Air Command. During the late 1950s and early 1960s, Schilling was part of the Strategic Air Command's Alert Force, a group of planes ready to be air-borne within fifteen minutes of a warning.[134]

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[131] The KC-97 was stationed at Smoky Hill until 1963. McClure, "No Bugles Will Blow," 153; Salina Journal 19 January 1952.
[132] McClure, "No Bugles Will Blow,"133, 146-147, 155. The Air Force gave the reactivated 310th and 40th Wings the right to claim the history of the same units in World War II in 1955, see Salina Journal 15 July 1955.
[133] McClure, "No Bugles Will Blow,"186.
[134] McClure, "No Bugles Will Blow,"183.

During this period, the base also was renamed in honor of Colonel David Carl Schilling, World War II fighter ace from Leavenworth who was killed in an auto crash. On April 6, 1956, the Salina Journal announced the beginning of a campaign to change the base's name to honor this Air Force hero. The change was intended to end negative associations from World War II and symbolize a new era for Smoky Hill with a significant role in national defense.[135] Senator Frank Carlson's office announced the official decision to change the name November 1, 1956 and a formal ceremony was held March 15, 1957.[136] Within the Air Force, the high command moved Smoky Hill from the 8th to the 15th Air Force on January 1, 1957.

After the announcement early in 1959 of an upgrade from B-47 to B-52 bombers, the future of Schilling Air Base seemed assured. Also, the Air Force planned to construct eight to ten Atlas ICBM sites with two Nike rocket bases to guard the base. A complex of 12 Atlas ICBM installations was completed in 1962, but the promised B-52s never arrived. The 40th Bomb Wing was transferred to Forbes Air Base on May 23, 1960, to make room for construction to strengthen the Schilling runways for the heavier B-52s and KC-135s.[137] Contractors completed work on the runways November 13, 1961. The total effective length necessary for B-52s was 13,330 feet. With this improvement, the Schilling runways were capable of handling any aircraft in the United States.[138]

Later on March 1, 1962, the 310th became a Strategic Aerospace Wing (SAW) combining missiles, bombers, and tankers into a single wing. The change reflected the integration of functions in the evolving Air Force. Although the Atlas F missiles went

[135] McClure, "No Bugles Will Blow," 249.
[136] McClure, "No Bugles Will Blow,"251.
[137] Salina Journal 1 April 1959; McClure, "No Bugles Will Blow," 267, 339.
[138] McClure, "No Bugles Will Blow," 379.

into operation, Schilling did not get the two Nike installations. On January 8, 1963, the Army announced on January 8, 1963 that Nike missiles were obsolete and the installation work stopped.[139] This was the first in a series of disappointments for local supporters of Schilling Air Base. The base did receive its first KC-135 jet tanker in March, 1964. Later, on October 20, the Air Force announced that B-52s would begin arriving on March 1, 1965. The 310th SAW was projected to become a heavy bomber wing.[140]

As early as 1948, the Kansas City Star noted the influence of the military base reporting that it "brought the world to Salina's doorstep." At this time, the town's population was 20,000 with an additional 7,000 personnel associated with the base.[141] By 1957, Schilling Air Force Base was Salina's major industry and the town's largest employer. In 1961 the base occupied 37,410 acres in Saline County (including the Gunnery Range, Phillips Village, and missile bases) and had an annual payroll over $25 million.[142] In 1964 personnel stationed at Schilling represented approximately twenty-five percent of the county population.

Because of the base's vital economic importance to Saline County, local residents were astonished to hear a radio news bulletin November 18, 1964 announcing the closing of Schilling Air Base by June 30, 1965. Secretary of Defense Robert McNamara announced that Schilling was one of 95 U.S. bases to be reduced or closed. The Air Force recommended closing Schilling because the base had older weapons systems (B-47s and Atlas F missiles). The Minuteman missile, successor to the Atlas, was ten times cheaper. Perhaps more important, the action was designed to release a group of trained

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[139] McClure, "No Bugles Will Blow," 348, 354.
[140] McClure, "No Bugles Will Blow," 355, 361, 379.
[141] Kansas City Star 1 August 1948; McClure, "No Bugles Will Blow," 93.
[142] McClure, "No Bugles Will Blow," 382, Salina Journal 16 March 1961.

personnel for the escalating Vietnam conflict. On November 19, 1964, the Department of Defense announced that the B-47 bomb wing would be inactivated by March, 1965. The last Atlas missile was pulled from the silo on March 7, 1965. All the B-47s were moved from Schilling by March 31. The last KC-135 tanker left April 15. The Air Force deactivated the 310th SAW on June 25, 1965 ending the much significant history of this unit.[143] Maintenance and caretaking activity on the base continued until April 3, 1967.[144]

Schilling Air Force Base officially closed on June 26, 1965, four days ahead of schedule. During the spring of 1965, a local Development Council drafted a land use plan for the site calling for a new municipal airport, a vocational-technical high school, a technical institute, and a second campus for Kansas Wesleyan University. Beech Aircraft Company leased hangars for production work. The Kansas State Highway Patrol opened its division headquarters in July of 1965 and the Westinghouse Corporation announced the opening of a fluorescent lamp factory at the old base with an estimated employment of 300-500 workers.[145] By 1967 interstate highways I-70 and I-35 converged at Salina providing important transportation advantages for manufacturing and distribution.[146]

By 1980 the former air base supported a diversified industrial center that employed one of every four workers in Salina. Industries on the old air field included Westinghouse, Federal Mogul (ball bearing plant), General Battery, Beech Aircraft

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[143] McClure, "No Bugles Will Blow," 439.

[144] McClure, 423-432; Robert A. McAuliffe, The Salina Story: Swords into Plowshares (Washington, D.C.: Department of Defense, 1966), 7.

[145] John E. Lynch, Local Economic Development after Military Base Closures (New York: Praeger Publishing, 1970), 196-198.

[146] Work on an interstate highway system began in 1956 with the designation of Interstate 70, an east-west route following U.S. Highway 40 from Kansas City to Oakley. Then a section of Interstate 35 was planned following U.S. Highway 81 between Wichita and Salina. Both used sections of the Kansas Turnpike. Sherry Schirmer and Theodore A. Wilson, Milestones: A History of the Kansas Highway Commission (Topeka, KS: Kansas Department of Transportation, 1986), 4-29, 5-12

Company, and Tony's Pizza (frozen products, local company).[147] Today the site of the former Air Base remains a vital center of economic development for Saline County.

[147] Dan Bearth, "Salina's Big Leap Out," Kansas Business News (November, 1980), 34-36.

Smoky Hill Weapons Range

Long after the closing of Camp Phillips and Schilling Air Base, the Smoky Hill Weapons Range continues in use as a material legacy of the United States military presence in Saline County. The Smoky Hill Air Base, northeast of Camp Phillips, used land on the southwest side of the camp as a gunnery range. This tract was subject to the mission secrecy that accompanied the World War II effort. Salvo, the Smoky Hill Army Air Base newspaper, reported on October 9, 1943, that the gunnery range was located somewhere near the base. Twenty-one men were stationed there to maintain it and the Operations Center was located in the area that had been Camp Phillips warehouses when the camp was constructed.[148]

Not until February 16, 1945 did the Salina Journal announce to the public that the War Department had transferred 32,000 acres from Camp Phillips to the Army Air Base for use as a bombing range and an air-to-ground gunnery range for the B-29s stationed at the air base. In that report, Colonel Ralph W. Rodieck, Base Commander, warned civilians against trespassing on the range because of the danger. He also informed local farmers that they would have to wait at least until the end of the war to possibly repurchase the land which had been condemned and included in Camp Phillips.[149]

In fact, the Gunnery Range remained an integral part of Smoky Hill Air Force Base after World War II. During this period, the tract was known as the OQ "ordinance qualification" Gunnery Range.[150] There was less need to keep secret activities at the range. As a warning to local farmers, the Salina Journal published a map on July 9, 1947,

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148 McClure, "No Bugles Will Blow," 13.
149 McClure, "No Bugles Will Blow," 14.
150 "No Bugles Will Blow," McClure cited an interview in the Salina Journal 28 September 1958 as the explanation of this name, 258.

showing where the planes were supposed to be practicing their aim on stationary targets.[151] When the Smoky Hill Air Base was deactivated in 1949, use of the gunnery range also ceased.

After the Korean War broke out in 1950, thirty men were detailed to the site in March, 1951, to reactivate the range. During the summer of 1951, men from Forbes AFB, Topeka, worked at the range and by August 2, 1951, there were sixty men working on the range and living in barracks on the air force base.[152] Four targets had been prepared by December 16, 1951, and were being used by B-29s from continental Air Force bases.[153] In 1955 Smoky Hill was the only practice range available in the 8th Air Force.[154]

Although the air-to-ground target practice on the gunnery range received the most public attention, there was another function left over from the training function of Camp Phillips. On January 15, 1953, the Salina Advertiser-Sun described the Basic Rifle Range located two miles southwest of old Camp Phillips. Regulations required "every airman to qualify at least once during every calendar year" with the weapon assigned.[155]

In 1955 members of the 2700th Explosive Ordinance Disposal Squadron from Hill AFB, Utah, began "a routine clearance of all unexploded ordinance which had accumulated over the past few years." This was the first time the gunnery range had been cleared since opening during World War II. The detail reported finding an average of fifteen live shells and bombs a day.[156]

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[151] McClure, "No Bugles Will Blow," 67.
[152] McClure, "No Bugles Will Blow," 123.
[153] McClure, "No Bugles Will Blow," 137. Salina Journal 16 December 1951.
[154] McClure, "No Bugles Will Blow," 138. Salina Journal 23 August 1955.
[155] McClure, "No Bugles Will Blow," 137.
[156] McClure, "No Bugles Will Blow," 138-139. Salina Journal 30 October, 1955 and Advertiser-Sun 20 October 1955.

During this period, in 1957, eighteen sections of grazing and hay land were opened for leasing in five parcels amounting to 11,700 acres. One year later, and an additional 1,446 acres were opening for biding.[157]

In 1958 the Air Force announced a planned expansion of the gunnery range which would serve all of the Strategic Air Command because the Air Force intended to close ranges in Florida and Arizona. Plans called for the installation of B-52 and B-47 turrets for practice firing at drones or flying targets. By early 1959, there were fifty-two maintenance personnel, pilots, and instructors at the range; about seventy-five men trained at the range and that number was expected to grow to 125 a month.[158] The range was operated by the 310th Operations Squadron. In 1961, the Air Force allocated $1.3 million for construction on the range. This included an extension of the water system from the Air Base to the range, construction of a sewage disposal facility, additions to buildings and new buildings, and roads.[159] In November of 1962, sealed bids were announced for the private leasing of approximately 2,110 acres of range land for grazing or restricted agricultural purposes by the U.S. Army Engineers, which oversaw the leasing for the Air Force. These were five-year leases beginning January 1, 1963.[160]

Activity on the gunnery range dramatically increased after the Air Force announced on October 24, 1963 that the range would be used extensively beginning November 1 by the Tactical Air Command (TAC), SAC, Air National Guard, and Air Force Reserve units. For an indefinite period, the range would be used seven days a

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[157] McClure, "No Bugles Will Blow," 257, Salina Journal 19 July 1957, 3 April and 25 September 1958.
[158] McClure, "No Bugles Will Blow," 258, Salina Journal 14 August and 5 October 1958; Salina Journal 22 March 1959.
[159] McClure, "No Bugles Will Blow," 353, Salina Journal 19 January and 3 November 1961.
[160] McClure, "No Bugles Will Blow," 354, Salina Journal 23 November 1962.

week, twenty-four hours a day. On July 1, 1964, the OQ Gunnery Range was transferred from SAC to the TAC.[161]

Salinans were assured on December 8, 1964 that the bombing range would not be affected by the closing of Schilling AFB. Some were disappointed that the range would not be sold to private owners and returned to the local tax rolls. At that time, there were twenty-three men assigned to operate the range (extended TDY from McConnell AFB, Wichita, Kansas). Approximately 32,000 acres were included in the range and approximately 27,000 acres were leased to farmers for agricultural purposes.[162] After the air base closing, the detachment had to live on the range. Two buildings at the north end were remodeled to make a dining hall and a forty-man dormitory.[163]

While the Air Force was closing Schilling Air Force Base, military leaders considered acquiring an additional 2,200 acres for the bombing range. This additional acreage was needed as a safety corridor for tactical fighter planes in their approach to targets on the range.[164] However, the Salina Journal criticized this move in a July 5, 1966 editorial:

> The Air Force should prove a critical need for national defense before it is allowed to confiscate 2,200 acres of crop and pasture land in Saline and McPherson counties as an addition to the existing Smoky Hill bomb range. That the need has not been studied thoroughly is perhaps indicated by the failure of the Air Force to consult county commissioners or other authorities in either county before making its request to the Congress. This region has a long record of excellent cooperation with the Air Force and the Journal's questioning of the new proposal should be understood in that context. If patriotism demands the sacrifice of more productive land, we must be for it.[165]

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161 McClure, "No Bugles Will Blow," 354. Salina Journal 28 June 1964.
162 McClure, "No Bugles Will Blow," 445. Salina Journal 8 December 1964 and 10 January 1965.
163 McClure, "No Bugles Will Blow," 446. Salina Journal 23 September 1965.
164 McClure, "No Bugles Will Blow," 447, Salina Journal 1 July 1966.
165 Salina Journal 5 July 1966.

Despite the editorial, the Air Force went ahead rapidly. On July 24, 1966, the Journal reported that the House Appropriations Committee had approved funding for the acquisition of the land and the realignment of targets at the range. In part to accommodate several retiring airmen from Schilling, personnel reached a high of between 165 and 200 airmen assigned to the bombing range during 1966. After that the range was operated with fewer and fewer personnel. In 1972 the range was leased to the Kansas Air National Guard. The property was assigned to the 184th Tactical Fighter Group (TFG), McConnell AFB, Wichita, Kansas, and about twenty-four guardsmen operated the facility.[166]

Air National Guard

In October, 1973, the 184th Tactical Fighting Group assumed responsibility for the Smoky Hill Range. Major General Edward R. Fry served as Kansas Adjutant General 1973-1980. After WW II, he was instrumental in the reactivation of the 127th Fighter Squadron, Kansas ANG, known today as 184th Bomb Wing. In the 1950s, he worked to obtain a second Air National Guard unit for the state--the 117th Fighter Interceptor Squadron. That unit today is the 190th Air Refueling Wing (Forbes Field, Topeka). In 1973, General Fry oversaw the transfer of the Smoky Hill Weapons Range from the Air Force to the Air National Guard.[167]

After the end of World War II, the 127th Observation Squadron was reorganized in September, 1946, and designated the 127th Fighter Squadron with an assignment of F-51 Mustangs. At the end of 1949, the unit received the F-84 Thunderchief. With the outbreak of the Korean Conflict, the unit mobilized in October, 1950. The redesignated

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[166] McClure, "No Bugles Will Blow," 448.
[167] See Museum of Kansas National Guard, http://skyways.lib.ks.us/museums/kng/tagfry.html 9/21/2004.

127th Fighter Bomber Squadron returned to Wichita in July, 1952. The 127th was assigned F-80 Shooting Star jet fighters in June, 1954 and designated as the 127th Fighter Interceptor Squadron. Planes were converted to the F-100 Super Sabre and the unit was designated the127th Tactical Fighter Squadron April 1961. Reorganized as the 184th Tactical Fighter Group in October 1962, the unit was deployed to South Korea in January, 1968 following the North Korean seizure of the U.S.S. Pueblo. The unit was released from active duty in June 1969. The unit was designated the 184th Tactical Fighter Training Group and assigned the F105 "Thunderchief" on March 25, 1971.

The 184th received their first F-4D"Phantom" August 7, 1979 and activated a squadron of F-16A/B "Fighting Falcon" aircraft in January, 1987. The unit was designated the 184th Fighter Group in March, 1992 and became a part of the Air Education and Training Command in July, 1993. The 184th Fighter Group was designated as the 184th Bomb Group in July 1994 and redesignated the 184th Bomb Wing in October, 1995. Presently, the 184th is the only Air National Guard unit with a B-1B heavy bomber mission flying a fleet of ten planes now located at McConnell AFB. The 184th is affiliated with Air Combat Command.[168]

Another Air National Guard unit in Kansas, the 190th ARW, began as the 440th Bombardment Squadron (Light) during World War II. The unit flew missions in Africa, Sicily, Italy, and France. At the end of the war, the unit was reorganized as the 117th Bombardment Squadron. After a hiatus, the unit was reactivated as the 117th Fighter Interceptor Squadron, Kansas Air National Guard, in 1957. The squadron flew F-80s from Hutchinson Naval Air Station and was redesignated the 190th Tactical Reconnaissance Group in 1962. The group transferred to Forbes AFB, Topeka in 1967.

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[168] See http://www.afakansas.org/184/html 6/24/2005.

In April, 1974, the unit converted to EB-57B aircraft. The 190th was equipped with the KC-135 Stratotanker in 1978 beginning the current air refueling mission. The 190th was the first unit to arrive at Jeddah, Saudi Arabia for service during operations Desert Shield/Desert Storm. Since September 11, 2001, the unit has been active in Operations Noble Eagle, Enduring Freedom and Iraqi Freedom.[169]

After the Warsaw Pact, the military coalition of Soviet Bloc countries, disbanded in 1991, the strategic bomber crews finally stood down from the long round-the-clock readiness for nuclear war September 27. Later, on June 1, 1992, the proud Strategic, Tactical, and Military Airlift Commands were ended and the Air Force was reorganized as the Air Mobility Command and Air Combat Command. By 1996 active duty-personnel and aircraft in the Air Force had dropped by thirty-five per cent from the previous decade. Active duty personnel declined from 607,000 to 388,200. The Air National Guard and Air Force Reserve personnel declined from 263,000 to 181,000. At the same time, however, the Air National Guard was integrated in "Total Force" operations to significantly increase Air Force capability.[170]

Currently, the Air National Guard Units in Kansas (Kansas State Headquarters, Topeka, Kansas), include the 127 WF (Forbes Field), 134 ACS (McConnell AFB), 184 ARW (McConnell AFB), 184 ARW, Det 1 (Salina, Kansas), and the 190 ARW (Topeka, Kansas.) The Smoky Hill Air National Guard Weapons Range is operated by personnel of the 184th Bomb Group. Located 15 miles west of Salina, within a buffer of 34,000 acres, is a 12,000-acre target area. There are dual conventional ranges, three large tactical ranges, and four drop zones for cargo aircraft. This is the largest of fifteen

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169 See http://www.kstope.ang.af.mil/history/history 190th.htm 6/24/2005.
170 Boyne, Beyond the Wild Blue, 282, 319, 417.

bombing ranges operated by the Air National Guard. The Smoky Hill Range provides the most realistic air-to-ground training available for all types of military aircraft. The range is most commonly used by the 138 Fighter Wing flying F-16s modified to deliver precision guided munitions. There are only three ANG air-to ground ranges in the United States where pilots can practice these deliveries. The 184th also carefully manages the natural and cultural resources of the Range, protecting the environment and providing recreational opportunities while generating revenues from agricultural leases.[171]

[171] See http://www.ksmcco.ang.af.mil/RootFiles/184BW/units/smoky/

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U. S. Military Training in Saline County--Unit Histories

Infantry Divisions, 1942-44

From 1942 to 1944, four U. S. Army infantry divisions trained at Camp Phillips, Kansas. This training was one of the final steps in preparation for combat in the European theater. All four units contributed to the liberation of Europe from Nazi control; they were among the small number of divisions that actually carried out the ground combat in Europe. The major units trained at Camp Phillips were the 94th Infantry Division, the 80th Infantry Division, the 79th Infantry Division, and the 44th Infantry Division.

94th Infantry Division

The 94th Infantry Division was activated September 15, 1942 at Fort Custer, Michigan, and sent overseas on August 6, 1944. Enlisted and officer cadres were drawn from the 77th Infantry Division stationed at Fort Jackson, SC. To this skeleton force, ROTC lieutenants and Officer Candidate School graduates were added to give the required number of officers. Range facilities at Fort Custer were inadequate, so the division moved to Camp Phillips, Kansas, in November, 1942. All arrived by Nov. 18. Camp Phillips was a "theater of operations" type camp. According to the unit historian, the site was "bleak, windswept, and on the whole generally depressing." Basic training began three days after Christmas. As reported,

> “the Division's stay at Camp Phillips was one of the most severe winters Kansas had ever experienced. It impeded training and caused acute misery among the troops. Out-of-doors activities were conducted in zero and sub-zero weather. At

> times the firing ranges were used under near-blizzard conditions. The coming of spring and early summer brought other extremes. First, it was rain and glue-like mud, then oppressive heat and blinding dust storms."[172]

After months of field training at Camp Phillips, the 94th Division moved in August, 1943, to the Second Army Maneuver Area in central Tennessee. On August 6, 1944, the division loaded and left New York on the converted luxury liner Queen Elizabeth. The troop ship arrived at Greenock, Scotland, near Glasgow, on August 11, 1944.[173]

The 94th landed on Utah Beach September 4, 1944 and opened its first command post in Normandy a few miles away. Soldiers moved into Brittany to contain some 60,000 German troops besieged in the Channel ports of Lorient and St. Nazaire. The 301st Infantry Regiment was the first to see combat on September 10, 1944. Over time, the 94th inflicted over 2,700 casualties on the enemy and took 566 prisoners before being relieved on New Year's Day 1945. Moving west into the Saar-Moselle Triangle, the Division seized Tettinger and Butzdorf on January 14. Counter-attacks followed and Butzdorf, Berg, and most of Nennig changed hands several times before being finally secured. On the 20th, an unsuccessful battalion attack against Orscholz, the eastern terminus of the Siegfried Switch Line, resulted in the loss of most of two companies. In early February the division took Campholz woods and seized Sinz. On February 19, units of the division stormed the heights of Munzigen Ridge, backbone of the Sarr-Moselle Triangle. Moving forward, the 10th Armored and the 94th Infantry secured the area from Orscholz to the confluence of the Saar and Moselle River by February 21, 1945. Then the division attacked across the Saar establishing and expanding a bridgehead.

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[172] Laurence G. Byrnes, History of the 94th Infantry Division in World War II (Nashville, TN: Battery Press, 1st ed. 1948, reprinted 1982), 2.
[173] Byrnes, History of the 94th Infantry Division, 1-8, 38.

By March 2, 1945, the Division stretched across a ten-mile front, from Hocker Hill on the Saar through Zerf, and Lampaden to Ollmuth. A German attack near Lampaden penetrated the front but was repulsed. On March 13, leading the XX Corps, the 94th broke out of the bridgehead and drove to the Rhine reaching the river March 21. With units of the 12th Armored Division, the 94th took Ludwigshafen. Then the division moved by rail and trucks to the vicinity of Krefeld, Germany, taking responsibility for containing the west side of the Ruhr pocket from positions along the Rhine. When this pocket of resistance was taken in mid-April, the 94th was assigned military occupation duties, first in Krefeld and later in the Dusseldorf areas. On May 7, 1945, the German High Command signed an unconditional surrender and the war ended in Europe.

The 94th Division was engaged in combat from September 10, 1944 to January 1, 1945; January 7, 1945 to March 25, 1945; April 2 to April 18, 1945. The division lost 1,-087 men and officers killed in action or died of wounds. There were 4,684 men wounded or injured in battle. 113 men were missing. There were 5,028 casualities due to trench foot, frozen feet or other non-battle causes. The 94th Division took 26,638 German prisoners and liberated hundreds of cities, towns, and villages.[174]

After serving 209 days of combat, the 94th Infantry Division returned to the United States February 6, 1946 and the division was inactivated February 9. Division commanders were Major General Harry J. Maloney (September 1942-May, 1945), Brigadier General Louis J. Fortier (June-July, 1945), and Major General Allison J. Barnett (August 1, 1945 to inactivation).[175]

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[174] Byrnes, History of the 94th Infantry Division, 477.
[175] "Combat Chronicle--94th Infantry Division," Accessed 11/11/2005 at http://www.army.mil/cmh-pg/lineage/cc/094id.htm.

80th Infantry Division

The 80th Division was constituted August 5, 1917 and activated at Camp Lee (now Fort Lee), Virginia. Made up primarily of draftees from Virginia, West Virginia, and Pennsylvania, the new division was nicknamed the "Blue Ridge Division." Deactivated after the Armistice, the 80th Division again was ordered to active service on July 15, 1942. The soldiers reported to Camp Forest, Tennessee, and later trained from June through August, 1943, at Camp Phillips, Kansas. After maneuvers at the Army Desert Training Center in the Mojave desert of California-Arizona, the 80th Division embarked on the *Queen Mary* from New York City on July 1, 1944. The division arrived at Greenock, Scotland on July 7 and went to Northwich, England for more training.

The 80th Division was assigned to the XII Corps, Third Army and landed on Utah Beach August 5, 1944. Three days later, the division advanced toward LeMans to help stop a German counter-attack and took over the LeMans bridgehead. During the next nine months, the 80th served in General George S. Patton's Third Army, fighting its way across Northern France, Belgium, and into Germany. By war's end, some units of the 80th had moved as far as Austria and Czechoslovakia. Along the way, the Division saved the city of Luxembourg from German troops commanded by Field Marshal Gerd von Rundstedt during the Battle of the Bulge (the Ardennes offensive) by making a 150-mile motorized march in just 36 hours to form a defensive line around the city.

The Battle of the Bulge began December 16, 1944, when the Germans attempted a breakthrough to seize Antwerp and split the Allied armies. With the 4th Armored and 26th Infantry Divisions, the 80th Division's 2nd Battalion, 318th Infantry, and the 1st Battalion, 319th Infantry, helped relieve American forces surrounded at Bastogne.

Veterans of the 80th Division recalled that the Bulge was their hardest battle because they faced two fierce enemies--the Germans and the weather. The bitter cold sapped the strength of men and machines. As Lieutenant John Ingles wrote, "slowly, 80th Artillerymen mastered the skills of keeping warm and fighting in the winter. We learned to camouflage our vehicles by painting them with blotches of black and white to match the pattern of fields and woods in the snow." On January 28, the last day of the Battle of the Bulge, the 80th received a ten-day rest from combat.[176]

Early in February, 1945, the 80th Division joined a force of 4,000,000 men in three army groups, seven armies, twenty-one corps and seventy-three divisions supported by 17,500 combat aircraft in the final attack on Germany.[177] The division crossed the Our and Sauer rivers into Germany during the first week of February. Because the combat efficiency of the 80th was rated excellent, the division was assigned important tasks. In early April, the 80th crossed the Rhine River and took the industrial city of Kassel. In Patton's book, War as I Knew It, the general commented, "the 80th Division of the XX Corps resumed the attack on Kassel and had a rather rough time of it, but whenever we turned the 80th Division on anything, we always knew the objective would be attained."[178] Proceeding eastward, the division also captured Gotha, Erfurt, and Weimar-Buchenwald (location of the infamous concentration camp). The 80th Division was recognized as one of the liberating units by the United States Holocaust Memorial Museum. By May, 1945, the 80th Division moved into Austria where they captured

[176] Robert T. Murrell and Edgar E. Bredbenner, Jr., eds., 80th "Blue Ridge" Infantry Division 2nd ed. (Paducah, KY: Turner Publishing, 1991), 44-46.
[177] 80th "Blue Ridge" Infantry Division, 47.
[178] 80th "Blue Ridge" Infantry Division, 53.

large numbers of German soldiers who preferred to surrender to the Americans rather than the Russians.

By V-E Day the 80th Division had captured more than 200,000 enemy soldiers. Few American divisions could match the combat record of the 80th Division. There were twenty-six infantry divisions, two airborne divisions, and fourteen armored divisions assigned to the Third Army. Five of those divisions fought through practically all of the Third Army's campaigns. These were known as "Patton's Iron Men," the 4th Armored--280 days of combat, 5th Infantry--276 days, 80th Infantry--274 days, 90th Infantry--272 days, 6th Armored--252 days. Reportedly, soldiers of the 80th fired the last shots of the European war in Czechoslovakia just before General Patton issued his cease-fire order at 0800 of May 8, 1945. Officially, the 80th Division lost 3,038 men killed in action. 442 died of wounds and 12,484 were wounded. 1,077 men were captured and 488 were listed as missing (476 returned to duty).[179]

80th Division Commanders were Major General Joseph D. Patch (July 1942-March 1943), Major General Horace L. McBride (March 1943-October 1945), and Major General Walter F. Lauer (October 1945-December 1945). The division returned to the States in January 1946 and was placed on inactive status.[180]

[179] 80th "Blue Ridge" Infantry Division, 56.
[180] "History of the 80th Division," 5 pages. Accessed 2/24/2005 at http://www.usarc.army.mil/80thDiv/DIVHIST.htm ; "Combat Chronicle" 2 pages. http://www.army.mil/cmh-pg/lineage/cc/080id.htm

79th Infantry Division

First organized and named in World War I, the 79th Infantry Division was activated again on June 15, 1942, with a cadre from the 4th Infantry Division. The division arrived at Camp Phillips, Kansas on December 4, 1943, for further training under winter conditions. The 79th moved to Massachusetts on March 31, 1944, sailed on the *Queen Mary,* and arrived in Liverpool April 7, 1944.

The 79th Division landed at Utah Beach, Normandy, on June 12-14, 1944. Arriving on D-Day +8, the division reinforced the first wave of American troops who had landed on the Normandy beaches. The division entered combat June 19 with an attack on the high ground west and northwest of Valognes and the high ground south of Cherbourg. The 79th entered Cherbourg on June 25, the first city of any size liberated in France. The division held a defensive line at the Ollonde River until July 2 and then attacked taking La Haye du Puits in house-to-house fighting July 8. On July 26, the division attacked across the Ay River, took Lessay, crossed the Sarthe River and entered LeMans August 8. The advance continued across the Seine on August 19. The 79th was the first division to have soldiers (engineers) cross the Seine.[181] German counter-attacks were repulsed from August 22-27 and the Division reached the Therain River August 31. Moving quickly to the France-Belgium border, the 79th encountered heavy resistance in taking Charmes in street fighting September 12. The division cut across the Moselle and Meurthe rivers September 13-23, cleared the Foret de Parroy in a severe engagement September 28-October 9, and attacked to win high ground east of Embermenil October 14-23. During this campaign, the division's combat teams met the best troops the

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[181] The Cross of Lorraine: A Combat History of the 79th Infantry Division 1st ed. 1946 (Nashville, TN: Battery Press, 1986), 18, 27, 48.

German Army commanders could throw into the battle but the enemy suffered three times as many casualties.[182]

The 79th was relieved on October 24 for rest and training at Luneville for the next sixteen days. Then the division was assigned the task of forcing a passage through the Vosges Mountains and driving the enemy out of Alsace. With an attack November 13, the division captured Sarrebourg with the assistance of the 44th Infantry Division. Also, the First Battalion of the 318th Regiment (79th) participated in the capture of Strasbourg with the Second French Armored Division. This attack carried the 79th across the Vezouse and Moder Rivers from November 18 to December 10 and into the Siegfried Line December 17-20. Until January 2, 1945, the 79th held a defensive line along the Lauter River, the boundary line between France and Germany at Wissembourg when it withdrew to Maginot Line defenses. A German attempt to establish a bridgehead west of the Rhine at Gambsheim resulted in fierce fighting. The 79th withstood German attacks at Hatten and Rittershoffen in an eleven-day battle before withdrawing to new defensive positions south of Haguenau on the Moder River January 19, 1945. Following eighty-seven days of continuous attacks and counter-attacks, the 79th was relieved by the 36th and101st Airborne Divisions on February 7, 1945.

After resting in Belgium in February and March, 1945, the division returned to combat March 24, 1945. In the plan to cross the Rhine, the 79th was assigned to protect the right flank of the XVI Corps. The division was noted in an Associated Press dispatch as one of the units that "spearheaded the Ninth Army's burst across the Rhine."[183] The division staged an assault crossing, drove across the Rhine-Herne Canal on April 7,

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[182] The Cross of Lorraine: A Combat History of the 79th Infantry Division, 74.
[183] The Cross of Lorraine: A Combat History of the 79th Infantry Division, 131.

secured the north bank of the Ruhr, and took part in clearing the Ruhr Pocket until April 13. When the 8th Infantry Division's advance from the south moved in front of the 79th on April 14, contact with the enemy ended after 302 days of combat.[184] The division then occupied the Dortmund, Sudetenland, and Bavarian areas while processing prisoners of war and displaced persons.

The 79th Division returned to the United States December 10, 1945 and was inactivated December 20. Division Commanders were Major General Ira T. Wyche (June 1942-May 1945), Brigadier General LeRoy H. Watson (May-July, 1945), Major General Anthony C. McAuliffe (July-August, 1945) and Brigadier General Leroy H. Watson (August 1945 to inactivation).[185]

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[184] The Cross of Lorraine: A Combat History of the 79th Infantry Division, 133.

[185] "Combat Chronicle--79th Infantry Division," 2 pages. Accessed 11/11/2005 at http://www.army.mil.cmh-pg/lineage/cc/079id.htm. See also "79th Infantry Division in World War II," Accessed 11/11/2005 at http://home.earthlink.net/~jwitmeyer/314Reunion/79id.html.

44th Infantry Division

The 44th Infantry Division was activated along with other National Guard units on September 16, 1940. The division was reorganized in January 1943. After maneuvers in Louisiana in February and March, 1944, the 44th went to Camp Phillips, Kansas for final overseas duty training.

The 44th Infantry Division went overseas on September 5, 1944. The division landed in France at Cherbourg on September 15, 1944 and trained for a month before entering combat on October 18 when it relieved the 79th Division in the vicinity of Foret de Parroy, east of Luneville, France, to take part in the Seventh Army drive to secure several passes in the Vosges Mountains. Within six days, the division was hit by a heavy German counterattack on October 25-26. The 44th led the 7th Army's November 13 attack on Avricourt, an anchor point on the German defense system. The 44th Division pushed through the Vosges Mountains and helped liberate Strasbourg along with the 2nd French Armored Division and the 79th Infantry Division. In mid-December, the 44th attacked Simserhof, a fort in the Maginot Line, and repulsed a German counter-attack at the 7th Army rear on December 25 that attempted to recapture the strategic province of Alsace.

Early in March after 144 days of combat, the 44th Division had a rest period. Then, the division moved across the Rhine at Worms on March 26 in the wake of the Third Division, relieved the Third on March 26--27, and crossed the Neckar River to attack and capture Manheim on March 29. After a training period, the 44th was assigned to support the tanks of the 10th Armored Division on the drive through southern Germany. The 44th Division took Ehingen on April 23, crossed the Danube and attacked southeast toward Imst, Austria. Deep in Austria, the Anti-Tank company, 324th Infantry, 44th Division, accepted the surrender of Werner von Braun and a dozen scientists from the important German research center at Peenemunde on the Baltic Sea who had been key in developing the V-2 bomb. Men from the forward regiments were climbing Tyrolean peaks and skirmishing through Alpine forests on May 7, the day the German 19th Army surrendered.[186] As German forces surrendered, the European war ended for the 44th.

After a short period of occupation duty, the 44th Division returned to the United States July 21, 1945 for retraining prior to redeployment. With the surrender of Japan, the 44th Division was inactivated November 30, 1945. The division served a total of 190 days in combat. Division commanders were Major General Clifford R. Powell (September 1940--August 1941), Major General James I. Muir (August 1941--August 1944), Major General Robert L. Spragins (August 1944--December 1944), Major General William F. Dean (January 1945--September 1945), and Brigadier General William A. Beiderlinden (November 1--November 14, 1945).[187]

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[186] Lt. Colonel Edward Boherty, Combat History, 44th Infantry Division, 1944-1945 (Atlanta, GA: Albert Love Enterprises, 1946), n. p.

[187] "Combat Chronicle--44th Infantry Division," accessed 2/24/2005 at http://www.army.mil/cmh-pg/lineage/cc/044id.htm See also "Send Me: Combat History of the 44th Infantry Division," accessed 2/24/2005 at http://home.twcny.rr.com/cod324th/senddme.htm

Army Air Force and Air Force Units

Although many Army Air Force and Air Force units have trained at the Smoky Hill Weapons Range, the following units have the most significant associations with the nearby Air Base and the range. During World War II, the Army Air Force established Smoky Hill Army Air Force Base a few miles east of Camp Phillips. The Army Air Force was based on the group and several groups were assigned to a wing. After World War II, under the Air Force/Strategic Air Command organization, the wing became the basic combat unit. The B-29 long-range bomber, for example, was first flown by groups and then, after World War II, by wings.

Smoky Hill Army Air Base became well-known as a B-29 training base, particularly for the 20th Bomber Command and the 21st Bomber Command (which was activated at Smoky Hill). Fliers in the 20th and 21st Bomber Commands played an important and decisive role in the United States victory over Japan in World War II. In June, 1945, the 20th and 21st Bombardment Commands were grouped under the U. S. Strategic Air Forces, Pacific, commanded by General Carl A. Spaatz. The main units of this force that trained at the Smoky Hill Army Air Base and the nearby Weapons Range were: the 21st Bombardment Command, 58th Bombardment Wing, 468th Bombardment Group; the 21st Bombardment Command, 73d Bombardment Wing, 499th Bombardment Group, and the 314th Bombardment Wing, 39th Bombardment Group.[188]

[188] During 1944-45, the order of battle, 20th Air Force, 21st Bombardment Command, consisted of the 58th Bombardment Wing (activated June 1944), 40th, 444th, 462nd, 468th Groups; 73rd Bombardment Wing (activated October, 1944), 497th, 498th, 499th, 500th Groups; 313th Bombardment Wing (activated December 1944-January, 1945), 6th, 9th, 504th, 505th Groups; 314th Bombardment Wing (activated February 1945), 19th, 29th, 39th, 330th Groups; 315th Bombardment Wing (activated June-July 1945), 16th, 331st, 501st, 502nd Groups; 509th Composite Group (activated July 1945).

When the Air Force reorganized in 1947 early in the Cold War, the 301st Bombardment Wing became the main unit at Smoky Hill Air Base. Other units, the 97th and 22nd Bombardment Groups, were attached to the 301st for training and became full-fledged wings after transfer from Smoky Hill.

Other units, the 40th and 97th Bombardment Wings also trained at Smoky Hill Air Force Base and the 40th was stationed there for several years. Later, the base was renamed Schilling Air Force Base and finally closed on June 26, 1965. The Air Force continued to operate the Weapons Range as a regional training facility until the site was transferred to the Air National Guard (ANG) in October, 1973. ANG units currently associated with the Range are the 184th Bombardment Wing and the 184th Air Refueling Wing.

20th Air Force, 20th Bomber Command

The 20th Bomber Command was activated on November 20, 1943. The unit was stationed at Smoky Hill Army Air Field from November 20, 1943 to February 12, 1944. Early in 1944, the 20th Bomber Command moved to India and was assigned to the Twentieth Air Force. The unit carried out very long range bombing assignments from June 1944 until March, 1945. The 20th moved to Okinawa and was based there from June, 1944, until the unit was inactivated on July 16, 1945. Commanders were Brigadier General Kenneth B. Wolfe, November 27, 1943; Brigadier General LaVerne G. Saunders, July 6, 1944; Major General Curtis E. LeMay, August 29, 1944; Brigadier General Roger M. Ramey, January 20, 1945 and Brigadier General Joseph Smith, April 25-July 16, 1945.[189]

[189] Maurer Maurer, Air Force Combat Units, 452-453.

20th Air Force, 21st Bomber Command

The 21st Bomber Command was activated on March 1, 1944. The unit trained at Smoky Hill Army Air Field from March 1, 1944 to June 10. Late in 1944, the command moved to the Marianas and was assigned to the 20th Air Force. The unit engaged in very long range bombardment operations until mid-July, 1945. The 21st Bomber Command was inactivated on July 16, 1945. Commanders were Colonel John B. Montgomery April 7, 1944; Brig. General Roger M. Ramey, June 15, 1944; Brig. General Haywood S. Hansell, August 28, 1944 and Maj. General Curtis E. LeMay, January 20-July 16, 1945.[190]

20th Air Force

Brigadier General Laverne G. Saunders was one of the key leaders in the development of the 20th Air Force. Saunders began World War II as a pilot at Hickam Field in Hawaii the day Pearl Harbor was attacked by the Japanese. Later, he flew B-17s at Midway, the Solomons, and on Guadalcanal. In March, 1943 Saunders was called back to Washington to become a deputy chief of Air Staff. In July Saunders began organizing and training the first B-29 wing--the 58th Bomb Wing (Very Heavy). This unit was assembled under the overall leadership of engineering expert Brigadier General Kenneth B. Wolfe. The 20th Bomber Command was activated at Smoky Hill Air Base near Salina, Kansas, in December with Wolfe in command. Combat groups were under operational control of Saunders' 58th Bomb Wing.

The task of developing the B-29, training its crews and basing the bomber in India and China for deployment against Japan was complex and demanding. The XB-29 first flew in September 1942; the first B-29 of 58th Bomb Wing landed in India in April,

[190] Maurer Maurer, Air Force Combat Units, 453-454.

1944; and 68 B-29s under General Saunders flew against the iron and steel works at Yawata, Japan on June 15, 1944. In a report in 1945, General H. H. Arnold, Army Air Forces Chief, wrote,

> Time was another hurdle. It meant producing the biggest bomber in the least time with a minimum of second-guessing and redesign. Much of the credit for the solutions of these two problems rests with Major General K. B. Wolfe and Brig. General Laverne Saunders and their staffs. One of the most interesting aviation engineering feats of recent years is the story of the development of the power plants used on the B-29. More than 2,000 major and minor engineering changes have been made to date in getting this engine to a point of practical combat perfection.

The B-29 bombing campaign from the Asian mainland against Japan was the forerunner of operations launched from Pacific island bases. In July Saunders replaced Wolfe as commanding general of 20th Bomber Command. In August, 1944, Saunders was replaced by Major General Curtis LeMay. The command gained much experience that it passed on to other B-29 units preparing for combat. The 20th moved to the Marianas in 1945 to take part in the final assault on Japan.[191]

20th Air Force, 58th Bombardment Wing

Formed in Kansas in 1943, the 58th Wing was one of the first units to fly the B-29 and consisted of four Bomb Groups: the 40th, 444th, 462nd, and 468th. In April, 1944 the four groups deployed to bases in India, then China, where they commenced operations against targets in Japan, Manchuria, China, Taiwan, Burma, the Malay Peninsula, Singapore, and Sumatra. On March 30, 1945, the 58th Bomb Wing moved to West Field on the island of Tinian where the unit continued offensive missions until the end of the war in August, 1945.

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[191] "Biographies: Brigadier General Laverne G. Saunders," 2 pages, accessed 11/11/2005 at http://www.af.mil/bios/bio.asp?bioID=7035.

58th Bombardment Wing, 468th Bombardment Group

The 468th Bomb Group, 58th Wing, was activated August 1, 1943 and redesignated the 468th Bombardment Group (Very Heavy) in November, 1943. The unit was stationed at Smoky Hill Army Air Force (AAF) field from August 1, 1943 to March 12, 1944. Equipped with B-29s, the group moved via Africa to the CBI theater from March through June, 1944. The group was assigned to the 20th Air Force in June, 1944.

The group carried out its first attack on railroad shops at Bangkok, Thailand on June 5, 1944. The 468th participated June 15 in the first AAF attack on Japan since the Doolittle raid in 1942. From bases in India, China, and Ceylon, the unit mined shipping lanes near Saigon, French Indochina, and Shanghai, China, and struck Japanese installations in Burma, Thailand, French Indochina, Indonesia, Formosa, China, and Japan. Targets included iron works, aircraft factories, transportation centers, and naval installations. The 468th received a DUC for participation in a daylight raid on the iron and steel works at Yawata, Japan on August 11, 1944.

The unit flew additional missions against Japan after moving to Tinian in the Marianas during February-May, 1945. The 468th participated in mining operations, incendiary raids on area targets, and high-altitude missions against strategic objectives. The unit dropped incendiaries on Tokyo and Yokohama in May, 1945. The unit received another DUC for a daylight raid on an aircraft plant at Takarazuka, Japan in July, 1945. After the war, the 468th dropped food and supplies to Allied prisoners and participated in show-of-force missions over Japan. The unit returned to the U.S. in November, 1945 where the unit was inactivated on March 31, 1946.[192] Commanders were Colonel

[192] "Army Air Forces: 468th Bombardment (Very Heavy)," 2 pages. Acessed 11/11/2005 at http://www.armyairforces.com/dbgroups.asp?Group=325.

Howard E. Engler 8 September 1943; Colonel Ted S. Faulkner, August 3, 1944 and Colonel James V. Edmundson, November 5, 1944-March 31, 1946.[193]

20th Air Force, 73rd Bombardment Wing

The 73rd Bombardment Wing played an important role in World War II. The 73rd was originally activated on February 17, 1943 as the 5th Heavy Bombardment Processing Headquarters. The unit was redesignated as the 73rd Bombardment Wing (Very Heavy) on November 20, 1943. The wing was stationed at Walker Army Air Field in Kansas from February 17, 1943 and at Smoky Hill Army Air Field from June 30 to February, 1944.

The 73rd Bombardment Wing moved to Saipan in 1944 and carried out heavy bombardment operations again the Japanese in the western Pacific from October, 1944 to August, 1945. The wing returned to the United States late in 1945. The unit was assigned to the Strategic Air Command on March 21, 1946 and inactivated on May 31, 1946. Commanders of the 73rd Bombardment Wing were Colonel Thomas H. Chapman, July 2 to November 27, 1943; Brigadier General Emmett O'Donnell, Jr., March 15, 1944; Colonel Morris J. Lee, September 16, 1945; Colonel Neil B. Harding, January 28 to May 14, 1946.[194]

499th Bombardment Group, 73rd Bombardment Wing

The 499th Bombardment Group (Very Heavy) was activated on November 20, 1943 and trained for combat with B-29s at Smoky Hill Army Air Field, Kansas from

[193] Maurer, Maurer, ed. Air Force Combat Units of World War II (Washington, DC: Office of Air Force History, 1983), 343-344.
[194] Maurer, Maurer, ed. Air Force Combat Units of World War II (Washington, DC: Office of Air Force History, 1983), 406-477.

December 1, 1943 to July 22, 1944. The unit moved to Isley Field on Saipan from July to November, 1944.

The 499th Bombardment Group began combat with attacks in the Truk Islands and on Iwo Jima. The group participated on November 24, 1944 in the first strike against Japan by Army Air Force planes stationed in the Marianas. The group flew a number of missions in daylight bombing strategic targets in Japan from high altitude. The 499th Group received a DUC for striking the Mitsubishi aircraft engine plant at Nagoya on January 23, 1945. The unit began to conduct night attacks in March, 1945, flying at low altitude to drop incendiaries on area targets in Japanese cities. The 73rd flew a series of attacks against enemy airfields on Kyushu to assist the Allied assault on Okinawa in April, 1945, and received another DUC for this action. Later the group dropped propaganda leaflets on Japan and after the war ended dropped food and supplies to Allied prisoners of war.

The 499th Bombardment Group returned to the United States in November, 1945 and the unit was inactivated on February 16, 1946. Commanders were unknown November 1943-January, 1944; Major Douglas C. Northrup, January 22, 1944; Colonel Thomas C. Musgrave, February 1, 1944; Colonel Samuel R. Harris, April 4, 1944; Colonel Morris J. Lee March 17, 1945; Lt. Colonel Walter E. Chambers, August 13, 1945-unknown.[195]

20th Air Force, 314th Bomb Wing, 39th Bombardment Group

The 39th Bombardment Group, 314th Bombardment Wing, was activated at Smoky Hill Army Air Field, Salina, Kansas, on April 12, 1944. The 39th Bombardment Group was activated on January 15, 1941. The group first was equipped with B-17s, then

[195] Maurer, Air Combat Units in World War II, 365-366.

B-24s in 1942. The unit was redesignated the 39th Bombardment Group (Very Heavy) on April 1, 1944. This was a very heavy bombardment unit organized to participate in the new B-29 Superfortress program. The group consisted of the 60th, 61st, and 62nd Squadrons. The unit moved to Dalhart, Texas on May 15. Colonel Potter B. Paige assumed command June 15, 1944. The unit moved back to Smoky Hill in August and September while waiting for the 499th Group to finish training. The unit was stationed at Smoky Hill Army Air Force Field, Kansas from April 1, 1944 to January 8, 1945.

After January 18, 1945, Colonel Paige was succeeded by Colonel John G. Fowler, who had returned from Guam, where he was deputy commander of the 314th Wing. He took the 39th Group overseas to the Army Air Base in Saipan. Airplanes and air personnel left Smoky Hill toward the end of March, 1945.[196]

After training with B-29s, the group moved to Guam early in 1945 for duty with the 20th Air Force. The 39th Group's first mission against the Japanese home islands was the assignment to bomb the Hodagaya chemical plant at Koriyama on April 12, 1945. The unit supported the Allied invasion of Okinawa from April through May, 1945, by attacking airfields that served as bases for kamikaze pilots. The 39th Group bombed military and industrial targets in Japan and participated in incendiary raids on urban areas from mid-May until the end of the war. The unit dropped food and supplies to Allied prisoners and took part in show-of-force missions over Japan after V-J Day. The 39th Bombardment Group returned to the United States in November--December, 1945. The unit was inactivated December 27, 1945.

Commanders after April 1, 1944 were Captain Claude J. Hilton, 28 April 1944; Major Gordon R. Willis, May 6, 1944; Major Campbell Weir May 11, 1944; Lt. Colonel

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[196] "39th Bomb Group (VH) History," 3 pages. Acessed 11/11/2005 at http://39th.org/39th/history.htm.

Robert W. Strong, Jr. June 10, 1944; Colonel Potter B. Paige, 15 June 1944; Colonel John G. Fowler, February 22, 1945; Colonel George W. Mundy, March 16, 1945; Colonel James E. Roberts, August 16, 1945; Lt. Colonel James C. Thompson, October 9, 1945; Colonel Robert J. Mason, October 13, 1945.[197]

301st Bombardment Wing

After World War II, the main unit at Smoky Hill Air Field was the 301st Bombardment Wing, Very Heavy. This unit was organized November 5, 1947 and redesignated the 301st Bombardment Wing, Medium, in August 1948. The 301st Bomb Group was stationed at Smoky Hill from November 5, 1947 to June 16, 1952. However, the unit was not operational from February 10, 1951 to June 16, 1952.

The 301st conducted strategic bombardment training during 1947-1948, coordinated aerial gunnery training for other SAC organizations from November 1947-January 1948, and began aerial refueling in 1949. The 301st was deployed in England December 1952-March 1953 and in French Morocco, February-April 1954.[198] The unit flew B-29s from 1947 to 1953 and added the tanker KB-29 from 1949 to 1953. The 301st flew B-47s from 1953-1961 and from 1963-1964. Later on June 15, 1964, the unit was redesignated the 301st Air Refueling Wing.

22nd Bombardment Wing

Additional units stationed at Smoky Hill Air Base were the 22nd and 97th Bombardment Groups. Activated as the 22d Bombardment Group, Medium, on August 1, 1948, the 22nd Group was attached to the Fifteenth Air Force, 301st Bombardment

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[197] Maurer, Maurer, ed., Air Force Combat Units of World War II (Washington, DC: Office of Air Force History, 1983 reprint of 1961edition), 95-96.
[198] Charles A. Ravenstein, Air Force Combat Wings, 1947-1977 (Washington, DC: Office of Air Force History, 1984), 145-146.

Wing while the unit was not operational. While based at Smoky Hill AFB, Kansas, the unit shared a commander in common with the 301st Bombardment Wing from May 18, 1948 to May 9, 1948. Then the unit moved to March AFB, California, May 10, 1949, and to Barksdale AFB, Louisiana, on November 7.[199]

40th Bombardment Wing

After the Korean War, the Smoky Hill Air Force Base supported even more airmen and planes. In World War II, the 40th Bombardment Wing flew bombers, including the B-29, against Japan. The wing was reactivated on May 28, 1952 and designated the 40th Bombardment Wing Medium, Strategic Air Command, but was not manned until early February, 1953. The 40th was attached to the 310th Bombardment Wing, Medium, at Smoky Hill from February 1 to May 1, 1953. The unit was controlled and trained by the 310th Bombardment Wing and began operations at Smoky Hill AFB on May 1, 1953. The new unit converted from B-29s to B-47s in 1954 and became combat ready in April, 1955.

The 40th was trained to be capable of conducting long range bombardment missions in any part of the world. The 40th Bomb Wing was deployed overseas in England in 1955 and in Germany in 1957. The 40th Bombardment Wing was associated with the 40th Air Refueling Squadron. Also, the 660th Strategic Missile Squadron was assigned to the wing from February 1, 1959 to January 1, 1962. .[200] The 40th moved from Schilling AFB to a new assignment at Forbes AFB, Topeka, Kansas on January 20, 1960.[201] The 548th Strategic Missile Squadron with Atlas missiles was attached to the

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[199] Combat Wings, 41-42.
[200] "40th Bombardment Wing," 3 pages. Acessed 11/11/2005 at http://www.globalsecurity.org/wmd/agency/40bw.htm.
[201] Combat Wings, 68-69.

40th Wing from January 1, 1964 to September 1, 1964. The unit was redesignated the 40th Strategic Aerospace Wing on February 1, 1964 and inactivated September 1, 1964.

310th Bombardment Wing (310th Strategic Aerospace Wing)

This unit began as the 310th Bombardment Group in World War II. Airmen flew B-25 bombers in support of operations in North Africa, Italy, France, Austria, and Yugoslavia. The 310th Bomb Group was inactivated September 12, 1945.

During the Korean War, the unit was designated the 310th Bombardment Wing, Medium, on March 15, 1952 and activated on March 28, 1952. The wing trained at Forbes AFB, Topeka, Kansas. The 310th Wing received B-29 bombardment training from the 90th Bombardment Wing from April to August , 1952. The 310th Bomb Wing moved to Smoky Hill AFB on September 4, 1952 and remained until June 25, 1965. The wing provided bombardment training to the 40th Bombardment Wing from February to May, 1953.[202] The 310th Wing flew B-29s from 1952 to 1954, added the KC-97 in 1952 and flew KC-135s from 1964 to 1965. The wing flew B-47 Stratojets from 1954 to 1965.

The 310th Bomb Wing was deployed to England from March 10 to June 8, 1955 and from October 3, 1956 to January 19, 1957. The wing added a strategic missile squadron (Atlas) in April, 1961 and the first Atlas missiles went on alert in September, 1962. Later, the unit was redesignated the 310th Strategic Aerospace Wing on March 1, 1962 and inactivated on June 25, 1965.[203] The unit was reactivated as the 310th Space

[202] Combat Wings, 158-159.
[203] "310th Bombardment Wing, 310th Strategic Aerospace Wing," 1 page. Acessed 11/11/2005 at http://www.strategic-air-command.com/wings/-310bw.htm.

group on September 4, 1997 to provide command and control for Department of Defense and Department of Commerce satellites.[204]

97th Bombardment Wing

This unit was organized as the 97th Bombardment Wing, Very Heavy, December 1, 1947 at Eielson Air Force Base, Alaska. Originally a temporary organization, the wing was comprised of components of the 97th Bombardment Group and 519th Air Service Group deployed from Smoky Hill Air Force Base, Kansas. The unit flew training missions over the Arctic Ocean. At the time, the Air Force conducted a service test of a combat wing organization that gave the wing commander the authority to direct activities rather than request that his flying mission receive support. The wing consisted of a combat group, airdrome group, maintenance and supply group, and a medical group. As the unit's March 1948 history stated, "the mission of the 97th Bombardment Wing (VHB) is to man, train, and maintain a self-sustaining strategic bombardment group capable of operations in any theater." While in Alaska, the 97th flew B-29 Superfortress missions over the Arctic Ocean, testing the aircraft and maintenance crews in the harsh climate.

At the end of the Alaskan deployment, the wing moved to Smoky Hill AFB in March, 1948. The wing was attached to the 301st Bombardment Wing for further training from March 17 to May 16, 1948. The unit was reorganized from a very heavy to medium bomb wing in July 1948 after moving to Biggs AFB, El Paso,Texas.[205] Later in 1959, the 97th Bomb Wing moved to Blytheville (later Eaker) AFB, Arkansas. The unit was redesignated the 97th Bombardment Wing, Heavy, on October 1, 1959 and received

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[204] "Fact Sheet: United States Air Force, 310th Space Group," 3 pages. Acessed 11/11/2005 at http://www.peterson.af.mil/hquafspc/Library/FactSheets/FactsSheets.asp?FactChoice=26.
[205] Ravenstein, Combat Wings, 137-138.

B-52s in 1960. The wing was redesignated the 97th Air Mobility Wing October 1, 1992.[206]

See Reference List in Appendix F.1 for citations

[206] "97th Bomb Wing," 5 pages. Acessed 11/11/2005 at http://www.globalsecurity.org/wmd/agency/96bw.htm.

RECOMMENDATIONS AND ACTION PLAN FOR CONTROL AND ABATEMENT OF INVASIVE AND NON-NATIVE SPECIES

PREPARED FOR

AIR NATIONAL GUARD READINESS CENTER
3500 FETCHET AVENUE
ANDREWS AFB, MD 20762-5157

AND

SMOKY HILL AIR NATIONAL GUARD RANGE
8429 WEST FARRELLY ROAD
SALINA, KS 67401-9407
SEPTEMBER 15, 2007

BY

CRAIG C. FREEMAN AND WILLIAM H. BUSBY
KANSAS BIOLOGICAL SURVEY

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G.1. INTRODUCTION

Humans intentionally and unintentionally have moved organisms around the planet for millennia. Thousands of species have been imported into the U.S. for food, fiber, shelter, ornamentals, and pets. However, under some conditions, non-native species can cause significant ecological and socio-economic problems by impacting the environment, agriculture, industry, and human health. Invasive species are among the most serious environmental threats of the 21st Century. Awareness of the problems caused by invasive species is growing, but solutions to these problems have lagged (Svejcar 2003). Early detection and immediate eradication are the most cost-effective control measures for undesirable invasive species.

This document summarizes the results of invasive and non-native species surveys conducted on the Smoky Hill Air National Guard Range (ANGR) in Saline County, Kansas, and provides an action plan for control and abatement of those species. The plan was developed in compliance with the legal mandates and directives that are outlined below, as well as the installation's 2007 Integrated Natural Resources Management Plan (INRMP) (engineering-environmental Management, Inc. 2007).

G.1.1. Laws, Directives, and Agencies Involved in Management of Invasive Species

Federal. Federal efforts to control invasive species comprise a patchwork of laws, regulations, policies, and programs. Federal laws that apply directly to the introduction of non-native species include the Lacey Act, Plant Protection Act, Noxious Weed Act, Noxious Weed Control and Eradication Act, Seed Act, Nonindigenous Aquatic Nuisance Prevention and Control Act, National Invasive Species Act, and Executive Order 13112. The Endangered Species Act has indirect application if an invasive species threatens a federally listed species. Copies of most federal laws are available at http://www.invasivespeciesinfo.gov/laws/publiclaws.shtml#ppa.

Lacey Act (16 U.S.C. 3371-3378, as amended). The Lacey Act, signed into law in 1900, protects plants and wildlife by creating civil and criminal penalties for a variety of violations. The Act prohibits trade in wildlife, fish, and plants that have been taken, possessed, transported, or sold illegally. The Act underscores other federal, state, and foreign laws protecting wildlife by making it a separate offense to take, possess, transport, or sell wildlife taken in violation of those laws. The Act prohibits the falsification of documents for most shipments of wildlife and prohibits the failure to mark wildlife shipments. The Act is administered by the Departments of the Interior, Commerce, and Agriculture through their respective agencies; the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and Animal and Plant Health Inspection Service. The Act is among the broadest and most comprehensive laws in the federal arsenal to combat wildlife crime. With increasing activity in international and domestic wildlife trafficking, the Lacey Act has become an important weapon to protect animals domestically and abroad.

Federal Plant Protection Act (7 U.S.C. 7701 as amended). The Federal Plant Protection Act, signed into law in 2000, consolidates all or parts of 10 existing U.S. Department of Agriculture plant health laws into one comprehensive law, including authority to regulate plants, plant products, certain biological control organisms, noxious weeds, and plant pests. The Plant Quarantine Act, Federal Pest Act, and Federal Noxious Weed Act are among the statutes subsumed by the Plant Protection Act. The Federal Plant Protection Act gives authority to the Secretary, and through delegated authority, the USDA's Administrator of the Animal and Plant Health Inspection Service (APHIS), to prohibit or restrict the importation, entry, exportation, or movement in interstate commerce of any plant, plant product, biological control organism, noxious weed, article, or means of conveyance if the Secretary determines that the prohibition or restriction is necessary to prevent the introduction of a plant pest or noxious weed into the U.S., or the dissemination of a plant pest or noxious weed within the U.S.

Federal Noxious Weed Act (7 U.S.C. 2801-2814 as amended). The Federal Noxious Weed Act was enacted in 1975 and established a federal program to control the spread of noxious weeds. It gives the Secretary of Agriculture authority to designate plants as noxious weeds by regulation, and the movement of all such weeds in interstate or foreign commerce is prohibited except under permit. The Secretary has authority to inspect, seize and destroy products, and quarantine areas if necessary to prevent the spread of such weeds. The Secretary also is authorized to cooperate with other federal, state, and local agencies, farmers associations, and private citizens in measures to control, eradicate, or prevent the spread of such weeds. Section 1453 of P.L. 101-624, the 1990 Farm Bill, enacted in 1990 (104 Stat. 3611) amended the Act by requiring each federal land-managing agency to designate an office or person adequately trained in managing undesirable plant species to develop and coordinate a program to control such plants on the agency's land, establish and adequately fund this plant management program through the agency's budget process, complete and implement cooperative agreements with the states regarding undesirable plants on agency land, and establish integrated management systems to control or contain undesirable plants targeted under the cooperative agreements. The law requires that any environmental assessments or impact statements that may be required to implement plant control agreements must be completed within one year of the time the need for the document is established. The Act defines both noxious weed and undesirable plant. Most states, including Kansas, have parallel legislation as a part of their agricultural regulation.

Noxious Weed Control and Eradication Act (P.L. 108-412). The Noxious Weed Control and Eradication Act, signed into law in 2004, amended the Plant Protection Act by adding a new subtitle, "Subtitle E—Noxious Weed Control and Eradication" (7 U.S.C. 7781-7786) to the Plant Protection Act. It requires the Secretary of Agriculture to develop a program to provide financial and technical assistance to weed management entities to control or eradicate noxious weeds on public and private lands. Actual authority is delegated from the Secretary of Agriculture to the Deputy Administrator for Plant Protection and Quarantine, APHIS.

Federal Seed Act (7 U.S.C. 1551-1611 as amended). The Federal Seed Act, signed into law in 1939, regulates interstate and foreign commerce in agricultural and vegetable seeds, requires labeling to prevent misrepresentation of seeds in interstate commerce, and requires standards with respect to certain imported seeds. It requires that all seed sold in interstate commerce and imported into the U.S. be labeled truthfully for quality. It generally has no jurisdiction over seed sold within state boundaries, where various state seed laws apply. However, state seed laws normally have similar requirements, and seed labeled in compliance with the Act generally would comply with the regulations of the state into which seed is shipped. Thus, the Act helps maintain the integrity of each state seed law and helps maintain the authority of state seed laws in regard to noxious weed seed regulations. The Act is enforced by the Seed Branch of the Livestock, Meat, Grain, and Seed Division of USDA.

Nonindigenous Aquatic Nuisance Prevention and Control Act (P.L. 101-646 (104 Stat. 4761, 16 U.S.C. 4701). Passed in 1990, the Nonindigenous Aquatic Nuisance Prevention and Control Act established a new federal program to prevent introduction of and to control the spread of introduced aquatic nuisance species and the brown tree snake. The Act was passed primarily in response to the introduction and spread of the Zebra Mussel in the Great Lakes. The U.S. Fish and Wildlife Service, the U.S. Coast Guard, the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, and the National Oceanic and Atmospheric Administration each have responsibilities, including membership on an Aquatic Nuisance Species Task Force established to develop a program of prevention, monitoring, control, and study. The Act calls for the prevention and control of aquatic nuisance species, development of a Zebra Mussel demonstration program, and preparation of state aquatic nuisance species management plans.

National Invasive Species Act (P.L. 104-332). When Congress reauthorized the Nonindigenous Aquatic Nuisance Prevention and Control Act in 1996, the Act was renamed the National Invasive Species Act. The new Act places further restrictions on ships arriving from outside the 200-mile U.S. Exclusive Economic Zone. The Act also authorizes important research and linked research results to decisions about whether further ballast water regulation is needed.

U.S. Executive Order 13112. Executive Order (EO) 13112 was signed in 1999, establishing the National Invasive Species Council. It created a Council of Departments dealing with invasive species. Currently, there are 10 departments and agencies on the Council, including the Department of Defense. EO 13112 was empowered by the National Environmental Policy Act of 1969 as amended, Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 as amended, Lacey Act as amended, Federal Plant Pest Act of 1939 as amended; Federal Noxious Weed Act of 1974 as amended, Endangered Species Act of 1973 as amended, and other pertinent statutes. The purpose of EO 13112 is to "prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause."

U.S. Department of the Interior (USDOI). The **U.S. Fish and Wildlife Service (USFWS)**, an agency within USDOI, has several programs that address management and control of invasive species. The agency leads efforts to develop and implement cooperative plans to manage and control infestations of aquatic nuisance species. The agency provides funding for implementation of state and regional aquatic nuisance species management plans that have been approved by the Aquatic Nuisance Species Task Force. A major effort on aquatic nuisance species is the 100th Meridian Initiative, the objective of which is to prevent the spread of the Zebra Mussel and other aquatic nuisance species in the 100th meridian jurisdictions and west, and to monitor and control detected populations of Zebra Mussels and other aquatic nuisance species through education, voluntary boat inspections and boater surveys, involvement of those who haul boats for commercial purposes, monitoring, rapid response, and evaluation. USFWS also has several habitat restoration programs that restore habitat degraded by invasive species as part of their overall habitat restoration activities.

U.S. Department of Agriculture (USDA). The USDA plays a critical role in conducting research on the prevention, eradication, and control of agricultural invasive species, and monitoring ecosystems impacted by invasive species. USDA evaluates non-indigenous species for agricultural use before they can be distributed commercially. The USDA maintains a wealth of information about invasive and potentially invasive species, which can be accessed through the National Invasive Species Information System at http://www.invasivespeciesinfo.gov/. Within USDA, the **Natural Resources Conservation Service (NRCS)** is the primary federal agency that works with private landowners to help them conserve, maintain, and improve their natural resources. NRCS emphasizes voluntary, science-based conservation, technical assistance, partnerships, incentive-based programs, and cooperative problem solving at the community level. The **Animal and Plant Health Inspection Service (APHIS)** is responsible for protecting and promoting U.S. agricultural health, administering the Animal Welfare Act, and carrying out wildlife damage management activities.

U.S. Army Corps of Engineers (USACE). The USACE develops, controls, maintains, and conserves the nation's water resources in accordance with the laws and policies established by Congress and the Administration. The Corps' Zebra Mussel Research Program was authorized by the Nonindigenous Aquatic Nuisance Prevention and Control Act. The USACE also works to control invasive aquatic plants on its properties. The Aquatic Plant Control Research Program provides economical and environmentally compatible technologies for identifying, assessing, and managing plant problems. The Corps' aquatic nuisance species programs were integrated into the Aquatic Nuisance Species Task Force for better coordination of aquatic nuisance species issues.

U.S. Department of Defense (DoD). DoD Directive 4715.1 (Environmental Security), DOD Instruction 4715.3 (Environmental Conservation Program), and DoD Instruction 4150.7 (Pest Management Program) collectively establish the process by which each DoD installation develops a pest management plan and incorporates that plan into natural resources planning and other installation activities. The Pest Management Program is overseen by the Armed Forces Pest Management Board (AFPMB); information about

AFPMB is available at http://www.afpmb.org/. **Department of the Air Force** Instruction 32-7064, Chapter 13 (Integrated Natural Resources Management, Chapter 13), Air Force Instruction 32-1053 (Pest Management Program), and Air Force Pamphlet 91-212 (Bird/Wildlife Aircraft Strike Hazard (BASH) Management Techniques) collectively define the process by which Air Force and Air Force Reserve units develop pest management and BASH plans and incorporate those plans into natural resource planning. Information about the USAF pest management program is available at http://www.afcesa.af.mil/ces/cesm/pest/cesm_pestmgt.asp.
Within the **Air National Guard (ANG),** responsibility for the pest management program rests with the ANG Pest Management Consultant in the Environmental Division, Directorate of Civil Engineering, Andrews AFB, Maryland. The ANG Pest Management Consultant must personally approve all pest management plans and all pesticides applied on ANG installations, and certify the training of all ANG pesticide applicators.

State of Kansas. Kansas has several statutes and programs to prevent and manage invasive species. Some programs are administered cooperatively with federal partners. State agencies involved in this work include the Department of Agriculture, Department of Wildlife and Parks, and Kansas Animal Health Department. The Kansas State University Research and Extension Service also plays a critical role in research and education.

Kansas Department of Agriculture (KDA). Among its many other regulatory responsibilities, KDA ensures responsible use of pesticides and nutrients, and protection of Kansas' natural and cultivated plants. Laws central to this mission include Kansas Pest Freedom Standards, the Plant Pest and Agricultural Commodity Certification Act, and the Kansas Noxious Weed Law. In 2002, KDA issued the first aquatic nuisance species plant quarantine in Kansas by levying quarantine on purple loosestrife (*Lythrum salicaria* L.). In 2004, KDA enacted a quarantine for all federally listed noxious weeds, including 19 aquatic plants, representing the first large scale effort to control aquatic nuisance plant species into and within the State. Within KDA, the Plant Protection and Weed Control Program ensures the health of the state's native and cultivated plants by excluding or controlling destructive pests, diseases, and weeds. Program staff examine and analyze pest conditions in crop fields, rangelands, greenhouses, and nurseries.

Among invasive plant species are those designated as noxious because they are major pests, usually of agricultural ecosystems. The State, based on recommendations from KDA, labels a plant species as noxious when it threatens economic activities. Kansas Statute 2-1314 assigns responsibility to all people who own or supervise land in Kansas to, "control the spread of and to eradicate all weeds declared by legislative action to be noxious on all lands owned or supervised by them and to use such methods for that purpose and at such times as are approved and adopted by the department of agriculture." State law deems noxious weeds as plants that are such a nuisance to the economy that landowners and extension agents are bound by law to destroy them. For the full text, see http://www.ksda.gov/includes/statute_regulations/plant_protection/07Noxious_weed.pdf.

The KDA Plant Protection and Weed Control Program lists 12 species as noxious in Kansas: kudzu (*Pueraria lobata* (Willd.) Ohwi [accepted name = *P. montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen & S. M. Almeida]), field bindweed (*Convolvulus arvensis* L.), Russian knapweed (*Centaurea repens* L. [accepted name = *Acroptilon repens* (L.) DC.]), hoary cress (*Cardaria draba* (L.) Desv. [accepted name = *Lepidium draba* L. subsp. *draba*]), Canada thistle (*Cirsium arvense* (L.) Scop.), quackgrass (*Agropyron repens* (L.) P. Beauv. [accepted name = *Elymus repens* (L.) Gould]), leafy spurge (*Euphorbia esula* L.), bur ragweed (*Ambrosia grayii* (A. Nelson) Shinners), pignut (*Hoffmannseggia densiflora* Benth. [accepted name = *Hoffmannseggia glauca* (Ortega) Eifert], musk thistle (*Carduus nutans* L.), Johnsongrass (*Sorghum halepense* L.), and sericea lespedeza (*Lespedeza cuneata* (Dum. Cours.) G. Don). In addition, two species are listed as county-option, meaning that counties may list them as noxious if they are deemed threats to economic activities: multiflora rose (*Rosa multiflora* Thunb.) and bull thistle (*Cirsium vulgare* (Savi) Ten.). Neither species is listed as noxious in Saline County (see www.ksda.gov/plant_protection/content/181).

Kansas Department of Wildlife and Parks (KDWP). The mission of KDWP is to conserve and enhance Kansas' natural heritage, wildlife, and habitats. Among policies administered by KDWP that are germane to the state's management of invasive species is KAR 115-18-10, which prohibits the importation, possession, or release of 11 species of wildlife into the state except by permit, KAR 115-20-3, which prohibits the release of all exotic wildlife onto the lands or into the waters of the state, and KAR 115-8-12, which prohibits stocking or releasing of wildlife on department lands or waters. KWDP, in cooperation with state and federal partners, implemented in 2005 an aquatic nuisance species management program. The program is the first large-scale, cooperative effort to control aquatic nuisance species in Kansas. A copy of the final plan is available at http://www.kdwp.state.ks.us/news/fishing/aquatic_nuisance_species/ks_nuisance_species_plan.

Kansas Animal Health Department (KAHD). The KAHD ensures the health, safety, and welfare of Kansas citizens through prevention, control, and eradication of infectious and contagious disease and conditions affecting livestock and domestic animals in the State of Kansas. KAHD regulates facilities that produce, sell, or harbor companion animals, and enforce the laws governing such facilities, directs a brand registration and inspection program to identify ownership of lost or stolen livestock, and informs the public of the status of the health of livestock in the state to promote understanding and gain public assistance in achieving this mission. KAHD monitors and is responsible for the eradication of foreign livestock diseases that threaten the state.

County. Saline County does not have specific ordinance regarding non-native plant or animal species. Control of state-listed, noxious weeds is the county is handled by the Saline County Noxious Weed Division, a unit of the Saline County government. Details are provided at http://www.saline.org/MV2Base.asp?VarCN=93.

G.1.2. Biological and Economic Impacts of Invasive Plants

Invasive plants are among the greatest threats to natural ecosystems worldwide. Problems associated with them have increased with expanding human populations, world travel, and international trade. An estimated 5,000 non-native plant species occur in the U.S. today (Morse et al. 1995). Non-native plants occupy an additional 4,600 acres of wildlife habitat each day in the U.S. (Babbitt 1998), and invasive weeds on croplands cost the U.S. an estimated $26.4 billion annually (Pimentel et al. 2000). Combined annual losses and damages plus control costs from aquatic weeds, crop weeds, weeds in pastures, and weeds in lawns, gardens, and golf courses are close to $34 billion (Pimentel et al. 2000). Non-native plants are of particular concern because many natural controls formerly regulating their populations are absent in the new, non-native environment. Among their many adverse impacts on natural communities (Randall 1995, 1996), non-native plant species often out-compete native species, reducing biodiversity, modifying habitat structure, and influencing ecological processes (Inderjit 2005).

G.1.3. Biological and Economic Impacts of Invasive Animals

A consequence of increasing human populations and world travel and trade is the rapid spread of organisms from their native lands to new environments around the world. Such species often arrive without the pests and parasites that limited their populations in their native land, enabling them to expand rapidly in their new location where they can out-compete native species, prey on native species, and spread pathogens and parasites. The brown tree snake has caused the extinction of dozens of birds and lizards on a single island, Guam. Zebra mussels colonizing North America reach densities of 700,000 per m^2 and will cause an estimated $5 billion a year in the U.S. just by clogging pipes in water system (Khalanski 1997). Crop losses due to introduced insect pests are estimated at $13 billion per year in the U.S. (Pimentel et al. 2000). The indiscriminate impacts of invasive species are accelerating, leading to less stable ecological systems and exacting a tremendous economic cost.

G.2. NON-NATIVE/INVASIVE PLANTS

G.2.1. Definitions

Executive Order 13112 (U.S. Executive Order 13112) defines a **native species** as "with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem". The term indigenous sometimes is used synonymously. In North America, a species generally is considered native if it was present on the continent in a particular ecosystem before 1492 – the year Christopher Columbus arrived in the New World. Conversely, a **non-native species** is one that was not present in a particular ecosystem before 1492. Other terms, often used more-or-less synonymously with non-native, include alien, established, exotic, foreign, introduced, and non-indigenous (Nesom 2000, Pyšek et al. 2004, U.S. Executive Order 13112). A non-native species can refer to a species brought to a particular ecosystem from another continent, region, ecosystem, or habitat. An **invasive species** is a non-native species whose introduction does or is likely to cause economic or environmental harm to human health.

G.2.2. Non-native Species in Kansas and on Smoky Hill ANGR

Four hundred forty-seven of the 2,123 species (21%) of vascular plants documented in Kansas outside of cultivation have been introduced since the arrival of Euro-Americans. Based on provenance data presented in Appendix B, the percentage of non-native taxa on Smoky Hill ANGR is 16% (see Chapter 3). All 56 non-native taxa on the installation were ranked according to alien status and invasiveness (Appendix B) using the following ranks: 0 = native; 1 = casual alien (includes persisting and non-persisting casual aliens); 2 = non-invasive, naturalized, 3 = invasive, non-transformer (rarely capable of causing major ecological changes in plant communities if established); and 4 = invasive, transformer (capable of causing major ecological changes in plant communities if established). The distribution of ranks among non-native taxa documented on Smoky Hill ANGR is summarized in Figure 3.4. The distribution of non-native plants among plant communities is summarized in Table G.1.

Introduced taxa with a rank of 1, 2, or 3 rarely become serious weeds in Kansas; however, under some circumstances, taxa with a rank of 3 can cause local management problems in native plant communities. Taxa with a rank of 1, 2, or 3 make up 90% of all non-native taxa documented on Smoky Hill ANGR. By comparison, taxa with an alien status rank of 4 have the demonstrated ability to transform native plant communities; they should be considered as serious potential threats that, under appropriate conditions, can compromise plant community function if left unchecked. Ten species with an alien status of 4 were found on Smoky Hill ANGR or, in the case of *Lespedeza cuneata*, are known historically from the installation: *Carduus nutans* L. (musk-thistle), *Convolvulus arvensis* L. (field bindweed), *Elaeagnus angustifolia* L. (Russian-olive), *Lespedeza cuneata* (Dum. Cours.) G. Don (sericea lespedeza), *Securigera varia* L. (common crown-vetch), *Bothriochloa bladhii* (Retz.) S. T. Blake (Caucasian bluestem), *Bromus inermis* L. (smooth brome), *B. japonicus* Thunb. (Japanese brome), *B. tectorum* L. (downy brome), and *Rosa multiflora* Thunb. (multiflora rose). Three of the 12 species listed by the Kansas Department of Agriculture as noxious are included on this list: *Carduus nutans*, *Convolvulus arvensis*, and *Lespedeza cuneata*. *Rosa multiflora*, with a rank of 4, and *Cirsium vulgare* (Savi) Ten. (bull thistle), with a rank of 3, both occur on the installation and are listed as county-option species by the Kansas Department of Agriculture. Neither of these species is listed as noxious by the Saline County Noxious Weed Department.

Among the 56 non-native species on the installation, 13 are among the 45 species most frequently listed noxious weed in the continental U.S. and southern provinces of Canada (Skinner et al. 2000). Only four of these, *Carduus nutans*, *Convolvulus arvensis*, *Cirsium vulgare*, and *Rosa multiflora*, are considered potentially invasive on Smoky Hill ANGR.

TABLE G.2. Management and control values for non-native plant species that are potentially invasive on Smoky Hill ANGR.

Species (Code)	Significance of Impact	Feasibility of Control
Bothriochloa bladhii (Bobl)	64	33
Bromus inermis (Brin)	53	23
Bromus japonicus (Brja)	38	49
Bromus tectorum (Brte)	43	49
Carduus nutans (Canu)	27	54
Cirsium vulgare (Civu)	31	44
Convolvulus arvensis (Coar)	32	35
Elaeagnus angustifolia (Elan)	73	35
Lespedeza cuneata (Lecu)	40	30
Rosa multiflora (Romu)	34	55
Securigera varia (Sevu)	24	50

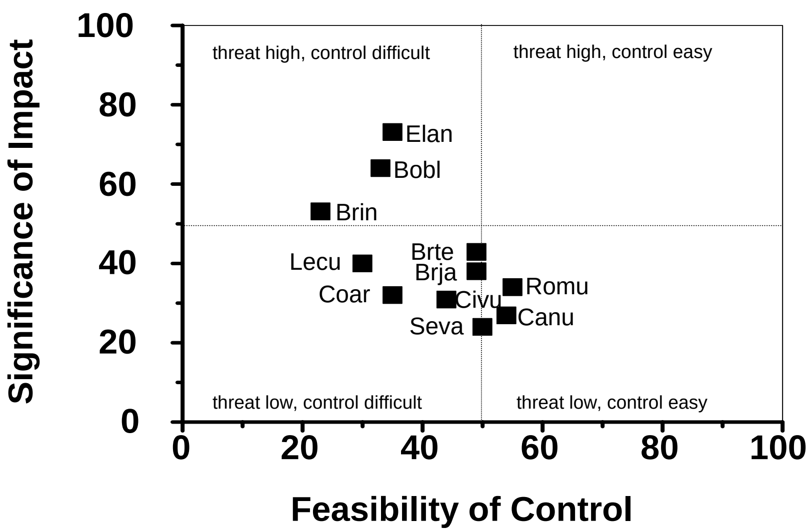

FIGURE G.1. Estimated significance of impact and feasibility of control of the 11 potentially most serious non-native invasive plants on Smoky Hill ANGR. Species codes are from Table G.2.

The 11 aforementioned species were ranked for management and control following procedures outlined by Hiebert and Stubbendieck (1993). This analytical approach ranks each species of interest using a series of criteria that estimate its significance of impact (current level of impact [distribution relative to disturbance regime, abundance, effect on natural processes and character, significance of threat on installation resources, level of visual impact to an ecologist] + innate ability of species to become a pest [ability to complete reproductive cycle in area of concern, mode of reproduction, vegetative reproduction, frequency of sexual reproduction for mature plant, number of seeds per plant, dispersal ability, germination requirements, competitive ability, known level of impact in natural areas]) and feasibility of control or management (abundance within installation [number of populations, aerial extent of populations] + ease of control [seed banks, vegetative regeneration, level of effort required, abundance and proximity of propagules near installation] + side effects of chemical/mechanical control measure + effectiveness of community management + biological control). Each species was scored for each criterion, yielding a numeric score for significance of impact (100 maximum possible points) and feasibility of control or management (100 maximum possible points). Scores for the 11 species are presented in Table 6.2.

When plotted on a scatter plot with feasibility of control on the x-axis and significance of impact on the y-axis, and higher numbers correspond to increasing ease of control and increasing impact, respectively (Figure G.1), most species appear to pose relatively low threat to plant communities on Smoky Hill ANGR. Only three species; *Elaeagnus angustifolia*, *Bothriochloa bladhii*, and *Bromus inermis* have impact and control scores both greater than 50, placing them in the "threat high, control difficult" category. All other species fall either in the "threat low, control difficult" or "threat low, control easy" categories.

This assessment suggests that, in their present state, most of the 11 non-native species believed to represent the greatest threat on Smoky Hill ANGR do not pose a serious threat to native plant communities. Scores for significance of impact range from 24—73. Three species, *Elaeagnus angustifolia*, *Bromus inermis*, and *Bothriochloa bladhii* have scores high enough to be considered high threats on the installation, though *Bromus inermis* is only marginally so. The remaining eight species have impact scores low enough to be considered low threats. Scores for feasibility of control range from 23—55; 9 species have scores of 50 or lower, indicating low feasibility of control. The two species with scores greater than 50, *Carduus nutans* and *Rosa multiflora*, are only marginally in the "easy to control" category.

While significance of impact and feasibility of control scores assigned to these 11 species are based mostly on intrinsic, life history attributes, scores are influenced partly by extrinsic factors, such as current population numbers and coverage on the installation. Management practices that favor expansion of existing populations and establishment of new populations inevitably will cause control scores to rise, elevating a species' perceived threat at the site. There are ongoing efforts to control *Carduus nutans* on Smoky Hill ANGR.

G.2.3. Management Methods

Web Sources:
http://www.ksda.gov/plant%5Fprotection/ - Kansas Department of Agriculture, Plant Protection and Weed Control Program
http://www.invasivespecies.net/database/welcome/ - Global Invasive Species Database

http://www.nps.gov/plants/alien/fact.htm - Plant Conservation Alliance's Alien Plant Working Group
http://res2.agr.ca/lethbridge/weedbio/index_e.htm#toc - Agriculture and Agri-Food Canada Classical Biological Control for Weeds
http://www.fs.fed.us/database/feis/index.html - USDA Forest Service Fire Effects Information Service
http://mdc.mo.gov/nathis/exotic/vegman/index.htm - Missouri Vegetation Management Manual

Various management methods are available for control or elimination of invasive, non-native plant species. These usually are grouped into four broad categories: mechanical, chemical, cultural, and biological methods (Lorenzi and Jeffery 1987). Integrated management approaches involve the use of techniques from two or more of these categories to control vegetation.

G.2.3.1. Mechanical Control. Mechanical management techniques involve the physical removal of undesirable plants from the soil, or the manipulation of the soil ultimately to reduce the reproductive success of weeds (Lorenzi and Jeffery 1987). Mechanical methods include hand-pulling, hand-cultivation (hoeing), digging, deep plowing, tilling, clipping or mowing, grazing, cutting, burning, and mulching.

Methods employed to control invasive species depend on the level of infestation, resources available, and environmental conditions. Hand-pulling, hand-cultivation, and digging often are used for small, accessible infestations of invasive and non-native plants, especially herbaceous species. Whole-plant removal and cutting often are used on shrubs and trees. If a site is heavily infested by non-native species and has few or no desirable species, or the short-term loss of those desirable species is acceptable, complete clearing of the site, followed by planting with desirable species, may be the best approach. Follow-up treatment with other control methods is likely after using heavy equipment because soil disturbance may create favorable conditions for regrowth of invasive plants from seeds and root fragments; it also may provide opportunities for colonization by other invasive species. Planting can be an effective but expensive approach to control of invasive species. A critical factor is to use plant material representative of local genotypes that are adapted to local environmental conditions. Plantings often take years to become well-established, and special attention may be needed to ensure proper establishment and succession.

Mechanical removal with heavy equipment may not be appropriate in natural areas because of disturbance to soil and non-target vegetation. Tilling can be used on level areas and is best used on cropland along with herbicides as part of a revegetation effort. Mowing can reduce seed production in some invasive species, especially annuals, depending on the timing. Mowing is a viable control option if done with sufficient frequency to prevent seed production by invasive species and eventually to eliminate root reserves supporting regrowth. Whole-plant removal for shrubs and trees can be highly effective, particularly if used in combination with follow-up fire and/or herbicide treatments.

Some techniques are based on the ecological principle of interspecific competition, in which the health of native plant communities is promoted to increase resource competition or to influence the timing of resource availability and, hopefully, to minimize the potential for invasion by non-native species or to put established, non-native species at a competitive disadvantage. Advances in our understanding of the factors causing plant succession, namely disturbance, colonization, and species performance, are allowing more accurate predictions about successional trajectories and the impact of management actions on the risk of weed invasion (Sheley and Krueger-Mangold 2003, Svejcar 2003).

Grazing can be considered a form of mechanical control. It can be extremely effective in controlling some non-native, invasive species, especially if used in combination with other control techniques. Care must be taken to manage grazing intensity, duration, and frequency to avoid damage to native species, which could give invasive species an opportunity to establish or spread.

Fire is a tool essential to the management of many types of grassland plant communities. It can be used to increase the vigor and reproductive success of native grasses and forbs by reducing standing dead biomass and recycling nutrients. Fire kills species that are not fire-tolerant (e.g., *Juniperus virginiana*), but repeated burns may be needed to control some invasive perennials, especially colonial ones. The spread of some species actually is stimulated by fire. The length of effect varies with the intensity and timing of the fire, and the species involved. A post-burn herbicide treatment will be more effective if time is allowed for adequate regrowth before the treatment. Too frequent burning can reduce native plant richness under some conditions.

G.2.3.2. Chemical Control. Herbicides can be classified based on their effect on plants, chemistry, or method of application (Lorenzi and Jeffery 1987). Most herbicides have several effects on plants, which dictate when and how they are used. A useful resource in this regard is Regehr et al. (2007), which provides detailed information about chemical control of weeds in fields, pastures, rangeland, and non-croplands. Miller (2004) also provides a useful overview of chemical control methods.

Selective herbicides are more toxic to some plant species than they are to others. Examples include atrazine, chlorsulfuron, 2,4-D, dicamba, picloram, and trichlopyr. Nonselective herbicides are generally toxic to plants without regard to species. Toxicity may vary according to rate or method of application. Nonselective herbicides must be applied by paying careful attention to weather and soil conditions to prevent movement and impacts to non-target species. Examples of nonselective herbicides include amitrole, bormacil, cacodylic acid, diuron, glyphosate, and paraquat. Contact herbicides cause localized injury to plant tissue where the chemical comes in contact with tissue. They are applied when target plants are actively growing and bear leaves. Good coverage is critical for effective control. Most contact herbicides are nonselective; examples include cacodylic acid, diquat, and paraquat. Translocated herbicides are moved within the plant. Some are effective when applied to foliage. Others are effective through root uptake from soil application. Most translocated herbicides are selective. Examples include atrazine, bromacil, chlorosulfuron, 2,4-D, dicamba, glyphosate, picloram, and tebuthiuron.

Generally speaking, seedlings of annual, biennial, and perennial plants are more susceptible to the actions of herbicide than are mature plants. Among annuals and biennials, effectiveness of herbicides generally decreases as plants mature, bud, flower, and fruit. In contrast, perennial plants generally are controlled most effectively during periods of regrowth (e.g., in the spring, after grazing, or after mowing) and during budding and early flowering stages. Control usually declines markedly as plants mature. Woody plants can be controlled almost anytime, but control is best when plants are small or when leaves are actively growing.

Use of selective herbicides can reduce target species and give desirable species a competitive advantage. Chemical control often is temporary, requiring repeated applications. Long-term commitment and sustained effort are essential for effective management using herbicides. Furthermore, chemical treatment can be expensive and must be used judiciously to comply with DoD and Air National Guard pesticide-use reduction goals, and the installation's pest management plan.

For herbaceous weeds, chemical treatment with a broadleaf herbicide, such as triclopyr amine (e.g., Garlon 3A) or a broad-spectrum post-emergent, such as glyphosate (e.g., Roundup or Rodeo) are the primary control methods recommended for most areas on Smoky Hill ANGR. However, these herbicides need to be applied carefully by certified pesticide applicators using spot application methods (e.g., spot sprayers, rollers, or sponges) to prevent impacts on desirable native forbs and grasses. Because of its soil activity, herbicides containing impazapyr (e.g., Plateau) should be used only with extreme caution. Under certain conditions, it spreads through underground root systems to non-target species in untreated areas.

Control of woody plants can be attained by applying herbicides in several ways. The most common application methods are foliar spray, cut stump treatment, basal bark application, frill or girdle application, and direct injection methods. In foliar treatments, herbicide is diluted and sprayed onto the foliage of the plant until the solution begins to run off the leaf surface (sprayed-to-wet). The basal bark application consists of the herbicide being applied directly to the bark at the base of the tree, typically with a backpack sprayer. The frill or girdle method (hack and squirt) involves cutting gashes into the tree around its circumference and then spraying or squirting herbicide into the gashes. Direct injection techniques utilize the same principle but employ specialized equipment to deliver the herbicide to the cambium for uptake. Herbicides such as triclopyr ester (e.g., Garlon 4) can be used to treat woody plants.

Nonselective herbicides, such as glyphosate, should be reserved for situations where total denudation is considered a viable option or where application can be tightly controlled to prevent impacts on non-target species. Total denudation must be considered carefully before being done; failure to follow through in a timely and complete fashion can yield a more serious invasive species problem than the one being controlled. A marker dye added to herbicides before they are applied allows more careful application.

Reliance on chemical control of invasive plants in rangeland has some serious drawbacks, including high cost per acre, decreasing effectiveness, negative effects on native biodiversity, and increased opportunities for environmental contamination (Louda and Masters 1993).

G.2.3.3. Cultural Control. As defined by Lorenzi and Jeffery (1987), cultural management employs techniques common to farm management for controlling weeds. Common techniques include the use of weed-free seed, cleaning of equipment, cover crops, smother crops, and crop rotation. Among cultural management techniques, equipment cleaning probably is the single most important technique for controlling the spread of non-native plant species on Smoky Hill ANGR. Mowing equipment, livestock trailers, and military equipment used on the installation have the potential to spread seeds and plant parts of non-native species to areas where the species currently do not occur. Other cultural management techniques are most critical on cropland and at sites where revegetation efforts are attempted.

G.2.3.4. Biological Control. Biological control has as its basic premise that specialized natural enemies can reduce the growth and reproduction of their prey resource and keep it in check (Louda and Masters 1993). The approach employs living organisms, such as pathogens, insects, or nematodes, called the biological control agent, to suppress invasive plant infestations to an acceptable level. Thousands of non-native plant species have been introduced to North America. Without their natural predators, many have become invasive. Efforts to develop biological control agents often involve finding such natural enemies in the land of origin of the pest plant species. A primary limitation to this approach is that suitable control agents have not been found for many invasive species. Generally, biological agents work slowly and rarely completely eradicate the invasive species. As the weed population decreases, so too will the control agent population. This usually sets in motion a recurring cycle in which control agent populations track, but are slightly out of phase with, the weed populations. There also is the risk of the biological control agent attacking non-target species during or after the eradication process.

Biological control is a sensible approach for control of remote infestations that cannot be accessed easily for treatment by other means. It generally is not a viable alternative for small, readily-accessible infestations. Biological control can be an important part of an integrated invasive plant management plan where control, rather than eradication, is the management goal.

G.2.4. Management Plan for Primary Nonnative/Invasive Plant Species

For each primary invasive species discussed below, we list literature and Web sources that may be useful to resource managers, provide background information about each invasive species, discuss its status on Smoky Hill ANGR, and provide control and management recommendations. A summary of management recommendation is presented in Table G.4. Woody plants comprise a guild of both native and non-native species that cause some management problems on Smoky Hill ANGR. Trees and shrubs have invaded parts of the installation, and some stands warrant control. Management of invasive, woody plants is discussed after the primary invasive species. All discussions draw heavily from Web sources listed at the beginning of each species account. For brevity, in-text citations are provided primarily for published references; in-text citations for Web references became too unwieldy. Chemical control information is taken largely from Regehr et al. (2007), supplemented from other sources where necessary. Herbicides listed by the Kansas Department of Agriculture as approved for control of noxious weeds in Kansas closely match those in Regehr et al. (2007). Refer to that publication for a complete list of chemicals and their recommended uses. Refer also to the Kansas Department of Agriculture, Plant Protection and Weed Control Program Web site (http://www.ksda.gov/plant%5Fprotection/) for general information about the Kansas noxious weed program and species-specific control information. Official control programs have been developed and promulgated by the Kansas Department of Agriculture for Kansas noxious weeds. They can be found with the Kansas Noxious Weed Law. Control and management recommendations generally review mechanical, chemical, cultural, and biological control methods available for each species. Based on these, we provide general management recommendations, which range from specific to general. Management plans for the control of invasive species should be adaptive – built on baseline information from this report and adjusted annually to meet specific management objectives. For this reason, we avoided being too prescriptive in our general management recommendations.

G.2.4.1. *Bothriochloa bladhii* (Retz.) S. T. Blake (Poaceae: Caucasian bluestem)

Web Sources:
http://extension.missouri.edu/explore/agguides/crops/g04674.htm - University of Missouri Extension; Caucasian Bluestem

Caucasian bluestem, also called Australian bluestem, is native in subtropical Asia and Africa. Seeds were introduced into the U.S. in 1929 and distributed to experimental stations in Kansas and Texas because of its potential as livestock forage (Schmidt and Hickman 2006). Escaped plants were first collected in Kansas in 1952. Since the 1970s, it has been used in revegetation projects, rights-of-way plantings, and in USDA Conservation Reserve Program seed mixtures. Caucasian bluestem currently is known from nearly 40 counties in Kansas, and it has become particularly abundant in parts of the Flint Hills and eastern Smoky Hills. Also documented in Missouri, Oklahoma, Texas, and New Mexico, there are only scattered references to Caucasian bluestem being an undesirable, less-palatable, aggressive invader of warm-season grass pastures and rangeland.

Caucasian bluestem is a warm-season, caespitose, perennial grass that grows to 1.5 m tall. When flowering or fruiting, the inflorescence usually is dark purple or brownish purple, slender, and 5—20 cm long. The species is relatively easy to establish from seed, withstands heavy grazing pressure, and produces high yields of forage under hot, dry, growing conditions. Life history information about the species is otherwise relatively limited.

Status on Smoky Hill ANGR. Species-specific surveys for Caucasian bluestem were not conducted on Smoky Hill ANGR. It was observed across the installation, usually scattered in rangeland and along roads.

Control and Management Recommendations. Control and management information is unavailable for Caucasian bluestem. It is planted for rangeland forage but is not as palatable as related, native, warm-season species. The species appears to be spreading in Kansas. Its life history attributes suggest that it has the potential to become a serious pest species in Kansas, and it will have to be monitored across the state and on the installation to determine if control is warranted.

General Management Recommendations. The management goal for Caucasian bluestem should be to control stands below action thresholds, which need to be established by installation managers. Until more is known about this species and the magnitude of the threat that it poses, managers on Smoky Hill ANGR should monitor Caucasian bluestem. Initial assessments suggest that control of Caucasian bluestem may be challenging once the species is well-established in rangeland.

We recommend that several grassland-dominated management units where populations of Caucasian bluestem occur (perhaps one being grazed and one not being grazed) be monitored annually. Plants bloom and fruit from late July until October, and are most easily recognized during this period. The cover of Caucasian bluestem should be estimated using standardized field assessment protocols to determine whether populations of the species are declining, stable, or spreading. If it is determined that Caucasian bluestem represents a genuine threat to native biodiversity on Smoky Hill ANGR, management prescriptions should be developed and implemented. Absent such information at the present time, research being conducted at Kansas State University on Konza Prairie may provide a starting point for understanding the threat and possible control approaches.

G.2.4.2. *Bromus inermis* Leyss. (Poaceae: smooth brome)

Web Sources:
http://www.npwrc.usgs.gov/resource/plants/exoticab/pipebrom.htm - USGS Northern Plains Wildlife Research Center Species Abstract; *Bromus inermis*
http://www.agdepartment.com/noxiousweeds/pdf/Smoothbrome.pdf - North Dakota Department of Agriculture Catalogue of Species; *Bromus inermis*

Smooth brome, also called Hungarian brome, Austrian brome, or awnless brome, is native in Eurasia. It was introduced to North America in 1884 for forage and erosion control. It was first collected in Kansas in 1894. It is a major forage and hay crop in the central and northern Great Plains.

Smooth brome is a cool-season, perennial grass that grows to 1 m tall. Plants bloom and fruit from May—July. Smooth brome often is a highly competitive weed of roadsides, woodlands, prairies, fields, lawns, and lightly disturbed sites. It vigorously reproduces vegetatively and produces high numbers of seeds that may remain viable in the soil for 2—10 years. It grows in a wide range of soils, though growing best on deep, fertile, well-drained silt loam or clay loam soils. Smooth brome is drought and temperature tolerant, becoming dormant during the warmer months and, depending upon soil moisture, may regrow in September or October. It tolerates flooding for up to 24 days and is considered to be moderately tolerant of saline conditions. Smooth brome does not appear to tolerate highly organic soils, possibly because of poor soil aeration, and it is not shade-tolerant.

Status on Smoky Hill ANGR. Species-specific surveys for smooth brome were not conducted on Smoky Hill ANGR. The species is ubiquitous on the installation. Populations were seen in rangeland, along roadsides, in formerly cropped areas, along streams and in moist ravines, and in sites that are periodically disturbed. Some dense stands may be remnants of cool-season pastures or hay meadows on farms before the installation was established.

Control and Management Recommendations. Control methods for smooth brome have been used with varying degrees of success. Most methods have unwanted effects on other, desirable plants, and the resulting disturbances may favor reinvasion by smooth brome or other invasive species.

Mechanical Control. Mechanical control of smooth brome includes prescribed burning, grazing, and mowing. Some studies suggest that late spring burns reduce smooth brome. Timing of prescribed burns is important; plants are susceptible to fire and can be killed when they are tillering. Burns conducted too early in the spring (March—April) usually have little impact. Root reserves are at the lowest level immediately prior to or at the boot stage – the optimal time for a prescribed burn. The disadvantage of such a burn is that it may adversely effect desirable vegetation. Repeated, annual burns from May to early June reduce smooth brome tiller numbers and favor growth and development of native, warm-season grasses. In the northern Great Plains, fire appears to be less effective or ineffective in controlling smooth brome (Sather 1987).

Smooth brome is generally tolerant of grazing but can be damaged by repeated, heavy, early spring grazing, probably because the meristem is more exposed and root reserves are reduced.

Repeated mowing for several years during the boot stage (usually when culms are 45—60 cm tall) may reduce the density of stands. Effective control has been achieved when mowing was proceeded by hot, moist weather followed by a dry period. Repeated mowing throughout the summer can keep root reserves low, reducing the vigor of plants, but some studies suggest that repeated mowing within a year are no more effective than is a single cutting annually when plants are in the boot stage.

Chemical Control. Most herbicides effective for control of smooth brome are not specific for the species or may not be specifically labeled for this use. Roundup (glyphosate) applied in April or May is effective on smooth brome in pastures and rangeland. Other chemicals that have controlled smooth brome are AAtrex (atrazine), Kerb (pronamide), Arsenal (imazapyr), Bromax (bromacil), and Princep (simazine).

Cultural Control. Unintentional introduction can result from contaminated vehicles. Once established at a site, most cultural control methods are too labor intensive to provide effective control of smooth brome.

Biological Control. No research has been done to develop potential biological controls because smooth brome is a forage grass. The bromegrass seed midge (*Stenodiplosis bromicola*) and chalcid flies are seed predators. Seedling blight and grasshoppers negatively impact seedling establishment.

General Management Recommendations. The management goal for smooth brome should be to control stands below action thresholds, which need to be established by installation managers. Smooth brome does not appear to be a serious threat either to the military mission or to agricultural practices on Smoky Hill ANGR. Established populations are difficult to control. Populations should be monitored periodically to ensure that they do not exceed tolerance thresholds for various activities on the installation. Rangeland management prescriptions that promote the overall health of native vegetation probably will keep smooth brome populations in check.

G.2.4.3. *Bromus japonicus* Thunb. (Poaceae: Japanese brome)

Web Sources:
http://www.agdepartment.com/noxiousweeds/pdf/Japanesebrome.pdf - North Dakota Department of Agriculture Catalogue of Species; *Bromus japonicus*

Japanese brome, also called Japanese chess, is native in central and southeastern Europe and Asia (Pavlick 1995). It was introduced to North America as a forage crop. The first collections from Kansas were made in 1889.

Japanese brome is a cool-season, winter annual grass that grows to 0.5 m tall. Plants can behave like spring annuals or biennials when sown in late March or early April (Finnearty and Klingman 1962). Japanese brome blooms and fruits from May to July. It can be a pest in wheat, alfalfa, fallow ground, rangeland, waste areas, roadsides, and other ruderal sites. Japanese brome is an aggressive colonizer and invades overgrazed pastures and rangeland by seeds. Plants are palatable before the inflorescences emerge and mature; mature plants can cause injury to livestock by causing infections of the eyes or mouth (Hull and Pechanec 1947). Dense stands can present a fire hazard.

Status on Smoky Hill ANGR. Species-specific surveys for Japanese brome were not conducted on Smoky Hill ANGR. The species was observed to be scattered to locally abundant in rangeland and in periodically disturbed sites across most of the installation.

Control and Management Recommendations

Mechanical Control. Control of Japanese brome in rangeland and pastures should emphasize rangeland management practices that promote healthy stands of native, perennial grasses and forbs. Elimination of seed sources is critical in controlling Japanese brome (Finnerty and Klingman 1962). Prescribed burning alone does not appear to be an effective approach, but burning can reduce stands by promoting more vigorous stands of perennial grasses and forbs. Seed production in small infestations can be reduced, but not eliminated, by mowing. The best time to mow Japanese brome for control in pastures is approximately one week after the emergence of the inflorescences (Finnerty and Klingman 1962). As with burning, mowing also may promote vegetative growth of nearby perennial species, putting Japanese brome at a competitive disadvantage.

Chemical Control. Several foliar herbicides can be used to control Japanese brome in the fall or early spring on rangeland; however, most herbicides are not specific to Japanese brome. More than a half-dozen herbicides are recommended for control of Japanese brome and other cool-season annual grasses on croplands.

Herbicide and lb active ingredient needed/acre	Formulated product/acre	Comments/limitations
Glyphosate 0.28 to 0.39 lb ae	8 to 11 fl oz 4.5 lb ae/gal **Glyphosate**	Apply to rangeland when native grasses are dormant in the fall or early spring and annual bromes are actively growing. Desirable cool-season grasses, such as western wheatgrass will be damaged. Do not use ammonium sulfate. See various labels for rates, directions, and precaution.

Cultural Control. Unintentional introduction can result from contaminated vehicles. Once established at a site, cultural control methods likely are too labor intensive to provide effective control of Japanese brome.

Biological Control. No insect biological control agents are currently available for control of Japanese brome.

General Management Recommendations. The management goal for Japanese brome should be to control stands below action thresholds, which need to be established by installation managers. Japanese brome does not appear to be a serious threat either to the military mission or to agricultural practices on Smoky Hill ANGR. Established populations are difficult to control. Populations should be monitored periodically to ensure that they do not exceed tolerance thresholds for various activities on the installation. Rangeland management prescriptions that promote the overall health of native vegetation probably will keep smooth brome populations in check. Local infestations, if sufficiently severe, can be controlled by grazing infested areas before plants bloom, or by spot spraying in the fall or early spring before native species are actively growing.

G.2.4.4. *Bromus tectorum* L. (Poaceae: downy brome)

Web Sources:
http://www.ianrpubs.unl.edu/epublic/live/g422/build/g422.pdf - University of Nebraska-Lincoln Extension, NebGuide; Downy Brome Control
http://www.agdepartment.com/noxiousweeds/pdf/Cheatgrass.pdf - North Dakota Department of Agriculture Catalogue of Species; *Bromus tectorum*

Downy brome, also called cheatgrass, downy cheatgrass, downy bromegrass, bronco grass, military grass, downy chess, or cheat, is native in the Mediterranean region of Europe. It was introduced into North America in 1861 (Klemmedson and Smith 1964). Downy brome was first collected in Kansas in 1920 and spread to all counties in the state by the 1940s.

Downy brome is a cool-season, winter annual grass that grows to 0.5 m tall. It blooms and fruits from May to July. It can be especially troublesome in wheat, alfalfa, fallow ground, rangeland, waste areas, roadsides, fencerows, and other ruderal sites, particularly in the western half of Kansas. It quickly invades overgrazed pastures and rangelands by seeds, which have awns that attach to the coats of cattle and other animals. Plants are palatable before the inflorescences emerge and mature; mature plants can cause injury to livestock by causing infections of the eyes or mouth (Hull and Pechanec 1947). Dense stands can present a fire hazard.

Status on Smoky Hill ANGR. Species-specific surveys for downy brome were not conducted on Smoky Hill ANGR. The species was observed to be scattered to locally abundant in rangeland and in periodically disturbed sites across most of the installation.

Control and Management Recommendations

Mechanical Control. Control of downy brome in rangeland and pastures should emphasize rangeland management practices that promote healthy stands of native, perennial grasses and forbs. Elimination of seed sources is critical in controlling downy brome (Finnerty and Klingman 1962). Prescribed burning alone does not appear to be an effective approach, but burning can reduce stands by promoting more vigorous stands of perennial grasses and forbs. Seed production in small infestations can be reduced, but not eliminated, by mowing. The best time to mow downy brome for control in pastures is approximately one week after the emergence of the inflorescences (Finnerty and Klingman 1962). As with burning, mowing also may promote vegetative growth of nearby perennial species, putting downy brome at a competitive disadvantage.

Chemical Control. Several herbicides can be used to control downy brome in the fall or early spring on rangeland; however, most herbicides are not specific to downy brome. More than a half-dozen herbicides are recommended for control of downy brome and other cool-season annual grasses on croplands.

Herbicide and lb active ingredient needed/acre	Formulated product/acre	Comments/limitations
Glyphosate 0.28 to 0.39 lb ae	8 to 11 fl oz 4.5 lb ae/gal **Glyphosate**	Apply to rangeland when native grasses are dormant in the fall or early spring and annual bromes are actively growing. Desirable cool-season grasses, such as western wheatgrass will be damaged. Do not use ammonium sulfate. See various labels for rates, directions, and precaution.

Cultural Control. Unintentional introduction can result from contaminated vehicles. Once established at a site, cultural control methods likely are too labor intensive to provide effective control of downy brome.

Biological Control. No insect biological control agents are currently available for control of downy brome.

General Management Recommendations. The management goal for downy brome should be to control stands below action thresholds, which need to be established by installation managers. Downy brome does not appear to be a serious threat either to the military mission or to agricultural practices on Smoky Hill ANGR. Established populations are difficult to control. Populations should be monitored periodically to ensure that they do not exceed tolerance thresholds for various activities on the installation. Rangeland management prescriptions that promote the overall health of native vegetation probably will keep smooth brome populations in check. Local infestations, if sufficiently severe, can be controlled by spot spraying.

G.2.4.5. *Carduus nutans* (Asteraceae: musk thistle, nodding thistle)

Web Sources:
http://www.ksda.gov/plant_protection/content/181/cid/587 - Kansas Department of Agriculture, Plant Protection and Weed Control Program; Musk Thistle
http://www.oznet.ksu.edu/library/crpsl2/L231.pdf - K-State Research and Extension; Musk Thistle Identification and Control
http://www.oznet.ksu.edu/library/entml2/L873.pdf - K-State Research and Extension; Biological Control of Musk Thistle in Kansas
http://www.oznet.k-state.edu/pr_forage/pubs/97notebook/fora39.pdf - K-State Research and Extension; Forage Facts - Musk Thistle Control
http://www.ianrpubs.unl.edu/epublic/live/ec176/build/ec176.pdf - University of Nebraska Cooperative Extension; Noxious Weeds of Nebraska – Musk Thistle
http://www.ag.ndsu.edu/pubs/plantsci/weeds/w799w.htm - North Dakota State University College of Agriculture; Perennial and Biennial Thistle Control
http://www.nps.gov/plants/alien/fact/canu1.htm - Plant Conservation Alliance's Alien Plant Working Group; Musk Thistle
http://www.agdepartment.com/noxiousweeds/pdf/Muskthistle.pdf - North Dakota Department of Agriculture Catalogue of Species; *Carduus nutans*

Carduus nutans is native in Europe and was introduced into the U.S. in the 1850s. It was first collected in Kansas in 1932 (Fick and Peterson 1995). The species has since been documented in nearly every county in the state.

Musk-thistle, a member of the sunflower family, usually is a biennial herb but occasionally occurs as a winter annual or summer annual. It grows to 2 m tall. Heads of purple or rose-colored flowers appear at the ends of the stems from May until early July. The species spreads by seeds, which are dispersed mostly by the wind, but occasionally also by water, livestock, wildlife, and machinery. Musk-thistle favors abandoned fields, overgrazed pastures, roadsides, and other sites where frequent disturbance exposes the soil. Plants are not shade tolerant. It can occur in native grassland but usually is restricted to areas of localized disturbance. Musk-thistle reduces forage production and utilization, competes with native species for water, light, and nutrients, and cattle will not graze forage plants in heavy infestations (Fick and Peterson 1995).

Musk-thistle is designated a noxious week in Kansas. The Kansas Department of Agriculture has developed and promulgated an official control program for musk-thistle.

Status on Smoky Hill ANGR. Musk-thistle was recorded in 23 of 30 management units that were surveyed; it infested an estimated 418.61 acres (Table 3.6, Figure 3.6). Canopy cover for all polygons was 1–10%. Populations were observed in prairies, former cropland, and in cultural vegetation types, but in nearly all cases they comprised scattered individuals in habitats that experienced recent or ongoing disturbance, most often from grazing or soil disturbance. Patches of exposed soil often were present where populations occurred. A quantitative comparison of 2001 and 2006 survey data could not be attempted because of differences in survey and mapping procedures. A qualitative comparison of maps for those two years does suggest roughly similar distribution patterns of *Carduus nutans* on the installation.

The 2006 survey data indicate that low-density populations are fairly common in management units containing the upper reaches of Spring Creek. By comparison, *Carduus nutans* occurs most often as isolated individuals along the upper reaches of Ralston Creek, east of Spring Creek. In units in the north half of Smoky Hill ANGR, most occurrences of *Carduus nutans* are small, often consisting of a few isolated individuals. Surveys indicate that the species occurs most frequently along streams and in mesic habitats in grazed pastures. Weed surveys were not conducted in the central part of the installation, so it is impossible to estimate the extent or significance of populations there.

Control and Management Recommendations

Mechanical Control. Prevention is of paramount importance for control of biennial thistles, which often invade overused or disturbed land. The best preventive measure in non-cropland is to maintain a healthy plant cover and to reseed disturbed areas with a desirable species as soon as possible. Establishing competitive grasses can reduce the size of rosettes and decrease thistle height, root weight, and crown size. Once thistles invade an area, several control options are available, depending on the location and land use. Most types of control are ineffective if carried out while thistles are in bloom, and an integrated management program generally is more successful than is a single control method.

Repeated mowing will reduce musk-thistle infestations. Plants should be mowed when they are in the early bud growth stage to prevent seed set. Several annual mowings are needed because of phenological variation within and among populations. A second mowing approximately one month after the first mowing yields significantly greater control. Plants should be mowed as close to the soil surface as possible; plants cut above the terminal bud before the stems elongate likely will regrow. It is critical to mow before flowers show color to preclude any seed production. Scattered individuals can be removed by digging the rosette 5—10 cm below the crown. Heads of thistles in late bud or bloom should be bagged, removed from the field, and burned to prevent seed development elsewhere. Annual tillage or crop competition will completely control biennial thistles.

Good grazing management is the first line of defense against musk thistle invasion on rangeland and pastures. Stocking rates designed to avoid overgrazing, maintaining a competitive cover of native vegetation and preventing bare ground, should be the management objective. Controlled and rotational grazing can prevent thistle establishment. Overgrazing makes rangeland more susceptible to invasion by weakening desirable species and exposing patches of bare soil where musk-thistle can establish. Fire has not proven to be an effective control measure unless it ultimately increases the vigor of native, perennial grasses and forbs, thereby reducing the amount of suitable habitat.

Chemical Control. Long-term control of thistles with herbicides depends on timely application for maximum effectiveness and on retreatments to reduce or deplete the seed bank of thistles. In pastures, rangeland, and on other non-cropland sites, fall is the preferred time to apply herbicides for biennial thistle control. Fall applications allow for more time to apply herbicides than in the spring and correspond to one of the most effective times for thistle control – when plants are in the rosette state. Seedlings that emerge in summer after tillage or previous herbicide applications will not bolt but remain in the rosette stage. Herbicides should be applied from October 1 until the soil freezes; applications after a killing freeze will minimize impacts from drift onto non-target plants. Herbicides are most effective when the air temperature is between 70°—90°F and with a 6—12 hour rain-free period (Fick and Peterson 1995). Seedlings that emerge after spraying will remain vegetative until the following spring and can be treated then. Long-term eradication of biennial thistles is difficult because of the large number of seeds that each plant can produce.

Biennial thistles can be effectively controlled with clopyralid, picloram, or dicamba. Clopyralid and picloram are the most effective of these herbicides and may be applied in the spring or fall. Picloram and clopyralid often are mixed with 2,4-D for broad spectrum weed control. Dicamba plus 2,4-D is an effective treatment and is best applied when the thistles are in the rosette growth stage. Triclopyr plus clopyralid is labeled for thistle control in non-cropland and CRP. Metsulfuron will control biennial thistles in the spring and will eliminate seed production when applied in the bolting to bud growth stages.

Herbicide and lb active ingredient needed/acre	Formulated product/acre	Comments/limitations
Chlorsulfuron 0.375 to 0.75 oz	0.5 to 1 oz **Telar DF**	Do not apply to cropland. Apply in spring from rosette to pre-bloom stages of growth. Do not allow spray drift to contact nearby crops or other non-target plants; injury can occur. Follow label directions and precautions.
Clopyralid/2,4-D 0.095 + 0.5 lb to 0.19 + 1 lb	2 to 4 pt **Curtail**	For use on rangeland, permanent grass pasture, CRP, and non-cropland. Apply to actively growing rosettes in the spring or fall or to bolted thistles up to the bud stage. Follow label directions.
Clopyralid/Triclopyr 0.375-0.56 lb	0.5 + 1.5 qt **Redeem R&P**	Apply lower rates to rosettes in the spring and the higher rate from mid to late bolt to early flowering stages.
Dicamba 0.33 lb	0.67 pt **Banvel** or **Clarity**	Apply in spring during rosette stage of growth. Can be applied for control in fall, if soil moisture is favorable and air temperature exceeds 50°F. Follow label directions.
Dicamba + 2,4-D 0.25 lb + 0.75 lb	0.5 pt **Banvel** or **Clarity** + 0.75 qt **2,4-D*** amine or LVE	Apply in spring during rosette stage of growth. Can be applied for control in fall, if soil moisture is favorable and air temperature exceeds 50°F. Follow label directions.
Diflufenzopyr/dicamba	4 oz **Overdrive**	For use on non-cropland, pasture, hay, and rangeland. Apply in the spring to actively growing rosettes or bolted thistles up to the bud stage. Add a non-ionic surfactant or methylated seed oil. Follow label directions.
Metsulfuron methyl 0.15 to 0.3 oz	0.25 to 0.50 oz **Escort XP** or **Cimarron**	Apply in the spring or fall to rosettes. Add 0.5 lb. 2,4-D to enhance activity up to flowering. Note: Do not apply if drought conditions exist at intended time of application.
Metsulfuron methyl + Dicamba + 2,4-D	Rate I **Cimarron Max**	Apply in the spring or early summer before flowering or in the fall. Add a nonionic surfactant or other adjuvant. Follow label directions.
Metsulfuron methyl + Chlorsulfuron	0.5 to 1 oz **Cimarron X-tra**	Apply in spring or early summer before flowering or to rosettes in the fall. Apply before the ground freezes.
Metsulfuron methyl + Chlorsulfuron	0.25 to 0.5 oz **Cimarron Plus**	Apply in spring or early summer before flowering or to rosettes in the fall. Apply before the ground freezes.
Picloram 0.13 lb	0.5 pt **Tordon 22K**	A restricted-use herbicide. Apply during rosette stage in the fall, before soil freezes. Follow label directions.
Picloram + 2,4-D 0.13 lb + 1.0 lb	0.5 pt **Tordon 22K** + 1 qt 4 lb/gal **2,4-D** amine, LVE, or mixed formulations	A restricted-use herbicide. Apply from rosette up to flowering stage in spring after soil thawing. Follow label directions.
Triasulfuron/Dicamba	4 oz **Rave**	Apply in spring to rosette stage or up to 5-inch-tall bolted thistles. Add 0.5 lb 2,4-D (1 pt 4 lb/gal) for enhanced control.
2,4-D amine 1.5 to 2 lb	1.5 to 2 qt 4 lb/gal **2,4-D** amine, LVE, or mixed formulations	Apply during rosette stage of growth. In spring, apply 2,4-D at 1.5 lb AE/A. For best control in fall, apply 2,4-D LVE at 2 lb/A. 2,4-D amine can be applied in fall, if soil moisture is favorable and air temperature exceeds 50°F.
Aminopyralid 0.047 to 0.078 lb	3 to 5 fl oz **Milestone**	Use for broadcast or spot treatment in rangeland, pastures, non-cropland, or CRP. Treat plants in the spring during rosette through bolting stages of development or in the fall. Follow label directions and precautions.

Aminopyralid + 2,4-D	1.5 to 2 pt **ForeFront R&P**	Use for broadcast or spot treatment in rangeland, pastures, and CRP. Treat plants in the spring during rosette through bolting stage of development or in the fall. Follow label directions and precautions.

Cultural Control. Avoid spreading thistle seed to uninfested areas with manure, mowers, or other farm equipment.

Biological Control. Two insects, musk thistle head weevil, *Rhinocyllus conicus* (Froelich), and musk thistle rosette weevil, *Trichosirocalus horridus* (Panzer), are approved for biological control in the Kansas Department of Agriculture musk-thistle control program. These weevils frequently use bull thistle as an alternate host (*q.v.*). Biological control plans must meet the requirements of K.S.A. Chapter 2, Article 13.4-8-41, which states:

Biological control plan. (a) No person shall use any predator, parasite, disease-causing organism, or any other substance or method to provide biological control of musk thistle without first having prepared a biological control plan that meets the requirements of this regulation. Each biological control plan shall state the area where biological controls are proposed. No person shall implement any part of a biological control plan unless that person first obtains both the written recommendation of the county noxious weed director for the area described in the plan and the written approval of the secretary. The location of a biological control area may be limited to specific areas where the application of herbicides would be difficult or inappropriate.
(b) No organism shall be used for the biological control of musk thistle except *Rhinocyllus conicus*, *Trichosirocalus horridus*, or any other organism approved by the Kansas department of agriculture as being effective for this purpose.
(c) A continuous musk thistle-free border shall be maintained around each site where biological control methods are used. This border zone shall be maintained free of musk thistle by either the application of approved chemicals or the use of approved cultural practices.
(d) Based upon the criteria set forth in subsection (e) below, the width of the border shall be specified by the county noxious weed director of the county in which the proposed biological control site is located. The width of the border shall not be less than 150 feet.
(e) The width of the border shall reflect the county noxious weed director's consideration of the following factors:

(1) The direction of the prevailing wind during the months of June and July;
(2) the presence of any shelter belts or hedgerows;
(3) the direction of the slope of the terrain;
(4) the density of the musk thistle population; and
(5) the density of the population of the organism to be used.

(f) Each approved biological control area plan shall meet all of the following requirements:

(1) Herbicide treatments for the control of musk thistle, when necessary, shall be made only during the periods from October 1st through April 15th.
(2) Hay shall not be moved from within the biological control area unless the biological control area has been inspected and certified as musk thistle-free by the

county noxious weed director within the seven days preceding the harvesting of the hay.

(3) The appropriate noxious weed control program shall be used to control any other noxious weed located within the biological control area.

(g) Failure to comply with any provision of an approved biological control plan or any provision of the Kansas noxious weed law or any rule and regulation promulgated there under shall constitute grounds for revocation of the biological control plan by the secretary. No approved biological control plan shall be revoked before the applicant has been given an opportunity to appear before the secretary or the secretary's designee regarding the proposed revocation.

Rhinocyllus conicus was introduced from Eurasia to control musk-thistle by reducing seed production (Hilbert and Brooks 2002). Larvae develop in the flower head and consume the seeds as they develop. The weevils can reduce seed production by nearly 80%, but they are attracted more to earlier blooming rather than to later blooming flowers. The late season flowers produce seeds with little damage from the weevil, which sustains the musk thistle population. It takes five to 10 years to build a population of insects high enough to greatly reduce seed production. *R. conicus* also will attack seed heads of many other thistle species, both native and introduced. *Trichosirocalus horridus* feeds on the apical meristem of the thistle rosette and developing stems. The feeding causes multiple stems to be formed when the plant bolts. However, these insects only partially control musk-thistle. A second control method such as chemical treatment is needed to stop the spread of the weed.

General Management Recommendations. The management goal for musk-thistle should be to control stands below action thresholds. As a listed, noxious weed in Kansas, plants should be eradicated to prevent reproduction. Managers at Smoky Hill ANGR have been monitoring populations of musk-thistle but have not employed systematic protocols to map populations and estimate canopy cover. We recommend that the mapping protocols used in this study be adopted so that periodic, quantitative comparisons can be made to determine if management prescriptions for control of musk-thistle are effective. Monitoring should be an ongoing part of the musk-thistle management plan. Surveys are likely to be most accurate and complete when plants are bolting or flowering, usually from May through July. After that, plants senesce and become more difficult to find. Plants are easily identified in the rosette stage but are more difficult to find in open rangeland. Annual monitoring and mapping of musk-thistle populations on all management units is warranted. Priority should be given initially to management units that were not surveyed for musk-thistles in 2006. We recommend that Smoky Hill ANGR management staff coordinate regularly with the Saline County Noxious Weed Director to explore the range of options available for control on the installation.

Installation managers have attempted to control musk-thistle using aerial spraying and on-the-ground spot spraying. Fall aerial spraying has been carried out using a C-130 aircraft applying 10 oz of Tordon 22K per acre of treated land. In our opinion, there is not adequate information to evaluate the effectiveness of aerial spraying for control of musk-thistle. Effectiveness can be assessed financially and biologically. As far as we know, there has been no cost-benefit analysis of the spraying program, and measures of biological effectiveness overlook several critical variables. Any measure of biological effectiveness should examine effects on both target and non-target species. Methods used heretofore to monitor musk-thistle have not been sufficiently rigorous to permit statistical comparisons, and the impact of other independent variables has not been measured or evaluated. This is the reason that we recommend that systematic monitoring protocols be adopted and employed. Monitoring alone will not allow managers to determine if population changes are due only to control efforts; other environmental factors also must be considered in any assessment.

Our recommendation to consider control methods other than aerial spraying is based on 1) principles of integrated pest management, which recommend aerial spraying as an approach of last resort, 2) the potential impacts of aerial spraying on non-target species, 3) DOD directives to use, where possible, non-chemical control options for invasive species, and 4) Section 21 of Exhibit A (DACA41-RE-B-06-2080; Land Use Requirements, Smoky Hill ANG Range, Kansas, Section A, General Requirements, which states, "Herbicides, insecticides, or other agricultural chemical will be used only when there are no other practical alternative methods." In our opinion, other practical alternative methods have not been attempted. Also, Section 13b of Exhibit A seems to contain a restrictive clause that limits the potential choice of "other practical alternative methods", stating that control shall be by spraying and/or mowing. Strictly interpreted, it excludes other potential control options, including mechanical, cultural, biological, or integrated approaches.

Tordon 22K is a restricted-use herbicide, meaning that that it may be used only by a certified pesticide applicator or under the direct supervision of a certified applicator. Pesticides may be labeled as restricted-use because of potential for or history of groundwater contamination, acute toxicity to humans, toxicity to vulnerable, non-target plants or animals, or known carcinogenic or mutagenic properties. The Armed Forces Pest Management Board (AFPMB) reviews and approves any introduction, stocking, and deletion of pest management materiel by the Defense Logistics Agency in the DOD supply system. Herbicides approved to be stocked by the Defense Logistics Agency and available to DOD components and all federal agencies are listed at http://www.afpmb.org/pubs/standardlists/dod%20pesticides%20list.pdf. Of the more than two-dozen herbicides approved for use by AFPMB, only two (2,4-D amine or LVE) are on KDA's list of herbicides approved for control of musk-thistle (and bull thistle).

Milestone, a herbicide introduced in 2006, shows great promise in controlling thistles. Milestone is a systemic, broad-spectrum, reduced-risk herbicide for broadleaf weed control. It is non-restricted; no special use permits are required for ground application, and buffer requirements are significantly reduced. The active ingredient in Milestone is aminopyralid, a growth regulator herbicide that mimics the action of auxin, a plant growth regulator. Three classes of growth regulator herbicides include phenoxy (2,4-D [2,4-D], 2,4-DB), benzoic (dicamba [Banvel, Clarity]), and pyridine (picloram [Tordon, Grazon), triclopyr [Garlon, Remedy], clopyralid [Stinger, Transline, Hornet], and aminopyralid [Milestone, Forefront]).

Aminopyralid, like other growth regulator herbicides, selectively controls broadleaf weeds in grasses. It has lower environmental risks over other products used in similar settings. It has a higher specific activity than other growth regulator herbicides and thus is used at lower rates. Aminopyralid has a significantly shorter half-life than clopyralid and picloram but is more persistent than 2,4-D or dicamba. It is relatively immobile in soil, with most of the chemical remaining within the upper foot of the soil profile. Products containing aminopyralid can not be applied directly to water but can be used to treat banks of ditches or other channels that do not carry water used for irrigation or drinking. The selectivity of aminopyralid falls between picloram and clopyralid. Clopyralid (Stinger/Transline) is highly selective. Aminopyralid is active against many important pasture weeds, including weeds in the Asteraceae (sunflower), Fabaceae (legume), and Solanaceae (nightshade) families. It has poor activity on weeds in the Apiaceae (carrot) family. While the risk of injury to trees or other non-target plants in treated areas has not been fully researched, data suggest that leguminous trees (black locust, honey-locust, redbud) may be injured if aminopyralid is applied under their dripline.

Three products contain aminopyralid: Milestone, Milestone VM, and ForeFront. Milestone and Milestone VM both contain 2 lb/gal aminopyralid but have slightly different markets. Milestone and ForeFront both are registered for use in pastures; ForeFront will provide broader spectrum control due to the addition of 2,4-D to the formulation. Milestone VM is registered for non-crop sites, especially industrial areas, roadsides, transmission line rights-of-way, campgrounds, etc. Milestone has no grazing or hay restrictions, whereas forage treated with ForeFront can not be harvested for hay within 7 days of application. Aminopyralid may persist in the manure and urine of animals feeding on treated forage, so animals should be grazed on untreated pastures for 3 days before being transferred to areas where sensitive broadleaf crops occur. A primary target for the aminopyralid products is biennial and perennial thistles. Research in the Midwest suggests that Milestone provides equivalent or better control of thistles than current standards (Grazon, Tordon, Transline). Applications can be made in the spring between bolting and bud formation, or in the fall to rosettes or seedlings. For musk- and bull thistles, Milestone is recommended at 3 to 5 oz/A for fall applications or spring applications prior to bolting. After the stems of biennial thistles have begun to elongate, Milestone should be applied at a rate of 4 to 5 oz/A.

Survey data from 2006 suggest that aerial spraying may be excessive, and has the potential to be indiscriminant, potentially reducing native broadleaf cover at the expense of thistles. Even if done carefully, the margin for error with aerial spraying is quite small due to annual phenological and environmental variation. Furthermore, there are equally effective, more selective, and generally more environmentally friendly alternatives to the restricted-use Tordon 22K. The long-term, negative impacts from aerial spraying on native biodiversity have not been studies and could outweigh the long-term benefits. Other control options exist, including mechanical, biological, and more focused chemical control. The approach employed should be dictated by the severity and location of the infestation, and on the resources available for control. Control thresholds should be set by installation managers to help them decide when population levels in particular management units have reached levels that warrant more aggressive control. Even with aggressive control measures, musk-thistle will remain a nuisance in areas where perennial vegetation is damaged or destroyed and where the soil has been exposed.

Adoption of range management practices that promote better stands of native grasses and forbs will lead to competitive exclusion of invasive, biennial thistles, as well as other weedy annuals and perennials. This, combined with timely and geographically focused application of herbicides, and other control methods, provides an option to aerial spraying. Areas of heaviest infestation, as determined by quantitative ground surveys, can be targeted for broadcast spraying. Individual plants or isolated populations can be targeted using backpack- or vehicle-mounted sprayers, or simply by digging them. Generally, the largest populations of biennial thistles occur where livestock congregate and loiter. Control of livestock around ponds and drainage areas is critical for long-term thistle control (see INRMP management goal WP-2). Wider use of exclusion fences around ponds and in draws would reduce the size of the areas impacted by cattle by increasing the perennial cover, reducing the amount of bare soil, and reducing opportunities for establishment and spread of biennial thistles.

G.2.4.6. *Cirsium vulgare* (Asteraceae: bull thistle)

Web Sources:
http://www.ksda.gov/plant_protection/content/181/cid/891 - Kansas Department of Agriculture, Plant Protection and Weed Control Program; Bull Thistle
http://www.ag.ndsu.edu/pubs/plantsci/weeds/w799w.htm - North Dakota State University College of Agriculture; Perennial and Biennial Thistle Control
http://www.agdepartment.com/noxiousweeds/pdf/Bullthistle.pdf - North Dakota Department of Agriculture Catalogue of Species; *Cirsium vulgare*

Bull thistle is native in Europe, North Africa, and west Asia (Mitich 1998). It first was collected in Kansas in 1894 and now occurs statewide except for the southwest sixth of Kansas. It is now the most widespread and common rangeland and pasture thistle in western North America.

Bull thistle is a biennial member of the sunflower family; it sometimes behaves as an annual or monocarpic, perennial forb. It grows to 2 m tall. Pink or violet flowers are produced in heads near the ends of the stems from late June through September. Bull thistle is found in pastures, on rangeland, along roadsides, and in other disturbed areas. It does not tolerate shading.

Bull thistle is designated a county-option noxious weed in Kansas. It is not listed as noxious in Saline County. The Kansas Department of Agriculture has developed and promulgated an official control program for bull thistle.

Status on Smoky Hill ANGR. Species-specific surveys for bull thistle were not conducted during this study. The species was observed to occupy essentially the same habitat as musk-thistle, and these two biennial thistles frequently co-occurred in areas frequented by livestock, such as around stock ponds, near old farmsteads, in moist draws, and in sites with disturbed, exposed soil. Bull thistle is not considered to be a major threat to native biodiversity at Smoky Hill ANGR at this time. Extreme care must be exercised in controlling this species where it occurs within or near native communities so as not to damage non-target species.

Control and Management Recommendations

Mechanical Control. As with musk-thistle, prevention is the best control for bull thistle. The best preventive measure in non-cropland is to maintain healthy plant cover and to reseed disturbed areas with a desirable species as soon as possible. Establishing competitive grasses can reduce the size of rosettes and decrease thistle height, root weight, and crown size. Once thistles invade an area, several control options can be used depending on the location and land use. Most types of control are ineffective if carried out while thistles are flowering, and an integrated management program generally is more successful than is a single control method.

Repeated mowing will reduce bull thistle infestations. Plants should be mowed when they are in the early bud growth stage to prevent seed set. Several annual mowings are needed because of phenological variation within and among populations. A second mowing approximately one month after the first mowing yields significantly greater control. Plants should be mowed as close to the soil surface as possible; plants cut above the terminal bud before the stems elongate usually regrow. It is critical to mow before flowers show color to preclude any seed production. Scattered individuals can be removed by digging the rosette 5—10 cm below the crown. Annual tillage or crop competition will completely control bull thistles.

Good grazing management is the first line of defense against bull thistle invasion on rangeland and pastures. Stocking rates designed to avoid overgrazing, maintaining a competitive cover of native vegetation and preventing bare ground, should be the management objective. Controlled and rotational grazing can prevent thistle establishment. Overgrazing makes rangeland more susceptible to invasion by weakening desirable species and exposing patches of bare soil where musk-thistle can establish. Fire has not proven to be an effective control measure unless it ultimately increases the vigor of native, perennial grasses and forbs, thereby reducing the amount of suitable habitat.

Chemical Control. Long-term control of thistles with herbicides depends on timely application for maximum effectiveness and on retreatment to reduce or deplete the seed bank of thistles. In pastures, rangeland, and on other non-cropland sites, fall is the preferred time to apply herbicides for biennial thistle control. Fall applications allow for more time to apply herbicides than in the spring and correspond to one of the most effective times for thistle control – when plants are in the rosette state. Seedlings that emerge in summer after tillage or after earlier herbicide applications will not bolt but will remain in the rosette stage. Herbicides should be applied from October 1 until the soil freezes; applications after a killing freeze will minimize impacts from drift onto non-target plants. Herbicides are most effective when the air temperature is between 70°—

90°F and with a 6—12 hour rain-free period (Fick and Peterson 1995). Seedlings that emerge after spraying will remain vegetative until the following spring and can be treated then. Long-term eradication of biennial thistles is difficult because of the large number of seeds that each plant can produce.

Biennial thistles can be effectively controlled with clopyralid, picloram, or dicamba. Clopyralid and picloram are the most effective of these herbicides and may be applied in the spring or fall. Picloram and clopyralid often are mixed with 2,4-D for broad spectrum weed control. Dicamba plus 2,4-D is an effective treatment and is best applied when the thistles are in the rosette growth stage. Triclopyr plus clopyralid is labeled for thistle control in non-cropland and CRP. Metsulfuron will control biennial thistles in the spring and will eliminate seed production when applied in the bolting to bud growth stages.

Herbicide and lb active ingredient needed/acre	Formulated product/acre	Comments/limitations
Picloram + 2,4 -D	**Grazon P+D** (see label for rates)	A restricted-use pesticide. Apply according to label directions. Follow directions, grazing limitations, and precautions on label.
Dicamba + 2,4-D	1 to 4 pt **Range Star**	See label for weed specific rates and grazing restrictions. Do not use on buffalograss as injury will occur.
2,4-D* amine, LVE, or mixed formulations 1 to 2 lb		Apply when problem weed has leaves and is growing actively. Do not let dairy animals graze on treated area within 7 days after treatment. Do not cut for hay for 30 days. Use 20 gal or more solution/A for ground application. Repeat applications may be necessary. Follow label directions.
Clopyralid + Triclopyr 0.375 to 0.56 lb	**Redeem R&P** (see label for rates)	Apply when weeds have emerged. Add a surfactant.
Triasulfuron/Dicamba	2 to 5 oz **Rave**	See label for directions, species, and restrictions.
Aminopyralid 0.047 to 0.109 l	3 to 7 fl oz **Milestone**	Apply to control broadleaf weeds. Can be tank mixed with other herbicides. Follow label directions and precautions.
Aminopyralid +2,4-D	1.5 to 2.6 pt **ForeFront R&P**	Apply when broadleaf weeds are actively growing. Follow label directions and precautions.
Metsulfuron methyl	0.1 to 1 oz **Cimarron**	Apply when weeds are less than 4 inches tall or in diameter. Can be tanked mixed with Clarity, Grazon P+D, 2,4-D, Tordon 22K, or Weedmaster. Include a non-ionic surfactant at 0.25-0.5% v/v.
Metsulfuron methyl + 2,4-D amine + dicamba	**Cimarron Max**	See label for rates, directions, restrictions, and cautions.
Metsulfuron methyl + Chlorsulfuron	**Cimarron X-tra** 0.5 to 2 oz	Apply when weeds are less than 4 inches tall or in diameter. Do not apply more than 1 oz/A to buffalograss. See label for tank mix and surfactant recommendations.
Metsulfuron methyl + Chlorsulfuron	**Cimarron Plus** 0.125 to 1.25 oz	Apply when weeds are less than 4 inches tall or in diameter. Do not apply more than 0.625 oz/A to buffalograss. See label for tank mix and surfactant recommendations.
Dicamba + Diflufenzopyr	2 to 8 oz **Overdrive**	Controls wide range of broadleaf weeds. Can be tank mixed with other herbicides. Follow label directions and precautions.

Cultural Control. Avoid spreading thistle seed to uninfested areas with farm and military equipment. Vigorous stands of native vegetation should be established as quickly as possible at sites where the soil is disturbed, such as construction sites, to reduce the chance of biennial thistles invading.

Biological Control. Two insects, musk thistle head weevil, *Rhinocyllus conicus*, and musk thistle rosette weevil, *Trichosirocalus horridus*, are approved for biological control in the Kansas Department of Agriculture bull thistle control program. These weevils frequently use the bull thistle as an alternate host. Biological control plans must meet the requirements of K.S.A. Chapter 2, Article 13.4-8-41 (*q.v.*).

General Management Recommendations. General management recommendations for musk-thistle control apply equally to bull thistle. The management goal for bull thistle should be to control stands below action thresholds, which need to be established by installation managers. We recommend that the systematic mapping protocols used in this study for musk-thistle be adopted so that periodic comparisons can be made to determine if management prescriptions for control of bull thistle and musk-thistle are effective. Monitoring should be an ongoing part of the bull thistle management plan. Surveys are likely to be most accurate and complete when plants are bolting or flowering, usually from late June through September. After that, plants senesce and become more difficult to find. Plants are easily identified in the rosette stage but are more difficult to find in open rangeland. Mapping of bull thistle populations on all management units annually may not be warranted. However, a monitoring strategy should be adopted that allows every management unit to be visited and mapped every few years.

Aerial spraying to control musk-thistle likely will impact bull thistle as well. However, perceived control benefits may be offset by negative impacts on native, broadleaf species. We believe that effective control of bull thistle and musk-thistle can be achieved by using an integrated management system that is responsive to the severity and location of infestations and on the resources available for control. Management practices that promote healthy native vegetation, especially good graminoid cover, probably will lead to competitive exclusion of these two biennial thistles, as well as other weedy annuals and perennials. Bull thistle likely will remain a nuisance primarily in areas where perennial vegetation is damaged or destroyed and where the soil has been exposed.

G.2.4.7. *Convolvulus arvensis* (Convolvulaceae: field bindweed)

Web Sources:
http://www.ksda.gov/plant_protection/content/181/cid/889 - Kansas Department of Agriculture, Plant Protection and Weed Control; Field Bindweed
http://www.oznet.ksu.edu/library/crpsl2/MF913.pdf - K-State Research and Extension Publications; Field Bindweed Control in Field Crops and Fallow
http://www.agdepartment.com/noxiousweeds/pdf/Fieldbindweed.pdf - North Dakota Department of Agriculture Catalogue of Species; *Convolvulus arvensis*

Field bindweed is native in Eurasia and Asia. It was first reported in North America in 1739 (Mitich 1991) and probably was brought to Kansas in infested wheat seed. The first Kansas collections were made in 1887, but reports of the species in the state predate that by more than a decade (Peterson and Stahlman 1989). It has been documented in every Kansas county.

Field bindweed is a herbaceous, deep-rooted, perennial vine of the morning-glory family. Stems can grow to 2 m long, and the roots can reach a depth 4.3 m (Mitich 1991). White or pinkish, funnel-shaped flowers are produced from June through September. Field bindweed spreads by rhizomes and seeds. The seeds are extremely persistent and can remain viable in the ground for decades. Seeds fall near the parent plant or can be transported by water, birds, or other animals. Field bindweed has been studied mainly as a crop pest; it competes aggressively with crops for water, nutrients, and light. Its impact on natural areas is less well known. It is found in a wide range of habitats but prefers strong sunlight and moderate to low moisture.

Field bindweed is designated a noxious weed in Kansas. The Kansas Department of Agriculture has developed and promulgated an official control program for field bindweed.

Status on Smoky Hill ANGR. Field bindweed is ubiquitous along roads, on current and former agricultural lands, and in sites experiencing periodic disturbance. Species-specific surveys were not conducted on Smoky Hill ANGR. Field bindweed does not appear to be a major threat to native biodiversity on the installation at this time. However, because it is designated as a noxious weed in Kansas, there are requirements for its control. Extreme care must be exercised in controlling this species where it occurs within or near native communities so as not to damage non-target species.

Control and Management Recommendations

Mechanical Control. Field bindweed may be controlled on cropland by planting competitive crops, by appropriate and timely cultivation, and by application of herbicides registered for use in infested crops or on cropland with no growing crop. An integrated program often results in a more effective control than does a single practice. On non-cropland, control usually involves hoeing or digging, or application of appropriate herbicides. Hoeing or digging are appropriate only for very small populations on non-cropland areas, such as gardens and flower beds. These approaches are ineffective as rangeland management techniques. Mowing is ineffective since it encourages a low growth form and plants can be missed. At sites previously used for agriculture, tilling may aid in controlling infestations. In pastures and on rangeland, healthy stands of native vegetation will reduce the chance of field bindweed invasion. Burning alone is not effective for control on rangeland, though it may enhance the vigor of desirable vegetation, thus putting field bindweed at a competitive disadvantage.

Chemical Control. Small stands or isolated individuals usually can be eradicated by spot spraying. Herbicides usually provide effective control, but do not eradicate, established populations of field bindweed. More than a dozen herbicides are available for use. A single herbicide application rarely will eliminate a stand of plants. Some grazing restrictions may apply to use of certain herbicides for control of field bindweed on rangeland.

Herbicide and lb active ingredient needed/acre	Formulated product/acre	Comments/limitations
Picloram + 2,4-D 0.25 to 0.5 lb + 1 lb	1 to 2 pt **Tordon** 22K + 1 qt **2,4-D**	Tordon 22K is a restricted-use pesticide. Can be broadcast applied to grasslands and fallow cropland. Persistent in soils. See label precautions for aerial applications.
Dicamba 1 to 2 lb	1 to 2 qt **Banvel** or **Clarity**	Apply as broadcast or spot treatment to actively growing plants after crop harvest and before killing frost. See label for cropping limitations.
Dicamba + Glyphosate 0.5 to 2 lb + 0.75 to 1.5 lb ae	1 to 4 pt **Banvel** or **Clarity** + 1 to 2 qt 3 lb ae/gal **Glyphosate**	Glyphosate products differ in concentration and adjuvant requirements. Refer to specific product labels for rate and adjuvant recommendations. Apply when weed is growing actively, at or beyond full bloom, or between August and October at least 8 weeks after last tillage. Do not disturb treated areas for 7 days after application. Do not plant wheat for 45 days for each pint of Banvel or Clarity applied. For best results, use fl at-fan nozzles. Always follow label directions.
Dicamba + 2,4-D 0.5 lb + 1 lb	1 pt **Banvel** or **Clarity** + 1 qt 4 lb/gal **2,4-D*** amine or LVE	Apply to pasture, rangeland, cropland, and non-cropland areas. Follow label directions and note cropping limitations.
Dicamba + 2,4-D 0.25 lb + 0.25 lb	0.5 pt **Banvel** or **Clarity** + 0.5 pt 4 lb/gal **2,4-D*** amine or LVE	Apply in the fall to actively growing bindweed in wheat that has at least three leaves and before a killing freeze. Wheat injury is possible, especially with cold wet weather after application.
Fosamine 8 to 24 lb	2 to 6 gal **Krenite S**	Do not use on food crops. Apply in non-cropland areas after plants begin to bloom.
Glyphosate 3 lb ae	1 gal 3 lb ae/gal **Glyphosate** (See glyphosate table)	Glyphosate products differ in concentration and adjuvant requirements. Refer to specific product labels for rate and adjuvant recommendations. Apply to actively growing bindweed in August to October on land not in crops. Can be applied as spot treatment in some crops. Follow label directions.
Picloram + 2,4-D 0.13 to 0.25 lb + 0.5 to 2 lb	0.5 to 1 pt **Tordon 22K** + 0.5 to 2 qt 4 lb/gal **2,4-D*** amine or LVE	Tordon 22K is a restricted-use pesticide. For reduction of field bindweed and for control of many annual weeds after wheat harvest and before planting winter wheat, barley, or oats. Apply after grain harvest and again about mid-May during fallow season. Do not treat with Tordon more than once in each calendar year. Avoid spray drift. Follow label directions.
Quinclorac 0.25 to 0.38 lb	5.3 to 8.0 oz **Paramount**	Apply to actively growing bindweed with at least 4-inch vines in sorghum or in fallow before planting sorghum or wheat. Always apply with crop oil concentrate or methylated seed soil adjuvant. Do not plant any crop other than wheat or sorghum within 10 months after application. Do not plant alfalfa for at least 24 months after application.
2,4-D 0.75 to 2 lb	0.75 to 2 qt 4 lb/gal **2,4-D*** amine or LVE	Apply in spring when plant is in bud stage or in fall after 12 inches of new growth. Follow label directions.
Imazapic 0.1875 lb	12 oz **Plateau**	Apply with an adjuvant (2 pt/acre methylated seed oil or 0.25% nonionic surfactant) to actively growing runners. For use on CRP, roadsides, and other non-cropland sites.
Imazapic + Glyphosate 0.1875 + 0.375 lb	32 oz **Journey**	Apply with 2 pt/acre methylated seed oil to actively growing runners on non-cropland.

Cultural Control. Field bindweed spreads by seed and by roots. New infestations result from planting crop seed contaminated with bindweed seed, from parts of bindweed roots transported by tillage machinery, or from other farm or ranch equipment or grazing animals that transport seeds or fruits. Seed are carried by birds, on the feet of animals, and on wheels of machinery. Seeds or plant parts can be spread by road machinery. Seeds also are dispersed by water. Grain and forage seed should be certified clean of bindweed seeds before planting, or cleaned before planting to remove bindweed and other weed seeds. For livestock feed, use grain, hay, and other uncontaminated feedstuffs. Harvesting, tillage, and other machinery should be cleaned before it leaves bindweed infested areas.

Biological Control. There are no biological controls approved for field bindweed. In cooperation with Kansas State University Department of Entomology, the Kansas Department of Agriculture is studying the potential of the bindweed gall mite (*Aceria malherbae*) to biologically control field bindweed. The gall mites create small galls on the midrib of leaves, which cause the field bindweed leaves to twist and fold. Heavily infested plants remain small, do not bloom, and consequently do not produce seed. A release program was initiated in the summer of 2006, and it is expected that several years will be needed for gall mite populations to expand to the point where the control program can be expanded.

General Management Recommendations. The management goal for field bindweed should be to control stands below action thresholds. As a listed, noxious weed in Kansas, plants should be eradicated to prevent reproduction. Annual monitoring and mapping of field bindweed populations on all management units is warranted. Field bindweed does not appear to be a serious threat to native grassland biodiversity on Smoky Hill ANGR. While small populations are not uncommon within management units dominated by grassland, they generally are associated with areas of localized disturbance, either from livestock or military activity. Maintenance of the overall health of grassland communities will help keep field bindweed populations under control. Field bindweed is more of a localized problem in and around croplands and developed areas on the installation. In such sites, herbicides provide the most effective means of control for well-established populations.

G.2.4.8. *Elaeagnus angustifolia* (Elaeagnaceae: Russian-olive)

Web Sources:
http://www.nps.gov/plants/alien/fact/elan1.htm - Plant Conservation Alliance's Alien Plant Working Group; Russian-olive
http://www.agdepartment.com/noxiousweeds/pdf/Russianolive.pdf - North Dakota Department of Agriculture Catalogue of Species; *Elaeagnus angustifolia*

Elaeagnus angustifolia is native in eastern Europe and western Asia. Russian-olive was introduced into the U.S. in the late 1800s as an ornamental. The earliest collections of naturalized plants from Kansas pre-date the 1940s. Widely grown in Kansas, naturalized plants are found most frequently west of the Flint Hills, especially in riparian corridors.

Russian-olive is a thorny shrub or tree that grows to 10 m tall. It produces fragrant, yellowish flowers from May through June; the drupe-like fruits mature from August through October. Russian-olive fixes nitrogen in its roots, giving it a competitive advantage over other species on bare, mineral substrates. It can out-compete native vegetation, interfere with natural plant succession and nutrient cycling, and cause groundwater depletion. The fruits are consumed by birds and other animals, which spread the seeds. Plants also spread vegetatively by suckers and root shoots, making eradication difficult. Russian-olive has been recommended widely for wildlife plantings, windbreaks, and surface mine reclamation, but enthusiasm for the species has waned as its aggressiveness has become better known, especially in the western U.S.

Status on Smoky Hill ANGR. *Elaeagnus angustifolia* was recorded in 23 of 30 management units surveyed and infested an estimated 87.86 acres (Table 3.6, Figure 3.7). Most occurrences consisted of isolated individuals, usually in riparian corridors and sheltered draws. Rarely did trees grow sufficiently close to form a continuous overstory canopy, and all but one of the polygons had a cover of 1–10%. Isolated individuals also were found on grazed, upland prairie in parts of the installation. We were unable to complete surveys in several units along the northwest edge of the installation (Units 31, 41, 51) where several large populations could be seen along tributaries to Castle Creek. Populations in these units should be mapped by installation personnel.

Control and Management Recommendations

Mechanical Control. Effective control of Russian-olive with stems <10 cm diameter can be obtained by pulling individuals from moist soil using a weed wrench or by cutting with a mulching mower. Mowing, cutting, girdling, chaining, and bulldozing can suppress Russian-olive on invaded sites, but the disadvantages include the need for frequent follow-up treatment, indiscriminate removal of other species, and severe soil disturbance. Additionally, these approaches are not effective without long-term monitoring and follow-up removal of sprouts. Repeated cutting probably will not kill trees but will keep them at brush height.

Chemical Control. Russian-olive can be killed using foliar, basal bark, or soil treatments. Seedlings and saplings can be killed with foliar treatments. Control is more difficult once trees mature and populations are well-established. The most effective control method for larger individuals is the cut-stump herbicide treatment. For felled trees, herbicide is applied to the stump and stem tops immediately after cutting. In addition to the herbicides listed below, Garlon 3A and Garlon 4 have been used widely for control of seedlings, saplings, and trees. Girdling and cutting are not effective controls by themselves because trees are likely to sprout below the girdled or cut areas or along roots. Generally, initial control methods require some ongoing suppression of stem and root sprouts and of new recruitment from seed.

Herbicide and lb active ingredient needed/acre	Formulated product/acre	Comments/limitations
Foliar Application		
2,4-D* amine + Dicamba 1 lb + 0.25 lb	1 qt **2,4-D*** + 0.5 pt **Clarity**	Apply from late May to mid-June when plant is growing actively. For aerial application, use 3 gal or more of total solution/A. For individual plant treatment, use 25 gal of solution; wet leaves for complete coverage.
Cut Stump or Frill Application		

Triclopyr	**Remedy** 25% in diesel oil or kerosene	Apply to stump or frill immediately after cutting. See label for rates, directions, and precautions. Best root control is obtained when application is made from mid-July to mid-January. Periods of dry weather also will aid in root control.
Triclopyr	**Pathfinder II**	A ready-to-use product. No mixing required. Apply product to wet the cut surface and sides of the stumps. Apply at any time, except when snow or water prevent spraying to the ground line.
Triclopyr + Fluroxypyr	**PastureGard** 50% in diesel oil or kerosene	Apply to stump or frill immediately after cutting. Thoroughly wet sides of stump, root collar, and cut surface. Apply at any time, except when snow or water prevent spraying to the ground line.
Imazapyr	**Arsenal** 10% in water	Apply to cambium area of freshly cut stump surface.
Soil Application		
Hexazinone	**Velpar L** 2 to 4 ml of product/inch of stem diameter or 1 to 2 pellets **Pronone Power Pellet Herbicide**/inch stem diameter	Apply from April through June in period of active growth. Apply Velpar L with exact delivery, hand-gun applicator. Precipitation is needed for activation. Do not apply to brush in standing water or use on marshy or poorly drained areas. Expect to see some grass damage. See label for additional instructions.

Cultural Control. Russian-olive should not be planted in shelter belts, windbreaks, or as an ornamental.

Biological Control. There are no biological agents approved by APHIS for use on Russian-olive. Two natural disease agents, Verticillium wilt and phomopsis canker, occur in North America. The diseases cause reddish brown or black cankers on branches and leaves, which may cause branches and leaves to die, but the diseases normally do not cause mortality to plants.

General Management Recommendations. The management goal for Russian-olive should be to eliminate it completely from the installation, which probably is achievable with a modest investment of energy and resources. Survey data suggest that Russian-olive currently is not a serious pest on Smoky Hill ANGR, but is has the potential to become one if not controlled. Some populations in riparian habitats are large enough to have begun to degrade native biodiversity. Left unchecked, these populations likely will continue to expand and cause further environmental degradation. Established populations can be very difficult to control, so concerted efforts to control Russian-olive while populations are small and densities are low is recommended.

Systematic surveys for Russian-olive should be done in those management units were surveys were not completed as part of this study, with priority given to units 31, 41, and 51, as well as within the Impact Area. Known populations should be monitored periodically, especially once control is initiated, to determine if measures are effective.

Larger stands of Russian-olive should be given priority for control. This may be carried out in conjunction with efforts to control other invasive, woody species. Control of isolated individuals may be done opportunistically. Small plants should be pulled. Cut-stump herbicide treatment is recommended for larger individuals. Treated areas should be checked in the season following application of control measures to ensure that treatments have been effective and to perform follow-up treatments if necessary.

G.2.4.9. *Lespedeza cuneata* (Fabaceae: sericea lespedeza)

Web Sources:
http://www.ksda.gov/plant_protection/content/181/cid/579 - Kansas Department of Agriculture, Plant Protection and Weed Control Program; Sericea Lespedeza
http://www.oznet.ksu.edu/library/crpsl2/mf2408.pdf - K-State Research and Extension; Sericea Lespedeza: History, Characteristics, and Identification
http://www.nps.gov/plants/alien/fact/lecu1.htm - Plant Conservation Alliance's Alien Plant Working Group; Chinese Lespedeza

Lespedeza cuneata, also called Chinese lespedeza, Chinese bush-clover, or sericea bush-clover, is native in eastern Asia. It was introduced to the U.S. in 1896, and its spread was aided by government programs that promoted its use for erosion control and as food and cover for wildlife. Sericea lespedeza was planted in the 1930s on strip-mined land in southeast Kansas (Ohlenbusch and Bidwell 2001); the first collection from naturalized plants in Kansas was made in 1950. It currently is known from more than 70 counties in Kansas, mostly in the eastern half of the state.

Sericea lespedeza is a perennial legume with slightly woody stems that can grow to 1.5 m tall. Flowers are whitish to creamy yellow with a purplish banner and appear from August through October. Seeds are dispersed in the fall, may be spread by birds, and can remain viable for more than 20 years. Seeds also have been spread to prairies and conservation reserve program plantings in contaminated hay and seed. Sericea lespedeza occurs extensively along roadsides and in pastures, but it can invade other sites, including thickets, fields, prairies, and woodlands. It is very drought hardy.

Sericea lespedeza can become highly invasive, forming dense populations that diminish native biodiversity or impede efforts at ecosystem restoration; it is particularly problematic in rangeland in the southern Flint Hills of Kansas. Sericea lespedeza is sometimes considered to provide high quality forage because of its high levels of crude protein but, compared to native grassland species of *Lespedeza*, sericea lespedeza is relatively unpalatable to livestock because of the high concentration of tannins in the tissues of mature plants. Tannin levels increase with plant maturity, increasing air temperature, and decreasing rainfall (Ohlenbusch and Bidwell 2001).

Sericea lespedeza is designated a noxious weed in Kansas. The Kansas Department of Agriculture has developed and promulgated an official control program for sericea lespedeza. It is the first federally listed forage crop to be declared a noxious weed (Ohlenbusch and Bidwell 2001).

Status on Smoky Hill ANGR. *Lespedeza cuneata* was not recorded in any of the management units (Table 3.6) during surveys conducted in 2006. The only report of this aggressive, pernicious weed is from two small populations at the south end of the installation. Management staff took quick and aggressive action to eradicate these populations.

Control and Management Recommendations. The most effective control of sericea lespedeza is achieved by early detection, isolation, and immediate eradication of plants with herbicides. Once established, integrated control usually is necessary to control seed production at acceptable levels.

Mechanical Control. Burning and grazing usually do not provide effective control on rangeland. Spring burning appears to have no negative effect on established plants and appears to enhance seed germination, promoting establishment of new plants. Late spring prescribed burns followed by intensive-early stocking (double stock until July 15 and then remove cattle) may reduce the occurrence of sericea lespedeza, although this approach may not yield consistent results (Smith 1997). Livestock consume sericea lespedeza in hay because field drying decreases tannin concentrations. Mature cattle grazing early in the season or under management-intensive grazing will consume sericea lespedeza. Under conditions of season-long and rotational grazing, cattle select grasses, giving the less palatable sericea lespedeza a competitive advantage over native species. Grazing sheep and meat goats in some infested areas can provide effective control in some areas. On cool-season pastures, proper fertilization and grazing during April and May may reduce the occurrence. Late grazing or no grazing will increase sericea lespedeza. Mowing in the late bud stage for 2—3 consecutive years from mid-July to late summer can reduce the vigor of stands.

Chemical Control. Few herbicides for broadleaf control provide good control of sericea lespedeza, however, foliar applications of triclopyr applied in June and July (plants in vegetative condition), and metasulfuron applied in September (plants in flowering or fruiting condition) are effective in killing plants. Mowing 1—3 months before herbicide application can assist control.

Herbicide and lb active ingredient needed/acre	Formulated product/acre	Comments/limitations
Metsulfuron methyl 0.24 to 0.6 oz	0.4 to 0.5 oz **Cimarron** or 0.5 to 1 oz **Escort XP**	Apply after bud/bloom stage until first frost. For aerial application, use 3 to 5 gal spray/A, flat-fan nozzles, and NIS. See label for additional instructions and precautions. Note: Do not apply if drought conditions exist at intended time of application.
Metsulfuron methyl + Dicamba + 2,4-D	Rate II **Cimarron Max**	Apply from beginning of flower bud initiation to full bloom. Note: Do not apply if drought conditions exist at intended time of application.
Metsulfuron methyl + Chlorsulfuron	**Cimarron X-tra**	Apply at Rate II from the beginning of flower bud initiation through the full-bloom stage. See label for additional instructions and precautions.
Metsulfuron methyl + Chlorsulfuron	**Cimarron Plus**	Apply at 0.625 oz/A beginning at flower bud initiation through the full-bloom stage. See label for additional instructions and precautions.
Triclopyr 0.5 to 1.0 lb	1 to 2 pt **Garlon 4**	Do not apply to cropland, including rangeland and pasture. Apply when the plants are actively growing. Use a minimum of 20 gal spray/A for ground application.

Triclopyr 0.5 to 1.0 lb	1 to 2 pt **Remedy**	Apply when the plants are growing actively in the vegetative stage (June) or in flower (late July to September). Use a minimum of 20 gal spray solution/A for ground application. For aerial application, use 3 to 5 gal spray/A. See label for additional instructions and precautions.
Triclopyr + Fluroxypyr 0.28 + 0.094 lb to 0.375 + 0.125 l	1.5 to 2 pt **PastureGard**	Apply when plants are 12 to 15 inches tall in the late spring to early summer before bloom. Use higher rate for dense stands or later stages of growth.

Cultural Control. Seed mixes used to plant areas for erosion control and for wildlife habitat should be certified to be free of sericea lespedeza and other weed species.

Biological Control. There are no biological controls currently approved for sericea lespedeza.

General Management Recommendations. The management goal for sericea lespedeza should be to eliminate it completely from the installation. The species is an extremely serious threat to prairie and woodland communities in eastern and central Kansas. Managers appear to have successfully eliminated two small population of *Lespedeza cuneata* that were discovered on the installation. Managers and lessees must remain vigilant. Periodic pasture surveys for sericea lespedeza should be conducted. Plants can be identified definitely in young, vegetative condition, but they are most conspicuous when flowering or fruiting (August—October). Distinguishing *Lespedeza cuneata* from native bush-clovers, especially *L. virginica*, *L. capitata*, and *L. stuevei*, is a problem for many ranchers, farmers, and land managers in southeast Kansas where two or more species sometimes co-occur with sericea lespedeza. Fortunately, *L. capitata* (round-head bush-clover) is the only native lespedeza documented on Smoky Hill ANGR, and it is the species least likely to be confused with sericea lespedeza. Ohlenbusch and Bidwell (2001) prescribe an integrated control program involving grazing, burning, mowing, and chemical control should well-established populations be discovered on the installation.

G.2.4.10. *Rosa multiflora* (Rosaceae: multiflora rose)

Web Sources:
http://www.ksda.gov/plant_protection/content/181/cid/589 - Kansas Department of Agriculture, Plant Protection and Weed Control Program; Multiflora Rose
http://www.extension.iastate.edu/Publications/PM863.pdf - Iowa State University Extension; Multiflora Rose and its Control
http://ohioline.osu.edu/b857/pdf/b857.pdf - The Ohio State University, College of Food, Agriculture, and Environmental Sciences; Multiflora Rose Control
http://www.nps.gov/plants/alien/fact/romu1.htm - Plant Conservation Alliance's Alien Plant Working Group; Multiflora Rose

Native in Japan, Korea, and eastern China, multiflora rose was introduced in North America in 1866 as rootstock for ornamental roses (Smith 1997). It first was collected in Kansas in 1957. It has been planted for erosion control, as a living fence, for wildlife cover, and as an ornamental. It currently is known from nearly 40 counties in the eastern half of the state.

Multiflora rose is a thorny shrub with arching canes to 4 m tall and clusters of white flowers that appear from May through June. Reddish orange or red, spherical fruits about 1 cm in diameter begin to appear in June and mature by October. Multiflora rose grows aggressively and produces abundant fruits that are eaten and dispersed by birds. It can form dense thickets that exclude native plants. It is found on a wide range of soil, moisture, and light conditions. Multiflora rose invades old fields, woodlands, forests, prairies, and some wetlands.

Multiflora rose is designated a county-option noxious weed in Kansas. It is not listed as noxious in Saline County. The Kansas Department of Agriculture has developed and promulgated an official control program for multiflora rose.

Status on Smoky Hill ANGR. Species-specific surveys for multiflora rose were not conducted on the installation. Only a few, widely scattered individuals were encountered during surveys for other invasive plants.

Control and Management Recommedations

Mechanical Control. Mechanical methods are used widely for managing multiflora rose, often in combination with other control methods. Small, isolated individuals can be killed by pulling them by hand. Repeated cutting or mowing three to six times each growing season for 2—4 years has proven effective in achieving high mortality of multiflora rose. In high quality natural communities, cutting of individual plants is preferred over mowing to minimize habitat disturbance. Periodic prescribed burns will hinder invasion. Grubbing or pulling of individuals with a heavy chain and tractor is successful only if all the roots are removed. New plants can grow from residual root pieces. Sheep and goats will forage on multiflora rose in pastures, and some studies show that goats can provide effective control.

Chemical Control. Herbicides have been used successfully to control multiflora rose, but the long-lived seeds, which build up in the seed bank, may necessitate follow-up treatments. Herbicides are available for foliar, dormant stem, and soil applications in pastures and rangeland. Dormant stem applications can be made in the late winter or early spring, before leaf emergence. Dormant treatments have some advantages over foliar applications. Because basal applications do not require coverage of the entire shrub, a smaller herbicide volume is needed, and less time and energy are required to treat individual shrubs. Foliar treatments generally are made in late spring when the shrub is green and actively growing. Thorough spray coverage of the foliage is essential for good control. Large spray volumes generally are required to obtain this coverage.

Herbicide and lb active ingredient needed/acre	Formulated product/acre	Comments/limitations
Foliar Application		
Glyphosate 1% solution	**Glyphosate**	Apply as spot treatment by hand equipment before leaves lose green color. Vegetation in treated area can be damaged. Avoid drift outside target area. Follow label directions and precautions.
Metsulfuron methyl 0.011 to 0.038 lb	0.3 oz **Escort XP** or 0.5 to 1.0 oz **Cimarron**	Apply in the spring, shortly after full-leaf stage. Complete coverage is necessary for effective control. Do not apply to tall fescue.
Picloram + 2,4-D	**Grazon P+D** (see label for rates)	A restricted-use pesticide. Apply according to label directions. Follow directions, grazing limitations, and precautions on label.
Picloram/2,4-D + Triclopyr 0.27/1 + 0.5 lb	2 qt **Grazon P+D** + 1 pt **Remedy** in 100 gal water	A restricted-use pesticide. Apply according to label directions. Follow directions, grazing limitations, and precautions on label. Label recommends 1 gal Grazon P+D plus 1-2 qt Remedy/100 gal spray solution.
Dormant Stem Application		
2,4-D/Triclopyr	**Crossbow** 1 to 4% in diesel oil or kerosene	Crossbow is a premix of 2 lb 2,4-D and 1 lb triclopyr/gal for control of many woody plants on rangeland and pasture. Thoroughly wet all stems. Treat any time when brush is dormant and the bark is dry. Follow label directions.
Dicamba	**Banvel** or **Clarity**	Apply to basal part of stems when plants are dormant. See label for rates, directions, and precautions.
Soil Application		
Tebuthiuron	**Spike 20P** (see label for rates)	Apply to soil surface on grid pattern or evenly spaced under drip line of plants. See label for rates, directions, and precautions. Spike 20P is recommended for multi-stemmed species, such as dogwood, buckbrush, and smooth sumac.

Cultural Control. Multiflora rose should not be planted for wildlife habitat or as an ornamental on the installation.

Biological Control. Biological control is not currently available for management of multiflora rose. Ongoing studies are examining rose rosette disease, a native viral pathogen, which is spread by a microscopic eriophyid mite. The disease was discovered in Canada in 1940. It occurs in the western U.S. and is spreading slowly eastward; it was first reported in Kansas in 1976. The virus holds potential for eliminating multiflora rose in areas where roses grow in dense patches, but the disease also could impact other native and cultivated rose species. The symptoms of infected plants are conspicuous in the spring; new leaves emerge pink to red in color and branches grow in a pattern called a witches broom. As the disease progresses, the leaves curl and turn yellow to brown and the tissue dies. Bushes will generally die out after 1—5 years of exhibiting symptoms. Rose rosette disease appears to have reduced populations of multiflora rose in some parts of Kanas.

General Management Recommendations. The management goal for multiflora rose should be to eliminate it completely from the installation. Given its rarity on Smoky Hill ANGR, multiflora rose currently is not a serious threat to native biodiversity, and control is fairly easy. Routine monitoring of management units should include surveys for multiflora rose. Individuals that are discovered should be eradicated immediately. In or near native plant communities, care should be exercised in controlling this species to minimize damage to non-target species.

G.2.4.11. *Securigera varia* (Fabaceae: common crown-vetch)

Web Sources:
http://www.invasive.org/eastern/eppc/COVA.html - Invasive Plants of the Eastern U.S., Southeast Exotic Pest Plant Council Invasive Plant Manual; Crown Vetch
http://tncweeds.ucdavis.edu/esadocs/corovari.html - The Nature Conservancy; Element Stewardship Abstract of *Coronilla varia*

Native in Europe, southwest Asia, and northern Africa, common crown-vetch has been planted widely in the U.S. since the 1950s for erosion control, bank stabilization, green fertilizer, and temporary ground cover. It was first collected in Kansas in 1946 and has been documented in nearly half of the counties in Kansas, mostly in the eastern half of the state.

Common crown-vetch is a perennial, nitrogen-fixing legume with stems to 2 m long and rhizomes to 3 m long. Spherical clusters of pinkish flowers are produced on short stalks along the stems from May through August. Plants spread rapidly by rhizomes and seeds. Crown-vetch seeds prolifically. The agents of seed dispersal are unknown, but animals likely play a role. Crown-vetch colonizes open sunny areas such as roadsides, fields, and stream banks. Under the correct conditions, it can invade prairies and other herbaceous plant communities.

Status on Smoky Hill ANGR. One small population of crown-vetch was found near the headquarters during surveys. Crown-vetch generally is associated with disturbed habitats, especially where it occurs as a relict of plantings for erosion control.

Control and Management Recommendations

Mechanical Control. Hand-pulling and digging of mature plants are effective only for controlling small infestations. However, extreme care must be taken to remove all pieces of stems, roots, and rhizomes to prevent resprouting. Mowing plants in the flower bud stage for two or three consecutive years may reduce vigor and control further spread (Smith 1997). Plants should be cut close to the ground before seeds mature, minimizing impact to adjacent native plants as much as possible. Prescribed burning alone has shown mixed success, with some studies reporting adequate control after several years of late spring burns in fire-adapted plant communities. Crown-vetch density is a possible confounding factor in the effectiveness of fire (Tu 2003). Crown-vetch is good quality forage and is highly palatable to cattle, horses, goats, and sheep (Tu 2003). Integrated control, involving cutting and herbicide treatment, or grazing and herbicide treatment, often is highly effective (see below).

Chemical Control. Herbicides should be applied while plants are growing actively. Roundup, Garlon 3A, and Escort have shown effectiveness in controlling crown-vetch.

A 1%-2% solution of Garlon 3A or Roundup thoroughly mixed with water is effective during the vegetative stage prior to branching or during flowering. Garlon 3A is selective to broadleaf plants and can be used in areas where grasses intermingle with target plants. Roundup is non-selective and will affect all plants that it contacts. Escort should be applied at a rate of 0.3g/gallon of water. Treatments should cover the leaves and stems of plants to the point of runoff. The addition of a non-ionic surfactant at a concentration of 0.5% improves the effectiveness of foliar treatments. Large infestations are best controlled with an integrated management approach. This may involve first removing much of the crown-vetch standing biomass by cutting or burning, then spraying either Roundup, 2,4-D, Garlon 3A, or Transline at recommended label rates on the cut stems and foliage. Follow-up treatments with herbicide likely are required to control surviving stems or new seedlings. After control efforts, active restoration to create dense native vegetation has the highest probability of long-term success. In areas with residual native vegetation, post-control restoration efforts may not be necessary, especially if the herbicide applied did little or no damage to desirable native species. Grazing in combination with herbicide treatment can provide good control. Grazing works similar to cutting or burning, removing much of the aboveground biomass. When followed by herbicide application on remaining stems and leaves, effective kill usually is achieved.

Cultural Control. Because of its potential to interfere with native and restored areas, crown-vetch should not be used as a cover plant for erosion control. Native grasses and forbs should be planted in such sites whenever possible.

Biological Control. There are no available biological controls for the control of common crown-vetch (Tu 2003).

General Management Recommendations. The management goal for common crown-vetch should be to eliminate it completely from the installation. It is not a threat to native biodiversity at Smoky Hill ANGR at this time. Control is fairly easy at low densities. Any plants discovered on the installation should be eradicated immediately, and managers should remain watchful for new populations, especially along perimeter and interior roads. No other species-specific recommendations are warranted at this time.

G.2.4.12. Invasive, Woody Plants

Web Sources:
http://www.oznet.ksu.edu/library/CRPSL2/MF1021.PDF - Rangeland Brush Management; Kansas State University Agricultural Experiment Station and Cooperative Extension Service
http://www.oznet.k-state.edu/pr_forage/pubs/97notebook/fora19.pdf - Forage Facts, Rangeland Brush and Weed Control; Kansas State University Agricultural Experiment Station and Cooperative Extension Service

Historically in central Kansas, fire, grazing, and drought restricted woody plants to riparian areas. At the time of Euro-American settlement, the area that is now Smoky Hill ANGR supported little woody vegetation (see Figure 2.2). During the past two centuries, fire suppression and the replacement of large, native herbivores with domestic livestock allowed many woody species to encroach into prairies, where, in many places, they have become a serious rangeland problem. Woody species can compete with grassland vegetation for moisture, light, and nutrients, thereby limiting rangeland production. Potential benefits of woody species control for livestock operations include increased forage quality, increased animal production, easier care and handling of animals, and reduction of potential fire hazards (Towne and Ohlenbusch 1992).

Complete removal of all woody plants in an area may not be practical or desirable. Isolated trees provide shade and shelter for livestock, can improve livestock distribution, and provide food and cover for wildlife. Along streams and in ravines, tree and shrub removal may increase soil erosion and remove wildlife habitat.

Status on Smoky Hill ANGR. Stands of invasive woody plants are most extensive in areas mapped as Go-back Land/Tallgrass Prairie (see Figure 2.7). They typically occur close to creeks and in areas with deeper soil, especially in the north-central part of Smoky Hill ANGR along Spring Creek, Ralston Creek, and their tributaries. Isolated stands also occur near old farmsteads and around some ponds. Common invasive woody species include both native and naturalized species, such as American elm (*Ulmus americana*), buckbrush (*Symphoricarpos orbiculatus*), common hackberry (*Celtis occidentalis)*, common honey-locust (*Gleditsia triacanthos*), eastern red-cedar (*Juniperus virginiana*), green ash (*Fraxinus pennsylvanica*), Osage-orange (*Maclura pomifera*), poison-ivy (*Toxicodendron radicans*), rough-leaf dogwood (*Cornus drummondii*), smooth sumac (*Rhus glabra*), and white mulberry (*Morus alba*).

Control and Management Recommendations

Mechanical Control. Prescribed burning is an efficient and cost-effective method of controlling woody plants on rangeland. Best control of woody plants generally is achieved when food reserves are lowest – mid- to late-April for most species – and when trees and shrubs are small, and there is enough herbaceous cover to provide fuel for a hot fire. Non-sprouting trees, such as eastern red-cedar, can be killed by a single burn if they are not too large (usually less than 2 m tall) and there is adequate fuel for a hot burn. Resprouting species, such as buckbrush, dogwood, elm, oak, and Osage-orange, may require late spring burns for two or more consecutive years until root reserves are depleted and plants become susceptible. Species that are dormant during late spring burns, such as smooth sumac, may be enhanced by such burns.

Mechanical control of resprouting woody species generally is feasible only for small or isolated patches. Nonsprouting species, like eastern red-cedar, can be killed at any time by cutting them at ground level. Resprouting species should be cut or mowed when root reserves are lowest, and several consecutive years of cutting or mowing generally are required to kill the plants. Resprouting can be prevented by applying herbicide to the stump immediately after cutting. Seedlings and sprouts of woody plants can be killed by browsing livestock in moderate or heavily stocked pastures. However, livestock normally do not consume woody plants except occasionally for variety in their diets.

Chemical Control. Most woody species are susceptible to herbicides when applied properly. Chemicals that are translocated to or taken up by the roots are preferable. Large or dense stands of some woody species may require broadcast spray either by air or ground sprayers to bring the stands to manageable levels. Most foliar herbicides should be applied at full leaf stage, when plants are actively growing. Once stands have been reduced to manageable levels, spot spraying can be used. Other chemical control techniques also may be effective. Basal bark or cut stump applications of Weedone 170 or Tordon RTU control a wide variety of species, including Osage-orange, common honey-locust, American elm, white mulberry, common hackberry, buckbrush, smooth sumac, and multiflora rose. Most of the same species can be controlled with foliar applications of Crossbow, Remedy + Tordon 22K + 2,4-D, or Remedy + 2,4-D, or by soil applications of Velpar L.

Cultural Control. Cultural controls are largely inappropriate for control of invasive, woody plants.

Biological Control. Biological controls are inappropriate for control of invasive, woody plants.

General Management Recommendations. The management goal for invasive, woody vegetation should be to control stands below action thresholds, which need to be established by installation managers. Thresholds set for each management unit may be most appropriate. Management units along Spring Creek and the upper reaches of Ralston Creek appear to be the most severely impacted by woody plant invasion. Specific stands targeted for control should be identified and delimited before control efforts are initiated. Control techniques used will depend on the size, severity, and location of the stands being controlled. Mechanical removal and prescribed burns should be used for control where possible, augmented by chemical control where necessary. Treated management units should be monitored using standardized assessment methods to determine if control efforts are effective. Management of invasive, woody vegetation is consistent with management goal RM-1 of the INRMP.

G.3. NON-NATIVE/INVASIVE ANIMALS

General information on vertebrate species that are exotic (not native in North America), and/or are potentially invasive or pest species on Smoky Hill ANGR is provided below. Included here is background information on the status, distribution, life history, behavior and management of each species and its abundance and seasonal distribution on Smoky Hill ANGR. Management recommendations and control techniques also are provided at the end of each species account and summarized in Table G.4.

G.3.1. Definitions

Definitions for non-native and invasive animal species follow those for plants (see G.2.1).

G.3.2. Non-native Species in Kansas and on Smoky Hill ANGR

Thirty-six of the 797 species (4.5%) of vertebrate animals documented in Kansas with self-sustaining (current or historic) populations have been introduced since the arrival of Euro-Americans. Of these 36 species, the majority (25 species) are fishes. Based on data in Chapter 4 and Appendix C, and in Busby and Guarisco (2000), the percentage of non-native vertebrate taxa on Smoky Hill ANGR is 1% (6 of 240 species). These six species are Common Carp (*Cyprinus carpio*), Ring-necked Pheasant (*Phasianus colchicus*), Rock Pigeon (*Columba livia*), European Starling (*Sturnus vulgaris*), House Sparrow (*Passer domesticus*), and House Mouse (*Mus musculus*). The distribution of these potentially invasive animals among plant communities is summarized in Table G.1. The low number of non-native species on Smoky Hill ANGR is attributable to at least two factors. First, the installation has no perennial streams that support a diverse fish fauna, and most non-native vertebrates are fishes. Second, most non-native species are found in disturbed and non-native habitats, and most of the land area on Smoky Hill ANGR supports native plant communities; areas of non-native vegetation are relatively small.

Little information is available on non-native invertebrates on Smoky Hill ANGR. Charlton et al. (2000) provide a partial list of insect species on the Army National Guard portion of Smoky Hill ANGR. The vast majority of the approximately 140 insect species on this list are native species. Many potentially invasive invertebrate species are listed in the Draft Kansas Terrestrial Invasive Species Plan (Kansas Department of Wildlife and Parks, unpublished); most of these are likely known or potential crop pests. The Kansas Department of Agriculture conducts surveys for pest species and lists six insects of particular concern in Kansas: Emerald Ash Borer, Asian Longhorned Beetle, Gypsy Moth, Japanese Cedar Longhorn Beetle, Red Imported Fire Ant, and Africanized Honey Bee (see: http://www.ksda.gov/plant_protection/content/184). No high risk invasive insects were predicted to occur on Smoky Hill ANGR as of April 2006 (Glenn Salsbury, Kansas Department of Agricultural, personal communication).

G.3.3. Management Methods

Web Sources:
http://www.ksda.gov/plant%5Fprotection/ - Kansas Department of Agriculture, Plant Protection and Weed Control Program
http://www.invasivespecies.net/database/welcome/ - Global Invasive Species Database
http://digitalcommons.unl.edu/icwdmhandbook/ - The Handbook: Prevention and Control of Wildlife Damage; University of Nebraska - Lincoln

A wide variety of management methods are available for control or elimination of invasive, non-native animal species. As with methods for control of plants, these can be grouped into four broad categories: mechanical, chemical, cultural, and biological. Integrated management approaches involve the use of techniques from two or more of these categories.

Mechanical management for animals consists of creating structural features that affect animal movement or behavior. Examples include constructing fences to exclude or contain animal movement or placing netting or material over materials to prevent access by animals (e.g., mesh wire around trees to prevent beaver damage). These methods can be expensive in terms of materials and labor for implementation, and generally are designed to protect small features or areas. Traps and weapons to capture or kill animals also fall under the heading of mechanical control.

Chemical management has historically referred to use of chemicals to kill ("-cides"; e.g., avicides, rodenticides, and pesticides) or inhibit growth ("-statics"; e.g., bacteriostatics) of target organisms. More recently, chemical control has been expanded to include chemical treatments that affect reproduction at the individual level. Examples are chemicals that induce temporary or permanent male sterility in animals such as deer. Such practices affecting reproduction are expensive due to costs of applying individual treatment to animals.

Cultural management involves habitat modification to influence the behavior of target species. Cultural management techniques include use of audible repellents, visual repellents, and changing habitat to attract or repel animals. Examples include draining a pond to eliminate Asian carp or other undesirable aquatic species, or removal of hedgerows or other woody vegetation to discourage white-tailed deer use of an area. Such habitat modifications also may affect the entire plant and animal community of a habitat, so such actions should only be taken after full consideration of the full spectrum of consequences for other species.

Biological management involves use of one (or more) organism to control the number of the target organism. Exotic species whose populations expand rapidly often have escaped from predators or parasites in their land of origin. Introduction of these predators or parasites to the site in question in expectation that they will control the target organism is referred to as biological control. The risk of introducing additional organisms (usually also exotic) in the hopes of controlling a target species is that it usually is difficult to predict the consequences of the introduction. Such organisms may act as predators or parasites on non-target species and create new invasive species problems. Usually, selection of biological control agents is limited to species that are fairly specific to the target host, and this only after careful consideration and testing. Use of the head weevil and rosette weevil in Kansas to control musk thistle is an example of biological control. One general feature of biological control is that eradication rarely is achieved. As the host species population decreases, populations of the biological control species also typically decrease, and at some point, the target species escapes detection by the parasite or predator. Thus, biological control acts to reduce numbers of the target species, not to eliminate them. Biological controls usually are applied in conjunction with other control methods. One advantage of biological control is that after the initial cost of introducing the agent, if successful, the agent is likely to reproduce successfully on its own and provide continuing control over time.

G.3.4. Management Plan for Non-native/Invasive Species

Species accounts and management plans are provided below for all six species of documented non-native vertebrates on Smoky Hill ANGR (Common Carp, Rock Pigeon, European Starling, House Sparrow, and House Mouse). Because so few non-native vertebrate species occur on the installation, plans for all six species are provided here. This does not mean, however, that these species should be considered invasive on the installation or that control measures are needed. Two native species (Canada Goose and Brown-headed Cowbird) also are included because of potential problems they pose to other wildlife or as a BASH threat.

For each non-native or potentially invasive species discussed below, we list literature and Web sources that are potentially useful to resource managers, provide background information about each species, discuss the species' status on Smoky Hill ANGR, and provide control and management recommendations. Discussions draw heavily from Web sources listed at the beginning of each species account. For brevity, in-text citations are provided primarily for published references; in-text citations for Web references became too unwieldy.

Control and management recommendations generally review methods for each species. Because control on Smoky Hill ANGR may not be warranted under current conditions, control methods for some species are summarized briefly. Details on control methods can be gleaned from identified Web sources for that species. General management recommendations, which range from specific to general, summarize the need for and direction of control measures on the installation. Management plans for the control of invasive species should be adaptive – built on baseline information from this report and adjusted annually to meet specific management objectives. For this reason, we avoided being too prescriptive in our general management recommendations.

G.3.4.1. *Cyprinus carpio* L. (Common Carp)

Web Sources:
http://animaldiversity.ummz.umich.edu/site/accounts/information/Cyprinus_carpio.html - University of Michigan Museum of Zoology; Diversity of Life; *Cyprinus carpio*
http://www.invasivespecies.net/database/species/ecology.asp?si=60&fr=1&sts=sss - Global Invasive Species Database; *Cyprinus carpio*
http://www.und.nodak.edu/org/ndwild/carp.html - North Dakota Outdoors; Control Methods for Carp
http://www.dpi.nsw.gov.au/research/branch/systems-research/wild-fisheries/outputs/2005/gilligan_-_gehrke_-_schiller_-_tesing_603 - Testing Methods and Ecological Consequences of Large-scale Removal of Common Carp

The Common Carp, a native in Europe, has been widely introduced and is now found worldwide except for the poles and northern Asia.

Carp were first introduced in Kansas about 1880 into farm ponds where they were raised as a source of food (Cross 1967). By about 1900, the fish had become widespread in the streams of the state. By the 1960s, carp had become the predominant large fish in the Kansas and other rivers. As carp became increasingly abundant, catches of other fish decreased, and the species gradually became viewed as undesirable. It is currently one of the most abundant and widespread fishes in Kansas. Cross (1967) observed that carp were so abundant and widespread in Kansas that eradication was not an option.

Carp often grow 30 to 60 cm in length and weigh 0.5 to 4 kg; it is not uncommon for Common Carp to reach 15 to 20 kg. Males are usually distinguished from females by the larger ventral fin. Carp are characterized by their deep body and serrated dorsal spine. Color and proportions are extremely variable, but scales are always large and thick.

Carp generally spawn in the spring and early summer depending upon the climate. They segregate into groups in the shallows to spawn. Carp prefer shallow waters with dense macrophyte cover. Males externally fertilize eggs, which the females scatter over macrophytes in a very active manner. The eggs stick to the substrate upon which they are scattered. A typical female (about 45 cm) may produce 300,000 eggs, with some estimates as high as one million over the breeding season. Females facilitate attachment of fertilized eggs to the substrate. There is no further parental care. Incubation is related to water temperature and has been documented at three days at temperatures of 25 to 32C. Fry average 5 to 5.5 mm in total length. Temperature, stocking density, and availability of food influence individual growth. By the time the fish reach 8 mm the yolk has disappeared and they begin to actively feed. Males typically become sexually mature at 3 to 5 years and females at 4 to 5 years.

There is a report of a common carp living an astounding 47 years, probably in captivity. Other reports of 17 to 20 years are probably more typical.

Carp are primarily selective benthic omnivores that specialize on invertebrates that live in the sediments. Newly hatched carp initially feed on zooplankton; specifically rotifers, copepods, and algae. Young of year carp feed on a variety of macroinvertebrates including chironomids, caddis flies, mollusks, ostracods, and crustaceans. Adult carp are known to eat a wide variety of organisms including, insects, crustaceans, annelids, mollusks, fish eggs, fish remains, and plant tubers and seeds. Carp feed by sucking up mud from the bottom, ejecting it, and then selectively consuming items while they are suspended. The feeding galleries of carp are easily recognized in shallow waters as depressions in the sediment. Carp typically can be found in small schools, although larger carp often lead a solitary existence.

Predators on young carp include large fish such as northern pike, muskellunge, walleye, and largemouth bass. Birds such as Great Blue Herons also eat them. Adults have no predators other than people.

Carp are an important food fish throughout much of the world except in Australia and North America, where the fish is considered unpalatable. The world catch rate of carp per year exceeds 200,000 tons. The more colorful carp, called Koi, are bred in captivity and sold as ornamental pond fish.

Common Carp is an introduced species throughout most of the world and generally is considered a nuisance. Problems associated with carp are habitat modification caused by stirring up water and making it less suitable for other fish species, competing with other fish for food, and eating the eggs of other fish species. Carp often overwhelm any ecosystem where they are introduced. The most successful control measures involve draining water bodies or poisoning. Trapping and gill-netting are also used to capture larger fish but these methods will not eliminate the species from a water body.

Status on Smoky Hill ANGR. The Common Carp is an abundant, naturalized resident in the Smoky Hill River and Saline drainages, and occurs in streams on the installation at times when the streams have sufficient water (Busby and Guarisco 2000). Because all streams on Smoky Hill ANGR are ephemeral, carp populations fluctuate with conditions, dying out during dry periods and recolonizing from downstream sources when suitable stream flow resumes. Common Carp are not stocked in ponds on the installation. Whether carp are able to colonize ponds during periods of high streamflow has not been determined, although they have not been reported to occur in installation ponds.

Control and Management Recommendations

Trapping or gill-netting can be used to capture larger fish. This can be timed with spawning seasons when large fish congregate in small areas and are more easily captured. Electro-fishing also has been used to capture and remove carp. Note that these methods have only a temporary effect on the population because young fish are not affected.

To prevent successful reproduction, draw-downs of water levels have been used in reservoirs during or shortly after the spawning season to prevent eggs from hatching. Like trapping, this approach needs to be repeated on an on-going basis to be effective.

Several techniques have been developed to control the movement of carp populations. These techniques include a fishway, carp exclosures, a water-filled dam, and a fencing system.

Chemical control using ichthyocides such as rotenone often has been used in the past to prevent carp spreading in new water bodies, but projects tend to be small and have significant impacts on other aquatic biota.

Common carp are extremely difficult to control in waters where they have become established. Available control methods tend to be expensive or labor intensive, and either do not remove all live stages of carp or are non-selective and impact other aquatic organisms.

General Management Recommendations. The Common Carp has small, temporary populations in the ephemeral streams on Smoky Hill ANGR. Given the large, well-established populations in streams that feed the installation, there is no practical method to control this fish on the installation. The potential damage to aquatic environments by carp on Smoky Hill ANGR is limited; control of this fish is not a priority. No management action is recommended at the present time. If there are concerns about Common Carp in ponds on the installation, a pond monitoring program should be developed to determine if carp populations occur. If they do, the need for control measures should be evaluated.

G.3.4.2. *Phasianus colchicus* L. (Ring-necked Pheasant)

Web Sources:
http://www.info.usda.gov/scripts/lpsiis.dll/TN/TN_B_7.htm - Natural Resources Conservation Service; Ring-necked Pheasant
http://www.mbr-pwrc.usgs.gov/bbs/grass/a3091.htm - North American Breeding Bird Survey; Ring-necked Pheasant
http://www.birds.cornell.edu/AllAboutBirds/BirdGuide/Ring-necked_Pheasant.html - Cornell Laboratory of Ornithology: Ring-necked Pheasant
http://www.desertusa.com/mag00/sep/papr/phante.html - Desert USA; Ring-necked Pheasant

The Ring-necked Pheasant is native to Asia. Its original range was from between the Black and Caspian Seas east to Siberia, Japan and China. Pheasants were introduced in 1857 to California and to other western states in the 1880s. The bird has become naturalized across much of North American from southern Canada to the central U.S. In Kansas, pheasants are widespread except in the southeastern part of the state.

The Ring-necked Pheasant commonly is found in agriculture farmlands with crops of corn, wheat, oats, barley, or hay, or in areas with grasslands mixed with small woodlands. The bird also inhabits wetlands with suitable dry microsites. They consume mostly plant foods such as waste grains or seeds, corn, wheat, oats, barley, weed seeds, and wild berries; they also eat large insects and occasionally mice or snails.

Courtship may start in February or March and last until August. Males call loudly, like a domestic rooster, to attract mates and define territories. Males strut before females with their ear tuft feathers raised and their red facial skin around the eyes engorged and prominent. Males defend territories (which average a few acres in size) from intruders, at times ending up in heated battles. The successful male often is polygynous. He may mate with several hens, which select their nest sites within the male's crowing area.

Green-buff or brown-olive eggs are laid from April to August, one brood per hen per season. From 5—23 eggs have been reported in nest sites, with the average number equaling about a dozen. At times, two hens may lay their eggs in one nest. Hens also may lay eggs in nests of other ground nesting birds such as Mallard, Blue-winged Teal, Gray Partridge, Northern Bobwhite, Wild Turkey, and Ruffed and Blue Grouse. Incubation, usually by the female, lasts 23 to 25 days. The hen cares for the young until they reach 35 to 42 days old. The male may protect the hen and her brood from intruders.

Young are precocial, moving about on their own within a few days after hatching. Females may use the "crippled bird act" to lure predators away from their chicks or nests.

Nesting cover is the single most important factor that limits pheasant populations in suitable habitat. Pheasants need undisturbed habitats primarily of grass and herbaceous plants, with erect vegetation reaching eight to twelve inches in height. Early season nests utilize dead residual vegetation from the previous growing season. A shallow depression or pocket scratched out by the female is lined with bits of grass or weeds. As spring matures, hens select sites in new plant growth areas along fence rows, pastures, grasslands or idle agricultural lands.

Pheasants prefer wooded shelter belts for winter survival. These areas provide loafing, feeding, roosting, and escape cover from predators such as foxes, coyotes, and bobcats. Wintering birds may form flocks for protection, usually with the sexes separate.

While the Ring-necked Pheasant is an exotic species in North America, it causes few problems and generally is highly valued as a game bird. One undesirable trait of pheasants is that they may compete with prairie chickens and grouse in some circumstances. Studies have documented cock pheasant harassment of prairie chickens and nest parasitism of prairie chicken nests by hen pheasants (Vance and Westemeier 1979).

Status on Smoky Hill ANGR. The Ring-necked Pheasant is a common year-round inhabitant at Smoky Hill ANGR in grasslands and agricultural areas. During breeding bird surveys an average of 17.9 pheasants were detected per survey, and at an average of 14.1 of 30 census stops. The great majority of birds was detected by call, which is easily heard over considerable distances. Given their high detectability with this survey method, Ring-necked Pheasants may not be as abundant as the survey numbers indicate, at least relative to most other bird species. Pheasant are hunted as a game bird on the installation.

Control and Management Recommendations

An account for Ring-necked Pheasant is included here because it is a non-native species. Control measures for Ring-necked Pheasant have not been widely developed due to a lack of demand. Habitat management can be used to influence pheasant populations by increasing or decreasing habitat suitability.

*General Management Recommendations***.** The Ring-necked Pheasant is generally not considered an invasive species. No control measures are recommended. Recreational hunting is practiced on the installation and is unlikely to have a significant long-term effect on the population.

G.3.4.3. *Branta canadensis* L. (Canada Goose)

Web Sources:
http://animaldiversity.ummz.umich.edu/site/accounts/information/Branta_canadensis.html. - University of Michigan Museum of Zoology; Animal Diversity Web; *Branta canadensis*
http://njaes.rutgers.edu/pubs/subcategory.asp?cat=6&sub=51 - Rutgers University Extension Service; Canada Goose Management
http://digitalcommons.unl.edu/icwdmhandbook/74/ - The Handbook: Prevention and Control of Wildlife Damage; Cleary; Waterfowl

The Canada Goose is a native species that is widespread in North America. Formerly one broadly distributed species with multiple subspecies, the Canada Goose has been divided into a large-bodied, interior- and southern-breeding species, and a small-bodied tundra-breeding subspecies. The large-bodied group is still known as Canada Goose (*Branta canadensis*) while the small-bodied group takes the name Cackling Goose (*Branta hutchinsii*). For the purpose of this discussion, Canada Goose refers to both *B. canadensis* and *B. hutchinsii*.

Most subspecies are migratory, breeding in Canada and Alaska, and wintering in the contiguous U.S. The relatively small numbers that breed in the contiguous U.S. are non-migratory or migrate short distances.

Canada Geese are found near waterways in open, grassy habitats such as grasslands, chaparral, and arctic tundra. They also inhabit man-made habitats that are open and grassy, such as golf courses, agricultural land, airports, and parks.

Canada Geese have a black neck, bill, and head with a white chin strap and occasional white patches elsewhere. The body usually is brownish-gray, although colors vary in some of the subspecies. In some of the smaller subspecies the body is dark brown, where as in some of the larger subspecies the body is a light gray. Underneath, the colors are much lighter and almost white on the tail. During flight the tail shows a white semi-circle just above the black tail. Females may be slightly smaller than males, although both are similar to each other in color pattern. The bill tapers from the base where it is high to the end where it has narrowed. These geese have large wings (127 to 173 cm wingspan) that can be used as weapons. Body size varies considerably among the subspecies and ranges from approximatly 4 to 16 lbs.

Goslings are yellow with some greenish-gray colorings on top of their heads and backs. Goslings of the darker subspecies have a brownish olive or blunt yellow coloring, while those of the lighter subspecies are lighter and brighter in color. These colors fade as the gosling grows into the adult color pattern. All goslings have black or blue-gray bills and legs that become darker as they age.

Canada Geese are monogamous. Pairs form during the winter, during migration or on their wintering grounds, for the next breeding season. Mated pairs may stay together for more than one year, sometimes staying together for life. The average clutch size is five eggs, ranging from 2 to 9 eggs. Females incubate the eggs, choose the location for nesting, and build the nest without males. Males defend the territory, nest, and eggs from intruders, such as other geese. Female Canada Geese pick nesting sites that are isolated but have good visibility. This allows them to readily see danger approaching and to be difficult for predators to reach. The nesting area also must have open water with low banks so they can have access to water plants and places to get into or out of the water. Swamps, marshes, meadows, lakes, and other such areas are among some of their favorite nesting spots. Small islands with short, grassy vegetation and muskrat houses are popular nesting sites.

Nests are simple and are made of weeds, twigs, grass, moss, needles, and other such materials. Once the eggs are laid, the nest is lined with feathers and down. Incubation begins after the clutch is complete. The incubation period lasts 23 to 30 days. Hatchlings fledge in 68 to 78 days after hatching. It is not clear how long Canada Geese live in the wild, but individuals in captivity have lived to at least 24 years. Mortality during the first year of life is high.

Canada Geese are highly social, being found in flocks at all times of the year except when nesting. Migration takes place in large flocks. Large winter aggregations form while on lakes, coastal waters, and mudflats. In flight, flocks form large V's or diagonally straight lines.

Canada Geese are herbivorous and eat a variety of grasses and crop plants such as wheat, beans, rice, and corn. Aquatic plants also are consumed.

Canada Geese can become a nuisance, especially when normally migratory birds become resident. They can overgraze lawns and crops, leading to erosion. On lawns, their feces can annoy humans. Build-up of fecal matter can lead to lower water quality by fostering bacteria and adding much nitrogen and phosphorus. Canada Geese can be pests in urban areas where they congregate on golf courses, beaches, parks, playing fields, and yards. Damage to winter wheat and other crops can be substantial.

Canada Goose populations are expanding rapidly. Across the U.S. and southern Canada, Breeding Bird Survey data show an annual growth rate of 7.9% from 1980 to 2005. As populations expand, interest in stabilizing or reducing populations is increasing and the species is increasingly viewed as a pest, at least in urban areas. Canada Geese are a popular game bird and hunting opportunities have expanded with increasing populations. Sport hunting does not appear to be controlling populations, however.

Status at Smoky Hill ANGR. The Canada Goose is a year-round resident at Smoky Hill ANGR. Numbers are highest from late fall through early spring. Numbers of breeding geese are small due to the limited amount of open water or wetland habitat available for nesting. A few pairs breed on the large ponds, especially ponds with islands. No Canada Geese were observed on the breeding bird survey route from 2003 to 2006 (Table G.3). This survey was not designed to sample pond habitats that might be used by geese.

During migration and winter, the small amount of grain field and open water habitat makes Smoky Hill ANGR relatively unattractive to geese, and most geese observed on the installation are migrants flying over the area. Central Kansas is a winter concentration area for this and other species of geese, and areas such as nearby Quivira National Wildlife Refuge commonly host 100,000 Canada Geese at one time.

The main threat posed by the Canada Goose on the installation is from geese in the air, particularly large migratory flocks passing through the area. Little can be done to alter goose movement patterns given that off-site factors drive goose behavior. Following BASH plan procedures to identify high risk times and conditions and reduce or avoid training flights under these conditions is recommended.

Control and Management Recommendations

A wide variety of methods have been developed to repel and control Canada geese. Methods fall into the following categories:

- Harassment
- Exclusion
- Nest and egg destruction
- Habitat modification
- Capture and euthanasia
- Regulated hunting

Full details on these methods are presented in Drake and Paulin (2003).

Habitat modification is an effective method of controlling Canada Goose populations (Drake and Paulin 2003). If habitats attractive to geese are minimized, fewer geese will be attracted to the area. Habitats to be avoided include 1) large areas of open water or marsh, 2) areas with short, green grass, and 3) recently harvested grain fields. None of these habitats are common on Smoky Hill ANGR and little habitat attractive to geese is available on the installation.

As a native migratory bird, the Canada Goose is federally protected by the Migratory Bird Treaty Act. Permits are required through the U.S. Fish and Wildlife Service for certain control techniques, including lethal control.

General Management Recommendations. At Smoky Hill ANGR, Canada Geese pose a threat primarily as a BASH risk. Consult the BASH Plan for details on Canada Goose control measures. Current habitat management appears to be doing a good job of minimizing the attractiveness of installation habitats to Canada Geese. The species is not a threat to natural habitats or species on the installation.

Other waterfowl species also pose a BASH risk. These species are not addressed individually in this plan, but management recommendations for Canada Goose apply in general to other waterfowl.

TABLE G.3. Average detections on standardized breeding bird surveys on Smoky Hill ANGR from 2003 to 2006. Surveys were conducted in May or June and involved counting all birds detected at each of 30 count stops. (Additional species records not reported here were obtained using other survey methods.)

Bird Species	Mean Birds Detected per Survey	Mean No. Stops with Species Detected
Ring-necked Pheasant	17.9	14.1
Canada Goose	0	0
Rock Pigeon	0	0
European Starling	6.5	2.2
Brown-headed Cowbird	25.3	12.4
House Sparrow	0	0

G.3.4.4. *Columba livia* Gmelin (Rock Pigeon)

Web Sources:
http://www.birds.cornell.edu/AllAboutBirds/BirdGuide/Rock_Pigeon_dtl.html - Cornell Laboratory of Ornithology; Rock Pigeon
http://www.afcesa.af.mil/ces/cesm/pest/cesm_pestman2.asp - AFCESA; Pest Management; Pigeon Control
http://digitalcommons.unl.edu/icwdmhandbook/69/ - The Handbook: Prevention and Control of Wildlife Damage; Williams and Corrigan; Pigeons (Rock Dove)

A common sight in urban areas throughout the world, the Rock Pigeon was introduced into North America in the early 1600s. Its populations expanded rapidly and now it is found throughout North and South America except for the northern regions of North America. Rock Pigeons are native to Europe, Asia, and Africa and have been associated with humans for over 5,000 years. Domesticated birds have been used for food and entertainment, including use as homing pigeons. Domesticated birds have been bred for various plumages and colors, and as these birds have interbred frequently with wild birds, the species now exhibits great variety in plumage characteristics.

Most Rock Pigeons are of mixed wild and domestic ancestry. They favor urban environments where they occupy buildings and their window ledges that mimic the rocky cliffs used by wild pigeons. They also are common in agricultural areas where they nest on silos, barns, or under bridges. Flimsy nests are constructed and used repeatedly over time. Breeding occurs throughout the warmer months and pairs may raise several broods per year. Food consists of seeds, fruit and, rarely, invertebrates. Birds commonly feed on waste grain on the ground.

Rock Pigeon droppings can accelerate the deterioration of buildings and increase cost of maintenance. Large quantities of droppings may kill vegetation and produce an objectionable odor. Around grain handling facilities, pigeons consume and contaminate large quantities of food destined for human or livestock consumption. They carry and spread disease to people or livestock through their droppings. They are known to transmit pigeon ornithosis, encephalitis, Newcastle disease, cryptococcosis, toxoplasmosis, salmonella food poisoning, and several other diseases. Furthermore, pigeons located around airports can be a threat to human safety because of potential bird-craft collisions.

Status at Smoky Hill ANGR. The Rock Pigeon is found on Smoky Hill ANGR in low numbers around buildings and developed areas, and may occasionally be found foraging in recently burned fields or in harvested crop fields. The shortage of suitable buildings for nesting is probably a limiting factor for this species. No Rock Pigeons were detected during breeding bird surveys in 2003—2006. However, these surveys did not target buildings and structures where the species is most likely to occur.

Control and Management Recommendations

Preventative measures that can be used include exclusion (for example, using wires or shock devices) and habitat modification (food and water supply elimination, etc.) (Williams and Corrigan 1994). Frightening, repellents, trapping, shooting, and nest removal may be useful and practical approaches to manage pigeons (Williams and Corrigan 1994). Toxicants also can be used to eradicate *C. livia*, including both oral and contact poisons, but oral poisons require pre-baiting before the toxicant is introduced (Williams and Corrigan 1994). Fumigants and *alpha-chloralose* are two other methods applied to control pigeons. However, fumigants are generally not practical. Additional discussion of control measures can be found in Williams and Corrigan (1994).

A combination of control methods often proves to be the most effective. Preventative measures, where access to roost and nest sites is reduced or eliminated by sealing attics and other openings in buildings, combined with trapping, has been found to be successful (see AFCESA web link at the beginning of species account).

General Management Recommendations. Control measures for Rock Pigeons are not recommended in the undeveloped areas of Smoky Hill ANGR because of their low numbers and minimal threat to the environment and other wildlife. Buildings and other structures should be monitored for the presence of pigeons. If Rock Pigeons become problematic around developed areas or in training areas, control measures should be taken.

G.3.4.5. *Sturnus vulgaris* L. (European Starling)

Web Sources:
http://www.birds.cornell.edu/BOW/ - Cornell Laboratory of Ornithology; European Starling
http://digitalcommons.unl.edu/icwdmhandbook/72/ - The Handbook: Prevention and Control of Wildlife Damage; Johnson and Glahn; Starling

All of the European Starlings found today in North America--and they number in the 200 million range--are descendants of approximately 100 birds introduced in New York City's Central Park in the early 1890s. A society dedicated to introducing into America all of the birds mentioned in the works of Shakespeare set these birds free. Previous attempts to introduce Starlings were made in the Northeast and on the West Coast as early as 1850, but all were unsuccessful. Today, European Starlings are seen from Alaska to Florida to northern Mexico.

Starlings are associated with man-altered environments, foraging in open country on short, mown or grazed grassland while avoiding woodlands, arid chaparral, and deserts. Starlings exploit a variety of food sources, taking invertebrates, fruits and berries, grain, and temporarily abundant food such as animal feed or garbage.

Throughout the year, European Starlings associate in flocks and form communal roosts at night, even during the breeding season. These roosts are larger during fall and winter, when roosts of more than a million birds are not uncommon. Starlings return to the same area to eat each day, usually early and late in the day, while traveling at other times in large flocks to more abundant but ephemeral food sources. Migratory behavior appeared in North American starlings shortly after their introduction; they are at least partly migratory throughout the Mid-Atlantic states and are mostly migratory in the Midwest and Great Lakes area. South of 40-degrees latitude they are non-migratory. Starlings are diurnal migrants and move out of northern areas, following major river valleys or the coastal plain, between September and early December. Spring migration takes place from mid-February to the end of March.

These highly social birds do not defend a territory beyond their cavity nest site, but males are very protective of their mates. They compete aggressively for nesting sites and may evict the occupants of desired holes, including the woodpeckers that excavated them. They often out-compete other hole-nesting species such as Eastern Bluebirds, Tree Swallows, Great Crested Flycatchers, and woodpeckers. Starlings usually return to nest in the same site every year.

Both males and females (especially in the fall) can sing and make a variety of calls, whistles, and more complex songs. The males typically sing two types of songs, one consisting primarily of loud whistles and the other a so-called “warbling song” that often incorporates mimicry of other species. An individual bird can mimic the vocalizations of up to 20 species, including Eastern Wood-Pewee, Killdeer, and Meadowlark.

European Starlings are stocky birds with short, square-tipped tails and pointed wings. During the breeding season, they can be distinguished quickly from blackbirds by their long, pointed, yellow bill; blackbirds have dark bills.

European Starlings cause damage to agricultural crops. Large starling flocks may descend on fruit and grain crop fields to forage, causing massive damage, and can have a heavy economic effect. Usurping nests by contamination (as well as physical competition) is also a major problem. European Starlings also are a public nuisance, can damage infrastructure, roof lining, etc., negatively affect aesthetics (Weber 1979). They can carry diseases that are transmissible to livestock and people, including gastroenteritis (TGE), a disease of swine, blastomycosis, and samonella.

In addition to having impacts on humans and livestock, European Starlings have negative effects on natural ecosystems. As cavity nesters, they compete with native species such as woodpeckers and bluebirds for nest sites. Studies documenting these effects have produced different results, but if populations of cavity nesters are declining in areas where starling populations are high, starling competition for nest sites may be a cause (Granholm 2004). European Starlings are extremely aggressive omnivores and compete with native fauna for food. Open-bill probing is most commonly used for ground invertebrates, their preferred food. During winter, when the diet may include more fruit, starlings are suspected of acting as a seed dispersal agent for exotic and invasive plants such as eastern red-cedar (*Juniperus virginiana*) and honeysuckle (*Lonicera* spp.).

Status on Smoky Hill ANGR. While starlings are generally associated with urban areas, they also have adapted well to natural habitats, and this is certainly the case at Smoky Hill ANGR. On breeding bird surveys on Smoky Hill ANGR an average of 6.5 Starlings was observed at 2.2 listening stops per survey (Table G.3). These numbers indicate the species is well-established and occurs in modest numbers during the breeding season**.** Pairs begin nesting in early spring and are multiple brooded, raising two or more broods over the course of the spring and early summer months. Nests are constructed in natural and man-made cavities, the most common of which are tree cavities created by woodpeckers. In the undeveloped portions of Smoky Hills ANGR, the principal risk posed by starlings is competition with native birds for nest cavities. Native cavity nesters likely to be affected by competition by starlings include Eastern Bluebird and most woodpecker species, especially Red-headed Woodpecker and Red-bellied Woodpecker. Dead, hole-ridden trees around ponds often host many pairs of nesting starlings. While starlings may negatively affect some native cavity nesting species, the scale and cost involved to control starlings throughout the installation makes intervention impractical.

Control and Management Recommendations

Manual methods such as exclusion, trapping, and shooting have been employed in an attempt to control European Starling populations. Where starlings are nesting in cavities in buildings and human structures, exclusion by plugging or preventing access to cavities, is an effective control method. Poisoning can be effective but should be limited to developed environments where native birds are scarce. “Starlicide Complete” (0.1% 3-chorlo p-toluidene hydrochloride) is one poison on the market. Starlings are wary and shooting is generally not an efficient control method. Mechanical controls include scaring with the use of sonic devices (Adeney 2001). As a non-native species, no federal permit is needed to kill European Starlings.

General Management Recommendations. European Starlings pose little risk to natural habitats and wildlife on Smoky Hill ANGR and control of the species is not recommended under current conditions. In addition, starlings are so common and widespread in the region, that lethal control is unlikely to have a long-term effect. If starlings become problematic around buildings, they should be treated as a pest management issue and control measures adopted. Exclusion from nest cavities by sealing off access should be the technique tried first, with other methods applied as needed.

G.3.4.6. *Molothrus ater* L. (Brown-headed Cowbird)

Web Sources:
http://www.birds.cornell.edu/BOW/ - Cornell Laboratory of Ornithology; Brown-headed Cowbird
http://animaldiversity.ummz.umich.edu/site/accounts/information/Molothrus_ater.html Animal Diversity Web; *Molothrus ater*
http://digitalcommons.unl.edu/icwdmhandbook/59/ - The Handbook: Prevention and Control of Wildlife Damage; Dolbeer; Blackbirds

Brown-headed Cowbirds are brood parasites, having completely abandoned the tasks of building nests, incubating eggs, and caring for hatchlings. Instead, each female deposits as many as 40 eggs per year in nests belonging to birds of other species. More than 200 species have provided host nests for cowbird eggs. The female cowbird finds these nests by watching from an observation post where she can look down on grassland species, by observing the nests of tree-nesting species while she walks quietly on the forest floor, or by crashing noisily through shrubbery with flapping wings to flush out potential victims. She typically chooses a nest with eggs smaller than her own and lays a single egg quickly at dawn once the host also has started laying eggs. Unlike the parasitic European cuckoos, Brown-headed Cowbirds do not evict their nest-mates, although the female may remove and sometimes eat eggs from the host nest. Instead, cowbird nestlings typically out-compete their smaller nest mates.

Found throughout the U.S. and southern Canada, the Brown-headed Cowbird evolved in North America's grasslands and is named for its habit of foraging among grazing animals. The cowbird's range expanded soon after many forested landscapes were cleared and large domesticated mammals were introduced. These events brought the cowbird into contact with naive populations of potential hosts, many of which had not yet had time to evolve strategies to deal with brood parasitism. Most species will abandon their nest if the cowbird egg is laid first. Some species recognize and reject cowbird eggs; others appear unable to distinguish either egg or nestling from their own legitimate offspring. When the egg is recognized but the host species is too small to remove the egg, the nest may be abandoned, or new nest material may be placed over the cowbird egg, insulating it from being incubated. Nests of Yellow Warblers, a frequent cowbird victim, have been found with up to six stories, as multiple Brown-headed Cowbird eggs were recognized and covered.

Although nesting success of the Brown-headed Cowbird's host is adversely affected, most species have not suffered population declines as a result of brood parasitism. Exceptions, however, include Black-capped Vireos, Least Bell's Vireos, and the endangered Kirtland's Warbler, a species whose very existence may depend on the continued control of Brown-headed Cowbird numbers within its limited range. In addition, brood parasitism by Brown-headed Cowbirds might contribute to the reduced success of some species in fragmented forest environments.

Cowbirds occur most often in grassland and agricultural/residential landscapes near open woodlands. In mixed landscapes, cowbirds are more common at woodland edges than in prairies, grasslands, and shrub-steppes. Cowbirds can be common in treeless, grassland habitats and actually reach their peak abundance in such habitats in the northern Great Plains (Figure G.2). However, recent data suggest that grassland habitats tend to have fewer accepting host species than forests, so parasitism rates tend to be lower than in forests. Grassland habitats also lack perch sites that female cowbirds use to scan for nesting hosts. In the Flint Hills in Kansas and Oklahoma, cowbird densities were highest in woodland edge (Jensen and Cully 2005), and parasitism rates were highest near woody vegetation and in grazed prairie (Patten et al. 2006).

Brown-headed Cowbirds are partially migratory, abandoning northern parts of their range and wintering most abundantly in the southeastern U.S., California, and Arizona. During migratory flights, cowbirds associate in flocks with Red-winged Blackbirds, Common Grackles, and Rusty Blackbirds, and less commonly with American Robins and Eastern Meadowlarks in the East and with Brewer's Blackbirds and Yellow-headed Blackbirds in the West. Like other blackbirds, Brown-headed Cowbirds shift their diet at the end of summer from insects to grains primarily in the fall and winter, foraging on the ground by walking.

The Brown-headed Cowbird is a native species that has expanded from its original range in the grasslands and savannas of central North America to throughout most of temperate North America. As a nest parasite that lays its eggs in the nests of many other bird species, a major concern has been the potential impact of cowbirds on the reproduction of host species. As cowbird populations have expanded, cowbirds have exploited host species that had not previously experienced egg parasitism, raising the concern that host species populations would decline. However, recent studies have failed to document population-level effects of cowbirds on host species (Mitchell and Rothstein 1999). In many instances, reproductive output of host species does not decrease despite high rates of cowbird nest parasitism.

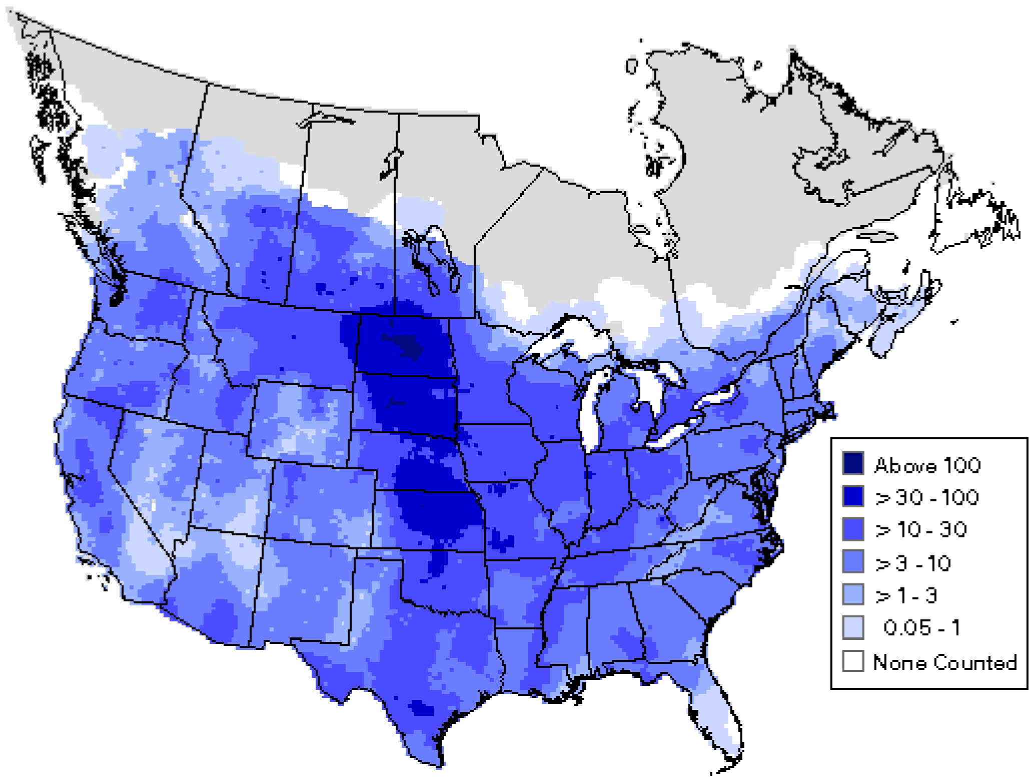

FIGURE G.2. June abundance of the Brown-headed Cowbird from North American Breeding Bird Survey data. Numbers are average birds detected per 50-stop census route.

Cowbirds also consume grain in croplands and in livestock feed lots. This is more likely to be a problem in the non-breeding season (fall through early spring) when cowbirds form large flocks, often together with Red-winged Blackbirds, and wander in search of food.

Status on Smoky Hill ANGR. The Brown-headed Cowbird is an abundant breeding bird at Smoky Hill ANGR. Some cowbirds remain through the winter months in central Kansas, but most migrate to the southern U.S. Cowbirds prefer open habitats and on Smoky Hill ANGR frequent grasslands, croplands, and savanna habitats. However, females will visit a variety of habitats, including riparian woodlands, to locate and parasitize nests of other bird species. On breeding bird surveys, an average of 25.3 cowbirds were detected per survey at an average of 12.4 stops (Table G.3), making it one of the most abundant breeding birds on the installation. This result is consistent with that of the Breeding Bird Survey (2007) that shows that the highest populations of the Brown-headed Cowbird in North American occur in the Great Plains from central Kansas to North Dakota (Figure G.2).

The main concern is whether cowbirds are substantially reducing populations of host species on the installation, a question for which there currently is no data. Studies in the nearby Flint Hills document parasitism rates and indicate that the Dickcissel is a primary host (Jensen and Cully 2006, Patten et al. 2006). Bell's Vireo also is a frequent cowbird host. However, Bell's Vireo populations appear to be stable in Kansas (BBS trend = 0.12 per year, NS) from 1975 to 2005, Dickcissel populations appear to be increasing (BBS trend = 1.34, $p < 0.001$), and Brown-headed Cowbird populations show a significant negative trend over this same period (BBS trend = -1.50, $p < 0.01$) (Breeding Bird Survey 2007). These data do not suggest the problem of cowbird parasitism is worsening, and in fact, it appears the reverse is true.

Control and Management Recommendations

The most effective treatment method for cowbirds during the breeding season is trapping. Large live-trap enclosures take advantage of the social nature of this species and once birds are in the trap, others are attracted. Trapping has been effectively used to reduce cowbird populations in the local area. Several limitations of trapping have been expressed however. First, cowbird control is a short-term solution that ignores the real problem of habitat degradation as a result of agriculture, grazing, and development. Second, studies show limited geographical reach of control; trapping at best reduces parasitism rates only near the trapping site.

Where large mixed-species flocks including cowbirds are a threat to cropfields or grain supplies (such as a livestock feedlots), poisoning can be an effective control measure. However, federal permits are required because this is a native species protected by the Migratory Bird Act.

General Management Recommendations. No species-specific control measures for Brown-headed Cowbird are warranted at this time. Even if data indicated that cowbird parasitism is substantially impacting native bird populations, the high cost and lack of long-term effect of a trapping program would make its justification difficult. Several land management actions are recommended based on results from Patten et al. (2006) and other studies. These include 1) minimizing cowbird perches by reducing isolated trees and woody edge habitat, 2) minimizing disturbances in grassland habitat such as roads and fences that create cowbird perches, and 3) leaving some grassland areas ungrazed given the evidence that parasitism rates are higher in grazed areas.

G.3.4.7. *Passer domesticus* L. (House Sparrow)

Web Sources:
http://www.birds.cornell.edu/BOW/ - Cornell Laboratory of Ornithology; *Passer domesticus*
http://animaldiversity.ummz.umich.edu/site/accounts/information/Passer_domesticus.html - University of Michigan Museum of Zoology: House Sparrow

http://digitalcommons.unl.edu/icwdmhandbook/71/ - The Handbook: Prevention and Control of Wildlife Damage; Fitzwater; House Sparrow

One hundred House Sparrows were introduced into Brooklyn in the fall of 1851 and the spring of 1852. From this initial introduction, the species expanded throughout the eastern U.S. and Canada. Aided by transplants from established populations and additional introductions from Europe (for example, into San Francisco and Salt Lake City in 1873—1874), the species now ranges from central and northeastern British Columbia to the James Bay and south to Panama.

The House Sparrow is one of the few introduced bird species that has succeeded greatly. The species is native in a region from Britain, northern Scandinavia, and northern Siberia to northern Africa, Arabia, India, and Burma. House Sparrows have been introduced into South America, southern Africa, Australia, and New Zealand, in addition to North America. A non-migratory species, House Sparrows are closely tied to human activity. This sparrow usually is absent from extensive woodlands and forests, and from grasslands and deserts. In the far northern parts of its range and in arid regions, House Sparrows typically are present only in the vicinity of human habitation. In agricultural areas, an average of 60% of its food comes from livestock feed, 36% from weed seeds, and 4% from insects. In urban areas, bird feeders provide more food for House Sparrows. The initial successful introductions in the late 1800s were made in urban areas, where House Sparrows adapted to using the feed and waste products of the horses that provided transportation at that time.

The number of House Sparrows in continental North America is estimated at approximately 150,000,000 birds, but Breeding Bird Survey data indicate that the population is declining, particularly in the eastern and central U.S. Changes in agricultural practices, in particular the shift to monoculture crop plantings, have been suggested as the cause.

Although House Sparrows are quite gregarious and nest in loose-knit colonies, they defend a small territory immediately surrounding the nest. Males defend these territories from other males, and females from other females. Holes are preferred as nest sites, but nooks and crannies in outbuildings and open sites in trees and shrubbery also are used. Young birds form flocks soon after fledging, and most disperse from the natal colony. Large post-breeding flocks roost in trees or brush near grain fields in agricultural areas or in cities, from which they fly to feeding areas. After arriving at the congregation site, the birds often engage in communal singing for up to an hour.

The House Sparrow displaces native species through competition for food resources. In rural areas, they may evict native birds from their nests. Species reported as driven away by House Sparrows include Eastern Bluebird, Carolina Wren, Purple Martin, and a variety of woodpeckers.

Early in its invasion of North America, House Sparrows began attacking ripening grains such as wheat, oats, corn, barley, and sorghum, and were considered a serious agricultural pest. They also will consume fruits and young vegetables.

Status on Smoky Hill ANGR. The House Sparrow is found near buildings at headquarters and operations at Smoky Hill ANGR. The species is a year-round resident and breeds throughout the spring and summer months in cavities and crevices. The House Sparrow rarely is encountered away from human-derived structures and consequently is not found in large numbers on the installation. No House Sparrows were observed on the breeding bird survey from 2003—2006. However, the survey route did not cover the developed areas of the range, so no quantitative data are available for House Sparrows in these areas.

Control and Management Recommendations

There are several ways to control House Sparrows. One is habitat modification. Roost and nest sites can be eliminated by blocking entrances large enough for sparrows to enter (about 2 cm). Buildings can be designed or altered to eliminate nesting places. In some areas, building codes are modified and architectural committees review plans to reduce nesting sites. Food sources can be reduced by removing edible human refuse, protecting small crops with bird netting, and practicing clean livestock feeding techniques. Feed also needs to be covered to protect it from bird droppings. Bird-resistant varieties of plants can be planted.

More direct methods of control include shooting, trapping, poisoning, and repelling. Birds can be shot with air guns and small arms containing BBs and dust shot. Trap types include funnel, automatic, triggered, and mist nets. Trapping generally is difficult because sparrows quickly learn to avoid traps and nets. House Sparrows can be repelled with noise, such as fireworks or alarms. Bird glues and Nixalite (trademark for "porcupine wire") annoy the sparrows. They also can be scared with scarecrows and motorized hawks. Destroying nests is another method of reducing sparrow populations.

Avitrol (trademark for 4-Aminopyridine) is the standard poison used to control sparrows. It is most effective in winter when food is scarce and bait is readily accepted. Grain is typically used, however, it is important to be aware of any local poison control laws before proceeding. Naphthalene is an olfactory repellent.

As a non-native species, there are no federal laws protecting House Sparrows.

General Management Recommendations. No control measures are recommended for House Sparrows in native habitats at Smoky Hill ANGR due to the absence of large sparrow numbers and the limited impact House Sparrows have in native habitats. House Sparrows should be monitored casually around buildings and developed areas, and if they become a problem, local control measures should be taken.

G.3.4.8. *Mus musculus* L. (House Mouse)

Web Sources:
http://animaldiversity.ummz.umich.edu/site/accounts/information/Mus_musculus.html - University of Michigan Museum of Natural History; House Mouse
http://www.invasivespecies.net/database/species/ecology.asp?si=97&fr=1&sts=sss - Global Invasive Species Database; *Mus musculus*
http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7483.html - University of California, Davis; Integrated Pest Management; House Mouse
http://digitalcommons.unl.edu/icwdmhandbook/4/ - The Handbook: Prevention and Control of Wildlife Damage; Timm; House Mice

The House Mouse originally may have been distributed from the Mediterranean region to China but now probably has a world distribution more extensive than any mammal other than humans. Its geographic spread has been facilitated by its commensal relationship with humans – a relationship that extends back at least 8,000 years.

House mice generally live in close association with humans – in houses, barns, and granaries. They also occupy cultivated fields, fencerows, and even wooded areas, but they seldom stray far from buildings. Some individuals spend the summer in fields and move into barns and houses with the onset of cool autumn weather. Due to their association with humans, House Mice can inhabit inhospitable areas (such as tundra and desert), which they would not be able to occupy independently.

House Mice are from 65 to 95 mm long from the tip of their nose to the end of their body; their tails are 60 to 105 mm long. Their fur ranges in color from light brown to black, and they generally have white or buff bellies. Their tails have very little fur and have circular rows of scales (annulations). They range from 12 to 30 g in weight.

The House Mouse has tremendous reproductive potential. Breeding occurs throughout the year, although wild mice may have a reproductive season extending only from April to September. Females generally have 5 to 10 litters per year if conditions are suitable, but as many as 14 have been reported. Gestation is 19 to 21 days but may be extended by several days if the female is lactating. Litters consist of 3 to 12 (generally 5 or 6) offspring, which are born naked and blind. They are fully furred after 10 days, open their eyes at 14 days, are weaned at 3 weeks, and reach sexual maturity at 5-7 weeks. Young mice are cared for in their mother's nest until they reach 21 days old. Soon thereafter, most young mice leave their mother's territory, though young females are more likely to stay nearby. Average life span is about 2 years in captivity, but individuals have lived for as long as 6 years. In the wild, most mice do not live beyond 12—18 months.

In the wild state, House Mice generally dwell in cracks in rocks or walls or make underground burrows consisting of a complex network of tunnels, several chambers for nesting and storage, and three or four exits. When living with humans, House Mice nest behind rafters, in woodpiles, storage areas, or any hidden spot near a source of food. They construct nests from rags, paper, or other soft substances and line them with finer shredded material. House Mice generally are nocturnal, although some are active during the day in human dwellings. House Mice are quick runners (up to 8 miles per hour), good climbers and jumpers, and swim well. Despite this, they rarely travel more than 50 feet from their established homes.

In the wild, House Mice eat many kinds of plant matter, such as seeds, fleshy roots, leaves and stems. Insects (beetle larvae, caterpillars, and cockroaches) and meat (carrion) may be taken when available. In human habitations, House Mice consume any human food that is accessible, as well as glue, soap, and other household materials. Many mice store their food or live within a human food storage facility.

Where House Mice are abundant they can consume huge quantities of grains, making these foods unavailable to other (perhaps native) animals. House Mice are important prey items for many small predators.

House Mice are major economic pests, consuming and despoiling crops and human foodstuffs, and also have been implicated in extirpations and/or extinctions of indigenous species in ecosystems they have invaded and colonized that are outside their natural range. They are host to a range of diseases and parasites infectious to humans, the most serious being bubonic plague (*Yersinia pestis*) and salmonella (*Salmonella* spp.). However, mice are considered relatively unimportant as vectors for their transmission to humans.

Status at Smoky Hill ANGR. The House Mouse appears to be rare in natural habitats on the installation. Three of four specimens documented in this study were captured near headquarters in the summer of 2003 during surveys for small mammals. The fourth was captured in a heavily grazed pasture. House Mice mostly occur in or near houses, buildings or other human-modified sites, and no surveys of such areas were part of this study. However, the fact that House Mice were detected away from human habitation makes it likely that they dispersed from nearby human habitations, most likely on Smoky Hill ANGR.

Control and Management Recommendations

Mice are controlled by poisoning, fumigation, trapping, repellants, and domestic cats (*Felis catus*). Most techniques are not species-specific and are designed to control mice in or near human dwellings or to eradicate mice from small islands where they pose a serious threat to breeding birds and where often no other small mammals are present.

Because House Mice are so small, they can gain entry into homes and other buildings much more easily than rats. As a result, House Mouse infestations are probably 10 to 20 times more common than rat infestations. Effective control involves sanitation, exclusion, and population reduction. Sanitation and exclusion are preventive measures. When a mouse infestation already exists, some form of population reduction such as trapping or baiting is almost always necessary.

A key to successful long-term mouse control is the limitation of shelter and food sources wherever possible. Trapping works well when mice are not numerous, or can be used as a follow-up measure after a baiting program. When considering a baiting program, decide if the presence of dead mice will cause an odor or sanitation problem. If so, trapping may be the best approach. Removal of mice should be followed by taking steps to exclude them so that the problem does not recur.

Several types of rodenticides are used in baits. The anticoagulant rodenticides are most commonly available and can be used in and around buildings. Because all rodenticides are toxic to humans, pets, and wildlife, take special precautions to prevent the poisoning of non-target animals.

Sanitation. Because mice can survive in very small areas with limited food and shelter, their control can be very challenging, especially in and around older structures. Most buildings in which food is stored, handled, or used will support House Mice if the mice are not excluded, no matter how good the sanitation. While good sanitation seldom will completely control mice, poor sanitation is sure to attract them and will permit them to thrive in greater numbers. Pay particular attention to eliminating places where mice can find shelter. If they have few places to hide, rest, or build nests and rear their young, they cannot survive in large numbers.

Exclusion. Exclusion is the most successful and permanent form of House Mouse control. "Build them out" by eliminating all gaps and openings larger than ¼ inch, through which mice will enter a structure. Steel wool makes a good temporary plug. Seal cracks in building foundations and around openings for water pipes, vents, and utility cables with metal or concrete. Doors, windows, and screens should fit tightly. It may be necessary to cover the edges of doors and windows with metal to prevent gnawing. Plastic screening, rubber or vinyl, insulating foam, wood, and other gnawable materials are unsuitable for plugging holes used by mice.

Traps. Trapping is an effective method for controlling small numbers of House Mice. Although time-consuming, it is the preferred method in homes, garages, and other structures where only a few mice are present. Trapping has several advantages: (1) it does not rely on potentially hazardous rodenticides; (2) it permits the user to view his or her success; and (3) it allows for disposal of trapped mice, thereby eliminating dead mouse odors that may occur when poisoning is done within buildings. Simple, inexpensive, wood-based snap traps are effective. Traps can be baited with a variety of foods; peanut butter is the most popular because it is easy to use and very attractive to mice. Multiple-capture live traps for mice, such as the Victor Tin Cat and the Ketch-All, also are available. They can catch several mice at a time without being reset, so labor requirements are reduced. Set traps behind objects, in dark corners, and in places where there is evidence of mouse activity. Traps can be set on ledges, on top of pallets of stored materials, or in any other location where mice are active. Use enough traps to make the trapping period short and decisive. Mice seldom venture far from their shelter and food supply, so space traps no more than about 10 ft apart in areas where mice are active.

An alternative to traps is glue boards, which catch and hold mice that are attempting to cross them, in much the same way flypaper catches flies. Place glue boards along walls where mice travel. Do not use them where desirable wildlife can contact them. Non-target animals that become caught on the glue board can be removed in most cases by using vegetable oil as a solvent to loosen the glue. Glue boards lose their effectiveness in dusty areas unless covered. Extreme temperatures also may affect the tackiness of glue boards.

Baits. Baits to control rodents are formulated with an attractant (generally food) and a rodenticide (toxin). Most rodenticides used to control mice around the home are already mixed with an attractant in commercially ready-to-use baits. The rodenticides in these baits are either anticoagulants or other rodenticides, such as single-dose toxicants and chronic rodenticides.

Anticoagulant Rodenticides. Anticoagulants cause death as a result of internal bleeding, which occurs as the animal's blood loses the ability to clot and capillaries are damaged. The active ingredients are used at very low levels and the onset of symptoms is delayed, so the rodent does not avoid the bait because of its taste or the onset of illness. When prepared with good-quality cereals and other bait ingredients, all anticoagulant baits provide good to excellent House Mouse control if placed in suitable locations for the mice. Because some anticoagulants require multiple feedings over several days before a lethal amount is ingested, fresh bait must be made available to mice continuously over a period of time. In practice, baits can be offered to mice for at least two weeks or as long as feeding occurs. While the newer anticoagulants (brodifacoum, bromadiolone, and difethialone) may cause death after a single feeding, the mice do not die until several days after feeding on the bait. Therefore, the method of setting the bait out is essentially the same as for the older anticoagulant products warfarin, diphacinone, and chlorophacinone.

Anticoagulants have the same effect on nearly all warm-blooded animals, but the sensitivity to these toxicants varies among species. If misused, anticoagulant poisoning can cause the death of pets, livestock, or desirable wildlife that may feed on the bait. Additionally, residues of anticoagulants that may be present in the bodies of dead or dying rodents can cause toxic effects to scavengers and predators. However, this "secondary hazard" from anticoagulants is relatively low when baits are used properly. Symptoms of anticoagulant poisoning in mammals include lethargy, loss of color in soft tissues such as the lips and gums, and bleeding from the mouth, nose, or intestinal tract. Because all rodenticides can be toxic to humans, particular care should be taken to keep rodent baits out of the reach of children. Vitamin K is the antidote for anticoagulant rodenticides, although in cases of severe poisoning whole blood transfusion is used. All baits must be used according to the label directions. Use rat and mouse baits in a way that makes bait available solely to rats or mice. The newer anticoagulants (brodifacoum, bromadiolone, and difethialone) have never been approved for use in agricultural or field situations or for use against ground squirrels, meadow mice (*Microtus*), pocket gophers, or any rodent other than house mice, Norway rats, and roof rats. This is because these newer materials are more persistent in the body once ingested, and thus they may pose a greater hazard to non-target wildlife, including predators and scavengers. Careful bait use will reduce the chance that rodenticide residues will occur in non-target animals.

Bait Selection and Placement. Several formulations of anticoagulant baits are available. Grain baits or pelleted forms often are packaged in small plastic, cellophane, or paper packets or are sold in bulk. The "place packs" are designed to keep baits fresh and to make it easy to place baits into burrows, walls, or other locations. Mice will readily gnaw into place packs and feed on baits.

Anticoagulant baits formed into paraffin or wax blocks are useful in damp locations where loose grain baits spoil quickly. Unfortunately, mice may not accept these blocks as readily as they do other baits. Baits containing certain grass seeds often are particularly well accepted by mice, even in the presence of other competing food items. Proper placement of baits is important for House Mouse control. Place baits no more than 10 ft apart in areas where mouse activity is evident. If mice are living in wall spaces, place baits inside the walls.

Other Rodenticides. In addition to the anticoagulant baits, three other rodenticides currently are available for use against the House Mouse. Although not anticoagulants, bromethalin and cholecalciferol are used in a manner somewhat similar to the anticoagulant products. These two materials are formulated to serve as chronic rodenticides, so that House Mice will have the opportunity to feed on exposed baits one or more times over the period of one to several days. Bait acceptance generally is good when fresh, well-formulated products are used. The third material, zinc phosphide, differs from bromethalin and cholecalciferol in that it is an acute toxicant that causes death of the mouse within several hours after a lethal dose is ingested. When using zinc phosphide baits, prebaiting (offering mice similar but nontoxic bait before applying the zinc phosphide bait) is recommended in order to increase bait acceptance. If acceptance of prebait is poor, do not apply toxic bait, but change the bait material or its placement. Zinc phosphide bait is not designed to be left available to mice for more than a few days; continuous exposure is likely to result in the mice learning to avoid the bait, a behavior known as "bait shyness." The advantage of using zinc phosphide bait is its ability to achieve a comparatively quick reduction of a mouse population. Because bait shyness can occur with zinc phosphide baits, these products should not be used more frequently than once or twice per year at any given location.

Bait Stations. Bait stations are very useful when applying the chronic and single-dose toxicant rodenticide baits. They protect rodenticides from weather and provide a safeguard to people, pets, and other animals. Bait stations should have at least two openings about 1 inch in diameter and should be large enough to accommodate several mice at one time. Place bait boxes next to walls (with the openings close to the wall) or in other places where mice are active. It is best to place bait stations between the source of shelter and the food supplies that the mice are using. Clearly label all bait boxes "Caution—Mouse Bait" as a safety precaution. Some rodenticide labels or situations may require use of approved tamper-resistant bait stations. If so, be sure to secure these stations to buildings by nailing or gluing them to walls or floors in a way that will not permit a person or animal to knock them over or shake the bait out. Where it is impossible to exclude rodents from structures, establish permanent bait stations in and around the perimeters of buildings. Place fresh bait in these stations to control invading mice before mouse populations become established. Check bait stations regularly and replace bait if it gets old and moldy, because mice will not eat moldy bait.

Electronic Devices. Although mice are easily frightened by strange or unfamiliar noises, they quickly become accustomed to regularly repeated sounds. Ultrasonic sounds, those above the range of human hearing, have very limited use in rodent control because they are directional and do not penetrate behind objects. They also lose their intensity quickly with distance. There is little evidence that electronic, sound, magnetic, or vibration devices of any kind will drive established mice or rats from buildings or provide adequate control.

General Management Recommendations. The House Mouse does not appear to be a threat in natural habitats on Smoky Hill ANGR, and no control measures are recommended in these areas. Populations should be monitored periodically in developed areas and controlled when they exceed action thresholds determined by the installation. If mice become a problem in and around the built environment, control measures should be taken or a private pest control firm contacted.

G.3.5. Potentially Occurring Invasive Species

Many invasive species that have not been documented on Smoky Hill ANGR have the potential to become established in the future. Other invasive species may be on the installation presently but remain undetected. While it is beyond the scope of this plan to anticipate all the species that pose a future risk, natural resource staff should remain vigilant for newly arrived invasive species. Among the potential species are Emerald Ash Borer (*Agrilus planipennis* Fairmaire), Gypsy Moth (*Lymantria dispar* L.), and Wild Boar (*Sus scrofa* L.). State agencies that list potentially invasive animals include the Kansas Department of Agriculture and the Kansas Department of Wildlife and Parks. These and other sources should be checked periodically to determine which invasive species are at risk of spreading to installation lands.

G.4. MANAGEMENT GOALS AND PHILOSOPHY

G.4.1. Integrated Pest Management

A logical, effective, and environmentally sensitive approach to the management of invasive species is that of integrated pest management (IPM). IPM combines the best available information about pest species and their environment, with common-sense practices to develop pest control methods that minimize pest damage by the most economical means and with the least possible hazard to people, property, and the environment. The IPM approach can be applied in agricultural and non-agricultural settings and takes advantage of all appropriate pest management options. IPM is not a single pest control method but, rather, a series of four steps.

The first step is to set action thresholds. Before taking any pest control action, IPM sets an action threshold – a point at which pest populations or environmental conditions indicate that pest control action must be taken. Knowing the level at which a pest will become an economic threat is critical to guiding future pest control decisions. The decision to pursue active control of an invasive species will depend on the degree to which native species are displaced and must be weighed against the impacts of controlling it. Resource restrictions likely will limit complete eradication of invasive species, and established guidelines for pest control at military installations must be consulted when planning control measures. In most cases, maintaining invasive species populations below some specified threshold is a more realistic goal than complete eradication of the species.

This assessment identified 11 species and 1 guild of species (invasive, woody plants) that may warrant control on Smoky Hill ANGR. Current status information suggests that complete eradication may be feasible for common crown-vetch, multiflora rose, Russian-olive, and sericea lespedeza. The remaining species, bull thistle, Caucasian bluestem, downy brome, field bindweed, Japanese brome, musk-thistle, smooth brome, and invasive woody plants, appear to be so well-established, or so difficult to control, that complete eradication is not realistic. Instead, action thresholds should be set for these species to determine when, and how, they should be controlled on the installation.

The second step is to identify and monitor pests. Not all non-native organisms require control. Many are innocuous, and some are even beneficial. IPM programs work to monitor pests and identify them accurately so that appropriate control decisions can be made in conjunction with action thresholds. Identification and monitoring removes the possibility that pesticides will be used when they are not really needed,or that the wrong kind of pesticide will be used.

Proper identification of exotic and native plants is critical to preserving native biodiversity at Smoky Hill ANGR. Resource personnel in charge of invasive species control must be certain of their target species, and must exercise care not to damage native plants when implementing treatment. Several useful references are available for the identification of weeds, including Barkley (1983), Lorenzi and Jeffery (1987), Stubbendieck et al. (2003), and Whitson et al. (1991).

A strong monitoring program that tracks the location and abundance of species of concern is a fundamental component of a sound program of invasive species control. Early detection, followed by immediate control, if necessary, will minimize the long-term costs (Miller 2004).

Method for gathering field data about invasive plants for this study, which are presented in Chapter 3, are summarized here for convenience. Data were recorded on standardized field forms (Figure 3.1). Mapping procedures followed the recommendations of Carpenter et al. (2002) and Anonymous (2002), with minor modifications. The minimum mapping unit for each occurrence was $<1m^2$ (individuals mapped), and the minimum distance between adjacent occurrences was 30 m (i.e., any two plants closer than 30 mi were mapped as part of the same occurrence). The minimum mapping distance was increased to 50—60 m in some fields because plants occurred at very low but uniform densities. Without increasing the minimum mapping distance between occurrences, excessive time would have been spent mapping dozens of small occurrences with no forseeable management benefits. Latitude and longitude of isolated occurrences (points, or polygons with at least one dimension up to 5 m) were determined with a hand-held Garmin GPS II$^+$. Boundaries of larger occurrences were drawn onto aerial photos taken 30 July 2001 by Western Air Maps, Inc. of Overland Park, Kansas, and at least one GPS reading within the occurrence polygen was recorded as a quality control measure. Population boundaries were approximated by digitizing polygons directly from aerial photographs. Each point or polygon was assigned the following attributes: date observed, observer(s), centroid point, canopy cover (using 10 cover classes) and area (calculated in ArcView).

The third step is prevention. As a first line of control, IPM programs work to manage the enviroment of concern to prevent pests from becoming a threat. In an agricultural crop, this may mean using cultural methods, such as crop rotation, use of pest-resistant varieties, and use of pest-free rootstock. These control methods can be very effective and cost-efficient and present little to no risk to people or the environment.

On Smoky Hill ANGR, management practices that promote healthy, native vegetation probably will lead to competitive exclusion of many weedy species that already are established on the installation, or will help at least to keep them in check. Such practices also will help prevent invasion by new weedy annual and perennial species.

The fourth step is control. Once identification, monitoring, and action thresholds indicate that control is required, and preventive methods are no longer effective or available, IPM programs evaluate the proper control method both for effectiveness and risk. Effective, low risk pest controls are employed first, including highly targeted, species-specific chemicals, or mechanical control, such as trapping or weeding. If further identification, monitoring, and action thresholds indicate that low risk controls are not effective, then additional, higher risk pest control methods should be attempted. IPM programs usually use broadcast spraying of non-specific pesticides as a last resort. Poorly implemented control measures for invasive species have the potential to be extremely damaging to native biodiversity. Conversely, soundly implemented measures to control invasive species can help maintain and enhance native biodiversity. More effort and cost is required for successful eradication of established infestations. In some cases, the cost of eradication can be prohibitive, and control is a more appropriate and cost-effective strategy (Ohlenbusch and Towne 1991). It some cases, it may be necessary to employ mechanical, chemical, or biological control methods, or perhaps integrated strategies, to eradicate aggressive exotic species or to knock them back to levels where they can be controlled effectively by approaches that have fewer collateral impacts or that are less costly.

G.4.2. Ecological Management

Ecological conditions and land management practices are generally good on Smoky Hill ANGR. The most impressive ecological feature is the large, intact coverage of tallgrass prairie. Military stewardship has seen the maintenance of prairie habitat and a reduction in habitat fragmentation since the 1940s through the restoration of cultivated areas back to native grassland. After more than 60 years, the vegetation of many of these "go-back" areas is similar to native prairie. The healthy ecological conditions on the installation are largely attributable to judicious use of grazing and fire, the two main sources of natural disturbance that have shaped the prairie over time. Fire was reintroduced as a management tool during the military era, and grazing was continued from the pre-military period. Native plants and animals are adapted to these natural disturbances; most non-native species are not.

If improvement in ecological conditions is to continue, enhancements to current management practices should be considered. First, grazing practices could be improved. In natural communities that evolved with native grazers, well-managed livestock grazing is usually beneficial to, or at least compatible with, the maintenance of natural communities. However, differences between native grazing systems and livestock grazing systems can result in significant changes in vegetation composition and structure. In general, grazing systems are developed to grow livestock, not to maintain natural communities or to enhance biodiversity (Fuhlendorf and Engle 2001). Traditional livestock grazing often results in reduced vegetative diversity and condition, and in turn, may adversely influence native animals. Timing, duration, intensity, and forage selectivity are among the factors that vary with grazing system and that influence vegetation. The main recommendation of range and wildlife experts (see Chapter 5) was to incorporate more mixed management; i.e., not do the same thing every year. Periodic rest from grazing, and changing grazing timing and intensity are some of the components of mixed management. An indication of the need for adjustment in grazing practices is the lower values of floristic quality index and lower numbers of conservative plant species in grazed versus hayed and ungrazed units (see Chapter 2.3). Practices like season-long grazing, when maintained for many years, are associated with a decline in conservative (decreaser) plant species. A recommended goal is to improve vegetation condition (as measured by the Floristic Quality Index) in grazing leases to the levels currently found in hay leases and in the Impact Area.

The consensus of range and wildlife experts was that the burn regime was generally appropriate for the site. The two types of fire that occur, controlled burns and wildfires, are very different. Controlled burn practices in the agricultural leases generally appear sound, although greater variation in the seasonal timing and intensity of burns likely would result in increased ecological benefits. Use of some late summer and fall burns, and occasional hotter burns, would create more heterogeneity in conditions and would better simulate historical fire patterns. Hotter burns would improve control of woody vegetation and might be accomplished by burning following a rest period from grazing when fuel levels are higher. Wildfires resulting from training can occur at any season and under a wide range of fuel load, moisture, and weather conditions. In this sense, they may be more similar to fires in pre-settlement times. The variation in seasonal timing of wildfires in training areas (but probably not the higher burn frequency) is predicted to have a positive effect on biodiversity over time.

Adoption of recommended management changes to benefit natural communities and biodiversity may involve additional costs. For example, if pastures are rested or if stocking rates are reduced, this will mean a loss in income from agricultural leases. However, the INRMP calls for managing the prairie ecosystem to promote greater ecosystem diversity and increase biodiversity (4.11.2 RM-2). Achievement of this goal is compatible with the military training mission and with agricultural use. While ecosystem management for biodiversity is secondary to the primary purpose of achieving the military mission, the goal of improved biodiversity should not be secondary to generation of income from agricultural uses. If tangible enhancements to biodiversity can be achieved by management changes, these changes should be seriously evaluated and encouraged independent of the effect on agricultural income.

G.5. FIVE-YEAR INVASIVE SPECIES MANAGEMENT PLAN

Generalized procedures for surveying, monitoring, and controlling invasive species on Smoky Hill ANGR are summarized in Figure G.3. The process begins with surveys to identify potential invasive species. If potential invasives are discovered, action thresholds are set, a monitoring plan is developed and implemented, and fieldwork is conducted in accordance with the monitoring plan to determine if the action threshold is exceeded. If the threshold is not exceeded, the species continues to be monitored. If the threshold is exceeded, appropriate control measures are used either to eradicate the species or to control it to the point where populations fall below the action threshold.

Based on the above procedures, and using information collected during this study, a five-year invasive species management plan was developed (Table G.5). Tasks are grouped into three major activities: planning, survey and monitoring, and control. Tasks are prioritized as 1 (required, implement within first year), 2 (strongly recommended, implement within 2 years), and 3 (recommended, implement within 5 years). For greater precision, each 3-month quarter of each year during which a task should be carried out has been marked on Table G.5. Parts of the plan are by necessity vague. Planning, and survey and monitoring activities have been identified with greater precision than are most control activities. This is because control should be an adaptive process, with the choice and timing of control methods predicated on the principles of integrated pest management.

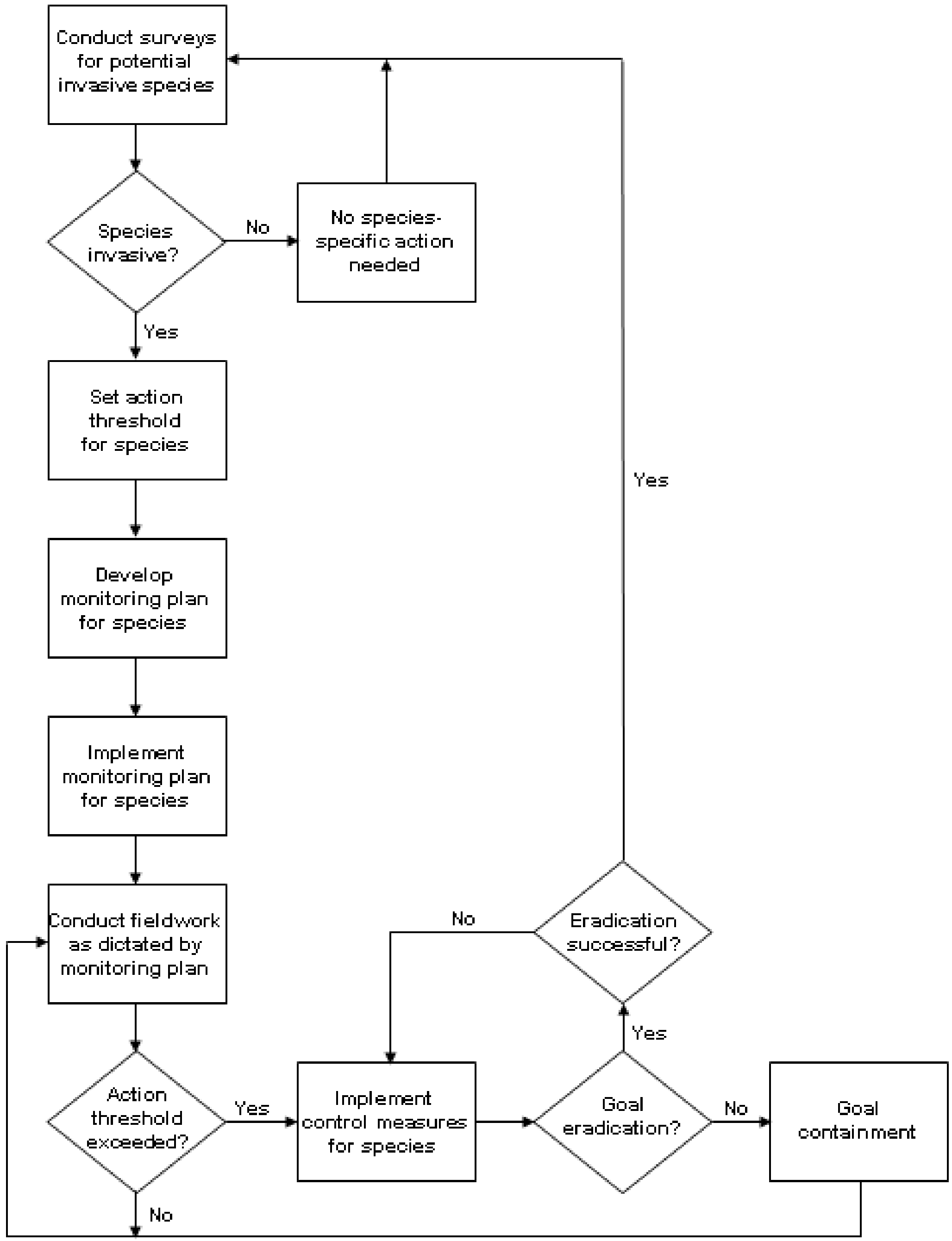

FIGURE G.3. Generalized procedures for surveying, monitoring, and controlling invasive species on Smoky Hill ANGR.

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TABLE G.1. Non-native vascular plants and vertebrate animals documented in Saline County and on Smoky Hill ANGR. Status codes: r = documented on Smoky Hill ANGR; s = documented in Saline County but not on Smoky Hill ANGR. Definitions for alien status (Alien Status) are provided in Chapter 6. Plant community codes: N1 = Ash-Elm-Hackberry Floodplain Forest; N2 = Dakota Hills Tallgrass Prairie; N3 = Dakota Sandstone Sparse Vegetation; A1 = Go-back Land/Tallgrass Prairie; A2 = Cultivated Fields; A3 = Windbreaks and Hedgerows; A4 = Ponds with 10 m Buffer; A5 = Developed Areas; A6 = Former Farmsteads; A7 = Military Practice Disturbed Areas; A8 = Firebreaks. Codes within Plant Community columns: Y = yes – species known on Smoky Hill ANGR and known to occur in plant community; P = potential – species potentially occurring on Smoky Hill ANGR in plant community (may not be documented on Smoky Hill ANGR or, if there, not necessarily documented in the plant community); N = no – species not known to occur on Smoky Hill ANGR and not likely to occur on Smoky Hill ANGR in plant community.

Scientific Name	Common Name	Alien Status	Plant Community										
			N1	N2	N3	A1	A2	A3	A4	A5	A6	A7	A8
PLANTS													
Conium maculatum L.	poison-hemlock	3	Y	N	N	N	P	Y	Y	P	Y	P	P
Pastinaca sativa L.	garden parsnip	3	N	N	N	N	N	N	N	Y	N	N	N
Torilis arvensis (Huds.) Link	field hedge-parsley	3	Y	N	N	Y	Y	Y	P	Y	Y	P	Y
Vinca minor L.	common periwinkle	3	N	N	N	N	N	P	N	N	P	N	N
Carduus nutans L.	Musk-thistle	4	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Centaurea cyanus L.	bachelor's-button	2	N	N	N	P	P	N	N	N	N	N	N
Cirsium vulgare (Savi) Ten.	bull thistle	3	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Lactuca saligna L.	willow-leaf lettuce	3	P	N	N	Y	N	P	P	Y	Y	P	P
Lactuca serriola L.	prickly lettuce	3	P	P	N	P	N	P	P	P	P	P	P
Leucanthemum vulgare Lam.	common ox-eye daisy	3	N	P	N	P	N	N	N	N	N	N	N
Sonchus asper (L.) Hill	prickly sow-thistle	2	Y	N	N	Y	N	P	P	P	P	N	N
Taraxacum erythrospermum Andrz. ex Besser	red-seed dandelion	3	Y	Y	N	Y	N	Y	Y	Y	Y	Y	P
Taraxacum officinale F.H. Wigg.	common dandelion	3	Y	Y	N	Y	N	Y	Y	Y	Y	Y	P
Tragopogon dubius Scop.	western salsify	3	Y	Y	N	Y	N	Y	N	Y	Y	P	N
Catalpa speciosa Warder	northern catalpa	3	Y	N	N	N	N	Y	P	N	Y	N	N
Barbarea vulgaris W.T. Aiton	bitter wintercress	3	N	N	N	P	P	P	N	P	P	P	P
Camelina microcarpa Andrz. ex DC.	little-pod false-flax	3	N	Y	N	Y	P	P	Y	P	P	P	P
Capsella bursa-pastoris (L.) Medik.	common shepherd's-purse	2	N	N	N	N	Y	N	N	Y	Y	P	P
Chorispora tenella (Pall.) DC.	blue-mustard	3	N	N	N	P	Y	N	N	P	P	Y	Y
Conringia orientalis (L.) Dumort.	treacle hare's-ear	2	N	N	N	P	P	N	N	N	P	N	N
Descurainia sophia (L.) Webb ex Prantl	flix-weed tansy-mustard	3	N	Y	N	Y	Y	Y	P	Y	Y	Y	Y

Scientific Name	Common Name	Alien Status	Plant Community										
			N1	N2	N3	A1	A2	A3	A4	A5	A6	A7	A8
Erysimum repandum L.	bushy wallflower	3	N	N	N	P	Y	P	P	P	Y	Y	Y
Hesperis matronalis L.	dame's rocket	3	P	N	N	N	N	P	N	P	P	N	N
Microthlaspi perfoliatum (L.) F.K. Mey.	perfoliate-pennycress	3	N	N	N	P	P	N	N	P	P	P	P
Nasturtium officinale R. Br.	common watercress	3	N	N	N	N	N	N	Y	N	N	N	N
Sisymbrium officinale (L.) Scop.	common hedge-mustard	3	N	N	N	P	P	N	N	N	P	P	P
Thlaspi arvense L.	field pennycress	3	N	N	N	P	Y	N	P	Y	Y	Y	Y
Cannabis sativa L.	hemp	3	Y	N	N	P	P	N	Y	N	Y	N	N
Arenaria serpyllifolia L. var. serpyllifolia	thyme-leaf sandwort	3	N	N	N	N	N	N	N	Y	N	N	N
Cerastium fontanum Baumg. subsp. vulgare (Hartm.) Greuter & Burdet	common mouse's-ear-chickweed	3	N	N	N	N	N	N	N	P	P	N	N
Dianthus armeria L.	Deptford pink	3	N	Y	N	P	N	N	N	N	N	N	N
Holosteum umbellatum L. subsp. umbellatum	jagged-chickweed	3	N	N	N	N	P	N	N	P	P	P	P
Saponaria officinalis L.	bouncingbet	2	N	N	N	N	N	N	N	N	P	N	N
Silene latifolia Poir. subsp. alba (Mill.) Greuter & Burdet	cowbell catchfly	2	N	N	N	N	N	N	N	N	P	N	N
Stellaria media (L.) Vill.	common chickweed	3	N	N	N	N	P	N	N	N	P	N	N
Stellaria pallida (Dumort.) Crép.	pale chickweed	3	N	N	N	N	P	N	N	N	Y	N	N
Kochia scoparia (L.) Schrad.	broom kochia	3	N	N	N	P	Y	Y	Y	Y	Y	Y	Y
Hypericum perforatum L.	common St. John's-wort	3	N	Y	N	P	N	N	N	N	N	N	N
Convolvulus arvensis L.	field bindweed	4	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Ipomoea coccinea L.	scarlet morning-glory	2	N	N	N	N	N	N	N	N	P	N	N
Ipomoea hederacea Jacq.	ivy-leaf morning-glory	3	N	N	N	N	Y	N	Y	N	N	N	Y
Elaeagnus angustifolia L.	Russian-olive	4	Y	Y	N	Y	N	Y	Y	Y	Y	N	N
Lespedeza cuneata (Dum. Cours.) G. Don	sericea lespedeza	4	N	Y	N	P	N	N	N	N	P	N	N
Lotus tenuis Waldst. & Kit. ex Willd.	narrow-leaf trefoil	2	N	N	N	P	N	N	N	P	P	N	N
Medicago lupulina L.	black medic	3	N	Y	N	Y	P	N	N	Y	Y	P	P
Medicago minima (L.) Bartal.	little medic	3	N	N	N	P	N	N	N	P	P	N	N
Melilotus albus Medik.	white sweet-clover	3	N	Y	N	Y	N	N	Y	Y	Y	N	N
Melilotus officinalis (L.) Pall.	yellow sweet-clover	3	N	Y	N	Y	N	N	Y	Y	Y	N	N
Securigera varia L.	common crown-vetch	4	N	P	N	P	N	N	P	Y	N	N	N
Trifolium campestre Schreb.	low hop clover	3	N	Y	N	Y	N	N	N	P	P	N	N
Trifolium repens L.	white clover	2	N	N	N	P	N	N	N	Y	P	N	N
Vicia villosa Roth subsp. varia	hairy vetch	3	N	P	N	P	P	N	P	P	P	N	N

Scientific Name	Common Name	Alien Status	Plant Community										
			N1	N2	N3	A1	A2	A3	A4	A5	A6	A7	A8
(Host) Corb.													
Vicia villosa Roth subsp. villosa	hairy vetch	3	N	Y	N	P	P	N	P	P	P	N	N
Geranium pusillum L.	small crane's-bill	2	N	N	N	N	N	P	N	Y	Y	N	N
Glechoma hederacea L.	gill-over-the-ground	2	N	N	N	N	N	N	N	N	P	N	N
Lamium amplexicaule L. var. amplexicaule	hen-bit dead-nettle	3	Y	N	N	N	Y	P	N	Y	Y	Y	Y
Marrubium vulgare L.	common horehound	2	N	Y	N	N	N	P	P	N	Y	N	N
Nepeta cataria L.	common catnip	2	Y	N	N	N	N	Y	P	P	Y	N	N
Prunella vulgaris L.	common selfheal	3	N	Y	N	N	N	N	Y	N	P	N	N
Allium cepa L.	cultivated onion	1	N	N	N	N	N	N	N	N	P	N	N
Allium vineale L.	field garlic	3	N	N	N	N	N	P	N	P	P	N	N
Asparagus officinalis L.	garden asparagus	2	N	N	N	N	N	N	N	P	Y	N	N
Muscari botryoides (L.) Mill.	common grape-hyacinth	2	N	N	N	N	N	N	N	N	P	N	N
Abutilon theophrasti Medik.	common velvetleaf	2	N	N	N	P	Y	N	Y	P	Y	Y	Y
Hibiscus trionum L.	flower-of-an-hour	3	N	N	N	N	Y	N	P	P	P	Y	Y
Malva neglecta Wallr.	common mallow	3	N	N	N	N	N	N	N	P	P	N	N
Mollugo verticillata L.	green carpetweed	3	N	N	N	N	P	N	P	N	N	P	P
Maclura pomifera (Raf.) C.K. Schneid.	Osage-orange	3	Y	Y	N	Y	N	Y	Y	Y	Y	N	N
Morus alba L.	white mulberry	3	Y	N	N	Y	N	Y	N	Y	Y	N	N
Aegilops cylindrical Host	jointed goat grass	3	N	N	N	Y	Y	N	N	N	P	N	N
Bothriochloa bladhii (Retz.) S.T. Blake	Caucasian bluestem	4	N	Y	Y	Y	N	N	N	N	Y	Y	N
Bromus inermis L.	smooth brome	4	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Bromus japonicus Thunb.	Japanese brome	4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bromus secalinus L.	rye brome	2	N	P	N	P	P	N	N	N	P	P	P
Bromus tectorum L.	downy brome	4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cynodon dactylon (L.) Pers. var. dactylon	common bermuda grass	3	N	N	N	P	N	N	P	Y	P	N	N
Digitaria ciliaris (Retz.) Koeler var. ciliaris	southern crab grass	3	N	N	N	P	N	N	P	P	P	P	N
Digitaria ischaemum (Schreb.) Muhl.	smooth crab grass	3	N	N	N	P	N	N	P	P	P	P	N
Digitaria sanguinalis (L.) Scop.	hairy crab grass	3	N	N	N	P	N	N	P	Y	P	P	N
Echinochloa crusgalli (L.) P. Beauv.	common barnyard grass	3	N	P	N	P	N	N	P	P	P	N	N
Eleusine indica (L.) Gaertn.	Indian goose grass	2	N	N	N	N	N	N	P	P	P	N	N
Eragrostis barrelieri Daveau	Mediterranean love grass	2	N	P	N	P	P	N	P	N	N	N	N
Eragrostis cilianensis (All.) Vignolo ex Janch.	stink grass	3	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Lolium perenne Willd. var. aristatum Willd.	perennial rye grass	2	N	N	N	N	N	N	N	P	N	N	N

Scientific Name	Common Name	Alien Status	Plant Community										
			N1	N2	N3	A1	A2	A3	A4	A5	A6	A7	A8
Panicum miliaceum L. subsp. miliaceum	Broom-corn millet	1	N	N	N	N	N	N	N	N	P	N	N
Poa bulbosa L.	bulbous blue grass	2	N	N	N	P	P	N	N	P	P	N	N
Poa pratensis L.	Kentucky blue grass	3	Y	Y	N	Y	N	P	Y	Y	Y	Y	N
Schedonorus arundinaceus (Schreb.) Dumort.	tall mountain-fescue	3	Y	Y	N	Y	N	P	Y	Y	Y	P	N
Setaria faberi R.A.W. Herm.	Chinese bristle grass	2	N	N	N	P	P	N	P	P	N	N	N
Setaria pumila (Poir.) Roem. & Schult.	yellow bristle grass	3	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Setaria viridis (L.) P. Beauv. var. viridis	green bristle grass	3	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Sorghum halepense (L.) Pers.	Johnson grass	3	P	N	N	N	P	N	P	P	P	N	P
Triticum aestivum L.	bread wheat	1	N	N	N	N	Y	N	N	P	N	N	N
Fallopia convolvulus (L.) A. Löve	dull-seed cornbind	3	N	N	N	N	P	N	P	P	P	N	N
Persicaria maculosa Gray	lady's-thumb smartweed	3	N	N	N	N	P	N	P	N	N	N	N
Polygonum arenastrum Boreau	sand knotweed	3	N	N	N	P	P	N	Y	Y	Y	P	N
Rumex crispus L.	curly dock	3	N	N	N	Y	N	N	Y	P	P	P	N
Rumex patientia L.	patience dock	3	N	N	N	P	N	N	P	P	P	P	N
Anagallis arvensis L.	scarlet pimpernel	3	N	N	N	P	P	N	P	N	N	N	P
Lysimachia nummularia L.	moneywort	3	N	N	N	N	N	N	N	P	P	N	N
Potentilla recta L.	sulfur cinquefoil	3	N	Y	N	Y	N	N	N	N	N	N	N
Rosa multiflora Thunb.	multiflora rose	4	Y	Y	N	Y	N	P	N	N	Y	N	N
Sherardia arvensis L.	field-madder	2	N	N	N	N	N	N	N	P	N	N	N
Linaria dalmatica (L.) Mill. subsp. dalmatica	Dalmatian toadflax	1	N	P	N	P	N	N	N	N	P	N	N
Verbascum blattaria L.	moth mullein	3	N	Y	N	Y	N	N	P	P	N	N	N
Verbascum thapsus L.	flannel mullein	3	Y	Y	N	Y	N	N	Y	N	N	N	N
Veronica arvensis L.	corn speedwell	3	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Veronica polita Fr.	wayside speedwell	3	N	N	N	P	P	N	P	P	P	N	N
Veronica serpyllifolia L. subsp. humifusa (Dickson) Syme	thyme-leaf speedwell	2	N	N	N	N	N	N	P	P	N	N	N
Veronica triphyllos L.	finger speedwell	2	N	N	N	N	P	N	N	P	N	N	N
Ailanthus altissima (Mill.) Swingle	tree-of-heaven	2	Y	N	N	N	N	P	N	N	Y	N	N
Tamarix ramosissima Ledeb.	salt-cedar	4	P	N	N	N	N	N	P	N	N	N	N
Ulmus pumila L.	Siberian elm	3	Y	Y	N	Y	N	Y	Y	Y	Y	N	N
Tribulus terrestris L.	speading puncturevine	3	N	Y	N	P	Y	N	P	Y	P	P	N
ANIMALS													
Phasianus colchicus L.	ring-necked pheasant	-	P	Y	P	Y	Y	Y	Y	N	P	Y	Y
Columba livia Gmelin	rock pigeon	-	N	N	N	N	Y	N	P	Y	N	P	P

Scientific Name	Common Name	Alien Status	Plant Community										
			N1	N2	N3	A1	A2	A3	A4	A5	A6	A7	A8
Sturnus vulgaris L.	European starling	-	Y	P	P	P	Y	Y	P	Y	Y	P	P
Passer domesticus L.	house sparrow	-	N	N	N	N	P	P	P	Y	P	P	N
Mus musculus L.	house mouse	-	N	N	N	Y	P	P	P	Y	P	P	N
Cyprinus carpio L.	common carp	-	N	N	N	N	N	N	P	N	N	N	N

TABLE G.4. Summary of management recommendations for invasive species at Smoky Hill ANGR. Threat levels (H = high, M = moderate, L = low) refer to threats to biodiversity and the military mission, defined as the potential for the invasive species to reduce or displace native species, or to disrupt or limit military training, respectively, on Smoky Hill ANGR if populations of the invasive species are not controlled. See Species Accounts for more information.

Species	Management Recommendations	Threat Level
Caucasian Bluestem	• Control stands below action thresholds • Monitor populations annually	M
Smooth Brome	• Control stands below action thresholds • Monitor populations periodically • Mechanical control suggested	L
Japanese Brome	• Control stands below action thresholds • Monitor populations periodically • Mechanical or chemical control suggested	L
Downy Brome	• Control stands below action thresholds • Monitor populations periodically • Mechanical control suggested	L
Musk Thistle	• Control stands below action thresholds • Monitor populations annually • Integrated control suggested	M
Bull Thistle	• Control stands to below action thresholds • Monitor populations annually • Integrated control suggested	M
Field Bindweed	• Control stands below action thresholds • Monitor populations periodically • Mechanical and cultural control suggested	L
Russian-Olive	• Eliminate from installation • Monitor populations periodically • Mechanical and chemical control suggested	M
Sericea Lespedeza.	• Eliminate from installation • Survey; no current populations known • Mechanical and chemical control suggested	H
Multiflora Rose	• Eliminate from installation • Monitor populations periodically • Mechanical and chemical control suggested	L

Crown Vetch	• Eliminate from installation • Survey for any populations • Mechanical, chemical, and cultural control suggested	L
Woody Invasive Plants	• Control stands below action thresholds • Monitor controlled populations for control effectiveness • Mechanical and chemical control suggested	H
Common Carp	• Monitor populations	L
Ring-necked Pheasant	• No recommendations	L
Canada Goose	• Discourage use by migratory birds with habitat management	H (BASH only)
Rock Pigeon	• Monitor populations near buildings • Control populations near buildings to below action thresholds • Control by exclusion and habitat modification are suggested	L
European Starling	• Monitor populations near buildings • Control populations near buildings to below action thresholds • Control by exclusion or poisoning is suggested	L
Brown-headed Cowbird	• Monitor populations periodically • Control populations below action thresholds • Control with habitat modication	M?
House Sparrow	• Monitor populations near buildings periodically • Control populations near buildings to below action thresholds • Control by exclusion and other methods	L
House Mouse	• Monitor populations near buildings periodically • Control populations near buildings to below action thresholds • Control by exclusion and other methods	L

TABLE G.5. Five-year management plan for invasive species on Smoky Hill ANGR. Tasks are grouped into three major activities: planning, survey and monitoring, and control. Numbers following each listed task correspond to the following priorities: 1 = required, implement within first year; 2 = strongly recommended, implement within 2 years; and 3 = recommended, implement within 5 years. Numbers at the tops of columns below years (1, 2, 3, 4) correspond to 3-month quarters for each year.

Tasks	2009				2010				2011				2012				2013			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
I. Planning																				
1. Develop integrated pest management plan (1)	x	x	x	x																
2. Identify management priorities for year (1)	x				x				x				x				x			
3. Review invasive species plan (3)																			x	x
II. Survey and Monitoring																				
A. PLANTS																				
1. Set management action thresholds for any species determined to be invasive (1)	x	x																		
2. Develop species-specific monitoring plans for invasive species (1)	x	x																		
3. Implement species-specific monitoring plans for invasive species (1—2)		x	x																	
4. Conduct surveys for invasive species (1—3)	x	x	x			x	x			x	x	x		x	x	x		x	x	x
4.1. Bothriochloa bladhii (2)											x				x				x	
4.2. Bromus inermis (3)														x				x		
4.3. Bromus japonicus (3)														x				x		
4.4. Bromus tectorum (3)														x				x		
4.5. Carduus nutans (1)		x				x				x				x				x		
4.6. Cirsium vulgare (1)		x				x				x				x				x		
4.7. Convolvulus arvensis (2)											x				x				x	
4.8. Elaeagnus angustifolia (1)	x	x																		
4.9. Lespedeza cuneata (1)			x				x				x				x				x	
4.10. Rosa multiflora (1)																				
4.11. Securigera varia (1)		x				x				x				x				x		
4.12. Invasive, woody species (2)											x	x			x	x			x	x
B. ANIMALS																				
1. Set management action threshold for any species determined to be invasive (1)	x	X																		
2. Develop species-specific monitoring plans for invasive species (2—3)	x	X																		
3. Implement species-specific monitoring plans for invasive species (2—3)		X	x																	
4. Conduct surveys for invasive species (3)					x	x														
4.1. Common carp (3)						x	x			x	x			x	x			x	x	
4.2. Canada goose (2)					x			x	x			x	x			x	x			x
4.3. European starling (3)						x	x			x	x			x	x			x	x	
4.4 Brown-headed cowbird (3)						x				x				x				x		

Tasks	2009				2010				2011				2012				2013			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
4.5. House sparrow (3)						x	x			x	x			x	x			x	x	
4.6 House mouse (3)								x				x				x				x
III. Control																				
A. PLANTS																				
1.1. Eradicate populations of Elaeagnus angustifolia (1)		x	x			x	x			x	x			x	x			x	x	
1.2. Eradicate populations of Lespedeza cuneata (1)			x				x				x				x				x	
1.3. Eradicate populations of Rosa multiflora (1)		x	x			x	x			x	x			x	x			x	x	
1.4. Eradicate populations of Securigera varia (1)		x	x			x	x			x	x			x	x			x	x	
1.5. Control populations of Bothriochloa bladhii (3)														x	x			x	x	
1.6. Control populations of Bromus inermis (3)														x				x		
1.7. Control populations of Bromus japonicus (3)														x				x		
1.8. Control populations of Bromus tectorum (3)														x				x		
1.9. Control populations of Carduus nutans (1)	x			x	x			x	x			x	x			x	x			x
1.10. Control populations of Cirsium vulgare (1)	x			x	x			x	x			x	x			x	x			x
1.11. Control populations of Convolvulus arvensis (2)										x	x			x	x			x	x	
1.12. Control Invasive, woody species (2)										x	x			x	x			x	x	
B. ANIMALS																				
2.1. Control populations of Common carp (3)									x	x	x	x	x	x	x	x	x	x	x	x
2.2. Control populations of Canada goose (2)									x			x	x			x	x			x
2.3. Control populations of European starling (3)										x	x			x	x			x	x	
2.4. Control populations of Brown-headed cowbird (3)										x	x			x	x			x	x	
2.5. Control populations of House sparrow (3)										x	x			x	x			x	x	
2.6. Control populations of House mouse (3)											x	x			x	x			x	x