Integrated Vegetation Management Recommendations

for George Washington Carver National Monument

A Thesis

Presented to

The Faculty of the Graduate School

At the University of Missouri

In Partial Fulfillment

Of the Requirements for the Degree

Fisheries and Wildlife Sciences

By

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JULY 2011

The undersigned, appointed by the dean of the Graduate School,

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Integrated Vegetation Management Recommendations

for George Washington Carver National Monument

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A candidate for the degree of

Master of Science

And hereby certify that, in their opinion, it is worthy of acceptance.

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ACKNOWLEDGEMENTS

First, I would like to thank the staff at George Washington Carver National Monument for their enthusiasm and participation in my research. I would especially like to thank Chief Ranger Lana Henry and Superintendent James Heaney for providing me with the opportunity to conduct my Master's research at their site, for their patience, and for the resources without which I could not have completed my study. And though I have never met him, I would like to thank former Superintendent Reginald Tiller for initiating this project with my advisor, Dr. Charles Nilon.

On that note, I would also like to thank Dr. Nilon for his guidance, advice, encouragement, and mentorship over the last three years. His positive attitude and knowledge have kept me motivated and focused, and I am very excited to continue working with him in the future. Additional thanks are directed to my committee, Dr. Robert Pierce and Dr. Gary Kremer, for their ideas and resources, which have helped a great deal in shaping the final products of my research.

I would also like to thank Suzanne Booker for moral support and for making my life better for so many years. Even though our lives had to take different directions, I will never forget what we shared. And perhaps most importantly I would like to thank my family, including my mom and dad, and my sisters, for their continued unwavering support and understanding that my quest in life has taken me far from home. I am very lucky to have such amazing people in my life.

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ABSTRACT

George Washington Carver National Monument (GWCA) is a 97 ha historic site in southwest Missouri. Park managers are responsible for management of more than 90 ha of grassland and woodland. There have been several efforts to develop a long-term monitoring program to support cultural and historical interpretation programs at GWCA. My study is a cooperative project to develop Integrated Vegetation Management Recommendations (IVMR) for GWCA that includes input from multiple agencies and stakeholders. Park staff will use three alternatives as a guide for monitoring and management. A key aspect of the plan is the use of Habitat Suitability Index (HSI) models and presence/absence surveys for four prairie indicator species (Henslow's sparrow, ornate box turtle, northern bobwhite quail, and prairie vole) to evaluate 53 314-m^2 circular plots for existing prairie structure. In 2009 and 2010 I found there were areas of mixed quality across the prairie units, and management recommendations were provided to GWCA to address limiting habitat characteristics (scores <0.50) from HSI data. In addition to the IVMR, two additional products were provided for GWCA. I compiled and evaluated prairie management practices since 1981 in the *George Washington Carver National Monument Prairie Restoration Management Review*. I also created a guidebook for using HSI models at GWCA, allowing park staff to prescribe applicable management techniques based on ranges of HSI scores. GWCA staff will be trained to implement an adaptive approach to management based on this project's habitat evaluation procedures.

CHAPTER 1: THESIS INTRODUCTION

Many National Park Service parks and monuments have been established under legislation that requires them to manage their property for a specific purpose. In the case of George Washington Carver National Monument (GWCA), the enabling legislation states, "The property acquired under the provisions of section 1 of this Act shall constitute the George Washington Carver National Monument and shall be a public national memorial to George Washington Carver. The Director of the National Park Service, under the direction of the Secretary of the Interior, shall have the supervision, management, and control of such national monument, and shall maintain and preserve it in a suitable and enduring manner which, in his judgment, will provide for the benefit and enjoyment of the people of the United States." The monument is intended to be a memorial to the life and accomplishments of George Washington Carver, and management at the park is driven by historical and cultural interpretation of Carver's life on the historic farm. The park staff at GWCA is skilled in historical and cultural interpretation, but similar to many national parks there is a need for assessing and managing natural resources on park grounds. GWCA has been conducting a prairie restoration program since 1980 and aims to continue doing so with a final, focused cultural landscape toward which the park can be developed. GWCA and other parks with a similar situation and management focus would benefit from a natural resources management tool that allows park staff to make management decisions that fit within the scope of the park's overall purpose.

The focus of my research is to inform park management how natural resources may be best used to enhance the cultural resources already present at GWCA. Much of the process has been designed to fit the needs of park staff and to suit the overall purpose of GWCA as defined by its governing documents. The final products of my research will provide a template for other national, state, and local parks on how cultural and historical resources can be combined with, enhanced, or created by the landscape itself.

GWCA is composed of the 97.1 ha (240 acres) of land acquired by Moses Carver via the Preemption Act of 1841 on which George Washington Carver lived during his formative years. George's mother was a slave owned by Moses, and George himself was born on the site sometime around the end of the Civil War. Since 1953, the Monument has been operated in dedication to the man who would gain fame through his work at the Tuskegee Institute in Tuskegee, Alabama. It is the first national monument dedicated to an African American, and the first to be dedicated to any American who was never President of the United States. Approximately 52.6 ha (130 acres) of the site are currently dedicated to restored native tallgrass prairie, which exist in varying stages of success after nearly 150 years of agricultural use and 30 years of restoration efforts. A 12.1 ha (30 acre) plot was recently acquired by GWCA that has yet to be affected by park management practices. The park is located in Newton County, Missouri, approximately 2.2 miles west of the city of Diamond, Missouri. It is included in the Joplin, Missouri metropolitan area.

GWCA is a relatively small site where the surrounding matrix has developed into an agrarian setting since George Washington Carver resided there. It would have historically been part of what is now known as Diamond Grove Prairie prior to development. Diamond Grove Prairie Conservation Area is currently a 345 ha (852 acre) site administered by the Missouri Department of Conservation, of which 230.7 ha (570 acres) are native unplowed prairie. It is located approximately 3.2 km (2 mi) from GWCA. GWCA's 97.1 ha add viable habitat to the region and with dedicated restoration could potentially provide high quality habitat for native species that are not currently present at the park.

Primarily managed as a cultural and historical interpretation site, the park's key attractions are memorial exhibits dedicated to the memory and accomplishments of George Washington Carver. He is best known for his work with the peanut, but Carver also concentrated his efforts in the areas of botany, mycology, sustainable agriculture, biofuels, waste management, and improving economic conditions for poor southern black farmers. Carver was a well-educated and deeply religious man who believed that he was carrying out God's work, particularly in helping the "man furthest down" and in mentoring many young students he had met throughout his life (McMurray 1981).

Important to the vision of GWCA is the emphasis George Washington Carver placed on conservation in his works, and how he may have drawn that inspiration while living on the Carver farm in the 1860s and 1870s. He was enamored with nature and took a particular interest in plants at an early age (Hersey 2011). Carver believed in the idea of "organic unity," which he described as "the mutual relationship of the animal, mineral, and vegetable kingdoms, and how utterly impossible it is for one to exist in a highly organized state without the other (Carver 1899 *in* Hersey 2011). "Organic unity" was essentially Carver's early definition of ecology. He believed that nature must be preserved because even neglected plants may serve a purpose to man, though he never suggested that nature be preserved only for man (Hersey 2011). To describe his utilitarian view, Carver said, "Nature does not expend its forces upon waste material, but that each created thing is an indispensable factor in the great whole, and one in which no other factor fit exactly as well" (Carver 1893 *in* Hersey 2011).

GWCA is important to local tourism due to its historic significance, and the life works of Carver are a testament to what he was able to accomplish despite humble beginnings and the treatment of African-Americans in the 1860s and 1870s. Carver was greatly influenced by nature early in life, and the products of my thesis will enhance the memorial aspect of the monument through the restoration of the native landscape he would have experienced.

Because GWCA is a monument to the life and inspirational vision of George Washington Carver, much of the management is focused on cultural and historical interpretation. There has not been a dedicated full-time natural resources staff since Biological Technician Barry Jones left the park in 1997. The scope of this project involves developing a process for making management decisions at parks with a cultural or historical focus. The techniques being devised utilize capital resources currently available to the park and traditional management practices applicable and available to park staff. In the case of GWCA, these management practices are already in use. The recommendations to be provided in my thesis will make use of GWCA's available resources and will look to guide long-term vegetation management both efficiently and effectively while fitting in the vision set forth by park administration. They will aid GWCA in assessing and improving its habitat for the purpose of enhancing the cultural and historical resources at the park.

The initiation of prairie restoration was guided by Dr. James Jackson of Missouri Southern State University and GWCA staff. An agricultural lease program was operated from the park's dedication through the 1980s and was gradually phased out to combine 37.8 ha (93.5 acres) with the existing 13.2 ha (32.35 acres) of remnant and restored prairie. Since the late 1990s, however, management actions have been prescribed with increasing external influence. The park's former Superintendent, Reginald M. Tiller, writes in the 2007 GWCA Long-Range Interpretive Plan that "active prairie restoration has not been occurring in the past ten years." The final product of this project is to integrate the influential agencies and stakeholders into Integrated Vegetation Management Recommendations that will provide GWCA with alternatives for managing the park's natural resources effectively and efficiently with regard to the historical and cultural landscapes.

The park currently consists of eight prairie management units, which are prescribed management actions yearly (Figure 3). They are labeled as Management Units 1, 2, 3, 4, 5, 6, 7, and 9. Units 1-7 covered most of the 85.0 ha (210 acres) GWCA prior to 2005. Approximately 52.6 ha (130 acres) are under some level of prairie restoration, while 32.4 ha (80 acres) are woodland and/or developed for visitor services. The 12.1 ha (30 acre) Unit 9, acquired in 2005, now fills out the original rectangular shape of the park in the southwest corner.

While progress has been made in restoring the native prairie areas at GWCA, the park staff has been working to determine the focus of cultural landscape development. The park mission statement is to “maintain, preserve, interpret, in a suitable and enduring manner, the life and legacy of George Washington Carver for the benefit and enjoyment of the people of the United States of America” (GWCA 2007). One of the purposes of the Monument is to “Preserve the setting of the Moses Carver farm and birthplace of George Washington Carver” (GWCA 1997). Identifying the cultural landscape for which GWCA would like to manage is important in determining what role the current prairie units will play. There have been several studies conducted since 1980 to assess and manage the prairie, but none actually assess the prairie’s role in cultural and historical interpretation. My thesis explores the history of management and cultural landscape and provides a strategy for future management decisions based on the premise that the restored prairie units are to be maintained. The current prairie landscape represents a combination of pre-settlement and Carver-era landscapes while capturing the spirit of the Monument’s namesake.

My initial task was to assess prairie management history and current prairie conditions. I prepared two documents for the park in the fall of 2009. First, GWCA prairie management documentation was summarized into a concise history entitled

George Washington Carver National Monument Prairie Restoration Management Review. Second, the existing physical structure of wildlife habitat in the prairie management units at GWCA was evaluated using a Habitat Suitability Index (HSI) model developed for each of four indicator species. This culminated in a report entitled *George Washington Carver National Monument 2010 Prairie Management Recommendations*. The HSI models have been developed over the course of this project for the use of park staff in determining what limiting factors must be addressed to improve habitat quality. The management actions used to address limiting factors are the same as those already used to improve native grass cover at the site. Management will be guided in a manner that provides a "suite" of varied habitat types that provide for a more diverse array of species. Data collected in 2009 and 2010 have provided baseline conditions for future management planning.

My project will develop a management tool that will provide suitable wildlife habitat for the four indicator species while considering the cultural and historical management goals of GWCA. Each indicator species specialist with its own unique requirements, and collectively they cover a broad array of prairie characteristics. Management of the prairie habitat is intended to enhance cultural interpretation objectives established through enabling legislation and long-term management planning. My goal is to progress the maturation of the restored prairie by improving overall prairie habitat using a system that assesses wildlife habitat and cultural objectives.

My thesis is organized as follows:

- Section 1: Introduction
- Section 2: *George Washington Carver National Monument Prairie Restoration Management Review*.
- Section 3 provides methods, results, and discussion for HSI model and indicator species presence sampling. The results of the HSI model data are presented as management recommendations as they would be applied by GWCA.
- Section 4 is the final product I have created for GWCA, *Integrated Vegetation Management Recommendations*. This section combines aspects of each of the previous sections and provided a basis for which future natural, historical, and cultural resources management at GWCA will be conducted.
- Section 5 is the *George Washington Carver Prairie Management Guidebook: Using Habitat Suitability Models*, which provides a step-by-step process for GWCA to monitor prairie conditions and prescribe management actions in the future.

This study has five objectives: 1) review the history of prairie management at GWCA; 2) develop methods for determining the presence/absence of four indicator species in each management unit; 3) assess the physical structure of prairie habitat using HSI models; 4) assign management actions to address limiting factors based on HSI scores; and 5) combine input from several agencies to create a management tool for long-term in-park natural and cultural resources planning.

CHAPTER 2: GEORGE WASHINGTON CARVER NATIONAL MONUMENT PRAIRIE RESTORATION MANAGEMENT REVIEW

In 1981, the administrators at the George Washington Carver National Monument (GWCA) in Diamond, Missouri implemented a Prairie Restoration Action plan designed to protect and maintain the existing remnant native prairie areas at the park. Since then, multiple management plans have been drafted to continue the ongoing efforts in restoration of the native historical prairie. In some cases the plans provide continuity and relatively clear vision for the future. In all cases, revisions were required to adapt to ever-changing conditions, unexpected results, and unresponsive sections of prairie. This report describes the methods for obtaining information on land usage and prairie management history at GWCA, and it will follow a chronological history of prairie management that describes the findings of my research. I will also present monitored management activities in 2009 and 2010 in addition to discussing the findings of the Management Review.

The objectives of the Management Review are to provide a chronological summary of the prairie management history at GWCA, and to evaluate previous prairie management for the purpose of developing a long-term vegetation management program that coincides with the historical and cultural interpretation programs at the park.

Methods

Upon initiating this project, GWCA provided me with hard copies of management documents that have been kept on file. These files included initial planning documents, management and monitoring plans, annual management prescriptions, Heartland Network (HTLN) Inventory and Monitoring documents, internal and external correspondence and memos, purchase receipts, grant proposals, and other miscellaneous documents. I acquired additional documents during the 2009 and 2010 field seasons in the GWCA file room and library. All documents that were not already in digital form were scanned and saved in .pdf format at the University of Missouri and provided to GWCA. I then summarized and condensed the contents of these documents into the *George Washington Carver National Monument Prairie Restoration Management Review* in chronological order.

Land management practices were monitored and researched 12 June - 31 July 2009 and 1 June -31 July 2010 while data were collected for indicator species presence and habitat suitability. I noted current Management Unit conditions in the field and discerned current management practices through literature searches and conversations with park employees.

Table 1: Reference list of Management Review documents.

Title	Author(s)	Year
Historic resource Study and Administrative History of George Washington Carver National Monument	Toogood	1973
George Washington Carver: Scientist and Symbol	McMurray-Edwards	1981
A Historic and Vegetational Survey of the Five Prairie Areas at George Washington Carver National Monument	Jackson and Bensing	1982
A Management Plan for the Five Prairie Areas at George Washington Carver National Monument	Jackson and Bensing	1982
George Washington Carver National Monument Prairie Management and Monitoring Program; Phase I Report: Vegetational Analysis and Management Recommendations	Groves et al.	1983
George Washington Carver National Monument Prairie Management and Monitoring Program; Phase II Report: Vegetational Analysis and Management Recommendations	Bensing et al.	1984
Prairie Restoration Action Plan	Jackson	1984
Prairie Restoration Action Plan	Jackson	1985
George Washington Carver: In His Own Words	Carver and Kremer	1991
Management Baseline and Monitoring Program	Wilson and Jackson	1994
Prairie Restoration Action Plan	Jones	1995
George Washington Carver National Monument General Management Plan	GWCA	1997
Resources Management Plan	GWCA	1999
Springs of Genius: An Integrated Management Plan for the George Washington Carver National Monument	Harrington et al.	1999
Wildland Fire Management Plan	Bloodworth	2004
George Washington Carver: For His Time and Ours; Special History Study: Natural History Related to George Washington Carver National Monument	Burchard	2005
George Washington Carver National Monument Long-Range Interpretive Plan	GWCA	2007
George Washington Carver's Missouri (Lecture)	Kremer	2008
George Washington Carver National Monument Natural Resources Condition Assessment	MoRAP and Heartland Network	2011
Prairie Management Presciptions and Miscellaneous Documents	GWCA	Various
Inventory and Monitoring Reports	Heartland Network	Various

Moses Carver and Settlement of Current Park Grounds

When Moses Carver relocated to Missouri from Ohio in 1838, he settled on 97 ha (240 acres) of native prairie landscape. According to the Preemption Act of 1841, "squatters" on 65 to 259 ha (160 to 640 acres) of unimproved land were able to purchase their plots after 14 months of improvements for no less than $1.25 per acre, which means that Carver may have originally paid only $300 for the original 240 acres (McMurray 1981), which he acquired in full by 1853 (Hersey 2011).

While Moses Carver was philosophically opposed to slavery, he purchased George's mother Mary in 1855 due to the fact that would-be farm hands were also taking advantage of abundant lands in the west (McMurray 1981). Moses Carver primarily trained and sold race horses, but was also a very successful beekeeper (harvested ~200 lbs. of honey per year), in addition to raising dairy cattle (also ~200 lbs. of butter per year), sheep, and pigs. Given his success in these areas, Moses may have only used agriculture for subsistence (Kremer 2011).

A land survey performed in 1842 showed the current area of GWCA as being almost entirely native prairie with some woody species located near the streams (Schroeder 1981, Jackson 1984). It is estimated that 45 ha of undisturbed prairie vegetation were present when George Washington Carver lived on site. Moses Carver sold the farm in the early 1900's, after which it was subjected to modern farming methods while under the ownership of the Shartel family (Harrington et al. 1999).

The Shartel Farm

Around 1916, the Carver farm was purchased by Cassius McLean Shartel, who served as a Missouri U.S. Representative from 1905-1907. The land was eventually acquired by his son, Stratton Shartel, a lawyer and Missouri Attorney General from 1928-1933. Under the Shartels' ownership, the farm was subject to modern agricultural practices such as cropping and grazing.

Photos from the GWCA Archives illustrate the farming techniques and structures that were present on the property in the 1950's:

- The woodlands (Carver Woods) in the central portion of the property were not present. Instead the trees that were present had a cleared and landscaped understory. It appears that this area was used for onsite transportation.
- The main Shartel house was a large dwelling in the center of the property just south of the Carver Branch.
- The Shartel farm buildings to the west-southwest of the Shartel house were likely in the same vicinity as the current Visitor Center and administration building.
- A pumphouse for Carver Spring existed just to the north of the main Shartel house on the south bank of the Carver Branch.
- There was a foot bridge immediately west of the pumphouse.

- Another pumphouse was located to the west of the Carver Spring pumphouse, and the two structures were close in proximity to one another. In the photographs, the only distinguishing feature was that the second pumphouse had a vehicle crossing immediately to the west.
- The areas currently managed as prairie units were used for cropping and grazing, with two small areas of native prairie possibly remaining.

Establishment of George Washington Carver National Monument

George Washington Carver National Monument was established by an act of Congress in 1943. Legislation to establish the Monument was first introduced in the House of Representatives on July 15, 1942, and in the Senate on October 13, 1942. No action was taken until after Carver's death on January 5, 1943. New bills were introduced at the 78th Congress on January 22, 1943, and on July 14, 1943 the Monument was authorized (Toogood 1973).

At the time, the United States was burdened with heavy involvement in World War II and needed to justify any costs that were not war-related. Richard Pilant, a distant relative of Moses Carver, campaigned heavily for the establishment of the monument. He justified his stance by writing, "it became of necessity a war measure designed to show our allies against the Herrenvolk that this was a land of opportunity for all races" (Burchard 2005). True to his character, George Washington Carver requested to Pilant before his death that only a simple marker be placed at the birth site, not a monument. Pilant was not to be deterred, writing over 700 letters to senators and congressmen endorsing the monument (Toogood 1973). Both Houses of Congress approved of the monument without a dissenting vote, and President Franklin D. Roosevelt signed the establishment of the monument into law on July 14, 1943 (Burchard 2005).

Upon the establishment of the monument in 1943, Congress began the task of acquiring the original Carver farm from its then owner, Mr. Stratton Shartel. The National Park Service had recommended only 85 ha for purchase, and Congress appropriated $30,000 for land acquisition and park development. Mr. Shartel's asking price was $73,000, though government officials had quoted the value of the farm at $15,000. Attempts at land acquisition continued until 1948, when Mr. Shartell sold the tract to Dawson W. Derfelt without explaining the government's interest in the property (Toogood 1973).

Congress then filed a petition to condemn the 85 ha, leading Mr. Derfelt to proclaim his ignorance of the circumstances. He was informed that the government intended to continue negotiations, but the maximum offer would remain $30,000. An appraisal was then conducted by Commissioners of the courts, who arrived at the value of $78,895 when considering right-of-ways, mineral rights, and inholdings claimed by the electric company and past property owners. It was not until June 14, 1951 when "the supplementary appropriation bill had been passed by Congress and deposit had been made in registry of the court of monies in condemnation of the land (Toogood 1973, pg. 58-59)," that the monument was actually established. The park dedication was conducted on July 14, 1953, with an estimated attendance of 1,000 to 2,000 people (Toogood 1973). The establishment of George Washington Carver National Monument awarded many unique honors for a monument at that time in the United States, including the life and scientific contributions of a man in agricultural science, an African-American, and a man other than a president. The monument was also the first in world history dedicated to inter-racial understanding and peace (Burchard 2005).

The native prairies on site are considered to be historically significant because they would have played a role in shaping who George Washington Carver would become (Jackson 1984). The prairies became even more valuable in the early 1980's when state and federal governments began to emphasize "the need to restore and maintain the native prairies of GWCA beyond the objective of historic restoration (Jackson 1984)." Objectives established by these agencies included protecting an endangered ecosystem, restoring wildlife habitat, preventing soil erosion, replenishing worn out soil, providing areas of scientific study, teaching ecological principles, providing high quality forage, and aesthetic appreciation (Jackson 1984).

There is a Visitor Center onsite presenting a Carver History Exhibit, an interactive education exhibit, a Carver biographical film, and a three-quarter mile nature trail through the grounds – mostly through the central woodlands. The park also includes the Moses Carver House, which was built in 1881 and moved to its current location in the early 1900's, the George Washington Carver birth site, and the Carver cemetery (Moses and his wife are buried there, while George is buried at Tuskegee University).

Management Review, 1977-2011

Pre-Management, 1977-1981

In June 1977, GWCA Superintendent Eugene J. Colbert consulted the Missouri Department of Conservation (MDC) on “the proper care of our native prairie area” (Colbert personal communication with GWCA 1977). Technician Tom Toney visited GWCA the same month and assessed the native prairie area, suggesting that the park institute a three-year burn cycle on the prairie area “south of the demonstration garden,” which likely meant what is now the southern half of Management Unit 4 (Figure 2). He also noted that fire is the best way to regenerate native species, followed by grazing, then haying, which should only be done on a rotational basis (GWCA Staff). Later that year, on 10 November, a memo was sent from the Regional Chief Scientist, Operations, to the Acting Associate Regional Director, Operations, Midwest Region, regarding a visit to GWCA the previous day. On his visit, the Chief Scientist (no name given) discussed prairie areas management with Ranger Mike Tennent, and stated that Ranger Tennent had been receiving valuable advice from the MDC and the local Soil Conservation Office. The Chief Scientist agreed with the prior suggestion to use controlled burning, cultivation, and later reseeding of one part of the prairie. The lack of a Resources Management Plan created a problem for instituting prairie management practices at the time, and the Chief Scientist advised Ranger Tennant to begin preparing an environmental impact assessment immediately if GWCA intended to conduct a prescribed burn the following spring. No documentation is available to confirm whether this was accomplished.

In 1981, Dr. James R. Jackson of Missouri Southern State University (p.k.a. Missouri Southern State College) in Joplin, Missouri received a grant from the George Washington Carver National Monument for a Prairie Management Study (personal communication GWCA Staff). Dr. Jackson set objectives for the analysis, which are summarized as follows (Jackson 1982a):

1. Summarize botanical features and relative condition of units;
2. Collect a sample of each species present at GWCA to analyze the presence of native vs. exotic species at the park;
3. Use the gathered information as a basis for management recommendations.

In 1982 Dr. Jackson completed "A Vegetational and Historical Analysis of the Five Prairie Management Unit Areas at George Washington Carver National Monument". This document provided an analysis of the prairie ecosystem at the Monument prior to the creation and implementation of the first Prairie Management Action Plan (PRAP) in 1982. In addition to providing background information about the historical and current ranges of prairie ecosystems, it summarized the historical land usage at GWCA and offered a contemporary description of the landscape. General management practices for prairie restoration were discussed and available literature up to 1982 concerning flora and fauna at GWCA was reviewed. Dr. Jackson described the existing five management units and provided an overview of geological features and soils types present at the Monument.

Prairie Restoration Action Plans and Monitoring, 1982-1993

The initial Prairie Restoration Action Plan was completed sometime in 1982 by Dr. Jackson and his research assistant Betty Bensing. The management objective that was the basis for natural resource management was stated in this plan: "To restore the historic scene to that of the Moses Carver Farm of the 1860's and 1870's." According to Jackson and Bensing, all five of the 1982 management units at GWCA were native prairie during the period when Carver lived on the farm. Three main management steps were outlined in this Plan (Jackson and Bensing 1982b):

1. Elimination of special problem plant populations such as invading non-native cool-season grasses and invading woody species;
2. Establishment of native prairie grasses and forbs;
3. Manipulative practices that will insure [sic] the stability of the native prairie species once they are established. These practices will be based on a monitoring program that evaluates each prairie unit.

The historical native prairie areas from the time of the Carver occupancy were split into five management units, which were "characterized on the basis of interviews, historical documents, aerial and ground photographs, vegetational plot sampling, compilation of a species list, soil classification, and soil analysis (Jackson and Bensing 1982b; Figure 2)." Based on the descriptions provided, each unit had its own distinguishing history and abiotic and biotic factors. Management Unit #1 (3.8 acres) was in the early stage of natural prairie succession in 1982 and was fairly undisturbed. Management Unit #2 (2.8 acres) was greatly overgrazed with little remnant prairie vegetation. Management Unit #3 (4.3 acres) also contained very little remnant prairie vegetation and was greatly disturbed by tillage. Management Unit #4 (4.6 acres) had been used for a number of different activities, was greatly disturbed by these stresses, and contained very little remnant prairie vegetation. Management Unit #5 (9.7 acres) showed areas of great disturbance mixed with areas of native prairie (Jackson and Bensing 1982b). Much of the remaining park acreage was involved in an agricultural lease program which included cropping and grazing (Jackson 1984).

While each unit had its own prescription, general management practices included prescribed fire, mowing, grazing, cropping, woody species removal, and planting and discing to establish native plants. The PRAP also set up a "First Year Management Practice Monitoring Program" and suggested future management practices, including a disclaimer stating that "it would be dangerous and naïve to prescribe specific management practices until the present practices can be evaluated (Jackson and Bensing 1982b)." The monitoring objectives and methods were:

1. Objectives

a. To determine the post-management practice prairie community biota using statistically significant and reproducible methods.

b. To make suggestions on modifying the management plan based on these findings.

2. Methods

a. Vegetation Composition – Two sample periods will be required each year. One in the spring to characterize the forbs and spring annuals and one in the fall to characterize the grasses and composites.

b. Photography – Fixed point and aerial photography of management unit areas in the spring and fall.

c. Presence Lists – Monthly visits to the management areas to collect, mount, and identify plants of the area.

d. Preparation of Reports – A progress report will be presented in July and a complete report with management recommendations will be presented in January of each year.

In a letter addressed to Superintendent Gentry Davis on 27 July 1982, Tom Toney stated that all seeded areas in four of the five management units looked good with the exception of Management Unit 4 (Toney personal communication 1982). Another letter from GWCA Biological Technician George Oviatt to Regional Ecologist Gary Willson included photographs taken of forbs that had established in Management Units 1, 4, and 5. The letter listed management actions that had been completed as of 31 March

1983 (GWCA Staff). Mr. Oviatt sent a second letter to Willson on 13 August 1983, this time providing photographs of some of the better areas in the prairie restoration. Mr. Oviatt also included a short, general update of what was needed for further restoration in the prairie areas (Oviatt personal communication to GWCA 1983).

Following the 1982 PRAP, Groves et al. (1983) completed the Prairie Management and Monitoring Program Phase I Report: Vegetational Analysis and Management Recommendations. The intent of this report was to evaluate the prairie management units' response to management actions undertaken in 1982. The preliminary findings showed that important native vegetation had increased in cover. The report identified remaining specific management problems, including cool season grasses and woody species encroachment, and recommended that burning, mowing, and limited herbicide use be employed in the future to combat non-native and problematic species (Groves et al. 1983).

The Prairie Management and Monitoring Program Phase II Report was completed by Bensing et al. (1984), and provided a much more detailed picture of the restoration effort. The purpose was to provide the "third series of management recommendations for the maintenance and perpetuation of prairie areas, within George Washington Carver National Monument, which are appropriate to the historic scene of 1860-1880." With this evaluation, the authors were able to show a direction for the 1982 and 1983 management actions. They provided the following observations (Bensing et al. 1984):

Management Unit 1: Cool season grass remained persistent. A good array of native grasses *Andropogon gerardii* (big bluestem), *Schizachyrium scoparium* (little bluestem; then referred to as *Andropogon scoparius*), and forbs typical of virgin prairie had been established.

Management Unit 2: Native species *S. scoparium* and *Sorghastrum nutans* (Indiangrass) were just beginning to establish. There remained a diverse population of weedy species.

Management Unit 3: Cool season grass woody species encroachment remained a problem. *A. gerardii* and *S. scoparium were* present, and sub-dominant native grasses of the genera *Panicum* and *Muhlenbergia* had been established.

Management Unit 4: Native grasses *S. scoparium* and two from the genus *Panicum* were observed, but weedy species dominated.

Management Unit 5: This unit was called a close approximation of mature prairie, and was then-described as "a beautiful recreation of the historic prairies of Carver's boyhood home". One cool season grass persisted that may cause a problem.

Management Unit 6: No significant management problems were noted, and the unit was said to be similar in quality to Management Unit 5.

The descriptions also discussed soil samples for each unit used to determine available nutrients, but the authors purposely made no plans to improve nutrients for the following reasons (Bensing et al. 1984):

1. Jackson and Bensing (1983) have suggested that native prairies exist naturally under conditions of acid soils and limiting nutrients.
2. An addition of fertilizer would favor cool season invaders more than the native warm season grasses.
3. The authors would like to have an additional year's worth of sample data before making fertilizer program recommendations.

The following management practices were suggested (Bensing et al. 1984):

Management Unit 1 Suggested Management Practices:

1. Late spring burn for cool season grass control (if necessary).
2. Spot application of herbicide for thistle control.
3. Mowing for annual weed control until July 15 (optional).

Management Unit 2 Suggested Management Practices:

1. Possible late spring burn depending on fuel load and cool season grass problem.
2. *Cercium* (thistle) control with Roundup.
3. Possible reseeding.
4. Mowing as above.

Management Unit 3 Suggested Management Practices:

1. Late spring burn.
2. Possible reseeding.
3. Mowing as above.

Management Unit 4 Suggested Management Practices:

1. Burn anytime to remove litter for effective herbicide application.
2. Herbicide application on cool season grasses.
3. Deep plowing for cool season grass control.
4. Planting in native grass species.

Management Unit 5 Suggested Management Practices:

1. Mowing as above.
2. Spot treatment with herbicide for [sumac] spp.

Management Unit 6 Suggested Management Practices

1. Mowing for annual weed control until July 15 (optional).

On 28 January 1983, GWCA was issued a Finding of No Significant Impact assessing the impacts of prairie management techniques. Regional Director Charles H. Odegaard signed the letter, which stated that no environmental impact statement was needed because negative impacts to the environment from management actions would be minimal and temporary. This document was then included in the 1984 PRAP. A draft of this PRAP was submitted on 24 August 1983 for review, and the final draft was submitted on 16 February 1984 by GWCA Superintendent Gentry Davis. The PRAP was approved on 28 March 1984 by the Regional Director. The 1984 update set forth the same primary management objectives as the previous PRAP, but mentioned that prairies were being restored for more than historic reasons due to State and Federal emphasis on prairie restoration. The main goals of the Plan were as follows (Jackson 1984):

1. Assessment of vegetational status for all proposed areas;
2. Elimination of existing populations of non-native species;
3. Establishment of a native prairie ecosystem;
4. Initiation of a continuous monitoring program to evaluate the status of the developing prairie.

The 1984 version of the PRAP incorporated an impact matrix that summarized the positives and negatives of proposed post-planting management practices. The proposed action is described, and impact categories include flora; fauna; cultural resources; visitor use/asthetics; protection population/areas; air quality; soil; interpretation; and laws, management policies, guidelines, and regulations. General alternative management practices were listed as fire, mowing, grazing, cropping (expected limited use), woody species removal, chemical control, and no management. Monitoring techniques from the 1982 PRAP were used, with the addition of two steps (Jackson 1984):

1. Vegetation Composition – Two sample periods will be required each year. One in the spring to characterize the forbs and spring annuals and one in the fall to characterize the grasses and composites.
2. Photography – Fixed point and aerial photography of management unit areas in the spring and fall.
3. Presence Lists – Monthly visits to the management areas to collect, mount, and identify plants of the area.
4. Preparation of Reports – A progress report will be presented in July and a complete report with management recommendations will be presented in January of each year.
5. Soil Analysis – Soil core analysis of prairie units and woodland study areas.
6. Prairie-Woodland Ecotone evaluation to be completed by Dr. James Jackson of Missouri Southern State College in January 1985.

Descriptions of the existing management units were more detailed, and management practices were altered based on the findings from 1982 and 1983 monitoring. Appendix B of this Plan shows the results of pre- and post-management evaluations for 1982-1983. There was an understanding that management techniques may not guarantee successful restoration, and that techniques should be modified to find the best possible result. Long-term management goals for each unit were set forth, and suggested actions for 1984 were listed accordingly. There was also more emphasis placed on pre-seeding management. This included protecting areas of GWCA known as "successional refuges," which are oldfield areas within which native prairie is experiencing unaided expansion (Jackson 1984).

Overall, the results from the prior management actions appeared to show a positive effect on every management unit except Management Unit 4. This unit is described as having a "diverse and bizarre history," including usage as a barnyard, plowed field, and roadway site, as well as containing pipelines and being used as a leaching field. It may have had several other uses. Three options were considered for management of this unit, and GWCA selected the option to apply herbicide after the cool-season grass green up; determine the vitality of remaining cool-season grasses; plow, disc, and reseed; and to take no action on the portion of the unit that responded positively to previous management (Jackson 1984).

Changes in management were made to each unit after evaluation of 1982-1983 management actions. Management Unit 1 needed to be re-seeded due to areas being affected by "adverse climactic conditions". Mowing was to be suspended after late July to allow warm season native grass growth. Mowing after July was also suspended in Management Unit 2 for the same reason. Management Unit 3 was not mowed in order to allow litter build-up for a prescribed burn the following year. The eastern section of this unit was to be re-plowed and spot applications of herbicide were used to control cool-season grasses. The management actions for Management Unit 4 were described above, and Management Unit 5 was removed from the prescribed burn program due to the success of previous management. This allowed the park to assess species diversity in the unit (Jackson 1984).

A sixth management unit was added to the 1984 PRAP to the west of Management Unit 4. It was approximately 1.5 acres and was designated Management Unit #6. This unit was exempted from the first PRAP, but was included in the prescribed burn plan. The same management techniques used in Management Unit 5 were to be applied to this new unit. It was originally intended to be an extension of Management Unit 5 until restored to a similar condition, then absorbed back into Management Unit 5 (Jackson 1994).

GWCA also decided in 1984 that leasing of park lands through the Agricultural Special Use Permit was not going to accomplish the management objective of recreating the historic scene. This subject was included at the end of the 1984 PRAP, stating that "20^{th} Century agricultural practices employed have distorted rather than enhanced the historic picture," and that practices were having a negative effect on the park's natural resources. Three specific management goals were set to correct this issue (Jackson 1984):

1. Establish a Historic Leasing Program under provisions of the National Historic Preservation Act – 1980 Amendments. This program will gradually reduce the acreage available for agricultural use over a five year period. The lease will answer short term objectives of maintaining the field until native grasses can be established and enabling rent money to stay within the park until the land lease is gradually reduced.
2. Initiate a program to establish native prairie grasses within the acreage being gradually removed for the leasing program.
3. Initiate a haying program. (This third goal was dropped for the 1985 PRAP.)

The expected results from these goals were to engage the most efficient use of park resources while enabling the most effective method for creating the historic scene. It was also believed that exotic plant species impacts would be minimized, and future management programs would involve only haying (Jackson 1985).

A schedule for implementation was created in 1984, and updated in 1985. The total acreage to be affected was 93.5 acres, with an expected five years to complete the transition. Additional Management units designated #7-14 were created for the purpose of gradual incorporation into the management program. Management for Management Unit 7 (2 acres) and Management Unit 8 (5 acres) was incorporated into the plan in 1985. Management Unit 9 (27.5 acres) and Management Unit 10 (15 acres) were also to be removed from the lease and re-seeded to native grasses in 1985. In 1986, Management Unit 11 (17 acres) was to be removed from the lease and re-seeded to native grasses, as was Management Unit 12 (18.5 acres) in 1987. The Historic Properties lease was set to expire in 1988, when both Management Unit 13 and Management Unit 14 (8.5 acres total) were to be re-seeded to native grasses (Jackson 1985). Several orders were placed for native grass and forb seed between 1982 and 1988 (GWCA Staff).

The completed and implemented 1985 PRAP was basically a revised version of the 1984 Plan. Barry Jones (1994) stated that “practices continued through 1993 under the guidance of the 1984 Plan.” A number of different management prescription formats were used under this plan. The 1988 prescription was completed electronically and featured organization of prescribed actions by action and by management unit per month. It looks as though this format could have been used in subsequent years, but does not show up again. Management activities for 1988 included burn, mow, seed, forbs reseed, mechanical removal of exotics, herbicide, vegetation analysis, aerial photography, and photo station (GWCA personal communication). In the first section, actions were listed with tentative dates to begin actions, approximate time to complete task, and area covered (acres). Items were checked off as completed, and some handwritten changes were made to tentative dates. The second section included a page for each unit that displayed a table of months versus management units, and an “X” was placed in the corresponding space on the table. All management actions appear to be completed as prescribed for 1988, with the possible exception of mechanical removal of woody species (GWCA personal communication). This action was not recorded in later management summaries for that year.

In 1989 the management units were converted to Management Units 1-7, as the agricultural lease on the property had expired, and the absorption of all lease units had been completed. These are recognized as the 1990 Management Units (Figure 3). A summary was completed in 1989 compiling management actions since implementation in 1982. Unfortunately, the reorganization of management units makes tracking management actions through the years somewhat difficult. Management Units 1, 2, and 3 were the same, while Management Unit 4 was the combined area of previous units 4 and 5. The new Management Unit 5 (formerly units 8, 12, 13, and 14) consisted of the large former agricultural/historic lease area in the southeast corner of the park. Management Unit 6 (formerly unit 10) was located in the eastern region of the park, and Management Unit 7 (formerly units 7, 9, and 11), then the largest unit, comprised most of the area north of the central woodlands (Jones 1995).

Management actions in 1990 were documented using a map of the seven management units. The first page provided a written summary of a Memorandum of Understanding with the Newton County 4-H Council and management actions completed in 1990. The 4-H agreement, dated 11 July 1990, was designed to provide the park with native warm season grass plantings in exchange for the ability to hay "specified established units", and was a five-year renewable contract. This agreement replaced the historic lease program, and was still in use in 2009. The summary of management actions basically describes the seven maps attached to it, each of which features a highlighted area of the map that received the specified management action (GWCA personal communication).

A hand-written burn plan was created for the 1991 and 1992 seasons. It appeared to be an informal communication to the attention of “Rebecca” from “Shirley” – most likely two GWCA staff employees. The plan prescribes burning Management Units 1, 2, and 4 due to the haying contract and because “old grass turns nasty”. It also mentions burning Management Unit 3 and a portion of Management Unit 7 to benefit stands of warm season grasses. Rebecca continues to explain that the “purpose for burning some and not others is because we need to leave some areas for nesting birds and habitat for small animals.” At this point, they appear interested in an alternative to burning and suggest mowing and raking grass clippings. There is some evidence that prairie management was a burden to park staff when Rebecca mentions “we wouldn’t be having this problem if we had staggered the management of the units (seeding) as we discussed earlier.” A prescription was drafted and Management Units 1, 2, 3, 4, and the western half of 7 were burned in 1991. Management Units 5 and 6 were listed as “attempted burn” and the eastern half of 7 was successfully burned in 1992. Other management actions including mowing, seeding, and haying were completed, most likely in conjunction with the 4-H agreement. Another document summarizing management actions between 1982 and 1991 was completed in this year. It builds upon the 1989 document and uses a different format.

The 17 June 1992 memo, “Prairie Management Actions, 1992” addressed to GWCA Superintendent from newly hired Biological Science Technician Barry Jones, provided an official course of action for that year. The Superintendent signed and dated the memorandum the same day. Jones writes that “The following report summarizes all proposed actions related to prairies or prairie restoration at George Washington Carver National Monument." Scheduled actions were displayed by the individual actions and by chronology. The "Schedule By Action" was split into "Active" and "Passive" management techniques. Active techniques included the following actions to be completed between March and December: mowing, haying, burning, mechanical eradication of woody plants, chemical eradication, and seeding. Passive techniques included: 1) monitoring of plant species transects, water, and rare species, including royal catchfly (*Silene regia*) and Henslow's sparrows (*Ammodramus henslowii*); 2) Plans (for monitoring); and 3) Other (Prairie Management Actions Summary to be completed by 31 December 1992). This is the first time *A. henslowii* is addressed in a management plan, and a nesting pair was indeed encountered in 1995 by GWCA Biological Technician Barry Jones (GWCA Files; Harrington et al. 1999).

Management prescriptions for 1993 were once again presented in another format. Again, Barry Jones issued a memo to the Superintendent, dated 15 April 1993. In this case a grid was used, with actions listed vertically on the left versus management units horizontally across the top. A date for each action to be performed in a specific unit was placed in the corresponding square on the grid. Actions were summarized by month on the second page. Proposed actions for this year included mowing, haying, burning, woody species removal, herbicide, seeding, and monitoring. In addition, the monitoring of *A. henslowii* and *S. regia* was scheduled to continue. Despite the changes in presentation, this plan continued to build upon the previous year.

Following up on the previous 12 years of management practices, a Prairie Management Baseline and Monitoring Program was completed under the supervision of Dr. Jackson by Louise Wilson of St. Catherine's College at Oxford University in England. The research objectives were (Wilson and Jackson 1994):

1. To reestablish a vegetation baseline by reporting the importance values, frequency, density, and cover values for the plant species present in each of the park's 8 Prairie Management Units and in two sample areas at Diamond Grove Prairie, and to represent the most important prairie species in distribution maps and develop vegetation type maps of the units. These values will also be compared to the data collected in the park's prairie units in the mid-1980s.
2. To determine the similarity of the park's prairies to a similar section of Diamond Grove Prairie and to establish Diamond Grove as a model for defining restoration and monitoring goals at George Washington Carver National Monument.
3. To design management suggestions that can be used to help restore the prairie vegetation to the historic scene of the Carver Boyhood Home. Part of these management suggestions will include prairie monitoring protocols for George Washington Carver National Monument that build on the use of Diamond Grove as a vegetational composition model.

The report notes that the 240 acres of GWCA were historically part of the virgin Diamond Grove Prairie (DGP), the 570-acre remnants of which are located approximately 4 km northwest of GWCA, which in turn was seen as a model for the prairie restoration at GWCA. Wilson and Jackson (1994) provided background information on DGP, and summarized the site history of GWCA. The authors noted that a Biological Technician (Barry Jones) was added to the park staff to enhance prairie management (Wilson and Jackson 1994).

A monitoring study completed by Wilson and Jackson (1994) compared five target species with cluster analysis between GWCA and DGP. The results evaluated the then-current status of the GWCA prairies as such: Management Units 3, 5, 6, and 7 were described as immature prairie; Management Units 1, 2, and 4 were described as moderately mature prairie; and Management Unit 7B (demonstration plot) was described as disturbed prairie. Jones (1995) provided a list of long-term restoration needs summary for each of these units. Wilson and Jackson (1994) provided an analysis of the vegetation of each management unit at GWCA and of selected units at DGP. They calculated species importance values based on the sum of relative cover and relative frequency of each species, calculated Shannon diversity including the calculation of importance values for each species, determined Shannon diversity and evenness for each management unit, and used cluster analysis to determine the similarity in species importance values between GWCA and DGP and GWCA and importance values measured in the park in 1982. The comparison showed that GWCA was closer in similarity to DGP in 1994 than it was in 1982. Wilson and Jackson (1994) discussed the results in depth, providing a description of each Management Unit. Desirable and undesirable species were outlined for each Management Unit, illustrated via maps showing sample lines with species locations marked. The following are summaries of the observations made in the report:

> Management Unit 1: Less disturbed than other areas; may never have been plowed, seeded, or fertilized prior to NPS ownership; management had been deemed successful to this point based on analysis; control of weedy species highest priority. Moderately immature (successional stage).

> Management Unit 2: Probably grazed until 1981, but not plowed; most disturbance likely occurred in 20 years prior to report; management had been deemed successful to this point based on analysis; increasing forb diversity was highest priority. Moderately immature.

> Management Unit 3: Used for agriculture after 1950s; fescue planted in 1965, land likely heavily fertilized; tall fescue (*Schedonorus phoenix*) had not changed in importance in unit since 1982; introduced native species have not been successful in outcompeting weedy species; not considered climax community. Immature.

Management Unit 4: Used for pasture since 1900; aerial photographs from 1952 show damage from livestock or tilling; tree removal and the presence of a road through the unit also may have contributed to disturbance; mixed stable and disturbed areas; south end was less disturbed, and had not been plowed in at least twenty years; management had been successful in some areas, while others still needed a “high level of management”; considered to be in climax stage in all but the northern part of the unit. Moderately mature.

Management Unit 5: Had only become prairie management area within last ten years; formerly leased under special use permit; some areas showed signs of restored prairie, but central and southern sections would “still require much more management”; recommend “weed control and burning or mowing” for less stable areas; *L. arundinacea* maintained a high importance value at this point; considered to be at an early succession stage; disturbance caused weeds to have competitive advantage. Immature.

Management Unit 6: Also has been management unit for less than ten years due to agricultural lease program; possibly very disturbed in the past; recommend “weed control and burning or mowing”; as with unit 5, considered to be in early successional stage due to the ability of weedy vegetation to outcompete native prairie species; was progressing slowly, needed increased management. Immature.

Management Unit 7: Part of agricultural lease as well; appeared to have been quickly returning to native prairie; was “mixture of mostly prairie species with some weedy species also showing a high level of dominance”; management should be concentrated to areas of weedy dominance, as rest of unit was being restored quickly. Immature.

Management Unit 7B: not being considered in this Management Review; management has not occurred in this unit, and it is very woody.

Wilson and Jackson (1994) concluded with a section on a monitoring protocol. They wrote four questions concerning the protocol, and included answers for park staff:

1. How frequently should prairie management units be subjected to a vegetational analysis in a monitoring program?
    - In 10-12 year intervals without testing, followed by 9-15 months of intensive analysis.
    - Essential to keep management records for burning, mowing, herbicide use, seeding, grazing, and climactic conditions for each unit.

- This interval chosen because it allows for significant changes and buffers anomalous climactic conditions.

2. Does the monitoring program reflect objectives of the park?
   - Needs to be adaptive to park's goals.
   - Continuously reevaluate program based on "historic mandate of the monument."
   - Goal is to continue use of Diamond Grove as model in tallgrass prairie restoration.
3. What are components of an analysis interval such as the one described in this report?
   - Must use vegetation sampling methods that are as similar as possible to those in this study.
   - Must be able to compare sample periods and "address unforeseen management questions."
   - Sample in spring/summer and again in fall.
4. How can the analysis interval be organized so that all of the interested individuals can be involved?
   - Three meetings to involve primary investigators, chief ranger, resource management personnel, park superintendent, and representatives from the Midwest Regional Office before sampling begins.
   - Should address objectives, procedure, and funding of research.

This report presented a complete and comprehensive prairie vegetation monitoring setup. With its complexity, it may not be necessary to follow to the letter, but it provides a skeleton for long-term in-park monitoring that needs to be performed only once per decade.

Updated Management Practices, 1995-1998

The 1995 PRAP draft was completed late in the year 1994, and was the first Plan to acknowledge the seven 1990 management units. It also notes the relation to DGP discussed in the Management Baseline and Monitoring Program. A detailed analysis of the vegetation makeup and a summary of past practices at GWCA were presented in this PRAP. Appendix I provided a "Sample of Prairie Restoration Site Plan," which included Site History, Site Objective, Site Analysis, Archaeological Concerns, Restoration Strategies, Seed Acquisition and Planting Mix, Species, and Monitoring. Appendix II gave an Action Summary by year from 1982-1994. Actions were presented vertically on the left of the table with unit numbers across the top. An "X" and a date (if available) were placed in the corresponding grid. A single page general summary was provided on the final page of the Appendix (Jones 1995).

Appendix III presents thorough procedures on vegetational monitoring and analysis methods. Appendix IV is the Demonstration Prairie Plan for Management Unit7B, with proposed restoration actions through December 2007 (Jones 1995). There is no record of this plan ever being executed.

GWCA General Management Plan, 1997

The Mission of GWCA as defined by the 1997 General Management Plan (GMP; GWCA 1997) is to "maintain, preserve, and interpret, in a suitable and enduring manner, the life and legacy of George Washington Carver for the benefit and enjoyment of the people of the United States of America."

The GMP states that the management of natural and cultural resources and the visitor services program supports the commemoration of George Washington Carver. Natural and cultural resources serve as symbols of significant events and influences on the character and life of Carver. The interpretive program enables people to use tangible resources to contemplate the intangible meanings of the Carver story. The landscape and visitor facilities create a memorial-like atmosphere with opportunities for the public to spend time reflecting upon Carver's experience and their own lives.

The plan has three Purpose Statements:

- Memorialize the life of George Washington Carver as a distinguished African American, scientist, educator, humanitarian, Christian, artist, and musician.
- Preserve the setting of the Moses Carver farm and birthplace of George Washington Carver.
- Interpret the life, accomplishments, and contributions of George Washington Carver, using a museum, wayside exhibits, and other interpretive strategies.

The plan has two Significance Statements for the park:

- George Washington Carver National Monument is significant because it was the birthplace and home where Carver spent his formative years that set him on the road to becoming one of this nation's most distinguished scientists and humanitarians.
- Although born a slave and orphaned as a baby, his early years were spent in a nurturing atmosphere with his adoptive white parents in an agrarian setting. Here he was given the opportunity to pursue his curiosity about the world around him.

The 1997 GMP noted the development of an integrated restoration study, *Springs of Genius*, which was underway to provide information to help guide the planning team in the management and treatment of the site's cultural landscape and its natural features.

***Springs of Genius*, 1999**

Dr. John Harrington of the University of Wisconsin-Stevens Point became the lead investigator on a project at GWCA in September 1994. According to the Cooperative Agreement, the objective was to "develop an integrated approach to landscape documentation and management through an interdisciplinary assessment of the cultural and natural features of the historic site. This project will serve as a national model for integrating cultural and natural resource research methods and landscape restoration techniques." To begin his project, Harrington provided a complete review of Barry Jones' 1995 draft PRAP. He made several recommendations for the improvement of management practices. Highlights of his analysis included labeling archaeological sites with the actual historical structure or event (rather than a number), stating what was sampled in Wilson and Jackson's (1994) monitoring study, providing individual management unit recommendations, and outlining goals for the Restoration Action Plan. Harrington also recommended specific strategies for each of the management units at the park (Harrington et al. 1999).

The final product of Harrington's project was *Springs of Genius: An Integrated Plan for the George Washington Carver National Monument*. There was an emphasis throughout the Plan about recreating the historic scene during George Washington Carver's – or at least Moses and Susan Carver's – occupancy of the farm. The authors believed that the prairie plantings as they existed during their project were more effective in portraying the pre-settlement scene rather than the Reconstruction Era farm (Harrington et al. 1999). This is in contrast to the original goal for prairie restoration, "to restore the historic scene to that of the Moses Carver Farm of the 1860's and 1870's." However, *Springs of Genius* goes further than any plan created for GWCA to in fulfilling the goal of managing cultural and historic resources. Three Master Plan options were presented to aid in recreating this scene: Boyhood Scene (1860s-1870s), Site as Experienced by George Washington Carver (1860s-1890s), and Current Visitor Services/Monument Systems Layout (1860s-1890s) (Harrington et al. 1999). Each option presented compromises in ecological and/or interpretation quality. Though these Master Plan options were well thought out and considered many aspects of the park's history and resources – cultural, natural, capital, and financial – GWCA ultimately moved forward in constructing a new Visitor Center and maintaining the maximum available prairie and woodland habitat. The restoration goals at GWCA have since changed from the original 1982 statement (Henry personal communication 2009a), and one could say that restoration of native prairie habitat can be seen as a memorial to George Washington Carver in addition to conserving North America's most endangered habitat.

Chapter 2 of *Springs of Genius*, "Cultural Resources: Assessing and Interpreting the History of the GWCNM Landscape", is considered by GWCA to be a very important and informative document (Henry personal communication 2009a). It was a thorough investigation of the history of the 240 acres that comprise the Moses Carver farm before, during, and after the Carvers and their relatives occupied the land. The authors described their efforts as such: "First, we have attempted to document the features of the Moses Carver farm over time, and to place them into regional and historical contexts … Second, we have investigated what is known about the local landscape – both the Moses Carver farm and, more generally, the landscape and environment of southwestern Missouri" (Harrington et al. 1999). They discussed several topics, including ownership history, on-site structures and layout, and the Carver family cemetery.

Chapter 3 described Natural Resources of the Region and History of Landscape Change at Settlement. Chapter 4 gave an assessment of the prairie plantings as they existed during the course of the study. DGP was also noted as a model for restoration in this plan, and vegetation sampling was performed at DGP in 1996 for comparison with the GWCA plantings. A unit-by-unit analysis of the prairie conditions was provided, including land use history, plant species composition, and an appraisal of overall quality as compared to DGP. The authors described overall plant species diversity at GWCA as being similar to DGP, but they observed differences in structural makeup. The primary difference was that DGP was comprised of native long-lived species, whereas GWCA consisted of many disturbance and short-lived species with a much larger non-native species presence. The authors often emphasized the idea that non-native species should cover less than 5% of the total area, and that restoration should be addressed from a standpoint of regional authenticity (e.g. proportional native species cover to nearby native prairies) (Harrington et al. 1999).

Harrington et al. (1999) also suggested that the management units should be reorganized into "natural zones" based on existing soils and topography:

Management Units 1, 2, and 7 combined into Unit A with two subunits (A_1 and A_2);

1. Management Unit 8 becomes Unit D and expanded to contain all of area north of Harkins Branch;
2. Management Units 3 and 6 combined and renamed B_1 and B_2. From southern property boundary to southern edge of Carver Branch and from west property boundary east to Carver trail;
3. Management Unit 5 divided into subunits C_1 and C_2 (based on soil types).

4. Use all areas of restoration as seed nursery rather than only Management Unit 2; promotes diversity and richness.
5. Management Unit 4 designated as Row Crops to north and pasture to south. Management Unit 1 to be designated as hayfield.

These new units were never adopted by GWCA. While the scientific basis behind reorganization is sound, the newer system is more complicated. It is also likely that the park decided to maintain the current system for continuity and because the new units combined and renamed the old units rather than truly changing them. The possibility also exists that park management was not willing to plow a portion of Management Unit 4, which at the time was regarded as the most successful restoration effort (Jones 1995). The continuing 4-H Memorandum of Understanding precludes the need to designate a single unit as a hay field.

Chapter 6 to described planting and site preparation methods, as well as specific procedures for planting in each of the natural zones. This is very useful information, and should be referenced if future seeding is to be done. Chapter 7 is the Site Management Plan, a comprehensive explanation of many concepts that should be useful for future management. Chapter 8 provided useful information on monitoring practices. All of these chapters contained useful recommendations on woodland management and monitoring, which should be evaluated for future restoration.

In summary, *Springs of Genius* is a lengthy, but extremely informative report that demonstrates a wealth of knowledge, and has been recognized by GWCA staff as an important historical document. It should also be considered a reference document for natural areas management, as it provides wide-ranging instruction and is regionally relevant. Perhaps the only part of this plan that are not useful at this point are the Master Plan options, but park staff have embraced some of the cultural aspects that have been presented, such as the planting of an orchard or reconsidering the use of grazing as a management technique (Henry personal communication 2009a). The Master Plan recommendations of *Springs of Genius* were not approved by the Midwest Regional Office.

1999 Resources Management Plan

A Resource Management Plan (RMP) developed by the GWCA Staff was also completed in 1999, which discussed the state of natural and cultural resources at GWCA, and how to preserve and promote those resources. The goals of the plan were:

1. To study the park's flora, fauna, and natural systems to provide baseline data;
2. To protect natural and cultural resources by identifying and mitigating threats to them; and,
3. To restore the natural and cultural resources that are damaged, lacking, or absent due to past operations and activities of humans.

The RMP begins the prairie evaluation by stating that the grasslands are in a "highly disturbed state," and that while some areas have responded well to treatment, others have been less successful. It makes note that some practices are experimental and must be monitored to determine effectiveness. When the plan was completed, no endangered or threatened species were present at the park, but an Endangered Species Management Plan will be created if any are discovered, or if a species known to occur at the park becomes listed (GWCA Staff 1999).

Many aspects of natural resources history are mentioned in the Resources Management Plan. Some of which are the former agricultural use units and the limited woodland areas on the banks of the streams on site (GWCA Staff 1999).

An interesting note presented in the plan is that Williams' Pond originally was dammed by concrete, but the concrete dam was removed for an earthen levee in the late 1970's. Though not an original feature of the historic landscape, the pond is considered an important and established ecosystem and wildlife resource, along with Carver, Harkins, and Williams' branches. Currently there are also areas of intermittent surface water in the area to the east of the pond in Management Unit 7 (GWCA Staff 1999), in Management Units 5 and 6 (Trauth and McCallum 2003), and in Dry Branch in the newly acquired unit. These areas generally contain water from runoff or groundwater seepage (GWCA Staff 1999).

The plan also notes that plant and animal species were likely more numerous in 1860s and 1870s than today, and that more non-native and less native species are present. Another interesting factor mentioned is the presence of feral dogs and cats as an ecological hazard on site (GWCA Staff 1999).

The RMP then discusses park fauna and flora, particularly bird surveys that were completed in the 1980s and which continued through the 1990s. It also mentions candidate and Missouri species of concern, including regal fritillary (*Speyeria idalia*), Arkansas darter (*Etheostoma cragini*), Loggerhead shrike (*Lanius ludovicianus*), and royal catchfly (*Silene regia*; found and documented at GWCA in 2009 and 2010). Finally, it provides information on geophysical studies, and monitoring and inventory of land use (GWCA Staff 1999).

Acquisition of the Remaining 30 Acres of the Carver Farm, 2004-2005

Mrs. Evelyn Taylor and her late husband, Bud, donated the 30-acre plot in the southwest corner of the monument to the Carver Birthplace Association in 2004 (Henry personal communication 2009b). The property was donated to the National Park Service on 22 June 2005, with a recording date of 13 July 2005 (Henry personal communication 2009c). As a result of this transaction, the park consists of all 97 ha from the Carver's occupancy. Of these, approximately 53 ha are native tallgrass prairie in varying stages of restoration, and approximately 32 ha are woodlands and the developed unit (Wait 2003). The remaining 12 ha are primarily fescue field and woodland with a power line right-of-way. This plot designated as Management Unit 9 in 2005, and is being evaluated for management potential. Zinc and lead ore mining operations were conducted on this unit in the 1930s. The tailings were cleared and the shafts sealed in 2004.

The Heartland Network

The Heartland Network Inventory and Monitoring Program has initiated several reports on the ongoing restoration of tallgrass prairie at the park.

The 2003 Inventory of Invasive Exotic Flora was completed by D. Alexander Wait of the Biological Sciences Department at Missouri State University. The report assessed presence, cover, and dispersion of seven target invasive and seven problematic species that occur at GWCA. Wait documented the most common native species occurring in the park. The stated goal for the project was to create a baseline to monitor patterns of invasion (Wait 2003).

Former GWCA Biological Technician Barry Jones, then of Allergon, completed the 2004 Vascular Plant Inventory. The goal of the report was to re-document plant taxa as collected in the late 1950s by Ernest J. Palmer. Jones calls the result a "revised flora of the monument" (Jones 2004).

In 2005, a Vegetation Community Monitoring Status Report was completed by Alicia Sasseen, a Plant Ecologist with the National Park Service. The study established seven long-term vegetation monitoring sites in the tallgrass prairie Management Units. Burned and unburned sites were compared between 2004 and 2005. Overall, 75% of species surveyed and 90% of cover were native species. The report also set a baseline for future monitoring of vegetation communities and changes through management actions, such as prescribed fire (Sasseen 2005).

The Invasive Exotic Plant Monitoring: Year 1 report was completed in 2007 by J. Tyler Cribbs et al. of HTLN Inventory and Monitoring. The team documented 26 invasive exotic plant taxa, and the report included maps and covers classes of each species within quadrats established at the park (Cribbs et al. 2007).

The most recent report is the 2009 Plant Community Monitoring Baseline Report by Kevin M. James and Gareth A. Rowell of HTLN Inventory and Monitoring. Their aim was to "detect and describe changes in the prairie community." The data from the aforementioned 2004-2005 survey was combined to create a 2004-2008 baseline sample period, as no statistically significant directional change was surmised. The report also states that the prairie is in "varying stages of restoration" (James and Rowell 2009).

Management Actions, 2000-2010

A thorough search of GWCA files was undertaken during the 2009 field season to attempt to fill in any gaps in management up to 1999, and to document management up to and including 2009. First, James and Rowell (2009) stated that prescribed fires were completed on Management Units 3, 5, 6, and 7 in April 2005 and Management Units 1 and 2 in 2008. Second, Management Units 3, 4, 5, and 6 were scheduled to be hayed in the fall of 2009, but were not due to complications with the contractor. A scheduled prescribed burn of Management Units 1, 2, and 7 in spring 2009 was cancelled due to rain (Henry personal communication 2009). In 2009, the Heartland Network developed a PDF map to illustrate prescribed burns that have been completed at GWCA from 1982-2008. In September 2010 GWCA performed a prescribed burn of Management Units 3, 4, 5, and 6 and developed an experimental herbicide and manual treatment program to address woody plant species invasion. Completed management actions since 1982 are outlined in Appendix 1.

Wildland Fire Management Plan

The Wildland Fire Management Plan was completed in September 2004 by Bobby Bloodworth, Area Fire Management Officer for Ozark National Scenic Riverways. The document centers on public safety, but also emphasizes cultural and natural resource conservation. The plan states that "the use of prescribed fire as a resource management tool is expected to meet an important vegetation management objective and act as a tool for controlling or eradicating invasive exotic species," and that the goal of fire management is to "use prescribed fire as a method of restoring and maintaining the cultural and natural landscape to meet resource objectives of the park." There are two important management considerations for natural resources conservation (Bloodworth 2004):

1. No unacceptable impacts to cultural resources or threatened and endangered species.

2. Ensure that public, organizations, and cooperating agencies are aware of any suppression or prescribed fire operation that may have an impact on them.

In addition, the Long-Term Prescribed Fire Strategy incorporates these additional objectives (Bloodworth 2004):

1. Protect and preserve the cultural resources of the park, manage vegetation, and reduce fuel loading.
2. Manage vegetation to maintain vistas, promote the growth of native vegetation, and control woody/invasive/exotic vegetation.
3. Assist with the establishment and maintenance of the desired cultural scene.

The park has no record of fire occurrence other than prescribed burns for prairie restoration, though the Plan states that the landscape of GWCA has not been altered by fire since the 1930s. Rather, it is a lack of fire that has resulted in the park woodlands progressing to a "mixed hardwood climax with woody species encroaching onto abandoned fields" (Bloodworth 2004).

As with any management plan, it is important to make changes as necessary maintain effectiveness. The Fire Management Plan addresses this concept through an Annual Readiness schedule and a monitoring program. Annual Readiness includes planning prescribed fire activities and reviewing plan revisions in March, and critiquing the fire season each December. Per the monitoring program, to adjust fire management to be most effective, “ecological changes such as species composition and vegetation structure will be monitored for several years after a fire,” and GWCA “will implement long- and short-term monitoring to assess accomplishments, and determine the positive and negative effects of management activities on cultural and natural resources” (Bloodworth 2004).

2007 Long Range Interpretive Plan

The Long-Range Interpretive Plan (LRIP) 2007 outlines the objectives the park has determined to be most important in cultural and historical interpretation. The LRIP outlines the Mission, Purpose, Significance, and enabling legislation for GWCA. The Visitor Experience Objectives provide a criteria for continuing prairie management with regard to the cultural and historical interpretation focus of GWCA.

2011 GWCA Natural Resources Condition Assessment

GWCA received a draft of the Natural Resources Condition Assessment (NRCA) in April 2011 from the Missouri Resource Assessment Partnership (MoRAP) and the Heartland Network. The NRCA assesses natural resource conditions based on a system of comparing current conditions to pre-established management targets. It is a qualitative assessment of resource condition based on available GWCA data and conceptual vegetation mapping. The NRCA provides valuable information in terms of improving particular attributes via indicators of natural resource condition. Indicators are physical characteristics (vegetation type, patch size, species richness, etc.) that are assessed based on how they fit within physical ranges or whether they are on the correct side of a threshold. Attributes are a step up from the Indicators and relay information about more general characteristics (landscape composition, land cover, diversity, etc.). Results are evaluated according to how well the "current condition approximates the management target" using a score between zero and one. The scale is color-coded in increments of two-tenths for interpretation purposes.

Observed Management Practices

2009 Prairie Management

Current information on prairie management is sometimes difficult to obtain because it is not documented regularly. In fact, one way that was suggested to find a recent Management Unit mowing date was to search employee service logs.

On 25 June 2009, approximately half of Management Units 1 and 7 were unexpectedly mowed by park maintenance. Field work was ongoing at this point, and mowing was halted. Fortunately, no data was lost, and in fact a second round of habitat suitability index (HSI) data was collected on the plots a month after the prairie had been mowed. In July an access “road” was mowed through Management Unit 5 toward the newly acquired unit to transport debris from the cleanup of two fallen trees near the Administration building. This practice is not recommended because of potential damage to prairie vegetation. There is also the potential of spreading seed from the fallen trees or an area of ornamental grass that had recently been seeded. There is also currently a more permanent access road that is not as direct a route, but still not inconvenient.

A haying contract was awarded to a local contractor, who was set to begin haying Management Units 3, 4, 5, and 6 the week of 5 July 2009, but as of September there has been no action. However, it is expected that these units will be hayed by the end of October.

Herbicide treatments were conducted on patches of invasive plants by a Student Conservation Association (SCA) intern. The treatments occurred mostly during June and July, when native warm season grasses begin to grow and flower. There were patches of dead vegetation in some areas that would be counterproductive to restoration, as non-native species could colonize these areas and create problems in future management. Nonetheless spot treatments were successful in some areas. The SCA intern made it his goal to eradicate invasive species of low abundance so as to limit the total number of species present. Future observations and HTLN monitoring will gauge the success of these herbicide treatments.

All prairie units were mowed again in late October or early November. Details on this action were not clear, though it appears that it was not a planned management action.

2010 Prairie Management

Land management practices were monitored and researched between while data were collected for indicator species presence and habitat suitability. Current Management Unit conditions were again noted in the field, and current management practices were further examined through literature searches and conversations with park employees.

Members of the HTLN Exotic Plant Management Team (EPMT) began an intensive herbicide and manual removal program designed to eradicate non-native species in the prairie and woodland units of GWCA. Sericea lespedeza (*Lonicera japonica*) was targeted heavily in 2009, and other invasive species were spot-treated. An SCA intern also worked with GWCA to develop an experimental treatment plan to address invasive species including sumac (*Rhus* spp.), sericea lespedeza, and crown vetch (*Coronilla varia*) in Management Units 1, 2, and 7. Methods to be tested include individual or combination effects of mowing, herbicide spraying, and hand removal. A map illustrating the sections and to be treated and a short guide to individual species removal was created to guide the experiment.

GWCA also made several seed purchases in 2010 for native forbs, native prairie grasses, and trees to be planted within the park. Some of these may be used to develop the Visitor Viewshed (see IVMR), while overall they are expected to improve native species cover and aesthetic value within the park.

A prescribed burn was conducted on 22 September 2010 in Management Units 3, 4, 5, and 6 covering 28.7 ha (70.9 acres). The focus of this burn was to control woody species, mostly sumac , that had been spreading across the southern units.

Discussion

Prairie Restoration Action Plans were created in 1982, 1984, 1995, and 1999. Dr. Jackson's 1982 PRAP set initial guidelines for prairie restoration, and by 1984 plans were underway to absorb the historic lease units into native prairie restoration. The 1995 Plan from Barry Jones built upon previous management and seemed to breathe new life into the project. John Harrington completed an informative and exhaustive Cultural Landscape Plan in 1999, which referred regularly to the 1995 Plan, but which is ultimately most useful for its historical study and prairie management recommendations. Some landscape enhancements are still under consideration (e.g. historic orchard and grazing), but the park could not follow through with many of the proposals, including the completion of any of the three Master Plan options (Henry personal communication 2009a). When the reorganization of the units was complete in 1989, the park was left with seven prairie management units of differing sizes, purposes, and histories, but similar goals for restoration. There have been attempts through the years to add an eighth unit north and west of Harkins Branch in the northwest corner of the grounds, but no management in this area has been documented. In addition, Management Unit 7 has contained up to three subunits (7, 7A, and 7B) that would require a high degree of attention, including one potential demonstration plot that might receive additional consideration in the future. For twenty years, the same seven management units have been used for the restoration effort. Harrington et al. (1999) suggested the reorganization of the units into "natural zones", but they were never implemented. In the Integrated Vegetation Management Recommendations section of my thesis I will propose a new management unit alignment that includes four “Zones”: North, South, Carver Woodland/Savanna, and Cultural.

GWCA could greatly improve prairie restoration by addressing alternating formats and strategies in management prescriptions. An important goal for future management at the park should be to use a uniform method of documentation of actions before and after they occur. It appears that some effort was made to establish uniformity throughout the restoration period (particularly under Barry Jones), but the reasons for the discontinuance of these practices are unclear. Possible reasons could be staff turnover either at the park or on the project itself, changes for the sake of effectiveness, advances in technology, request by park management/administration, etc.

An accurate and up-to-date internal recordkeeping system for prairie management activities would also be beneficial for GWCA to avoid discrepancies and provide ease of access. For instance, Bloodworth (2004) outlined a schedule of prescribed fire events from 2005-2009. However, conflicting documentation exists as to whether burns were conducted each year. One spreadsheet prepared for the park by an intern shows prescribed burns occurring each year between 2005-2008, while a Heartland report from 2009 explains that burns occurred in only 2005 and 2008 (James and Rowell 2009). The PDF map created by HTLN in 2009 shows multiple burns over several units between 2005 and 2008, but does not coincide with the other two reports. However, because HTLN is the official monitoring entity associated with GWCA, their report will be considered authoritative. GWCA could consider employing a seasonal technician, a qualified Volunteer In Parks (VIP) volunteer, and/or a Student Conservation Association intern for intensive in-park inventories.

One major objective of the recommendations to be presented to park management is to provide a means for current employees with historic interpretation backgrounds to be able to evaluate habitat for future management decisions without needing an extensive scientific background. The park does not currently retain a park biologist, and has not since Barry Jones left the park in 1997. Another important aspect is to provide the means to develop a monitoring plan that can be completed with the same goals. Habitat suitability index (HSI) models provide a quantitative means for both management decisions and prairie structure monitoring. Perhaps the most important goal for management moving forward is to develop a uniform system for management, monitoring, and documentation that gains the support of all levels of park staff, from National Park Service administration to the workers performing the management techniques. Management recommendations from this study will look to address these concepts from the perspective of the current GWCA staff. However, if a natural resources professional is hired in the future, he or she will be able to interpret data collected by these methods. Data can be used in tandem with more species-specific monitoring performed by the Heartland Network, which performs monitoring and inventory duties, and may afford a more efficient usage of NPS resources.

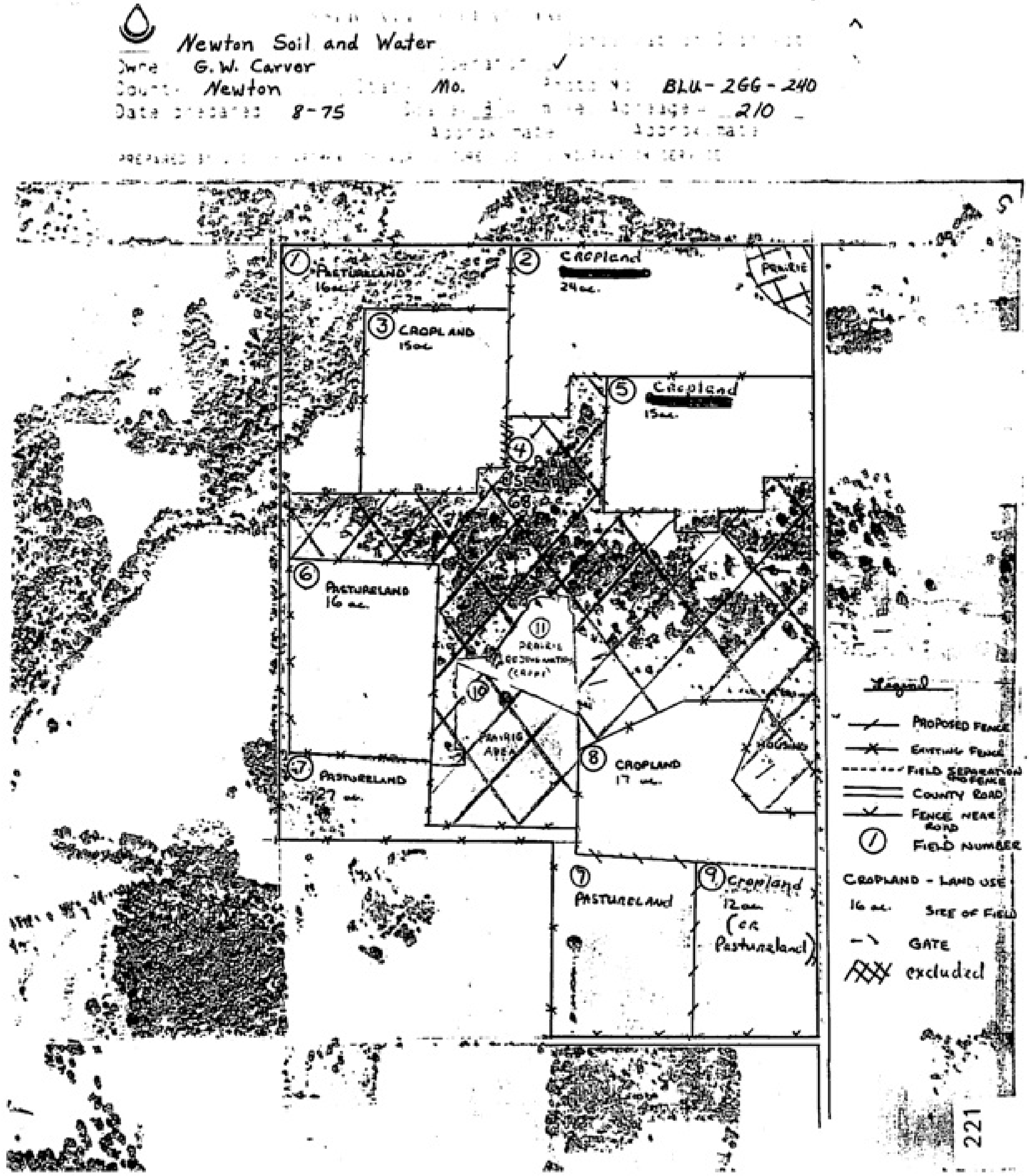


Figure 1: 1975 Map of GWCA landscape

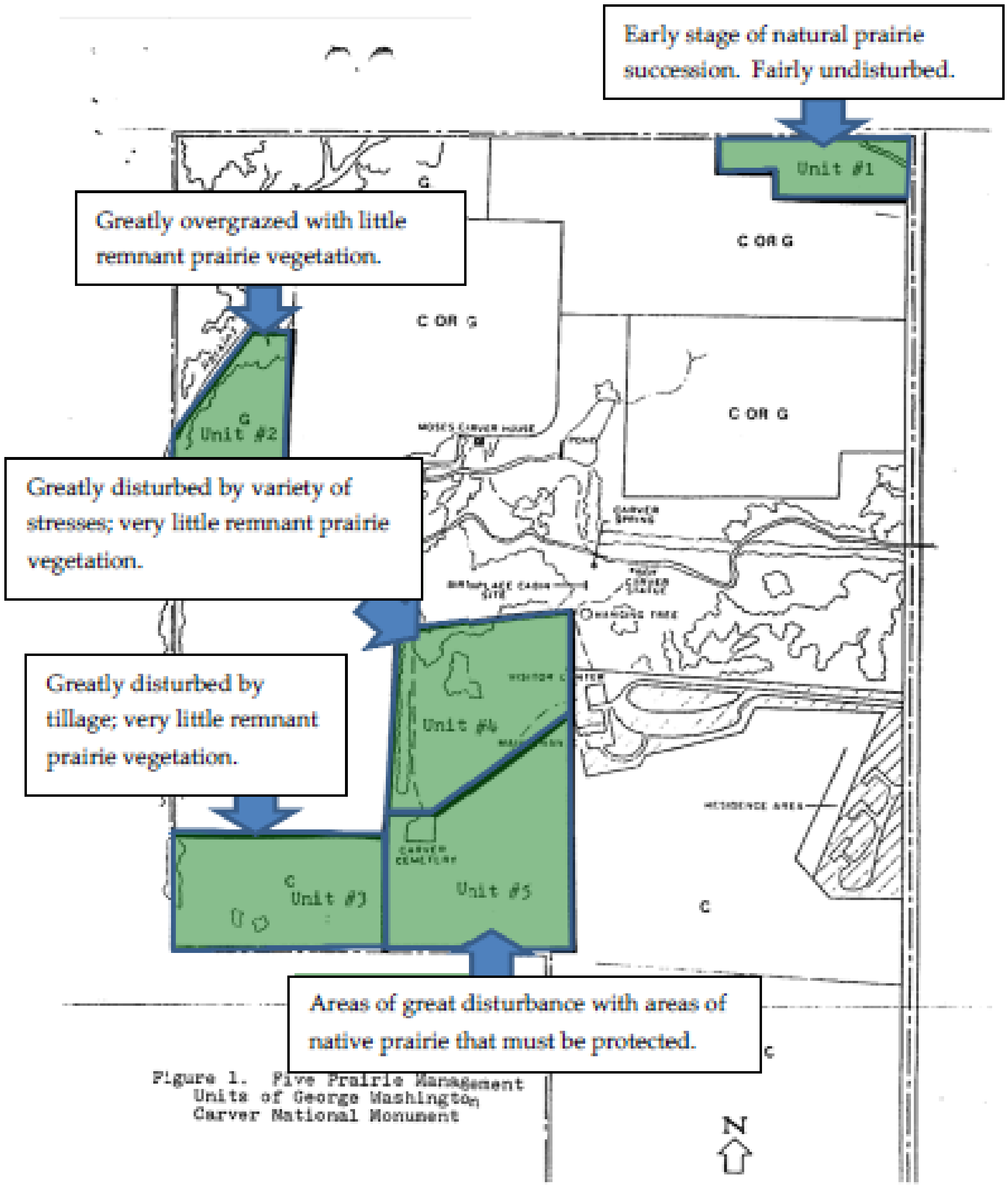


Figure 2: 1982 Map of the Prairie Management Units at GWCA

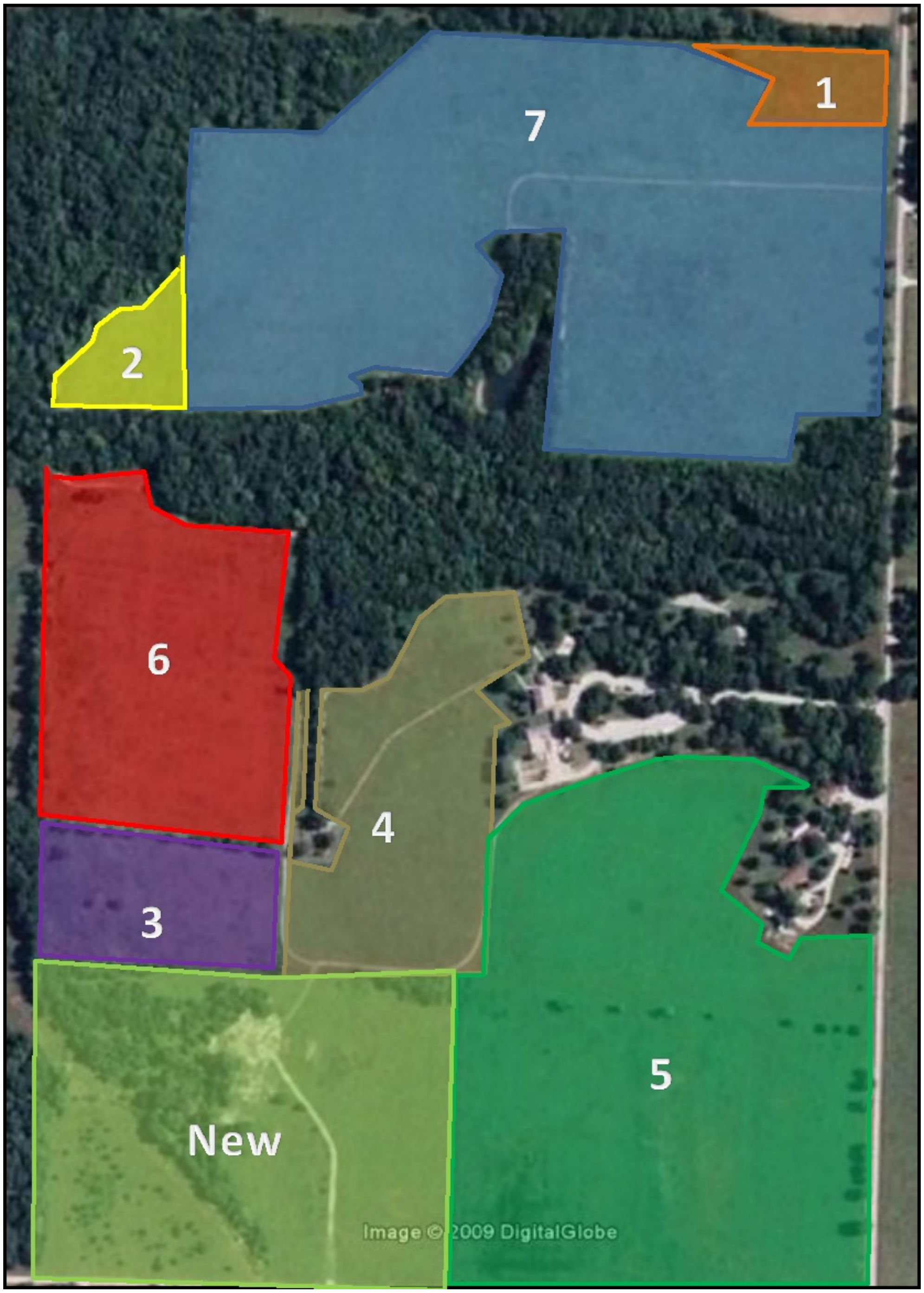


Figure 3: 1990 Map of the Prairie Management Units at GWCA

Appendix 1: Management Action History at GWCA

The following Excel spreadsheets summarize management actions that have been completed at GWCA between 1982 and 2010. This format of recording management actions could be continued by park staff to create a simple and effective long-term recordkeeping system. The 1982 Management Units correspond with Figure 2 and the 1990 Management Units correspond with Figure 3. Where applicable, the 1990 Management Unit spreadsheets include management performed in those units under the 1982 alignment, providing a complete history of management for those units.

Management Methods and Dates for Management Unit #1 (1982-1989 Map)

Year	Prescribed Fire	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Agricultural/Historic Lease	Date	Other	Date
1982	Prescribed after bluegrass greened up to reduce cool season grass competition and stimulate existing warm season grasses	3/24/1982	Used to control weed growth. Eastern portion mowed to 6".	7/3/1982	Overseeding of native grass and forb seed (using Truax Drill) to increase percentage of native grasses within stand.	5/10/1982	Mechanical removal and cutting of woody species and poke *Phytolacca americana* on raised portion of western section. Then, frequent observation of woody sprout growth from remaining rootstock.	Early 1982				
			Western portion mowed to 10".	8/1/1982								
1983	Prescribed burn to reduce cool season grasses.	3/31/1983	Western half of unit mowed to 6".	6/2/1983	Western portion reseeded using MDC Truax Drill.	5/13/1983-5/14/1983	Selective hand cutting of smooth sumac, locust, and pokeberry.	7/23/1983 and 8/6/1983				
1984			Western portion mowed to 6"	6/1/1984	Forbs from Swem study established	4/23/1984	Selective hand cutting of smooth sumac, locust, and pokeberry.					
					Indian Paintbrush from roadside established	5/30/1984						
					Chism contract 1000 forbs	6/9/1984-6/10/1984						
1985							Selective hand cutting of smooth sumac, locust, and pokeberry.					
1986			Eastern portion mowed to 12"	5/21/1986			Selective hand cutting of smooth sumac, locust, and pokeberry.					
1987			Entire unit mowed to 12"	7/15/1987			Selective hand cutting of smooth sumac, locust, and pokeberry.					
1988			Entire unit mowed to 12"	6/9/1988			Selective hand cutting of smooth sumac, locust, and pokeberry.					
			Entire unit mowed to 12"	7/20/1988			Selective hand cutting of smooth sumac, locust, and pokeberry.					
1989	Prescribed burn to reduce cool season grasses.	4/5/1989	Entire unit mowed to 12"	6/19/1989			Selective hand cutting of smooth sumac, locust, and pokeberry.					

Management Methods and Dates for Management Unit #2 (1982-1989 Map)

Year	Prescribed Fire	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Agricultural/Historic Lease	Date	Other	Date
1982			Rotary mowed to 8-10" to remove weed cover and allow native grasses to grow.	Aug-92	Light disking and seeding initiated using MDC Truax Drill	May-82	Removal of a small number of young invading trees	1982	Grazing (agricultural)	1982	Plowed unit	1982
1983					Reseeded using MDC Truax Drill. Adverse climactic conditions in 1982 caused some areas to be lost to invading weeds.	5/13/1983-5/14/1983			Grazing (agricultural)	1982		
1984	Prescribed Fire	4/24/1984			Indian Paintbrush from roadside established	5/30/1984						
					Contract for 600 forbs	6/9/1984-6/10/1984						
1985			Mowed	Aug-85								
1986												
1987			Entire unit mowed to 12"	May-87								
			Entire unit mowed to 12"	Jul-87								
1988			Entire unit mowed to 12"	6/9/1988								
			Entire unit mowed to 12"	8/4/1988								
1989	Prescribed Fire	4/5/1989	Entire unit mowed to 12"	6/19/1989								
1990												
1991	Prescribed Fire	Spring 1991									Hayed unit.	Jul-91
1992											Hayed unit.	Jul-92
1993*	Prescribed Fire	11/15/1993-11/30/1993			Forbs	11/15/1993-11/30/1993	Woody species removal	8/1/1993-8/30/1993			Applied Fear (with application of Roundup after first heavy fall frost) for fescue, and Soho for Johnsongrass	6/20/1993-7/10/1993
1994	Prescribed Fire	Dec-94			Seeded grass (mix?)	Dec-94						
					Seeded forbs (mix? #?)	Dec-94						

Management Methods and Dates for Management Unit #3 (1982-1989 Map)

Year	Burning	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Agricultural/Historic	Date	Other	Date
1982	Upper section burned to impact cool season grasses and prepare ground for seeding. Lack of heavy ground cover limited burn to sparse patches.	3/24/1982			Shallow disking and reseeding (using MDC Truax Drill) of upper dry mesic portion initiated.	Spring 1982; after 3/24	Lower portion plowed to remove fescue growth. Later evaluation showed this had limited success.	1982			Fence removed between MU3 and MU5.	None.
							Rocks removed from unit.	Spring 1982				
							Hand cutting of woody species in upper portion.	1982				
1983	Prescribed burn in upper portion to reduce growth of cool season grasses.	3/31/1983	Upper portion mowed to 10-12".	6/30/1983			Hand cutting of woody species in upper portion.	1983			Roundup herbicide applied to lower portion.	7/23/1983
1984	Prescribed burn in upper portion to reduce growth of cool season grasses.	4/24/1984			Indian paintbrush from roadside established.	5/30/1984	Hand cutting of woody species in upper portion.	1984			Plowed unit.	Apr-84
					Lower portion hand seeded.	6/6/1984					Disked unit.	Apr-84
					Contract for 1200 forbs.	6/9/1984-6/10/1984					Roundup herbicide applied to lower portion to eliminate fescue.	5/24/1984-5/25/1984
1985			Upper portion mowed to 10-12".	Jun-85								
1986			Lower portion mowed to 12".	9/15/1986								
1987			Lower portion mowed to 12".	Jul-87								
1988			Upper portion mowed to 12".	6/15/1988	Lower portion seeded with native warm season grasses (big bluestem, little bluestem, switch grass, and Indian grass).	5/16/1988-5/17/1988						
			Lower portion mowed to 12".	6/21/1988	Lower portion 200 forbs.	5/28/1988						
			Upper portion mowed to 12".	8/2/1988								
			Lower portion mowed to 12".	8/2/1988								
1989												

Management Methods and Dates for Management Unit #4 (1982-1989 Map)

Year	Prescribed Fire	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Agricultural/Historic	Date	Other	Date
1982	Prescribed after bluegrass greened up to reduce cool season grass and woody species competition, remove organic matter to facilitate reseeding, and to stimulate existing warm season grasses	3/24/1982			Shallow disking and reseeding using MDC Truax Drill.	5/10/1982						
1983	Successful prescribed burn to reduce cool season grasses and promote growth of native grasses.	3/31/1983	Eastern portion mowed.	6/24/1983	Eastern portion seeded.	5/13/1983-5/14/1983						
					Seeding for forbs.	Jul-83						
1984	Western portion prescribed burn.	3/31/1984	Haying eastern portion.	5/31/1984								
1985					Upper portion seeded for grasses.	May-85					Applied herbicide.	6/11/1985
											Applied herbicide.	6/22/1985
1986			Northeast portion mowed.	9/22/1986-9/26/1986	Planted forbs (lead plant, white prairie clover, compass plant, royal catchfly, and blazing star)	5/28/1986-5/31/1986						
1987			Mowed to 12".	May-87								
			Mowed to 12".	Jul-87								
1988	Prescribed burn.	4/13/1988	Mowed to 12".	5/4/1988								
			Mowed to 12".	6/13/1988								
			Mowed.	7/29/1988								
1989			Mowed to 12".	6/14/1989								

Management Methods and Dates for Management Unit #5 (1982-1989 Map)

Year	Prescribed Fire	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Agricultural/Historic	Date	Other	Date
1982	Prescribed after bluegrass greened up to reduce cool season grass and woody species competition, remove organic matter to facilitate reseeding, and to stimulate existing warm season grasses	3/24/1982			Shallow disking and reseeding using MDC Truax Drill.	5/10/1982	Hand cutting of sumac.	1982			Removed fence separating MU5 from MU3 and interior lane fence running along west boundary of MU5.	None.
											Disked unit.	Spring 1982
1983	Successful prescribed burn to reduce cool season grasses and promote growth of native grasses.	3/31/1983	Northeast corner mowed to 6" to reduce impact of cool season grasses.	6/24/1983	Northeast corner experienced rapid growth of cool season grasses, which heavily impact newly seeded native species. Reseeded using MDC Truax Drill.	5/13/1983-5/14/1983	Selective hand cutting of smooth sumac and poke.	7/23/1983			Individual grasses and forbs transplanted from county road beds to northeastern corner.	None.
					Roadside forbs transplanted.	7/23/1983					Wick herbicide application.	6/1/1983
											Wick herbicide application.	8/10/1983
1984			Mowed sumac areas.	6/1/1984	Forbs established.	4/23/1984	Hand cutting of sumac.	1984			Wick herbicide application.	5/24/1984
					Indian paintbrush from roadside established.	5/30/1984						
					Contract for 1800 forbs.	6/9/1984-6/10/1984						
					Roadside shooting star transplanted.	6/23/1984						
1985					Forbs transplanted.	Summer 1985	Hand cutting of sumac.	1985			Wick herbicide application.	6/18/1985
1986			Mowed.	9/22/1986-9/26/1986			Hand cutting of sumac.	1986				
1987			Mowed to 12".	May-87			Hand cutting of sumac.	1987				
			Mowed to 12".	Jul-87								
1988	Prescribed burn.	4/13/1988	Mowed to 12".	5/17/1988-5/18/1988								
			Mowed.	8/1/1988								
1989			Mowed to 12".	6/15/1989								

Management Methods and Dates for Management Unit #1 (1990 Map)

Year	Prescribed Fire	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Other	Date
1990										
1991	Prescribed burn to reduce cool season grasses.	Spring 1991							Hayed unit.	Jul-91
1992									Hayed unit.	Jul-92
1993										
1994	Prescribed burn to reduce cool season grasses.	Apr-94							Herbicide applied.	1994
1995										
1996										
1997	Prescribed burn.	3/6/1997								
1998	Prescribed burn.	9/29/1998								
1999										
2000	Prescribed burn.	3/28/2000								
2001										
2002										
2003										
2004										
2005	Prescribed burn.	4/24/2005								
2006										
2007	Prescribed burn.	4/3/2007								
2008										
2009			Mowed to 6".	Fall 2009						
2010										

Management Methods and Dates for Management Unit #2 (1990 Map)

Year	Prescribed Fire	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Other	Date
1990										
1991	Prescribed Fire	Spring 1991							Hayed unit.	Jul-91
1992									Hayed unit.	Jul-92
1993	Prescribed Fire	11/15/1993-11/30/1993			Forbs	11/15/1993-11/30/1993	Woody species removal	8/1/1993-8/30/1993	Applied Fear (with application of Roundup after first heavy fall frost) for fescue, and Soho for Johnsongrass	6/20/1993-7/10/1993
1994	Prescribed Fire	Dec-94			Seeded grass (mix?)	Dec-94				
					Seeded forbs (mix? #?)	Dec-94				
1995										
1996										
1997										
1998										
1999	Prescribed burn.	3/30/1999								
2000										
2001										
2002										
2003										
2004										
2005	Prescribed burn.	4/24/2005								
2006										
2007	Prescribed burn.	4/3/2007								
2008										
2009			Mowed to 6".	Fall 2009						
2010							Cut stump sumac removal, prep for herbicide.	Summer 2010	Wand-spray Pasturegard.	Summer 2010

Management Methods and Dates for Management Unit #3 (1990 Map)

Year	Burning	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Other	Date
1990	Presribed burn to reduce growth of cool season grasses.	Spring 1990								
1991	Presribed burn to reduce growth of cool season grasses.	Spring 1991								
1992									Hayed eastern portion of unit.	Jul-92
1993										
1994	Prescribed burn in upper portion to reduce growth of cool season grasses.	Apr-94								
1995										
1996										
1997	Prescribed burn.	3/6/1997								
1998										
1999	Prescribed burn.	3/30/1999								
2000										
2001										
2002										
2003										
2004										
2005	Prescribed burn.	Apr-05								
2006	Prescribed burn.	3/25/2006								
2007										
2008	Prescribed burn.	4/21/2008								
2009			Mowed to 6".	Fall 2009						
2010	Prescribed burn.	9/22/2010								

Management Methods and Dates for Management Unit #4 (1990 Map)

Year	Prescribed Fire	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Other	Date
1990	Prescribed burn.	Spring 1990								
1991	Prescribed burn.	Spring 1991							Hayed unit.	Jul-91
1992										
1993							Selective hand-cutting of woody invasives.	1993		
1994	Prescribed burn.	Apr-94								
1995										
1996										
1997										
1998	Prescribed burn.	9/29/1998								
1999										
2000										
2001										
2002										
2003										
2004										
2005	Prescribed burn.	4/24/2005								
2006	Prescribed burn.	3/25/2006								
2007	Prescribed burn.	4/3/2007								
2008										
2009			Mowed to 6".	Fall 2009						
2010	Prescribed burn.	9/22/2010			Seeded with native forbs.	Summer/ Fall 2010				

Management Methods and Dates for Management Unit #5 (1990 Map)

Year	Prescribed Fire	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Agricultural/Historic Lease	Date	Other	Date
1982									Agricultural lease (grazing).	1982		
1983									Agricultural lease (grazing).	1983		
1984									Historic Lease (cropping).	1984		
1985									Historic Lease (cropping).	1985		
1986									Historic Lease (cropping).	1986		
1987									Historic Lease (cropping).	1987		
1988									Historic Lease (cropping).	1988		
1989									Historic Lease (cropping).	1989		
1990			Mowed.	Summer 1990	Disk and seed.	1990						
1991			Mowed.	May/June 1991								
1992	Attempted prescribed burn.	Apr-92	Mowed SW corner.	5/7/1992-5/8/1992	Seeded northern half and SE quarter.	Apr-92						
1993			Mowed.	Jun-93	Seeded southeast and southwest sections.	Apr-93					Applied herbicide.	1993
1994							Selective hand cutting of woody and exotic species.	1994				
1995	Prescribed burn.	2/22/1995										
1996												
1997	Prescribed burn.	3/6/1997										
1998												
1999												
2000	Prescribed burn.	3/28/2000										
2001												
2002												
2003												
2004												
2005	Prescribed burn.	Apr-05										
2006	Prescribed burn.	3/25/2006										
2007												
2008	Prescribed burn.	4/21/2008										
2009			Mowed to 6".	Fall 2009								
2010	Prescribed burn.	9/22/2010										

Management Methods and Dates for Management Unit #6 (1990 Map)

Year	Prescribed Fire	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Agricultural/Historic Lease		Other	Date
1982	Prescribed burn.	3/24/1982			Initial seeding.	5/10/1982	Selective hand cutting of woody and exotic species.	1982	Historic Lease (cropping).	1982	Disked unit.	Spring 1982
					Contract for 400 forbs.	6/9/1982-6/10/1982						
1983	Prescribed burn.	3/31/1983					Selective hand cutting of woody and exotic species.	1983	Historic Lease (cropping).	1983		
1984							Selective hand cutting of woody and exotic species.	1984	Historic Lease (cropping).	1984		
1985			Mowed.	Jul-85	Seeded unit for grass.	May/June 1985	Selective hand cutting of woody and exotic species.	1985			Herbicide applied.	1985
1986			Mowed.	Sep-86	Planted forbs (lead plant, white prairie clover, compass plant, royal catchfly, and blazing star).	5/28/1986-5/31/1986	Selective hand cutting of woody and exotic species.	1986				
1987			Mowed to 12".	May-87	Seeded eastern portion of unit for grass.	Apr-87	Selective hand cutting of woody and exotic species.	1987	Historic Lease (cropping).	Fall 1987	Plowed and disked unit.	Apr-87
			Mowed to 12".	Jul-87	Seeded unit for forbs.	April/June 1987						
1988			Mowed.	May-88	Seeded unit for grass and forbs.	May-88	Selective hand cutting of woody and exotic species.	1988				
1989	Prescribed burn.	4/5/1989	Mowed to 12".	6/13/1989			Selective hand cutting of woody and exotic species.	1989				
			Mowed to 12".	10/3/1989								
1990	Attempted prescribed burn.	Spring 1990										
1991					Seeded unit.	1991					Plowed unit.	1991
1992	Attempted prescribed burn.	Mar-92	Mowed.	Jun-92								
1993							Selective hand cutting of woody and exotic species.	1993				
1994												
1995	Prescribed burn.	2/22/1995										
1996												
1997	Prescribed burn.	3/6/1997										
1998												
1999	Prescribed burn.	3/30/1999										
2000												
2001												
2002												
2003												
2004												
2005	Prescribed burn.	Apr-05										
2006	Prescribed burn.	3/25/2006										
2007												
2008	Prescribed burn.	4/21/2008										
2009			Mowed to 6".	Fall 2009								
2010	Prescribed burn.	9/22/2010										
2011												

Management Methods and Dates for Management Unit #7 (1990 Map)

Year	Prescribed Fire	Date	Mowing	Date	Seeding	Date	Mechanical	Date	Agricultural/Historic Lease	Date	Other	Date
1982									Historic Lease (cropping)	1982	Plowed/Disked unit.	1982
1983									Historic Lease (cropping)	1983		
1984									Historic Lease (cropping)	1984		
1985			Mowed. (MU9)	1985	Seeded for grass. (MU9)	May-85					Plowed/Disked unit. (MU9	May-85
											Applied Herbicide. (MU9)	1985
1986									Historic Lease (cropping)	1986		
1987			Seeded eastern portion fo	May-87					Historic Lease (cropping) (	Fall 1987	Plowed/Disked unit. (MU9	Apr-87
1988	Prescribed burn. (MU9)	Apr-88	Mowed. (MU9)	Aug-88	Seeded for grass and forbs (MU9)	May-88			Historic Lease (cropping)	1988		
1989	Prescribed burn. (MU9)	Apr-89	Mowed.	Jul-89	Seeded for grass. (North MU9)	Mar-89			Historic Lease (cropping)	1989	Plowed/Disked unit. (Nort	Mar-89
1990	Prescribed burn on wester	Spring 1990	Mowed all but northeast s	Summer 1990	Seeded eastern section for grass.	1990					Plowed/Disked western pc	Summer 1990
1991	Prescribed burn on easter	Mar-91	Mowed.	May/June 1991								
1992	Prescribed burn on wester	Mar-92	Mowed all but southeast s	Jun-92	Seeded all but southeastern section for grass.	Apr-92						
1993			Mowed.	Jun-93	Seeded southeastern section for grass.	Apr-93	Selective hand-cutting of woody and non-native species.	1993				
1994	Prescribed burn on easter	Apr-94					Selective hand-cutting of woody and non-native species.	1994				
1995												
1996												
1997	Prescribed burn.	3/6/1997										
1998												
1999												
2000	Prescribed burn.	3/28/2000										
2001												
2002												
2003												
2004												
2005	Prescribed burn.	Apr-05										
2006												
2007	Prescribed burn.	4/3/2007										
2008												
2009			Mowed to 6".	Fall 2009								
2010			Brush hogged eastern half twice to 4-6 inches.	July and August 2010			Cut stump sumac removal, prep for herbicide. (Center section of MU 7)	Summer 2010			Foliar herbicide spray (Round-up and Pasturegard). (Westernmost section of MU 7)	Summer 2010
2011	Prescribed burn?											

CHAPTER 3: METHODS, RESULTS, AND DISCUSSION

Introduction

HSI data and indicator species presence were collected via the methods described in the next section. Limiting factors, or the features that need to be improved through management, are recognized as those with the lowest HSI scores. Management actions are then identified to address these limiting factors and other factors observed while scoring prairie units.

Habitat Suitability Index Models

An HSI model measures a set of variables that relate to the suitability of a particular site for the species in question, based on reviews of literature pertaining to the ecology and habitat requirements of the target species. Higher HSI scores are typically indicative of habitat that promotes reproductive success and survivorship. The dynamic contrast of varying levels of habitat quality can also be measured using this method (Burgman et al. 2001). HSI models also provide interdisciplinary teams a standardized method to inventory and monitor existing conditions, then to predict the effects of management actions based on how they will affect each characteristic score (Urich and Graham 1983).

The initial benefit of assessing habitat suitability is to create a baseline quantitative representation of habitat features. HSI models can be used to determine the factors that limit the use of GWCA's prairie units by the four indicator species: prairie vole (*Microtus ochrogaster*), ornate box turtle (*Terrapene ornata ornata*), northern bobwhite quail (*C. virginianus*), and Henslow's sparrow (*Ammodramus henslowii*). All of these species at least partially depend on prairie characteristics, and all are known to have occurred at GWCA (Harrington 1999, Trauth and McCallum 2003, Dietz 2009, Robbins 2005 respectively). All chosen indicator species except *M. ochrogaster* are subject to some level of management concern (BirdLife 2008a, Redder et al. 2006, BirdLife 2008b).

HSI models used in the first year of this study may need to be altered (i.e. adjusting possible score values, adding/subtracting characteristics) to provide optimal accuracy in habitat evaluation. In addition, the HSI models are not intended to be a predictor of species presence, but an evaluation of prairie unit physical structure. However, suitable habitat does not guarantee species presence (Urich and Graham 1983). This could be due to a variety of known or unknown factors.

Recommendations for future prairie management will be made using HSI models as a guide for management decisions. Our recommendations will be concentrated in wildlife habitat improvement, but will not directly address the species makeup (i.e. native vs. non-native) of the prairie plantings. However, they will address the physical characteristics that would be present in the optimal habitat for each indicator species. The management actions that will be used to address HSI limiting factors are the same as those typically used for prairie restoration and management. GWCA staff, the

Heartland Network, and the National Park Service have the ultimate responsibility of establishing management actions.

The Heartland Network has expressed interest in maintaining the prairies at GWCA using a “suite” of habitat types. For example, one section of the park could be used to promote Henslow’s sparrow habitat while another is used to promote bobwhite quail habitat. Because these two birds have very different habitat requirements, the intention would be to improve habitat for each in different sections of the park at a given time. This practice would obviously affect HSI scores in particular areas, but the steps taken to maintain these habitat features are simulating natural prairie succession. Conversely, the size of GWCA allows for “suites” to be maintained without causing too much habitat degradation for the other indicator species. For example, quail generally require all vegetation levels within a close proximity, from bare ground to established woodlands (Pierce and Gallagher 2005). Henslow’s Sparrows require at least 30 ha (~48 acres) of native grassland (Reinking et al. 2000). GWCA’s northern units (~36 ha or 57 acres) and southern units (~44 ha or 71 acres, not including unit 9), when grouped together, are capable of supporting habitats for each species, potentially even simultaneously.

By addressing low HSI scores, management actions can be prescribed and their effects on prairie structure over a given area can be predicted (Urich and Graham 1983). Species presence cannot necessarily be guaranteed or predicted using these models, but specific scores for each habitat feature can be obtained (except for distances to features that cannot be controlled by GWCA).

Presence

I am conducting a presence survey for my thesis to determine whether the indicator species are currently present at GWCA. Presence data will show where in the park species are using habitat and may provide some information about wildlife habitat and the success of management actions. The methods I used were developed so that GWCA may use them in the future to assess species presence of not only the indicator species, but any species that may be encountered using these methods. I have not compared the presence of indicator species with habitat suitability.

Methods

HSI Data Collection

The first step in evaluating the restoration program is to establish the status of existing habitat at the Monument. To do this, I have compiled HSI models to assess the availability of habitat for four indicator species: prairie vole (*Microtus ochrogaster*), ornate box turtle (*Terrapene ornata ornata*), northern bobwhite quail (*Colinus virginianus*), and Henslow's sparrow (*Ammodramus henslowii*). Using this method I have assessed existing prairie restoration conditions and identified limiting factors of habitat suitability for the indicator species.

The HSI models for the Henslow's sparrow and prairie vole are adapted from Baskett et al. (1980). The HSI model for northern bobwhite quail is adapted from a combination of Baskett et al. (1980) and Bidwell et al. (2009). Due to the lack of a previously published HSI model for the ornate box turtle, one was created for these recommendations combining information from reviewed literature (including Bernstein and Black 2005, Converse et al. 2002, Converse and Savidge 2003, Dodd 2001, Legler 1960, and Redder et al. 2006) and following the Fish and Wildlife Service's guidelines for habitat appraisal (USFWS 1980).

The locations of HSI plots were adapted from the latest Heartland Network Inventory and Monitoring GWCA bird monitoring status report (Pietz 2009). HSI data were collected between 22 June-8 July 2009 and 25 June-16 July 2010. A total of 70 permanent monitoring points or “plots” were established on the grounds of GWCA for point counts. According to the methods for site selection in the Heartland Network’s report, the plots were established “by overlaying a systematic grid of 100 x 100 meter cells (originating from a random start point). The orientation of the grid was rotated 45 degrees to prevent monitoring sites from being influenced by man-made features (roads, fences, etc.) located along cardinal directions” (Pietz 2009). Of the 70 established plots, eighteen are located in wooded areas, and were either moved if near a prairie unit edge or not evaluated in this study. After modifications there were 55 plots for 150 acres of grassland habitat (including the newly acquired 30 acres of fescue pasture). These plots were chosen for use in this study due to uniform spatial coverage of the grounds and to maintain continuity with Heartland Network Inventory and Monitoring reports. All waypoint coordinates were entered into a GPS unit for location then marked with temporary flags before data collection. Flags were collected at the conclusion of data collection.

To collect HSI data, I walked from the edge of each prairie unit to the marker (wooden stake with a red flag) designating each HSI plot. Then I would loop one end of a 10 m string over the end of the marker. This string would then be stretched out to its full length. I took a picture of each plot from its northernmost point, facing south. These pictures have been saved digitally for reference. Next, I explored the circle created by the radius of the 10 m string. I made observations on ground cover, what native warm season grasses were present, invasive species, forb cover, and any other notable features. Following the visual assessment, I completed the HSI models, making observations and taking measurements as necessary. I also took pictures of many forbs, grasses, and wildlife species for the purpose of identification and archiving important or unusual flora and fauna. When the HSI models were completed, I wrapped the string around my hand, made sure to collect all my equipment, and moved on to the next point. Each plot required approximately 15-30 minutes to complete.

HSI model features were scored on a scale of one to ten or one to five, one being the lowest, depending on the importance of the characteristic. When scoring for each plot was completed, the characteristic scores were entered into Microsoft Excel to be summed and divided by the maximum possible score to determine the overall HSI score for the plot. Scores range from 0.1 to 1.0, with 1.0 being optimum habitat. When all plots had been assessed, the scores for plots contained within each management unit were averaged to provide a score for the entire unit. The scores for each characteristic were also averaged for each species in each unit. This process identified factors that have helped determine proposed management actions for 2010 and 2011.

Characteristics

The actual HSI models used for data collection are included in Chapter 5, Appendix IV of my thesis. The following characteristics were scored for each indicator species (with maximum score in parentheses):

Henslow's Sparrow (40)

1. Average height of vegetation (10)
2. Diversity of vegetation heights (5)

3. Shade producing woody invasion (10)
4. Average litter depth (5)
5. Forb canopy (5)
6. Distance to water (5)

Prairie Vole (45)

1. Grass and forb cover (10)
2. Shade producing woody invasion (10)
3. Average litter depth (10)
4. Size of oldfield/grassland (5)
5. Number of important food plant species comprising more than 1% of total plants present (5)
6. Soil texture: internal drainage (5)

Ornate Box Turtle (35)

1. Availability of thermoregulatory cover (10)
2. Number of available food groups within 100 m (10)
3. Soil types (10)
4. Distance to water (5)

Northern Bobwhite Quail (70)

1. Distance from center of plot to nearest bare or sparsely vegetated ground (10)
2. Nesting cover quantity (10)
3. Grassland management practices (10)
4. Habitat Edge (10)
    a. Average width of habitat edge (5)
    b. Habitat edge surrounds (5)
5. Vegetative escape and concealment cover: shrubs and herbs (5)
6. Distance to cropland (10)
7. Distance to water (5)
8. Distance to forest (5)
9. Distance to oldfield (5)

Presence

Presence data were collected between 29 June-30 July 2009 and 30 June-30 July 2010. With this data I determined whether the four focal species occur in each of the eight established management units. When a species was present in a plot or trapping station, it received a score of one, regardless of the number encountered. When a species was absent, it received a score of zero. Collecting presence data provided an estimate for spatial distribution of each species. Because the focus of these recommendations was to improve physical habitat required for the presence of each species, collecting and analyzing data for abundance and density were not necessary. Therefore, all animals were released and not tagged. Other vertebrate species encountered in the drift fences and Sherman traps were recorded.

Ornate Box Turtle – Individuals of this species were encountered in management units 5 and 7 in a study published in 2003 (Trauth and McCallum), though occurrence was considered rare. To determine presence of *Terrapene o. ornata*, drift fences were erected in each unit and foot and vehicle searches were performed daily. Fences were placed in areas between the center of each management unit and a water source. Rolls of aluminum flashing either 7.62 m or 15.24 m long and between 25.4-50.8 cm tall were placed in a 10 cm deep by 10 cm wide trench dug with a Ground Hog T-4 operator propelled trencher. (Rocky and dry soil conditions in addition to time and labor constraints prevented us from being able to dig with shovels.) When the fence was in place, the trench was filled in on either side using the displaced soil. Construction was done in this manner to prevent small individuals from traveling under the fences.

In 2009, fences were installed to coincide with prairie vole Sherman trapping. One to three fences were erected per unit depending on unit size (with the exception of Unit 4 and Unit 9) and transferred when Sherman trap lines were relocated. Two 3-gallon buckets with modifications to protect animals from heat were placed at both ends and on either side of the drift fences as pitfalls. Each pitfall was checked and any captured animals were released in the morning and the evening. In 2010, one or two fences were erected in each unit (with the exception of Unit 9) between 30 June-1 July and monitored again twice daily until they were removed on 28 July. This improvement on 2009 was meant to increase data collection and decrease human impact as vegetation structure is regained through the season. All species found in pitfalls will be recorded for reference purposes, but not used in data analysis.

Foot and vehicular searches were performed any time volunteers and I were traveling in or to management units on site. A daily log was kept, and all occurrences of box turtles (including the three-toed box turtle, *Terrapene carolina*) were recorded. Volunteers taking part in bird surveys will also be encouraged to record any sightings of *Terrapene o. ornata* while moving between plots.

Prairie Vole – A study published in 2005 (Robbins) noted that 64 prairie voles were trapped using live Sherman traps, but distribution per management unit data was not available. For my study, methods were adopted from Nilon and Huckstep (1998). I set up a sampling transect with a random starting point along the long axis of each unit, with trapping stations set up in 30 m intervals. Trap stations consisted of five total traps 10 x 10 m square, with three traps placed along the transect line (one trap on center of square at 30 m interval mark, plus one trap 5 m away on either side). The number of trap stations varied based on the size of each management unit. There were five stations in Unit 1 (1.54 ha), five stations in Unit 2 (1.19 ha), seven stations in Unit 3 (1.74 ha), seven stations in Unit 4 (5.79 ha), thirteen stations in Unit 5 (15.79 ha), twelve stations in Unit 6 (6.07 ha), nineteen stations in Unit 7 (18.83 ha), and ten stations in Unit 9 (12.20 ha). Traps were set in each unit for five trap nights and checked the following morning within three hours of sunrise. Two management units per week were sampled between 29 June-24 July 2009 and 30 June-26 July 2010. In 2010, trap lines were set at the next longest axis or roughly perpendicular to the 2009 trap lines. All species found in Sherman live traps were recorded for reference purposes, but only *M. ochrogaster* was used in data analysis. Prairie voles are expected to be found sporadically in drift fence pitfalls.

Henslow's Sparrows and Northern Bobwhite Quail – Harrington et al. (1999) confirms that a breeding pair of Henslow's sparrows were observed onsite in 1995 as part of the monitoring program established by Barry Jones in the 1995 Prairie Restoration Action Plan. A series of bird surveys were conducted in the 1990s by Biological Technician Barry Jones and his crew. The survey showed *A. henslowii* for the first time on 17 April 1995 in the northeastern section of Subzone 7. Mr. Jones continued to "search diligently" throughout his employment, and survey records show that the bird was present through 1997 when the surveys ended. As many as five were observed on a single day three times (11 May 1995, 8 June 1995, and 13 June 1997) (GWCA Staff). In a recent study, Pietz (2009) reported that an average of 0.21 northern bobwhite individuals were encountered per each of the 70 study plots.

Methods similar to those presented in the bird monitoring protocol by Pietz et al. (2008) will be used in this study. Volunteers associated with GWCA, the Audubon Society, and/or Master Naturalists assisted during surveys. This survey is conducted by GWCA every year and was used in this project for data consistency. Observations for each plot were completed in five-minute sampling periods with volunteers documenting any of the two focal species seen or heard. Volunteers then traveled to the next study plot, documenting any encounters with the any of the four focal species on their way. A survey of this type was completed in both 2009 and 2010, though not all of the 70 plots were surveyed in either year. In 2010, two additional bird surveys were performed by walking the perimeter of the management units. All species and abundance of birds were recorded in both surveys, though the focus is on only *A. henslowii* and *C. virginianus*.

Results

Though a revised management zone alignment is being proposed to GWCA, HSI and presence data were collected under the 1990 Management Unit alignment, and results will be presented as such. Future data collection should account for the combination of these units should GWCA choose to use the new alignment.

HSI Scores

The following is a summary of HSI data for each species in each management unit. Scores of 0.01-0.50 are considered "limiting factors", scores of 0.51-0.75 are considered "intermediate factors", and scores of 0.76-1.00 are considered "optimum features". Limiting factors are features that need immediate attention in management. Intermediate factors are less urgent, but should be observed for negative trends. Optimal features are the positive features of habitat suitability that should be conserved. This ranking system was chosen to provide GWCA with a priority level for addressing prairie characteristics through management actions. Ideally, each characteristic should reach the optimum feature, except in the case where a management action temporarily lowers it. For example, performing a prescribed burn or haying will remove the litter layer for the following warm season's growth.

This section will provide a list of characteristics scored at each level and the corresponding table of management recommendations by unit, first for 2009, then for

2010. I provide a description for the limiting factors present in each unit to more specifically explain what caused the low score. The HSI score for each characteristic is in parentheses. Explanations of HSI scores are based on the respective HSI model development. The table of management recommendations lists the unit, indicator species, limiting factor, management action, and expected outcome for each limiting factor.

2010 GWCA Prairie Management Recommendations

2009 GWCA Management Unit #1

Limiting Factors

Henslow's Sparrow (Overall Score: 0.60): Shade producing woody invasion (0.10) indicates the invasion of sumac (*Rhus* spp.) throughout the unit. Forb canopy (0.20) indicates that little or no forb cover is available for food or song perches.

Prairie Vole (0.49): Grass and forb cover (0.10) refers again to the invasion of sumac in Unit 1. Both are important food species for prairie voles. Shade producing woody invasion (0.10) is related to sumac invasion. Prairie voles avoid woody vegetation (Schwartz and Schwartz 2001). Food plant species (0.40) shows low vegetative diversity.

Ornate Box Turtle (0.71): Available food groups (0.50) are an indicator of biodiversity. This characteristic includes several food sources (grasses, legumes, fruit, etc.) due to the omnivorous nature of this species. (See HSI model in Appendix I.) Distance to water (0.40) cannot be altered, but is included for assessing habitat quality.

Northern Bobwhite Quail (0.69): Nesting cover quantity (0.30) indicates the percentage of warm season grasses in the unit, and is affected by the sumac invasion. Grassland management (0.20) refers to grass and forb cover, which provide cover and food for this species.

Intermediate Factors

Henslow's Sparrow: Average litter depth (0.60).

Northern Bobwhite Quail: Distance to oldfield (0.60)

Optimum Features

Henslow's Sparrow: Average height of vegetation (1.00); diversity of vegetation heights (1.00); distance to water (0.80).

Prairie Vole: Average litter depth (0.80); size of grassland (1.00); soil texture (1.00).

Ornate Box Turtle: Thermoregulatory cover (0.80); soil type (1.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (1.00); habitat edge (1.00); vegetative escape and concealment cover (1.00); distance to water (1.00); distance to forest (1.00).

Recommendation for 2010: Follow recommendations of Heartland Network for sumac control. Perform prescribed burn in spring 2010.

Table 2: 2010 Management Recommendations for Management Unit 1.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
1	Henslow's Sparrow	Shade producing woody invasion	Follow HTLN sumac control recommendations. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
1	Henslow's Sparrow	Forb canopy	Seed with native forb mix from local seed distributor. May postpone in areas where sumac is being treated.	Increase forb cover and diversity.
1	Prairie Vole	Grass and forb cover	Perform prescribed burn in 2011. Seed native grass and forbs into areas of low cover.	Increase NWSG and forb cover.
1	Prairie Vole	Shade producing woody invasion	Follow HTLN sumac control recommendations. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
1	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor. May postpone in areas where sumac is being treated.	Increase forb cover and diversity.
1	Ornate Box Turtle	Available food groups	Seed with native forb mix from local seed distributor. May postpone in areas where sumac is being treated.	Increase forb cover and diversity.
1	Northern Bobwhite Quail	Nesting cover quantity	Follow HTLN sumac control recommendations. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
1	Northern Bobwhite Quail	Grassland management	Perform prescribed burn in 2011.	Increase NWSG and forb cover.

The most important action to be taken in Unit 1 is to control the invasion of smooth sumac (*Rhus glabra*) and winged sumac (*Rhus copallinum*). Several limiting factors from HSI data can be addressed if sumac cover decreases. Sumac is responsible for high levels of woody invasion, and was observed in the field to shade out native prairie grasses and forbs. It also decreases diversity of grasses and forbs. Food availability and nesting structure are strongly affected by these factors. As grasses are driven out, litter from the previous season's growth is unavailable.

The recommendations of the Heartland Network for sumac control will be effective in addressing these factors. It is also recommended that park staff only mow in the areas that sumac is currently growing to allow flowering of native species. Management Unit 1 may soon be combined with units 2 and 7 to create Zone 1. It may be managed to provide diversity in habitat features, which is a requirement of Northern Bobwhite (Pierce and Gallagher 2005). For example, it could be burned in a separate from current Management Unit 7 to provide bare ground for foraging.

When sumac cover is under control, the next step will be to establish greater cover and diversity of native grasses and forbs. I have recommended to GWCA the development of a Visitor Viewshed to surround Carver Trail north and south of the Carver Woods. The Visitor Viewshed will increase the cover and diversity of native grasses and forbs in the area immediately visible from the walking trail. This should also provide a natural seed bank for spreading these species to other areas of the surrounding Zones.

Johnsongrass in this unit should be controlled using Plateau herbicide (Kansas Department of Agriculture 2006). Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

2009 GWCA Management Unit #2

Limiting Factors

Henslow's Sparrow (0.79): Average litter depth (0.40) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and nest building.

Prairie Vole (0.69): Food plant species (0.40) shows low vegetative diversity. Soil drainage (0.40) indicates that soil is not sandy enough for digging runways, but cannot be easily changed.

Ornate Box Turtle (0.76): Soil type (0.40) is not easily managed, but means that soil is not suitable for digging forms (burrows) used for nesting, hibernating, or escape from weather conditions.

Northern Bobwhite Quail (0.82): Distance to cropland (0.50) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Henslow's Sparrow: Diversity of vegetation height (0.70); shade producing woody invasion (0.75); forb canopy (0.70).

Prairie Vole: Shade producing woody invasion (0.75); average litter depth (0.60).

Optimum Features

Henslow's Sparrow: Average height of vegetation (1.00); distance to water (1.00).

Prairie Vole: Grass and forb cover (0.85); size of grassland (1.00).

Ornate Box Turtle: Thermoregulatory cover (0.90); available food groups (0.85); distance to water (1.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (1.00); nesting cover quantity (0.90); grassland management (0.90); habitat edge (1.00); vegetative escape and concealment cover (0.90); distance to water (1.00); distance to forest (1.00); distance to oldfield (1.00).

Recommendation for 2010: Perform prescribed burn in spring 2010. Monitor woody species invasion. Spot application of Roundup herbicide for sericea lespedeza (*lespedeza cuneata*).

Table 3: 2010 Management Recommendations for Management Unit 2.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
2	Henslow's Sparrow	Average litter depth	Perform prescribed burn in spring 2010.	Eliminate woody encroachment from Carver Woods; promote growth of NWSG to provide suitable litter layer in 1-2 years. Recycle nutrients.
2	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor (optional for 2010). Perform prescribed burn.	Improve native plant species cover and diversity.

Based on HSI data, the main limiting factors that could be addressed are litter depth and diversity of plant species. Litter depth will vary based on management from the previous year, and should be controlled as an extension to the much larger Unit 7.

It is recommended that Unit 2 be part of a prescribed burn in 2010. This would help to control encroaching woody invasion from Unit 7 and Carver Woods. It would also promote native warm season grass cover and address areas with too much litter.

Spot herbicide application of Roundup is an effective control for sericea lespedeza. Care must be taken to avoid non-target killing of native plants near lespedeza (MDC 1997). Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

2009 GWCA Management Unit #3

Limiting Factors

Henslow's Sparrow (0.61): Forb canopy (0.30) indicates that little or no forb cover is available for food or song perches. Distance to water (0.30) cannot be altered, but is included for assessing habitat quality.

Prairie Vole (0.64): Food plant species (0.40) shows low vegetative diversity. Average litter depth (0.50) means that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and for voles to construct their runway networks and nests.

Ornate Box Turtle (0.83): Distance to water (0.40) cannot be altered, but is included for assessing habitat quality.

Northern Bobwhite Quail (0.74): Distance to cropland (0.20) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Henslow's Sparrow: Average vegetation height (0.75); shade producing woody invasion (0.60).

Prairie Vole: Grass and forb cover (0.60); shade producing woody invasion (0.60).

Optimum Features

Henslow's Sparrow: Diversity of vegetation height (0.80); average litter depth (0.80).

Prairie Vole: Size of grassland (1.00); soil texture (1.00).

Ornate Box Turtle: Thermoregulatory cover (0.90); available food groups (0.80); soil type (1.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (1.00); nesting cover quantity (0.85); grassland management (0.80); habitat edge (0.80); vegetative escape and concealment cover (1.00); distance to water (0.80); distance to forest (1.00); distance to oldfield (1.00).

Recommendation for 2010: Follow the Heartland Network's recommendations for sumac control for mowed units. Perform a prescribed burn in 2011.

Table 4: 2010 Management Recommendations for Management Unit 3.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
3	Henslow's Sparrow	Forb canopy	Follow HTLN recommendations for sumac control including mowing. Seed with native forb mix from local seed distributor (optional for 2010).	Reduce sumac cover and allow forb canopy to cover more area.
3	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor (optional for 2010).	Improve diversity and cover of native species.
3	Prairie Vole	Average litter depth	Follow HTLN recommendations for sumac control including mowing.	Improve litter depth for prairie vole nests and runways. Recycle nutrients lost from haying.

Limiting factors for this unit include forb canopy cover and lack of plant diversity. These two factors are related. There are some areas lacking in grass and forb cover, which appear to be due to stress from haying implements. This is visible from tire tracks and straight lines of bare ground through the unit. There are also some areas being affected by sumac invasion.

The Heartland Network's recommendations for sumac removal should be applied to this unit. However, sumac does not dominate large tracts as it does in Unit 1 or Unit 7. It is mixed throughout grass cover, and extreme care should be taken with any herbicide application. It is recommended that this unit be mowed for sumac control, but not burned in 2010. Areas not affected by sumac should be allowed to grow to flowering height.

Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

2009 GWCA Management Unit #4

Limiting Factors

Henslow's Sparrow (0.59): Shade producing woody invasion (0.43) indicates the invasion of sumac throughout the unit. Average litter depth (0.50) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and nest building. Distance to water (0.35) cannot be altered, but is included for assessing habitat quality.

Prairie Vole (0.66): Shade producing woody invasion (0.43) Shade producing woody invasion (0.10) is related to sumac invasion. Prairie voles avoid woody vegetation (Schwartz and Schwartz 2001). Food plant species (0.40) shows low vegetative diversity.

Ornate Box Turtle (0.86): Distance to water (0.45) cannot be altered, but is included for assessing habitat quality.

Northern Bobwhite Quail (0.70): Distance to cropland (0.23) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Henslow's Sparrow: Average vegetation height (0.75); forb canopy (0.65).

Prairie Vole: Grass and forb cover (0.63); average litter depth (0.73).

Northern Bobwhite Quail: Grassland management (0.75); habitat edge (0.60).

Optimum Features

Henslow's Sparrow: Diversity of vegetation height (0.85).

Prairie Vole: Size of grassland (1.00); soil texture (1.00).

Ornate Box Turtle: Thermoregulatory cover (1.00); available food groups (0.80); soil type (1.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (1.00); nesting cover quantity (0.80); vegetative escape and concealment cover (1.00); distance to water (0.85); distance to forest (0.90); distance to oldfield (0.85).

Recommendation for 2010: Follow the Heartland Network's recommendations for sumac control for mowed units. Possibly perform a prescribed burn in 2011.

Table 5: 2010 Management Recommendations for Management Unit 4.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
4	Henslow's Sparrow	Shade producing woody invasion	Follow HTLN sumac control recommendations for mowed units. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
4	Henslow's Sparrow	Average litter depth	Mow areas where sumac is growing. Allow to rest where it is not. Prescribed burn in 2011.	Goal is to reduce sumac cover and provide suitable litter depth by 2012.
4	Prairie Vole	Shade producing woody invasion	Follow HTLN sumac control recommendations. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
4	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor (optional for 2010).	Improve diversity and cover of native species.

Sumac invasion is universal across this unit. It is distributed evenly among grasses across the southern section of the unit and dominant in patches across the northern section. This contributes to the low score in shade producing woody invasion for Henslow's Sparrow and Prairie Vole. There are large areas where plant species diversity is lacking, but also some areas near the Carver cemetery where forbs flourish among native warm season grasses. Vegetation height was also a bit low, which may have also been affected by the distribution of sumac.

It is recommended that this unit also follow the proposed management actions for sumac removal as presented by the Heartland Network. The exception would be in the area to the west of the Carver Trail and cemetery where the wildflowers are growing well. This area should be allowed to rest until fire treatment is prescribed.

Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

2009 GWCA Management Unit #5

Limiting Factors

Henslow's Sparrow (0.71): Forb canopy (0.32) indicates that little or no forb cover is available for food or song perches. Distance to water (0.40) cannot be altered, but is included for assessing habitat quality.

Prairie Vole (0.82): Food plant species (0.40) shows low vegetative diversity.

Ornate Box Turtle (0.76): Distance to water (0.40) cannot be altered, but is included for assessing habitat quality.

Northern Bobwhite Quail (0.74): Distance to cropland (0.19) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Henslow's Sparrow: Average litter depth (0.60).

Ornate Box Turtle: Thermoregulatory cover (0.75); available food groups (0.72).

Northern Bobwhite Quail: Habitat edge (0.60).

Optimum Features

Henslow's Sparrow: Average vegetation height (0.88); diversity of vegetation height (0.87); shade producing woody invasion (0.87).

Prairie Vole: Grass and forb cover (0.81); shade producing woody invasion (0.87); average litter depth (0.83); size of grassland (1.00); soil texture (1.00).

Ornate Box Turtle: Soil type (1.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (1.00); nesting cover quantity (0.90); grassland management (0.89); vegetative escape and concealment cover (1.00); distance to water (0.92); distance to forest (0.93); distance to oldfield (0.88).

Recommendation for 2010: Allow to rest in 2010. Apply Plateau herbicide to Johnsongrass using Heartland Network vehicle-mounted methods.

Table 6: 2010 Management Recommendations for Management Unit 5.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
5	Henslow's Sparrow	Forb canopy	Allow to rest. Seed with native forb mix from local seed distributor (optional for 2010).	Improve native species diversity and cover. Allow litter layer to develop and recycle nutrients.
5	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor (optional for 2010).	Improve native species diversity and cover.

Low forb canopy indicates that the unit should be seeded for forbs or receive transplants in the future. It also denotes that plant diversity overall should be improved.

This unit should also follow the management actions prescribed by the Heartland Network for both sumac and Johnsongrass (*Sorghum halepense*). This unit may be a candidate for the proposed "Untreated Unit" to be treated with the vehicle-mounted wick applicator. Johnsongrass should also be treated using Plateau herbicide (Kansas Department of Agriculture 2006). However, sumac and Johnsongrass may not occur in close enough proximity to one another to be captured in the same experimental unit. Unit 5 does have the greatest Johnsongrass invasion, however.

This unit may also benefit from one or two "rest" years from haying to allow native grass cover to be rehabilitated. There were areas of bare ground either in or near HSI plots, which show signs of compaction by tractor tires.

Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

2009 GWCA Management Unit #6

Limiting Factors

Henslow's Sparrow (0.74): Average litter depth (0.40) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and nest building. Forb canopy (0.44) indicates that little or no forb cover is available for food or song perches.

Prairie Vole (0.75): Average litter depth (0.48) means that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and for voles to construct their runway networks and nests. Food plant species (0.40) shows low vegetative diversity.

Ornate Box Turtle (0.77): None.

Northern Bobwhite Quail (0.81): Distance to cropland (0.28) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Henslow's Sparrow: Average height of vegetation (0.70).

Ornate Box Turtle: Thermoregulatory cover (0.74); available food groups (0.72); distance to water (0.60).

Optimum Features

Henslow's Sparrow: Diversity of vegetation height (0.88); shade producing woody invasion (0.96); distance to water (0.84).

Prairie Vole: Grass and forb cover (0.78); shade producing woody invasion (0.96); size of grassland (1.00); soil texture (0.92).

Ornate Box Turtle: Soil type (0.90).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (1.00); nesting cover quantity (0.98); grassland management (0.96); habitat edge (1.00); vegetative escape and concealment cover (1.00); distance to water (0.92); distance to forest (1.00); distance to oldfield (1.00).

Recommendation for 2010: Allow unit to rest in 2010. Sumac in the unit should be monitored. It has not become problematic in this unit, but given its invasiveness to other units, it has the potential to be. If deemed problematic, refer to the Heartland Network's sumac control recommendations. Seed the unit with native forbs.

Table 7: 2010 Management Recommendations for Management Unit 6.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
6	Henslow's Sparrow	Average litter depth	Allow to rest in 2010. Possible prescribed burn in 2011 or 2012.	Allow a litter layer to develop and recycle nutrients.
6	Henslow's Sparrow	Forb canopy	Seed with native forb mix from local seed distributor (optional, but encouraged for 2010).	Improve native species diversity and cover.
6	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor (optional, but encouraged for 2010).	Improve native species diversity and cover.

The two factors that need to be addressed in Unit 6 are litter depth and plant species diversity. Native warm season grass cover is adequate, but there are also areas of thin vegetation due to tire tracks from haying and mowing implements.

This unit would benefit from a year or two of rest, followed by a spring burn. Specific areas where sumac is beginning to invade should be addressed using the recommendations provided by the Heartland Network. This unit would also benefit greatly from a seeding program to establish native plant species in bare spots occurring due to haying or spot herbicide treatments of invasive species. Establishment of native species in these areas will prevent non-natives from encroaching.

A long-term goal for this unit would be to address tall fescue that is growing on the service road between the unit and Carver Woods. While driving the gator on this road, seeds were released in the vehicle and surrounding areas. To address this invasion, conduct a prescribed burn in late winter (February or March) along the service road. Apply Plateau imazapic herbicide (12 oz./acre with a surfactant) in April along the road (Barnes 2004). Reseed using native seed collected and treated on-site, or purchase from a local vendor. Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999). The land does not need to be tilled (Washburn et al. 1999). There is a USDA Natural Resources Conservation Service Center located in Neosho, MO that could be consulted for materials and guidance (http://offices.sc.egov.usda.gov/locator/app?service=page/ServiceCenterSummary&stateCode=29&cnty=145).

2009 GWCA Management Unit #7

Limiting Factors

Henslow's Sparrow (0.70): Shade producing woody invasion (0.44) indicates the invasion of sumac in patches throughout the unit. Forb canopy (0.35) indicates that little or no forb cover is available for food or song perches.

Prairie Vole (0.63): Shade producing woody invasion (0.44) indicates the invasion of sumac in patches throughout the unit. Food plant species (0.43) shows low vegetative diversity.

Ornate Box Turtle (0.77): None.

Northern Bobwhite Quail (0.80): None.

Intermediate Factors

Henslow's Sparrow: Average litter depth (0.62).

Prairie Vole: Grass and forb cover (0.67); average litter depth (0.56).

Ornate Box Turtle: Available food groups (0.72); distance to water (0.60).

Northern Bobwhite Quail: Grassland management (0.75); distance to oldfield (0.60).

Optimum Features

Henslow's Sparrow: Average height of vegetation (1.00); diversity of vegetation height (0.76); distance to water (0.96).

Prairie Vole: Size of grassland (1.00); soil texture (0.88).

Ornate Box Turtle: Thermoregulatory cover (0.84); soil type (0.86).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (0.98); nesting cover quantity (0.81); habitat edge (1.00); vegetative escape and concealment cover (1.00); distance to cropland (0.76); distance to water (1.00); distance to forest (1.00).

Recommendation for 2010: Follow recommendations of Heartland Network for sumac control. Perform prescribed burn in 2010. Seed the unit with native forbs.

Table 8: 2010 Management Recommendations for Management Unit 7.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
7	Henslow's Sparrow	Shade producing woody invasion	Perform prescribed burn in 2010. Follow HTLN sumac control recommendations. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
7	Henslow's Sparrow	Forb canopy	Seed with native forb mix from local seed distributor (optional, but encouraged for 2010).	Improve native species diversity and cover.
7	Prairie Vole	Shade producing woody invasion	Perform prescribed burn in 2010. Follow HTLN sumac control recommendations. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
7	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor (optional, but encouraged for 2010).	Improve native species diversity and cover.

Limiting factors for this unit include shade producing woody invasion and overall plant diversity. There are expanses which could benefit from the seeding of forbs.

Unit 7 contains areas that need immediate attention and areas that are in good condition. Near Unit 1 and in the eastern section of the unit are areas of sumac invasion that could be addressed using the Heartland Network's suggestions for sumac control. There are also isolated Johnsongrass invasions that could be addressed using their recommendations. This unit is likely the best candidate to contain the proposed

“Untreated Unit” to be treated with the vehicle-mounted wick applicator, particularly in the northeast corner of the park.

Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

2009 GWCA Management Unit #9

Limiting Factors

Henslow's Sparrow (0.64): Average litter depth (0.23) is due to thick ground cover of tall fescue (*Schedonorus phoenix*). There is not enough bare ground around stands of grass to allow a litter layer. Forb canopy (0.23) indicates that little or no forb cover is available for food or song perches.

Prairie Vole (0.81): Food plant species (0.37) shows low vegetative diversity.

Ornate Box Turtle (0.56): Thermoregulatory cover (0.49) is primarily due to the thickness of the understory of tall fescue. There is very little bare ground between grass stands for turtles to traverse. Available food groups (0.49) are an indicator of biodiversity. This characteristic includes several food sources (grasses, legumes, fruit, etc.) due to the omnivorous nature of this species. (See HSI model in Appendix I.)

Northern Bobwhite Quail (0.57): Nesting cover quantity (0.21) indicates the percentage of warm season grasses in the unit, and is affected by the presence of tall sumac. Grassland management (0.43) refers to grass and forb cover, which provide cover and food for this species. Distance to cropland (0.16) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Henslow's Sparrow: Shade producing woody invasion (0.71); distance to water (0.54).

Prairie Vole: Shade producing woody invasion (0.73).

Ornate Box Turtle: Distance to water (0.57).

Northern Bobwhite Quail: Vegetative escape and concealment cover (0.54).

Optimum Features

Henslow's Sparrow: Average vegetation height (0.93); diversity of vegetation height (0.86).

Prairie Vole: Grass and forb cover (0.76); average litter depth (0.97); size of grassland (1.00); soil texture (1.00).

Ornate Box Turtle: Soil type (0.86).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (1.00); habitat edge (1.00); distance to water (0.80); distance to forest (1.00); distance to oldfield (1.00).

Recommendation: Though HSI data was collected for Unit 9, there has been no prairie restoration by GWCA in this unit, so I have not provided recommendations based on limiting factors at this time. Instead, I have provided some long-term options for Unit 9.

The unit is currently dominated by tall fescue in the grassland areas and trees along the intermittent Dry Branch creek. Native warm season grasses were observed in the eastern portion of the unit encroaching from Unit 5.

1. Use appropriate fescue control to re-plant to native prairie. Seeding of the unit could be accomplished through seed collections done by volunteers or through purchasing of seed through a local vendor. Appropriate control would include conducting a prescribed burn in late winter when fescue begins to green up (late February). The burn should be followed by a spring application of Plateau imazapic (12 oz./acre with a surfactant) Plateau does not harm native grasses, and re-planting to native grasses can be done in a single year (Washburn et al. 1999). Native grass and forb seed from on-site seed collection and treatment or from a local seed dealer can be seeded directly into the dead fescue field without tilling (Barnes 2004). There is a USDA Natural Resources Conservation Service Center located in Neosho, MO that could be consulted for materials and guidance (http://offices.sc.egov.usda.gov/locator/app?service=page/ServiceCenterSummary&stateCode=29&cnty=145).

2. Leave the unit as-is and use as an interpretive tool. Because this unit is already fenced, this area could be used as a grazing pasture. This would benefit the cultural aspect of the park, and it would prevent further encroachment of woodlands into the grassland area.
3. Observe the progress of native warm season grasses invading from the east. If progress is steady, it could be encouraged by spraying areas of fescue and re-seeding prior to warm season green up (Barnes 2004).

2011 GWCA Prairie Management Recommendations

The following is a summary of the 2010 HSI scores. The only difference from the 2009 summary is that the characteristic score in parenthesis is followed by the previous year's designation (Limiting Factors = LS, Intermediate Factors = IF, and Optimal Features = OF) and difference in score.

2010 GWCA Management Unit #1

Limiting Factors

Henslow's Sparrow (Overall Score: 0.58, -0.02): Shade producing woody invasion (0.20, LF, +0.10) indicates the invasion of sumac (*Rhus* spp.) or other woody species in the unit. Average litter depth (0.40, IF, -0.20) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and nest building.

Prairie Vole (0.51, +0.02): Grass and forb cover (0.50, LF, +0.40) indicates the invasion of *Rhus* or other woody species in the unit. Both grasses and forbs are important food species for prairie voles (Schwartz and Schwartz 2001). Shade producing woody invasion (0.20, LF, +0.10) indicates the invasion of *Rhus* in the unit. Prairie voles avoid woody vegetation (Schwartz and Schwartz 2001). Average litter depth (0.30, OF, -0.50) indicates that insufficient litter is available for building runways and nests.

Ornate Box Turtle (0.83, +0.12): Distance to water (0.40, LF, 0.00) cannot be altered, but is included for assessing habitat quality.

Northern Bobwhite Quail (0.79, +0.10): None.

Intermediate Factors

Henslow's Sparrow: Forb canopy (0.60, LF, +0.40).

Prairie Vole: Food plant species (0.60, LF, +0.20).

Northern Bobwhite Quail: Distance to oldfield (0.60, IF, 0.00)

Optimum Features

Henslow's Sparrow: Average height of vegetation (0.80, OF, -0.20); diversity of vegetation heights (0.80, OF, -0.20); distance to water (0.80, OF, 0.00).

Prairie Vole: Size of grassland (1.00, OF, 0.00); soil texture (1.00, OF, 0.00).

Ornate Box Turtle: Thermoregulatory cover (0.90, OF, +0.10); available food groups (0.80, LF, +0.30); soil type (1.00, OF, 0.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (0.90, OF, -0.10); Nesting cover quantity (0.90, LF, +0.60); grassland management (0.20, LF, +0.70); habitat edge (1.00, OF, 0.00); vegetative escape and concealment cover (1.00, OF, 0.00); distance to cropland (1.00, OF, 0.00); distance to water (1.00, OF, 0.00); distance to forest (1.00, OF, 0.00).

Recommendation for 2011: Follow recommendations of Heartland Network for sumac control. Perform prescribed burn in spring or fall 2011.

Table 9: 2011 Management Recommendations for Management Unit 1.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
1	Henslow's Sparrow	Shade producing woody invasion	Follow HTLN sumac control recommendations. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
1	Henslow's Sparrow	Average litter depth	Allow to rest after next prescribed burn.	The litter layer will develop in the years following the prescribed burn, increasing breeding bird habitat and helping to control non-native species.
1	Prairie Vole	Grass and forb cover	Perform prescribed burn in 2011.	Increase NWSG and forb cover.
1	Prairie Vole	Shade producing woody invasion	Follow HTLN sumac control recommendations. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
1	Prairie Vole	Average litter depth	Allow to rest after next prescribed burn.	The litter layer will develop in the years following the prescribed burn, increasing breeding bird habitat and helping to control non-native species.

The most important action to be taken in Unit 1 is to control the invasion of smooth sumac (*Rhus glabra*) and winged sumac (*Rhus copallinum*). Several limiting factors from HSI data can be addressed if sumac cover decreases. Sumac is responsible for high levels of woody invasion, and was observed in the field to shade out native prairie grasses and forbs. It also decreases diversity of grasses and forbs. Food availability and nesting structure are strongly affected by these factors. As grasses are driven out, litter from the previous season's growth is unavailable.

The recommendations of the Heartland Network for sumac control will be effective in addressing these factors. It is also recommended that park staff only mow in the areas that sumac is currently growing to allow flowering of native species. In the future when sumac is under control, Unit 1 should be managed as an extension of Unit 7, which is considerably larger. It may also be managed to provide diversity in habitat features, which is a requirement of Northern Bobwhite (Pierce and Gallagher 2005). For example, it could be burned in a separate year from Unit 7 to provide bare ground for foraging. The proposed management actions by the Heartland Network will provide this effect in the interim.

Johnsongrass in this unit should be controlled using Plateau herbicide (Kansas Department of Agriculture 2006). Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

The lack of a litter layer in this unit may have been caused by the decomposition of grass clippings from the fall 2009 mowing of the prairie units. Because the litter layer was present in 2009 and no prescribed burns were performed in that year, the litter layer and 2009 vegetation must have been mulched and decomposed prior to field sampling in 2010. Ordinarily the recommended action would be to allow the prairie to rest to redevelop this layer, but because GWCA's current priority is to eradicate problematic sumac, a prescribed burn should be performed in late summer or fall of 2011. In the following years, sumac should be monitored and addressed in the locations where it has invaded while allowing the surrounding unit to continue natural growth.

2010 GWCA Management Unit #2

Limiting Factors

Henslow's Sparrow (0.81, +0.02): Average litter depth (0.40, LF, 0.00) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and nest building.

Prairie Vole (0.60, -0.09): Average litter depth (0.25, IF, -0.35) indicates that insufficient litter is available for building runways and nests; food plant species (0.40, LF, 0.00) indicates low vegetative diversity. Soil texture (0.40, LF, 0.00) indicates that soil is not sandy or drained enough for digging runways, but cannot be easily changed.

Ornate Box Turtle (0.64, -0.12): Soil type (0.40, LF, 0.00) is not easily managed, but indicates that soil is not suitable for digging forms (burrows) used for nesting, hibernating, or escape from weather conditions.

Northern Bobwhite Quail (0.75, -0.07): Distance to cropland (0.50, LF, 0.00) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Henslow's Sparrow: Shade producing woody invasion (0.75, IF, 0.00); forb canopy (0.70, IF, 0.00).

Prairie Vole: Shade producing woody invasion (0.75, IF, 0.00).

Ornate Box Turtle: Thermoregulatory cover (0.70, OF, -0.20); available food groups (0.65, OF, -0.20).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (0.70, OF, -0.30); nesting cover quantity (0.75, OF, -0.15).

Optimum Features

Henslow's Sparrow: Average height of vegetation (0.90, OF, -0.05); diversity of vegetation height (1.00, IF, +0.30); distance to water (1.00, OF, 0.00).

Prairie Vole: Grass and forb cover (0.80, OF, -0.05); size of grassland (1.00, OF, 0.00).

Ornate Box Turtle: Distance to water (1.00, OF, 0.00).

Northern Bobwhite Quail: Grassland management (0.85, OF, -0.05); habitat edge (1.00, OF, 0.00); vegetative escape and concealment cover (0.90, OF, 0.00); distance to water (1.00, OF, 0.00); distance to forest (1.00, OF, 0.00); distance to oldfield (1.00, OF, 0.00).

Recommendation for 2011: Perform prescribed burn in spring or fall 2011. Monitor woody species invasion. Spot application of Pasturegard for sericea lespedeza (*lespedeza cuneata*).

Table 10: 2011 Management Recommendations for Management Unit 2.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
2	Henslow's Sparrow	Average litter depth	Allow to rest after next prescribed burn.	Eliminate woody encroachment from Carver Woods; promote growth of NWSG to provide suitable litter layer in 1-2 years. Recycle nutrients.
2	Prairie Vole	Average litter depth	Allow to rest after next prescribed burn.	The litter layer will develop in the years following the prescribed burn, increasing breeding bird habitat and helping to control non-native species.
2	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor. Perform prescribed burn.	Improve native plant species cover and diversity.

Based on HSI data, the main limiting factors that could be addressed are litter depth and diversity of plant species. Litter depth will vary based on management from the previous year, and should be controlled as an extension to the much larger Unit 7.

It is recommended that Unit 2 be part of a prescribed burn in 2011. This would help to control encroaching woody invasion from Unit 7 and Carver Woods. It would also promote native warm season grass cover and address areas with too much litter.

GWCA began using Pasturegard as an effective control for sericea lespedeza in 2010. It will not harm native warm season grasses. Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

The lack of a litter layer in this unit may have been caused by the decomposition of grass clippings from the fall 2009 mowing of the prairie units. Because the litter layer was present in 2009 and no prescribed burns were performed in that year, the litter layer and 2009 vegetation must have been mulched and decomposed prior to field sampling in 2010. Ordinarily the recommended action would be to allow the prairie to rest to redevelop this layer, but because GWCA's current priority is to eradicate problematic sumac, a prescribed burn should be performed in late summer or fall of 2011. In the following years, sumac should be monitored and addressed in the locations where it has invaded while allowing the surrounding unit to continue natural growth.

2010 GWCA Management Unit #3

Limiting Factors

Henslow's Sparrow (0.55, -0.06): Shade producing woody invasion (0.50, IF, -0.10) indicates the invasion of *Rhus* or other woody species in the unit. Average litter depth (0.40, OF, -0.40) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and nest building. Forb canopy (0.30, LF, 0.00) indicates that little or no forb cover is available for food or song perches. Distance to water (0.30, LF, 0.00) cannot be altered, but is included for assessing habitat quality.

Prairie Vole (0.54, -0.10): Shade producing woody invasion (0.50, IF, -0.10) indicates the invasion of *Rhus* in the unit. Average litter depth (0.10, LF, -0.40) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and for voles to construct their runway networks and nests. Food plant species (0.30, LF, -0.10) indicates low vegetative diversity.

Ornate Box Turtle (0.73, -0.10): Distance to water (0.40, LF, 0.00) cannot be altered, but is included for assessing habitat quality.

Northern Bobwhite Quail (0.70, -0.04): Distance to cropland (0.20, LF, 0.00) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Henslow's Sparrow: Diversity of vegetation height (0.70, OF, -0.10).

Prairie Vole: Grass and forb cover (0.70, IF, +0.10).

Ornate Box Turtle: Thermoregulatory cover (0.65, OF, -0.25); available food groups (0.70, OF, -0.10).

Northern Bobwhite Quail: Grassland management (0.70, OF, -0.10).

Optimum Features

Henslow's Sparrow: Average vegetation height (0.85, IF, +0.10).

Prairie Vole: Size of grassland (1.00, OF, 0.00); soil texture (1.00, OF, 0.00).

Ornate Box Turtle: Soil type (1.00, OF, 0.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (0.90, OF, -0.10); nesting cover quantity (0.80, OF, -0.05); habitat edge (0.80, OF, 0.00); vegetative escape and concealment cover (1.00, OF, 0.00); distance to water (0.80, OF, 0.00); distance to forest (1.00, OF, 0.00); distance to oldfield (1.00, OF, 0.00).

Recommendation for 2011: Follow the Heartland Network's recommendations for sumac control for mowed units. Otherwise allow unit to rest. Seed unit with native forbs.

Table 11: 2011 Management Recommendations for Management Unit 3.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
3	Henslow's Sparrow	Shade producing woody invasion	Follow HTLN recommendations for sumac control including mowing. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
3	Henslow's Sparrow	Average litter depth	Allow areas without a sumac invasion to rest.	The litter layer will develop in the years following the 2010 prescribed burn, increasing breeding bird habitat and helping to control non-native species.
3	Henslow's Sparrow	Forb canopy	Follow HTLN recommendations for sumac control including mowing. Seed with native forb mix from local seed distributor.	Reduce sumac cover and allow forb canopy to cover more area.
3	Prairie Vole	Shade producing woody invasion	Follow HTLN recommendations for sumac control including mowing. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
3	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor.	Improve diversity and cover of native species.
3	Prairie Vole	Average litter depth	Allow areas without a sumac invasion to rest.	Improve litter depth for prairie vole nests and runways. Recycles nutrients lost from haying.

Limiting factors for this unit include forb canopy cover and lack of plant diversity. These two factors are related. There are some areas lacking in grass and forb cover, which appear to be due to stress from haying implements. This is visible from tire tracks and straight lines of bare ground through the unit. There are also some areas being affected by sumac invasion.

The Heartland Network's recommendations for sumac removal should be applied to this unit. However, sumac does not dominate large tracts as it does in Unit 1 or Unit 7. It is mixed throughout grass cover, and extreme care should be taken with any herbicide application. It is recommended that this unit be mowed for sumac control. Areas not affected by sumac should be allowed to grow to flowering height.

Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

The lack of a litter layer in this unit may have been caused by the decomposition of grass clippings from the fall 2009 mowing of the prairie units. Because the litter layer was present in 2009 and no prescribed burns were performed in that year, the litter layer and 2009 vegetation must have been mulched and decomposed prior to field sampling in 2010. This unit should be allowed to rest in 2011, except in areas of sumac invasion, which should be monitored and addressed in the locations where it has invaded while allowing the surrounding unit to continue natural growth.

2010 GWCA Management Unit #4

Limiting Factors

Henslow's Sparrow (0.53, -0.06): Shade producing woody invasion (0.26, LF, -0.17) indicates the invasion of *Rhus* or other woody species in the unit. Average litter depth (0.40, LF, -0.10) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and nest building. Forb canopy (0.36, IF, -0.29) indicates that little or no forb cover is available for food or song perches. Distance to water (0.44, LF, +0.09) cannot be altered, but is included for assessing habitat quality. The distance to water score increased in 2010 due to the addition of an HSI plot in the northern part of the unit.

Prairie Vole (0.47, -0.19): Shade producing woody invasion (0.26, LF, -0.17) indicates the invasion of *Rhus* or other woody species in the unit. Average litter depth (0.12, IF, -0.61) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and for voles to construct their runway networks and nests. Prairie voles avoid woody vegetation (Schwartz and Schwartz 2001). Food plant species (0.36, LF, -0.04) indicates low vegetative diversity.

Ornate Box Turtle (0.71, -0.15): Distance to water (0.44, LF, -0.01) cannot be altered, but is included for assessing habitat quality. The distance to water score decreased in 2010 due to the addition of an HSI plot in the northern part of the unit. (The maximum range for distance to water is 100 m for *Terrapene o. ornata* as opposed to 0.25 km for *A. henslowii*. This explains the difference in effect for each species as a result of adding the plot.)

Northern Bobwhite Quail (0.67, -0.03): Distance to cropland (0.22, LF, -0.01) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite. The distance to cropland score decreased in 2010 due to the addition of an HSI plot in the northern part of the unit.

Intermediate Factors

Prairie Vole: Grass and forb cover (0.54, IF, -0.09).

Ornate Box Turtle: Thermoregulatory cover (0.62, OF, -0.38); available food groups (0.66, OF, -0.14).

Northern Bobwhite Quail: Nesting cover quantity (0.72, OF, -0.08); grassland management (0.66, IF, -0.09); habitat edge (0.60, IF, 0.00).

Optimum Features

Henslow's Sparrow: Average vegetation height (0.82, IF, +0.07); diversity of vegetation height (0.84, OF, -0.01).

Prairie Vole: Size of grassland (1.00, OF, 0.00); soil texture (1.00, OF, 0.00).

Ornate Box Turtle: Soil type (1.00, OF, 0.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (1.00, OF, 0.00); vegetative escape and concealment cover (1.00, OF, 0.00); distance to water (0.88, OF, +0.03; increased due to added plot in Unit 4); distance to forest (0.90, OF, +0.02; increased due to added plot in Unit 4); distance to oldfield (0.85, OF, -0.01; decreased due to added plot in Unit 4).

Recommendation for 2011: Follow the Heartland Network's recommendations for sumac control for mowed units. Seed unit with native forbs for the Visitor Viewshed.

Table 12: 2011 Management Recommendations for Management Unit 4.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
4	Henslow's Sparrow	Shade producing woody invasion	Follow HTLN sumac control recommendations for mowed units. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
4	Henslow's Sparrow	Average litter depth	Mow areas where sumac is growing. Allow to rest where it is not.	Goal is to reduce sumac cover and provide suitable litter depth by 2012.
4	Henslow's Sparrow	Forb canopy	Follow HTLN recommendations for sumac control including mowing. Seed with native forb mix from local seed distributor.	Reduce sumac cover and allow forb canopy to cover more area.
4	Prairie Vole	Shade producing woody invasion	Follow HTLN sumac control recommendations. Mow only areas where sumac is growing.	Decrease sumac coverage and increase native warm season grass (NWSG) cover.
4	Prairie Vole	Average litter depth	Mow areas where sumac is growing. Allow to rest where it is not.	Goal is to reduce sumac cover and provide suitable litter depth by 2012.
4	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor.	Improve diversity and cover of native species.

Sumac invasion is universal across this unit. It is distributed evenly among grasses across the southern section of the unit and dominant in patches across the northern section. This contributes to the low score in shade producing woody invasion for Henslow's Sparrow and Prairie Vole. There are large areas where plant species diversity is lacking, but also some areas near the Carver cemetery where forbs flourish among native warm season grasses.

It is recommended that this unit also follow the proposed management actions for sumac removal as presented by the Heartland Network. The exception would be in the area to the west of the Carver Trail and cemetery where the wildflowers are growing well. This area should be allowed to rest until fire treatment is prescribed again.

Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

The lack of a litter layer in this unit may have been caused by the decomposition of grass clippings from the fall 2009 mowing of the prairie units. Because the litter layer was present in 2009 and no prescribed burns were performed in that year, the litter layer and 2009 vegetation must have been mulched and decomposed prior to field sampling in 2010. This unit should be allowed to rest in 2011, except in areas of sumac invasion, which should be monitored and addressed in the locations where it has invaded while allowing the surrounding unit to continue natural growth.

2010 GWCA Management Unit #5

Limiting Factors

Henslow's Sparrow (0.67, -0.04): Average litter depth (0.40, IF, -0.20) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and nest building. Forb canopy (0.28, LF, -0.04) indicates that little or no forb cover is available for food or song perches. Distance to water (0.40, LF, 0.00) cannot be altered, but is included for assessing habitat quality.

Prairie Vole (0.64, -0.18): Average litter depth (0.18, OF, -0.64) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and for voles to construct their runway networks and nests. Food plant species (0.35, LF, -0.05) indicates low vegetative diversity.

Ornate Box Turtle (0.67, -0.09): Distance to water (0.38, LF, -0.02) cannot be altered, but is included for assessing habitat quality. The distance to water score decreased in 2010 due to the addition of an HSI plot in the central part of the unit.

Northern Bobwhite Quail (0.68, -0.06): Distance to cropland (0.19, LF, 0.00) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Prairie Vole: Grass and forb cover (0.68, OF, -0.13).

Ornate Box Turtle: Thermoregulatory cover (0.58, IF, -0.17); available food groups (0.58, IF, -0.14).

Northern Bobwhite Quail: Nesting cover quantity (0.73, OF, -0.17); habitat edge (0.60, IF, 0.00).

Optimum Features

Henslow's Sparrow: Average vegetation height (0.93, OF, +0.05); diversity of vegetation height (0.82, OF, -0.05); shade producing woody invasion (0.81, OF, -0.06).

Prairie Vole: Shade producing woody invasion (0.82, OF, -0.05)); size of grassland (1.00, OF, 0.00); soil texture (1.00, OF, 0.00).

Ornate Box Turtle: Soil type (1.00, OF, 0.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (0.91, OF, -0.09); grassland management (0.78, OF, -0.11); vegetative escape and concealment cover (1.00, OF, 0.00); distance to water (0.91, OF, -0.01; decreased due to added plot in Unit 5); distance to forest (0.92, OF, -0.01; decreased due to added plot in Unit 5); distance to oldfield (0.88, OF, 0.00; no change due to added plot in Unit 5).

Recommendation for 2011: Allow to rest in 2011. Apply Plateau herbicide to Johnsongrass using Heartland Network vehicle-mounted methods. Seed unit with native forbs.

Table 13: 2011 Management Recommendations for Management Unit 5.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
5	Henslow's Sparrow	Average Litter Depth	Allow areas without a sumac or Johnsongrass invasion to rest.	The litter layer will develop in the years following the 2010 prescribed burn, increasing breeding bird habitat and helping to control non-native species.
5	Henslow's Sparrow	Forb canopy	Allow to rest. Seed with native forb mix from local seed distributor.	Improve native species diversity and cover. Allow litter layer to develop and recycle nutrients.
5	Prairie Vole	Average Litter Depth	Allow areas without a sumac or Johnsongrass invasion to rest.	Improve litter depth for prairie vole nests and runways. Recycles nutrients lost from haying.
5	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor.	Improve native species diversity and cover.

Low forb canopy indicates that the unit should be seeded for forbs or receive transplants in the future. It also denotes that plant diversity overall should be improved.

This unit should also follow the management actions prescribed by the Heartland Network for both sumac and Johnsongrass (*Sorghum halepense*). This unit may be a candidate for the proposed "Untreated Unit" to be treated with the vehicle-mounted wick applicator. Johnsongrass should also be treated using Plateau herbicide (Kansas Department of Agriculture 2006). However, sumac and Johnsongrass may not occur in close enough proximity to one another to be captured in the same experimental unit. Unit 5 does have the greatest Johnsongrass invasion, however.

This unit may also benefit from one or two “rest” years from haying to allow native grass cover to be rehabilitated. There were areas of bare ground either in or near HSI plots, which show signs of compaction by tractor tires.

Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

The lack of a litter layer in this unit may have been caused by the decomposition of grass clippings from the fall 2009 mowing of the prairie units. Because the litter layer was present in 2009 and no prescribed burns were performed in that year, the litter layer and 2009 vegetation must have been mulched and decomposed prior to field sampling in 2010. This unit should be allowed to rest in 2011, except in areas of sumac and Johnsongrass invasion, which should be monitored and addressed in the locations where it has invaded while allowing the surrounding unit to continue natural growth.

2010 GWCA Management Unit #6

Limiting Factors

Henslow's Sparrow (0.67, -0.07): Average litter depth (0.36, LF, -0.04) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and nest building. Forb canopy (0.24, LF, -0.20) indicates that little or no forb cover is available for food or song perches.

Prairie Vole (0.62, -0.13): Average litter depth (0.10, LF, -0.38) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and for voles to construct their runway networks and nests. Food plant species (0.40, LF, 0.00) indicates low vegetative diversity.

Ornate Box Turtle (0.76, -0.01): None.

Northern Bobwhite Quail (0.77, -0.04): Distance to cropland (0.28, LF, 0.00) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Henslow's Sparrow: Shade producing woody invasion (0.74, OF, -0.22).

Prairie Vole: Shade producing woody invasion (0.74, OF, -0.22).

Ornate Box Turtle: Thermoregulatory cover (0.68, IF, -0.06); distance to water (0.60, IF, 0.00).

Optimum Features

Henslow's Sparrow: Average height of vegetation (0.80, IF, +0.10); diversity of vegetation height (0.80, OF, -0.08); distance to water (0.84, OF, 0.00).

Prairie Vole: Grass and forb cover (0.80, OF, +0.02); size of grassland (1.00, OF, 0.00); soil texture (0.92, OF, 0.00).

Ornate Box Turtle: Available food groups (0.76, IF, +0.04); soil type (0.90, OF, 0.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (0.90, OF, -0.10); nesting cover quantity (0.86, OF, -0.12); grassland management (0.88, OF, -0.08);

habitat edge (1.00, OF, 0.00); vegetative escape and concealment cover (1.00, OF, 0.00); distance to water (0.92, OF, 0.00); distance to forest (1.00, OF, 0.00); distance to oldfield (1.00, OF, 0.00).

Recommendation for 2011: Allow unit to rest in 2011. Sumac in the unit should be monitored. It has not become problematic in this unit, but given its invasiveness to other units, it has the potential to be. If deemed problematic, refer to the Heartland Network's sumac control recommendations. Seed the unit with native forbs.

Table 14: 2011 Management Recommendations for Management Unit 6.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
6	Henslow's Sparrow	Average litter depth	Allow areas without a sumac invasion to rest.	The litter layer will develop in the years following the 2010 prescribed burn, increasing breeding bird habitat and helping to control non-native species.
6	Henslow's Sparrow	Forb canopy	Seed with native forb mix from local seed distributor (optional, but encouraged for 2010).	Improve native species diversity and cover.
6	Prairie Vole	Average Litter Depth	Allow areas without a sumac invasion to rest.	Improve litter depth for prairie vole nests and runways. Recycles nutrients lost from haying.
6	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor (optional, but encouraged for 2010).	Improve native species diversity and cover.

The two factors that need to be addressed in Unit 6 are litter depth and plant species diversity. Native warm season grass cover is adequate, but there are also areas of thin vegetation due to tire tracks from haying and mowing implements.

This unit would benefit from a spring burn in the near future. Sumac and woody vegetation is under control, and native warm season vegetation needs a boost. Specific areas where sumac is beginning to invade should be addressed using the recommendations provided by the Heartland Network. This unit would also benefit greatly from a seeding program to establish native plant species in bare spots occurring due to haying or spot herbicide treatments of invasive species. Establishment of native species in these areas will prevent non-natives from encroaching.

A long-term goal for this unit would be to address tall fescue that is growing on the service road between the unit and Carver Woods. While driving the gator on this road, seeds were released in the vehicle and surrounding areas. To address this invasion, conduct a prescribed burn in late winter (February or March) along the service road. Apply Plateau imazapic herbicide (12 oz./acre with a surfactant) in April along the road (Barnes 2004). Reseed using native seed collected and treated on-site, or purchase from a local vendor. Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999). The land does not need to be tilled (Washburn et al. 1999). There is a USDA Natural Resources Conservation Service Center located in Neosho, MO that could be consulted for materials and guidance (http://offices.sc.egov.usda.gov/locator/app?service=page/ServiceCenterSummary&stateCode=29&cnty=145).

The lack of a litter layer in this unit may have been caused by the decomposition of grass clippings from the fall 2009 mowing of the prairie units. Because the litter layer was present in 2009 and no prescribed burns were performed in that year, the litter layer and 2009 vegetation must have been mulched and decomposed prior to field sampling in 2010. This unit should be allowed to rest in 2011, except in areas of sumac invasion, which should be monitored and addressed in the locations where it has invaded while allowing the surrounding unit to continue natural growth.

2010 GWCA Management Unit #7

Limiting Factors

Henslow's Sparrow (0.72, +0.02): Average litter depth (0.39, IF, -0.23) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and nest building.

Prairie Vole (0.62, -0.01): Average litter depth (0.10, LF, -0.38) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and for voles to construct their runway networks and nests. Food plant species (0.43) shows low vegetative diversity.

Ornate Box Turtle (0.76, -0.01): None.

Northern Bobwhite Quail (0.78, -0.02): None.

Intermediate Factors

Henslow's Sparrow: Shade producing woody invasion (0.60, LF, +0.16); forb canopy (0.55, LF, +0.20).

Prairie Vole: Grass and forb cover (0.69, IF, +0.02); shade producing woody invasion (0.60, LF, +0.16).

Ornate Box Turtle: Available food groups (0.66, IF, -0.06); distance to water (0.60, IF, 0.00).

Northern Bobwhite Quail: Distance to oldfield (0.60, IF, 0.00).

Optimum Features

Henslow's Sparrow: Average height of vegetation (0.93, OF, -0.07); diversity of vegetation height (0.78, OF, +0.02); distance to water (0.96, OF, 0.00).

Prairie Vole: Size of grassland (1.00, OF, 0.00); soil texture (0.88, OF, 0.00).

Ornate Box Turtle: Thermoregulatory cover (0.84, OF, 0.00); soil type (0.86, OF, 0.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (0.86, OF, -0.12); nesting cover quantity (0.81, OF, -0.79); grassland management (0.77, IF, +0.02); habitat edge (1.00, OF, 0.00); vegetative escape and concealment cover (1.00, OF, 0.00); distance to cropland (0.76, OF, 0.00); distance to water (1.00, OF, 0.00); distance to forest (1.00, OF, 0.00).

Recommendation for 2011: Follow recommendations of Heartland Network for sumac control. Perform prescribed burn in spring or fall 2011. Seed the unit with native forbs for the Visitor Viewshed.

Table 15: 2011 Management Recommendations for Management Unit 7.

Unit	Species	Limiting Factor	Management Action	Expected Outcome
7	Henslow's Sparrow	Average Litter Depth	Allow to rest after next prescribed burn.	The litter layer will develop in the years following the prescribed burn, increasing breeding bird habitat and helping to control non-native species.
7	Prairie Vole	Average Litter Depth	Allow to rest after next prescribed burn.	The litter layer will develop in the years following the prescribed burn, increasing breeding bird habitat and helping to control non-native species.
7	Prairie Vole	Food plant species	Seed with native forb mix from local seed distributor.	Improve native species diversity and cover.

Limiting factors for this unit include native plant diversity and average litter depth. There are expanses which could benefit from the seeding of forbs.

Unit 7 contains areas that need immediate attention and areas that are in good condition. Near Unit 1 and in the eastern section of the unit are areas of sumac invasion that could be addressed using the Heartland Network's suggestions for sumac control. It appears that some of these areas have improved since 2009. There are also isolated Johnsongrass invasions that could be addressed using their recommendations. This unit is likely the best candidate to contain the *proposed "Untreated Unit" to be treated with the vehicle-mounted wick applicator, particularly in the northeast corner of the park.*

Seeding procedures are outlined in the 1999 *Springs of Genius* report (Harrington et al. 1999).

The lack of a litter layer in this unit may have been caused by the decomposition of grass clippings from the fall 2009 mowing of the prairie units. Because the litter layer was present in 2009 and no prescribed burns were performed in that year, the litter layer and 2009 vegetation must have been mulched and decomposed prior to field sampling in 2010. Ordinarily the recommended action would be to allow the prairie to rest to redevelop this layer, but because GWCA's current priority is to eradicate problematic sumac, a prescribed burn should be performed in late summer or fall of 2011. In the following years, sumac should be monitored and addressed in the locations where it has invaded while allowing the surrounding unit to continue natural growth.

2010 GWCA Management Unit #9

Limiting Factors

Henslow's Sparrow (0.57, -0.07): Forb canopy (0.37, LF, +0.14) indicates that little or no forb cover is available for food or song perches.

Prairie Vole (0.63, -0.63): Average litter depth (0.33, OF, -0.64) indicates that the unit has been hayed or burned recently and has not yet developed a suitable litter layer. This is not necessarily negative, but the litter layer is important for nutrient cycling and for voles to construct their runway networks and nests. Food plant species (0.26, LF, -0.11) indicates low vegetative diversity.

Ornate Box Turtle (0.54, -0.02): Thermoregulatory cover (0.39, LF, -0.10) is primarily due to the thickness of the understory of tall fescue. There is very little bare ground between grass stands for turtles to traverse. Available food groups (0.49, LF, 0.00) are an indicator of biodiversity. This characteristic includes several food sources (grasses, legumes, fruit, etc.) due to the omnivorous nature of this species.

Northern Bobwhite Quail (0.57, 0.00): Nesting cover quantity (0.10, LF, -0.11) indicates the percentage of warm season grasses in the unit, and is affected by the presence of *S. phoenix*. Vegetative escape and concealment cover (0.46, IF, -0.08) indicates that vegetation used to hide nests and escape predators decreased. This is primarily due to one plot occurring in an area that was recently cleared of all vegetation. Distance to cropland (0.16, LF, 0.00) cannot be changed by GWCA management. Cropland is a valuable food source for Bobwhite.

Intermediate Factors

Henslow's Sparrow: Average vegetation height (0.60, OF, -0.33); diversity of vegetation height (0.51, OF, -0.34); shade producing woody invasion (0.71, IF, 0.00); average litter depth (0.51, LF, +0.29); distance to water (0.54, IF, 0.00).

Prairie Vole: Grass and forb cover (0.67, OF, -0.09); shade producing woody invasion (0.73, IF, 0.00).

Ornate Box Turtle: Distance to water (0.57, IF, 0.00).

Northern Bobwhite Quail: Grassland management (0.67, LF, +0.24).

Optimum Features

Prairie Vole: Size of grassland (1.00, OF, 0.00); soil texture (1.00, OF, 0.00).

Ornate Box Turtle: Soil type (0.86, OF, 0.00).

Northern Bobwhite Quail: Distance to bare or sparsely vegetated ground (0.94, OF, -0.06); habitat edge (1.00, OF, 0.00); distance to water (0.80, OF, 0.00); distance to forest (1.00, OF, 0.00); distance to oldfield (1.00, OF, 0.00).

Recommendation: Once again, I have not provided specific recommendations to assess the limiting factors in Unit 9 because it has not undergone prairie restoration. Instead, I am providing an additional long-term recommendation to supplement the three that were provided for 2010.

1. Develop Unit 9 as a northern bobwhite breeding habitat. The Heartland Network and MoRAP (2011) provided a draft version of their Natural Resources Conservation Assessment (NRCA) to GWCA in the spring of 2011 that provides specific vegetation community types which conceptually would have been present pre-European settlement. By following HSI model procedures and meeting management targets as described in the NRCA, GWCA could choose to develop this unit as restored native prairie that transitions to woodland along the Dry Branch. The NRCA refers to the prairie units as "Upland Grassland Resource Units," which contain the vegetation types bluestem prairie and mesic tallgrass prairie. The woodland is designated as post oak-bluestem prairie/savanna. Bobwhite prefer a matrix of habitat types ranging from bare ground to short and tall grasses to shrubs to woodland (Pierce and Gallagher 2005). All of these vegetation types are currently available in Unit 9, and bobwhite are present. However, other native wildlife would benefit from this unit transitioning to a more native landscape.

Site-Wide Recommendations

Seed Collection and Treatment

A potential project for GWCA would be to collect seeds from native grasses and treat them on site. This would be a valuable interpretive and educational tool for children and volunteers. It would aid in appreciation of native vegetation and teach students how seeds are collected and processed for this purpose. The seeds could then be used to enhance the Prairie Management Units at the park. Given the strong volunteer support the park receives, this program would be beneficial to the volunteers and the park by providing a valuable resource for a relatively small start-up cost.

Aesthetic Improvements

Some observations were made regarding aesthetic improvements during sampling in 2010. These recommendations will accomplish goals in cultural interpretation and natural resources conservation. They will recreate some aspects of the historic scene and/or provide easier management of prairie units.

1. Thin the woodlands on either side of Carver Branch near the western edge of the park. Identify any Bur Oak (*Quercus macrocarpa*), and leave these trees standing, as this species is naturally-occurring in prairie ecosystems. Eliminating any woodland that was not present historically will provide more connectivity between north and south prairie management units. It also prevents woodland encroachment on to prairie units. According to Dr. James Jackson (1995),

woodlands only covered approximately 10 m on either side of the creeks on site prior to fire and grazing suppression.

2. Similar to the first aesthetic recommendation, trees could be thinned from the Carver House back to Williams Branch. Though the house was not previously located here, and Williams Pond is an important park resource (and should not be removed), thinning the woodlands would recreate scenery closer to the way it existed during the Carvers' residence on the site.
3. Woody growth should be removed from the area known as Unit 7B near the eastern end of the park. This area has been mentioned as a possible interpretation site for prairie management in previous restoration action plans (Jackson 1995).

Cleaning Haying and Mowing Implements

Johnsongrass introduction at the park has long been linked to haying implements that were not sanitized of non-native seeds prior to use. When any park or contractor implements are used at GWCA, they should be thoroughly cleaned in the maintenance area or prior to arriving at the park, respectively.

Presence Data

Prairie Vole (*Microtus ochrogaster*)

M. ochrogaster was present in each of the eight management units in 2009, and in only MUs 1, 4, 6, and 7 in 2010. Thought actual abundance was not calculated, the data suggests that overall abundance decreased between 2009 and 2010.

Table 16: Presence of *M. ochrogaster* at GWCA in 2009

Unit	Stations	Traps	Nights	Total Traps	Present?	# Encountered
1	5	25	5	125	Yes	26
2	5	25	5	125	Yes	16
3	6	30	5	150	Yes	10
4	7	35	5	175	Yes	4
5	13	65	5	325	Yes	3
6	12	60	5	300	Yes	19
7	19	95	5	475	Yes	21
9	10	50	5	250	Yes	1
Total	77	385	40	1925	Yes	100

Table 17: Presence of *M. ochrogaster* at GWCA in 2010

Unit	Stations	Traps	Nights	Total Traps	Present?	# Encountered
1	5	25	5	125	Yes	2
2	5	25	5	125	No	0
3	6	30	5	150	No	0
4	7	35	5	175	Yes	4
5	13	65	5	325	No	0
6	12	60	5	300	Yes	5
7	19	95	5	475	Yes	8
9	10	50	5	250	No	0
Total	77	385	40	1925	Yes	19

Ornate Box Turtle (*Terrapene ornata ornata*)

Terrapene o. ornata were not encountered in 2009, and two were encountered in MU 6 in 2010 – one via foot search and one lodged in a Sherman trap. No drift fences were installed in MU4 in 2009 or in MU 9 in either year, though foot and vehicle searches were performed in both units regularly.

Table 18: Presence of *Terrapene o. ornata* at GWCA in 2009 and 2010.

2009			**2010**		
Unit	**Present?**	**# Encountered**	**Unit**	**Present?**	**# Encountered**
1	No	0	1	No	0
2	No	0	2	No	0
3	No	0	3	No	0
4	No	0	4	No	0
5	No	0	5	No	0
6	No	0	6	Yes	2
7	No	0	7	No	0
9	No	0	9	No	0
Total	No	0	Total	Yes	2

Northern Bobwhite Quail (*Colinus virginianus*) and Henslow's Sparrow (*Ammodramus henslowii*)

Volunteer bird surveys were performed in June 2009 and 2010. *C. virginianus* were encountered in Units 4, 5, 6, 7, and 9 in 2009, and Units 4, 5, 7, and 9 in 2010. No *A. henslowii* were observed in 2009 or 2010, though their presence was documented at nearby Diamond Grove Prairie. Because birds may be encountered multiple times among survey point, the number encountered is not included here.

Table 19: Presence of *Colinus virginianus* at GWCA in 2009 and 2010

2009		**2010**	
Unit	**Present?**	**Unit**	**Present?**
1	No	1	No
2	No	2	No
3	No	3	No
4	Yes	4	Yes
5	Yes	5	Yes
6	Yes	6	No
7	Yes	7	Yes
9	Yes	9	Yes
Total	Yes		Yes

Table 20: Presence of *Ammodramus henslowii* at GWCA in 2009 and 2010

2009		2010	
Unit	**Present?**	**Unit**	**Present?**
1	No	1	No
2	No	2	No
3	No	3	No
4	No	4	No
5	No	5	No
6	Yes	6	No
7	No	7	No
9	No	9	No
Total	No		No

Discussion

The five objectives of my thesis were: 1) review the history of prairie management at GWCA; 2) develop methods for determining the presence/absence of four indicator species in each management unit; 3) assess the physical structure of prairie habitat using HSI models; 4) assign management actions to address limiting factors based on HSI scores; and 5) combine input from several agencies to create a management tool for long-term in-park natural and cultural resources planning.

From the beginning of my research, it was important to work extensively with the park to determine the products and information that would best help GWCA in managing their prairie restoration. My first product, *George Washington Carver National Monument Prairie Restoration Management Review*, provided a comprehensive review of prairie management at GWCA from the planning stages, to expansion of the prairie units, to current management practices. The review provided the park with a reference document for the history of prairie management and its effectiveness while setting the stage for the rest of my research. It was also important to GWCA because reviewing so many documents can be a cumbersome task for newer or seasonal staff, or to a staff skilled in historic or cultural interpretation that lacks dedicated natural resources technicians. Park personnel were generally concerned with their regular duties and often had difficulty remembering when recent prescribed burns had occurred or when prairie units had been hayed or mowed. Included with the report were Excel spreadsheets that document previous management activities while standardizing future monitoring of management activities. I felt this was important because without a dedicated technician, there was no method in place for documenting management actions. To document past activities, I had to peruse many documents that had not been accessed in years. The document would need to be updated at least yearly, but with the provided spreadsheets GWCA has the ability to do so quickly and easily. The review may also provide a guide for other parks to compile their management histories into a narrative form that incorporates land use history and landscape management. This might be particularly helpful to parks with small staffs or high turnover rates, or to simply keep track of methods, goals, or philosophies that have or have not been successful.

During my field season I had the opportunity to monitor and document management activities as they were prescribed and/or implemented. The park Superintendent was very supportive and interested in the project. His honest admission that he was not well educated in natural resources management was balanced by numerous questions on how my work was progressing and what different things meant, whether in regard to nature or to the park itself. GWCA's Chief Ranger served as Natural Resources Coordinator and was responsible for planning management actions in addition to her regular duties in administration and interpretation. The prescribed burn coordinator was a park ranger whose main responsibilities were managing the George Washington Carver archives and artifacts while also providing interpretational content for park visitors. I developed a rapport with the maintenance crew during my two summers at GWCA, as they were most likely going to be performing much of the labor involved with future management. They were generally interested in nature and understood many basic concepts behind prairie restoration and the importance of conservation. One of the maintenance technicians had a background in biology, and I was able to provide some preliminary training for him in HSI methods. Though the support for my project was very high, it was still apparent that the staff at GWCA needed a clearer vision as to why the prairie mattered and how it would fit into their final cultural landscape.

The park conducts yearly prairie management meetings to prescribe management actions, but it was not always organized in regard to prairie management. For instance, in June 2009 a maintenance technician brush-hogged significant portions of units 1, 2, and 7; and in July 2010 he brush-hogged most of unit 9. In the fall of 2009, he mowed the entire prairie. None of these actions were prescribed. He felt he was performing his regular duties and was not aware of how he may have affected prairie structure and wildlife habitat. The HSI characteristic of average litter depth for *A. henslowii* and *M. ochrogaster* indicated that the litter layer was inadequate in 2010 due to the full prairie brush-hogging that occurred in the fall of 2009. Presence data seemed to support this assumption, as *M. ochrogaster* presence was down significantly in 2010. A logical explanation for this was that the grass clippings had adequate time to decompose, leaving bare ground beneath prairie vegetation that would not support nests for grassland birds or runways for small mammals. However, the unplanned mowing events did have a slight positive effect on lowering sumac cover. I have recommended to the park that in the future only areas that have sumac cover should be mowed to preserve standing vegetation and the litter layer.

Another stakeholder that was important to involve in my research was the National Park Service's Heartland Network (HTLN) Inventory and Monitoring program. HTLN compiles, analyzes, and provides data on wildlife and vegetation at GWCA. They also maintain monitoring programs at GWCA and several other parks within their region. I had originally intended to conduct my own vegetation cover survey as part of my thesis with only *A. henslowii* and *Terrapene o. ornata* as indicator species , but upon meeting with HTLN decided to focus more on HSI models and presence surveys. The rationale was that HTLN already maintained enough vegetation data and wanted information to supplement what they were already doing. Together we decided on adding *M. ochrogaster* and *C. virginianus* in order to include a small mammal and a bird of local conservation concern, respectively. On two occasions I had the opportunity to provide tours to HTLN personnel to familiarize them with specific areas of the park with non-native species invasions. This information in addition to their own surveys aided them in concentrating their efforts to specific areas, especially when the Exotic Plant Management Team was created in 2010. I also had the opportunity to discuss with them my ideas for future planning, including many that were included in my *Integrated Vegetation Management Recommendations*. They in turn shared with me the development of their Natural Resources Conservation Assessment (NRCA). Together we determined that the park would be better managed through the use of larger, consolidated units that included a Visitor Viewshed intended to improve aesthetics and wildlife habitat near Carver Trail.

One issue that came up with HTLN regarded the use of HSI models as a management tool for GWCA. The HSI models were intended as an internal program that allows the park to monitor their prairie units and determine appropriate management actions based on the scores of individual characteristics. The NRCA uses management targets that are interpreted on a scale of zero to one (closer to one meaning that the characteristic approaches the optimal target) to assess attributes similar to HSI characteristics. Many of them could be addressed using HSI models, as the models allow the user to forecast the results of management, or at least to see where improvements can be made (Urich and Graham 1983). I believe that GWCA and HTLN can pool their resources to allow HSI data, NRCA targets, and inventory and monitoring to work hand-in-hand.

Indicator species presence data showed that three of the four indicator species were encountered at GWCA. *M. ochrogaster* was encountered in every unit in 2009 with 100 total caught. Individuals were not marked, so some may have been caught more than once. In 2010, *M. ochrogaster* was encountered only in units 1, 4, 6, and 7 with 19 total caught. Traplines in 2010 were set roughly perpendicular to 2009 traplines, but the same food was used and trapping occurred over the same dates. The hispid cotton rat (*Sigmodon hispidus*) was caught regularly in Sherman traps in 2009, but was rarely encountered in 2010. This leads me to conclude that the 2009 mowing events had a negative effect on small mammal presence at GWCA. In turn, this may affect predator species in the vicinity of GWCA, as both rodents are important prey species. *Terrapene o. ornata* was not encountered in 2009, and only two were encountered in 2010. Both were found in unit 6 during foot searches. In 2009, drift fences were erected for a week at a time, while in 2010 they were allowed to stand for two months in each unit. The drift fences would likely be more effective if they were installed prior to vegetation green up and allowed to stand for several months, if not permanently. Dry, rocky soil necessitated the use of a mechanical trencher to dig trenches. The trencher caused some disturbance in vegetation that may have diverted potential encounters. Also, I would recommend fitting each pitfall with a funnel-shaped tunnel to lead animals to the pitfalls, which should always be shaded. *C. viginianus* was encountered in units 4, 5, 6, 7, 8, and 9 in 2009, and in units 4, 5, 7, 8 and 9 in 2010. Coveys were encountered only in units 5 and 9. Other encounters signify that GWCA habitat is being used regularly. *A. henslowii* was not present in either year and has not been documented at the park since 1997.

HSI scores showed a general negative change between 2009 and 2010 (Appendix 1). Below is a discussion of HSI scores from the perspective of evaluating management practices between 2009 and 2010. Potential human error may arise from HSI data collection, but should be minimized because most scores represent measurements or ranges that can be verified. While training a maintenance technician, his recorded scores differed minimally from mine on the plots he sampled independently.

M. ochrogaster saw the most considerable decrease in overall score per unit, which was caused by the lack of a litter layer as discussed above. The average litter depth characteristic score decreased between 0.18 and 0.64 on a scale of zero to one for each management unit. Units 3, 4, 5, and 6, all on the south side of Carver Woods, decreased in score for shade producing woody invasion. The north side units 1, 2, and 7 either stayed the same or increased in score, which indicates that the unexpected mowing event in June 2009 may have decreased sumac cover. The southern units were burned in September 2010 to address woody invasion. Grass and forb cover, size of grassland, food plant species, and soil texture showed little or no change.

Terrapene o. ornata saw an overall increase in unit 1, but a small to moderate decrease in every other unit. Unit 1 increased in thermoregulatory cover and available food groups, while all other units showed small decreases in these characteristics. As expected, there was no change in soil type or distance to water.

C. virginianus increased slightly overall in unit 1, and decreased very slightly in units 2, 3, 4, 5, 6, and 7. Unit 1 increased in grassland management (native grass and forb cover) and quantity of nesting cover, but changed very little in other characteristics. This again may have been a result of lowered sumac cover from the unplanned 2009 mowing events. Nesting cover quantity decreased in all other units, and grassland management decreased in every other unit except 7 and 9, where the scores also increased. This may be attributed to the lack of previous years' vegetation or the inability to determine grass type before flowering.

A. henslowii showed very little change in overall HSI scores. The maximum decrease was -0.07 while the maximum increase was 0.03. Average vegetation height and diversity of vegetation height decreased in northern units 1, 2, and 7 in 2010, again due to lower sumac cover. This also indicates that vegetation height was not optimal and lowered the unit's value as bird habitat. These characteristics increased slightly in southern units 3, 4, 5, and 6, where no sumac management occurred. Unit 9 decreased considerably in vegetation height due to the July 2010 mowing event. Shade producing woody invasion scores also increased in the northern units, indicating less sumac, while the southern unit scores decreased. All units except 2 and 9 showed decreases in average litter depth. Unit 2 contains a large patch of ashy sunflower (*Helianthus mollis*) around one of its two HSI plots, which considerably lowers the score for this characteristic. Unit 9 contained grass clippings. Forb canopy decreased in units 4, 5, and 6, and it increased in units 1, 7, and 9. There was no change in units 2 or 3. *A. henslowii* is a prairie specialist that requires high quality habitat for nesting.

Management actions were recommended based on the most efficient and effective method of addressing limiting factors. The models allow for simple yet informed decision making for GWCA. The *George Washington Carver National Monument Prairie Management Guidebook: Using Habitat Suitability Index Models* was developed with GWCA personnel in mind. It explains in plain language what an HSI model is and how it is used as a management tool. The HSI models are intended to guide management, but will not be effective in dealing with all aspects of prairie management. They are an adaptive form of management, but if a program such as patch-burn grazing or other long-term scheduled actions were introduced, they would be more effective as a monitoring tool. The four indicator species were chosen for their collective ability to represent prairie specialist species. They assess soil, ground level habitat, vegetation diversity, distances to critical resources, and vertical structure, among other prairie structure features that would be important to a number of species found at GWCA.

Rather than providing an actual long-term management plan for GWCA, this sequence of reports has provided a tool for thinking about what is going on at the park. At this point, three goals for prairie management stand out for GWCA: increasing diversity of native vegetation, replacing pioneer species with conservative species, and improving the physical structure of the prairie. Both the NRCA and the HSI models will help GWCA move closer to accomplishing these goals. The goal most important to GWCA given their purpose as a monument is to determine how to manage the prairie units along with historical and cultural features. My final product, *Integrated Vegetation Management Recommendations for George Washington Carver National Monument* (IVMR), directly addresses this question. The Chief Ranger and I were able to create three viable alternatives for future park management. GWCA also has the opportunity to pick and choose from these alternatives as they see fit to best accomplish their goals. The first alternative is a facsimile of the 1860s and 1870s Moses Carver Farm. Originally the NRCA alternative was a full prairie restoration based on the original extent of native prairie at the monument. It was changed because the NRCA would accomplish the same goals, it is based on a system used in multiple parks, and HTLN would be involved in the overall management of the prairie. The third alternative is a combination of many ideas brought to me by park staff and focuses on maximizing both prairie habitat quality and the cultural landscape.

Beyond GWCA, parks with an historical focus would benefit from this type of management. Given that the IVMR was developed for a National Park, it may be most effective as a tool for other National Parks, but its principles could be applied anywhere where the focus is more than nature preservation. Recreating the native landscape is important at GWCA because the Carvers originally settled the land and would have experienced it in its pre-European settlement state. Other parks may look to restore the landscape to a time period, in which case the evaluation criteria could be applied. I have also mentioned to GWCA that improvement of the native landscape could lead to increased visitation, especially with Diamond Grove Prairie in close proximity. At the monument visitors would have the opportunity to learn about an historical figure important to our nation's history and to experience native wildlife habitat. In summary, the IVMR process looks to give managers an inventory of the natural, historic, and cultural resources at their parks and allows them to determine the characteristics for which they should manage to restore the desired landscape. It also provides a template for how cultural and historic interpretation features can be enhanced or even created by the landscape.

Appendix 1: 2009 and 2010 HSI Scores

2009

Prairie Vole (*Microtus ochrogaster*)

		Characteristics					
Unit	HUV	I.	II.	III.	IV.	V.	VI.
1	0.49	0.10	0.10	0.80	1.00	0.40	1.00
2	0.69	0.85	0.75	0.60	1.00	0.40	0.40
3	0.64	0.60	0.60	0.50	1.00	0.40	1.00
4	0.66	0.63	0.43	0.73	1.00	0.40	1.00
5	0.82	0.81	0.87	0.83	1.00	0.40	1.00
6	0.75	0.78	0.96	0.48	1.00	0.40	0.92
7	0.63	0.67	0.44	0.56	1.00	0.43	0.88
9	0.81	0.76	0.73	0.97	1.00	0.37	1.00

Ornate Box Turtle (*Terrapene ornata ornata*)

		Characteristics			
Unit	HUV	I.	II.	III.	IV.
1	0.71	0.80	0.50	1.00	0.40
2	0.76	0.90	0.85	0.40	1.00
3	0.83	0.90	0.80	1.00	0.40
4	0.86	1.00	0.80	1.00	0.45
5	0.76	0.75	0.72	1.00	0.40
6	0.77	0.74	0.72	0.90	0.64
7	0.77	0.84	0.72	0.86	0.60
9	0.56	0.49	0.49	1.00	0.57

Northern Bobwhite Quail (*Colinus virginianus*)

		Characteristics								
Unit	HUV	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
1	0.77	1.00	0.30	0.20	1.00	1.00	1.00	1.00	1.00	0.60
2	0.92	1.00	0.90	0.90	1.00	0.90	0.50	1.00	1.00	1.00
3	0.82	1.00	0.85	0.80	0.80	1.00	0.20	0.80	1.00	1.00
4	0.78	1.00	0.80	0.75	0.60	1.00	0.23	0.85	0.90	0.85
5	0.82	1.00	0.90	0.89	0.60	1.00	0.19	0.92	0.93	0.88
6	0.91	1.00	0.98	0.96	1.00	1.00	0.28	0.92	1.00	1.00
7	0.90	0.98	0.81	0.75	1.00	1.00	0.76	1.00	1.00	0.60
9	0.63	1.00	0.21	0.43	1.00	0.54	0.16	0.80	1.00	1.00

Henslow's Sparrow (*Ammodramus henslowii*)

		Characteristics					
Unit	**HUV**	**I.**	**II.**	**III.**	**IV.**	**V.**	**VI.**
1	0.60	1.00	1.00	0.10	0.60	0.20	0.80
2	0.79	1.00	0.70	0.75	0.40	0.70	1.00
3	0.61	0.75	0.80	0.60	0.80	0.30	0.30
4	0.59	0.75	0.85	0.43	0.50	0.65	0.35
5	0.71	0.88	0.87	0.87	0.60	0.32	0.40
6	0.74	0.70	0.88	0.96	0.40	0.44	0.84
7	0.70	1.00	0.76	0.44	0.62	0.35	0.96
9	0.64	0.93	0.86	0.71	0.23	0.23	0.54

2010

Prairie Vole (*Microtus ochrogaster*)

		Characteristics					
Unit	**HUV**	**I.**	**II.**	**III.**	**IV.**	**V.**	**VI.**
1	0.51	0.50	0.20	0.30	1.00	0.60	1.00
2	0.60	0.80	0.75	0.25	1.00	0.40	0.40
3	0.54	0.70	0.50	0.10	1.00	0.30	1.00
4	0.47	0.54	0.26	0.12	1.00	0.36	1.00
5	0.64	0.68	0.82	0.18	1.00	0.35	1.00
6	0.62	0.80	0.74	0.10	1.00	0.40	0.92
7	0.62	0.69	0.60	0.38	1.00	0.37	0.88
9	0.63	0.67	0.73	0.33	1.00	0.26	1.00

Ornate Box Turtle (*Terrapene ornata ornata*)

		Characteristics			
Unit	**HUV**	**I.**	**II.**	**III.**	**IV.**
1	0.83	0.90	0.80	1.00	0.40
2	0.64	0.70	0.65	0.40	1.00
3	0.73	0.65	0.70	1.00	0.40
4	0.71	0.62	0.66	1.00	0.44
5	0.67	0.58	0.58	1.00	0.38
6	0.76	0.68	0.76	0.90	0.64
7	0.76	0.84	0.66	0.86	0.60
9	0.54	0.39	0.49	1.00	0.57

Northern Bobwhite Quail (*Colinus virginianus*)

		Characteristics								
Unit	**HUV**	**I.**	**II.**	**III.**	**IV.**	**V.**	**VI.**	**VII.**	**VIII.**	**IX.**
1	0.86	0.90	0.90	0.90	1.00	1.00	1.00	1.00	1.00	0.60
2	0.75	0.70	0.75	0.85	1.00	0.90	0.50	1.00	1.00	1.00
3	0.70	0.90	0.80	0.70	0.80	1.00	0.20	0.80	1.00	1.00
4	0.67	1.00	0.72	0.66	0.60	1.00	0.22	0.88	0.92	0.84
5	0.68	0.91	0.73	0.78	0.60	1.00	0.19	0.91	0.92	0.88
6	0.77	0.90	0.86	0.88	1.00	1.00	0.28	0.92	1.00	1.00
7	0.78	0.86	0.79	0.77	1.00	1.00	0.76	1.00	1.00	0.60
9	0.57	0.94	0.10	0.67	1.00	0.46	0.16	0.80	1.00	1.00

Henslow's Sparrow (*Ammodramus henslowii*)

		Characteristics					
Unit	**HUV**	**I.**	**II.**	**III.**	**IV.**	**V.**	**VI.**
1	0.58	0.80	0.80	0.20	0.40	0.60	0.80
2	0.44	0.95	1.00	0.75	0.40	0.70	1.00
3	0.55	0.85	0.70	0.50	0.40	0.30	0.30
4	0.53	0.82	0.84	0.26	0.40	0.36	0.44
5	0.67	0.93	0.82	0.81	0.40	0.28	0.40
6	0.67	0.80	0.80	0.74	0.36	0.24	0.84
7	0.72	0.93	0.78	0.60	0.39	0.55	0.96
9	0.57	0.60	0.51	0.71	0.51	0.37	0.54

CHAPTER 4: INTEGRATED VEGETATION MANAGEMENT RECOMMENDATIONS FOR GEORGE WASHINGTON CARVER NATIONAL MONUMENT

Introduction

The objective of the Integrated Vegetation Management Recommendations (IVMR) is to provide a framework for developing a long-term landscape management program for the George Washington Carver National Monument (GWCA) in Diamond, MO. It will combine aspects of natural, historical, and cultural interpretation at the park with input from several stakeholders involved with natural resources management at the park. While these recommendations are specific to GWCA, the methods and strategies can be applied to other parks with similar goals. These would include small parks and/or parks that specialize in interpretation history, culture, or other topics. It is intended to be a source of guidance for parks that primarily use external input to make educated management decisions. The purpose of this report is to address issues identified in managing the park's natural resources, and make recommendations for management of the natural and cultural landscapes.

GWCA administration is ultimately responsible for management decisions at the Monument, but without dedicated full-time natural resources staff, the park needs a long-term plan that will aid in managing cultural and natural resources efficiently and effectively.

Prairie management recommendations are being developed using Habitat Suitability Index (HSI) models. Data collection for the HSI models was completed in 2009 and 2010. Recommendations were provided for 2010 in the *2010 Prairie Management Recommendations* (Burfield and Nilon 2009b), and similar recommendations were provided to the park for 2011 in the *GWCA Prairie Management Guidebook: Using Habitat Suitability Index Models* (Burfield and Nilon 2010b).

The *GWCA Prairie Management Guidebook* provides step-by-step instructions on collecting HSI data, analyzing and interpreting HSI data, and applying management actions based on these analyses. GWCA will be responsible for collecting data in the future for prairie management. HSI models will assist park staff in both management decisions and monitoring of prairie conditions.

Management Planning

The Mission of GWCA is to "maintain, preserve, and interpret, in a suitable and enduring manner, the life and legacy of George Washington Carver for the benefit and enjoyment of the people of the United States of America."

The General Management Plan (GWCA Staff 1997) states that the management of natural and cultural resources and the visitor services program will support the commemoration of George Washington Carver. Natural and cultural resources will serve as symbols of significant events and influences on the character and life of Carver.

The interpretive program will enable people to use tangible resources to contemplate the intangible meanings of the Carver story. The landscape and visitor facilities will create a memorial-life atmosphere with opportunities for the public to spend time reflecting upon Carver's experience and their own lives.

Purpose Statements outlined in the GMP include:

- Memorialize the life of George Washington Carver as a distinguished African American, scientist, educator, humanitarian, Christian, artist, and musician.
- Preserve the setting of the Moses Carver farm and birthplace of George Washington Carver.
- Interpret the life, accomplishments, and contributions of George Washington Carver, using a museum, wayside exhibits, and other interpretive strategies.

The park's Significance Statements outlined in the GMP include:

- George Washington Carver National Monument is significant because it was the birthplace and home where Carver spent his formative years that set him on the road to becoming one of this nation's most distinguished scientists and humanitarians.
- Although born a slave and orphaned as a baby, his early years were spent in a nurturing atmosphere with his adoptive white parents in an agrarian setting.

Here he was given the opportunity to pursue his curiosity about the world around him.

The 1997 GMP noted the development of an integrated restoration study which was underway, but was to provide information to help guide the planning team in the management and treatment of the site's cultural landscape and its natural features. However the recommendations of this completed study, the *Springs of Genius Integrated Management Plan for GWCA* (Harrington 1999), were not approved by the Midwest Regional Office.

Identified Issues

The GMP identified the following cultural and natural resource management issue, "Several prairies have been established in areas which were previously farmed. The NPS recommended in the 1966 master plan that the site's landscape be restored to the landscape that existed when George Washington Carver was a boy. This recommendation has never been carried out because there has not been sufficient information to accurately restore the landscape. Current and past studies underway have made it clear that there is not sufficient information to restore the boyhood landscape. The National Park Service is legislatively-mandated to preserve the site of the birthplace of George Washington Carver and the Moses Carver farm. The park's legislation directs the monument to be a memorial to Carver's entire life, not just his boyhood. This legislation does not require a restoration of the landscape or buildings.

The best approach to managing the park's cultural and natural resources in accordance with park's legislation needs to be determined."

The GWCA Natural Resource Condition Assessment (NRCA, draft April 2011) prepared by the Missouri Resource Assessment Partnership (MoRAP) identified the following issues:

- Disturbance or recovery in grassland and woodland from previous land usage;
- Too many patches and too small individual patches of vegetation types in Reporting Units;
- Degradation of bird habitat, especially for species of concern; and
- Higher than desirable cover of invasive non-native vegetation.

Goals

The goals of the IVMR are to:

- Identify the optimum combination of cultural, historic, and natural areas landscapes;
- Make recommendations on Management Zone configurations based on published literature, park documents, historic vegetation, and cultural/historical interpretation;
- Use habitat suitability index (HSI) models to assess the impact these changes will have on GWCA's value as wildlife habitat; and
- Develop guidelines for an evaluation tool that similar sites can use to plan landscape management that meets more than one functional purpose.

Methods

To develop the IVMR for GWCA, we incorporated wildlife habitat assessment data, historical prairie management documentation, literature on George Washington Carver himself, the goals of GWCA management, inventory and monitoring data and recommendations from the Heartland Network, and input and data from other outside stakeholders. The process has included researching the life of George Washington Carver, determining land use history of the 240 acre plot that is now GWCA, reviewing prairie management practices since 1981, collecting HSI and indicator species presence data, and cooperation with outside stakeholders. This document is the final of four documents being prepared for GWCA, and draws upon the first three.

Through the research and field studies, we developed three potential vegetation management alternatives for the IVMR:

Alternative 1: Historic Vegetation Management would restore the conditions at GWCA to the historic base map developed by Harrington (1999, Figure 4).

Alternative 2: Natural Resources Condition Assessment would restore the prairie similar to its presumed pre-European settlement makeup, based on data from HTLN, MoRAP, GWCA, HSI models, and the NRCA itself.

Alternative 3: Integrated Cultural/Natural Vegetation Management would combine native landscape restoration with agricultural areas and exhibits to memorialize the work for which Carver became famous.

Each of the management alternatives were assessed based on the following five evaluation factors:

1. **Impact in meeting the park's mission, purpose, and significance**
2. **Impact in meeting interpretive and visitor experience objectives**
3. **Impact on preservation of cultural landscape features**
4. **Impact upon wildlife habitat based on Habitat Suitability Index models**
5. **Impact on the park's ability to manage the natural and cultural resources (i.e. resources needed, costs, impacts to existing landscape)**

The first step in completing the IVMR was to review documentation from GWCA that addresses long-term planning at the Monument. The Long-Range Interpretive Plan (LRIP) 2007 outlines the objectives the park has determined to be most important in cultural and historical interpretation. The LRIP outlines the Mission, Purpose, Significance, and enabling legislation for GWCA. Other documents reviewed include the 1997 General Management Plan (GMP); the 1982, 1985, and 1995 Prairie Restoration Action Plans (PRAPs); other GWCA prairie management and monitoring plans; and the Springs of Genius Integrated Management Plan for GWCA (Harrington 1999).

Next, we provided a chronological history of the park's land use in the *George Washington Carver National Monument Prairie Restoration Management Review* (Burfield and Nilon 2009). The *Review* included literature and documents that detail the legal and landscape history of the site, as well as a full account of prairie management history at GWCA. A concise land use summary has been included for the IVMR.

GWCA received a draft of the Natural Resources Condition Assessment (NRCA) in April 2011. The NRCA assesses natural resource conditions based on a system of comparing Current Conditions to pre-established Management Targets. It is a qualitative assessment of resource condition based on available GWCA data and conceptual vegetation mapping. The NRCA provides valuable information in terms of improving particular Attributes via Indicators of natural resource condition. Indicators are assessed based on how they fit within physical ranges or whether they are on the correct side of a threshold. Results are evaluated according to how well "current condition approximates the management target" using a score between zero and one. The scale is color-coded in increments of two-tenths.

HSI data from 2009 and 2010 were consulted to aid in decision making. The HSI models assessed the physical structure of the prairie in regard to the habitat requirements of four indicator species (prairie vole, ornate box turtle, northern bobwhite quail, and Henslow's sparrow). For Alternatives 1, 2, and 3, each management unit characteristic in Zones 1 and 2 has been assigned an HSI score based on the maximum projected impact that each alternative is predicted to have upon the indicator species' habitat. HSI models may be used in conjunction with NRCA Management Targets to improve the physical structure of the grassland units.

Finally, we used soils data from the Center for Applied Research and Environmental Systems (CARES) and a conceptual historic soil compatibility vegetation map developed by MoRAP (2010) to determine the extent to which the prairie zones at GWCA could be suitably expanded.

For each alternative, we broadly described how each zone would be managed under the corresponding configuration. We also assessed the impacts that each alternative would have on the realization of GWCA's goals using the aforementioned five evaluation factors.

As stated in the National Park Service Park Planning Program Standards (2004), the National Park Service uses planning to bring a logical framework, analysis based on current scholarship and science, public involvement, and accountability into decision making. The NPS takes a comprehensive approach to decision making about parks that integrates the management of natural and cultural resources, visitor enjoyment and other uses, and associated management activities and development over relatively long periods of time (typically 15 to 20 years). This decision making takes place within a dynamic, continuously changing environment. Because this working environment is not static -- or even highly predictable – the success of park management depends largely upon the capabilities of park managers and staffs to continuously process new information and use it creatively, often in partnership with others, to resolve complex and changing issues.

The alternatives outlined in this report have gone through an evaluation process, analyzing fundamental resources and values that are key to achieving the park's purpose. It is the hope of the Principal Evaluator and Research Assistant that this report will prove useful as the NPS continues the process of defining the preferred alternative for management of natural resources within the cultural landscape of George Washington Carver National Monument.

GWCA Land Use History

Vegetative Cover

According to a land survey conducted in 1842, the Carver farm was almost entirely native prairie and savanna (Schroeder 1981). Jackson (1984) estimates that woodlands about 10 m wide were present on either side of the Carver and Harkins Branches of Shoal Creek.

In 2010, representatives from the Missouri Resource Assessment Partnership (MoRAP) presented conceptual historic soil compatibility and current vegetation maps with color-coded designations to represent ground cover (Appendices 1 and 2). The historic soil compatibility vegetation map is based on soil types and most of the area of the current prairie management units was designated as, in descending order: little bluestem/prairie dropseed-big bluestem, bluestem prairie; post oak/chinquapin oak-bluestem, post oak-bluestem prairie or savanna; and big bluestem/prairie cordgrass-switchgrass, mesic tallgrass prairie. Management Unit 2 is the only prairie unit that appears to be outside of a prairie/savanna designation as white oak/bur oak-pecan, floodplain forest (small drainages). In the extreme northwest corner of the property, the land cover type was historically white oak/bur oak-pecan, floodplain forest (small drainages), but is currently designated as Upland Prairie and Savanna woodland. This area will likely remain forested because the forest extends off the property to the west.

The current vegetation map (Appendix 2) is based on existing conditions at GWCA. It describes almost all of prairie management units as being Upland Successional and Disturbance Grasslands. The remaining areas located in Management Units 2 and 7 are denoted as Bottomland Successional Herbaceous Vegetation.

The Carver Farm

Moses Carver settled the site of GWCA in 1838, eventually acquiring the current 240 acres of park land via the Preemption Act of 1841. The Act allowed “squatters” to purchase plots of 160 to 640 acres of “improved” land for no less than $1.25 per acre (McMurray 1981). Moses purchased George Washington Carver’s mother Mary Carver in 1855. The farm was likely used for subsistence for at least the first couple of decades (Kremer 2008). Moses Carver primarily trained and sold race horses as well as beekeeping and raising cattle, sheep, and pigs (Kremer 2008, Fuller and Mattes 1957). It is estimated that approximately 110 acres of native prairie existed at the Carver Farm during Carver’s boyhood years (Harrington 1999).

The Shartel Farm

Around 1916, the Carver farm was purchased by Cassius McLean Shartel, who served as a Missouri U.S. Representative from 1905-1907. The land was eventually acquired by his son, Stratton Shartel, a lawyer and Missouri Attorney General from 1928-1933. Under Shartel ownership, the farm was subject to modern agricultural practices such as cropping and grazing.

Photos from the GWCA Archives illustrate the farming techniques and structures that were present on the property in the 1950's. The woodlands (Carver Woods) in the central portion of the property were not present. Instead the trees that were present had a cleared and landscaped understory. It appears that there was much transportation in this area. The main Shartel house was a large dwelling in the center of the property just south of the Carver Branch. The Shartel farm buildings to the west-southwest of the Shartel house were likely in the same vicinity as the current Visitor Center and administration building. A pumphouse for Carver Spring existed just to the north of the main Shartel house on the south bank of the Carver Branch. There was a foot bridge immediately west of the pumphouse. Another pumphouse was located to the west of the Carver Spring pumphouse, and the two structures were close in proximity to one another. In the photographs, the only distinguishing feature was that the second pumphouse had a vehicle crossing immediately to the west. The areas currently managed as prairie units were used for cropping and grazing, with two small areas of native prairie possibly remaining.

Acquisition of GWCA Tract

President Franklin D. Roosevelt signed into establishment the George Washington Carver National Monument on July 14, 1943, at which time Congress began negotiating the acquisition of 210 of the original 240 acres of the Carver farm. While Mr. Shartel was asking for $73,000, Congress had only appropriated $30,000 for land acquisition and park development. In 1948, Mr. Shartel sold the tract to Dawson W.

Derfelt without mentioning the government's interest in the property. After the government filed a petition to condemn the 210 acre plot, Mr. Derfelt proclaimed his ignorance of the circumstances. Though Congress originally informed him the maximum offer would remain $30,000, the farm was appraised at a value of $78,895 by the Commissioner of the courts. Congress appropriated funds on June 14, 1951, and the park was formally dedicated on July 14, 1953 in front of 1,000 to 2,000 attendees (Toogood 1973).

At the time of the National Park Service's acquisition, the farm was described as "well improved" (Harrington 1999). The Shartel property also included the 80 acres directly to the north of the Monument, which was not purchased by the NPS and is now a working farm. There is currently a thin strip of woodland separating the two properties.

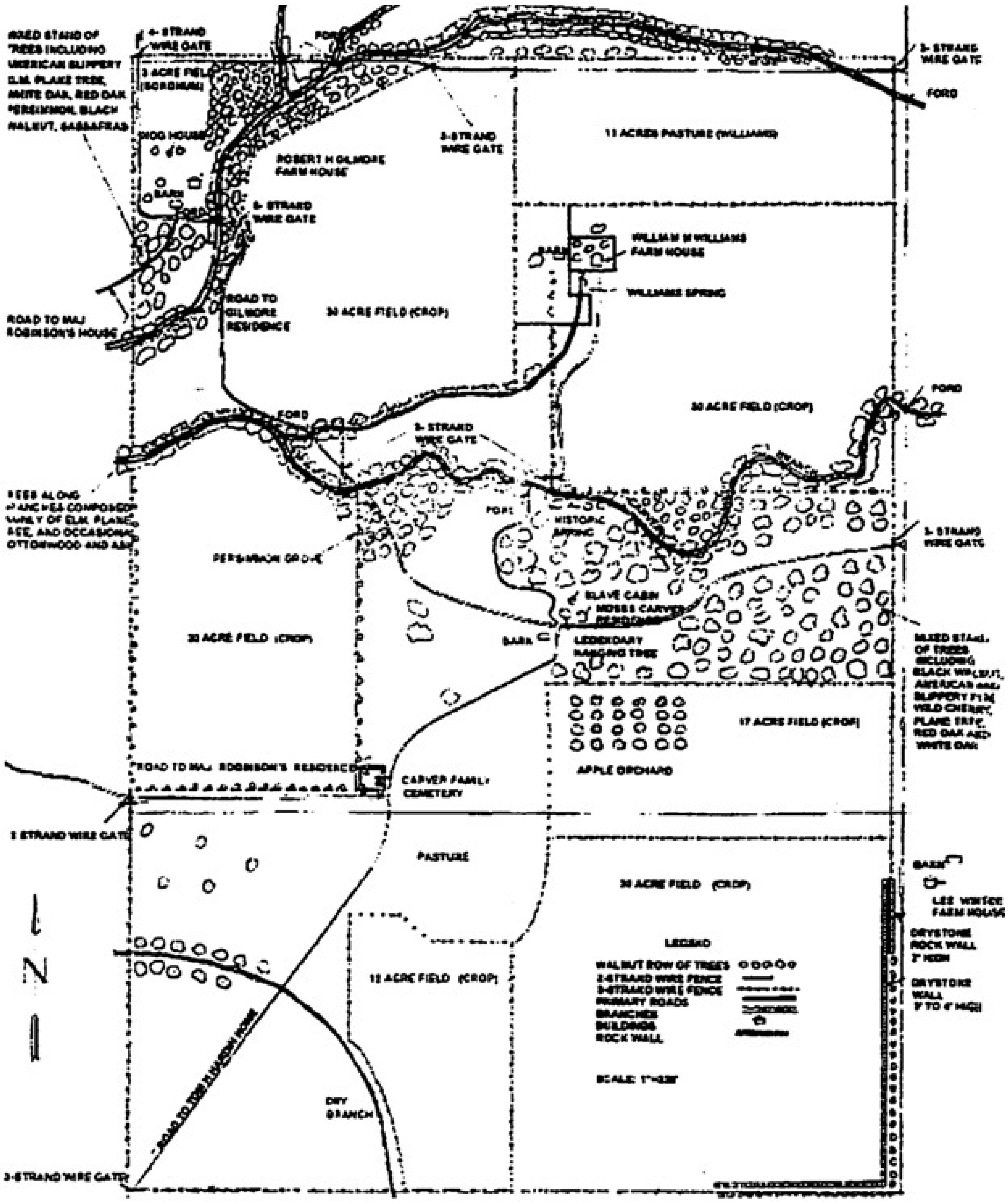


Figure 4: 1863-1864 Carver Farm Historic Base Map

Prairie Units

Jackson and Bensing (1982) established the original five Management Units (Figure 2) in their Vegetational and Historical Analysis. The units were intended to represent native prairie that was present during the Carvers' occupancy. Each unit was characterized through species lists, soil classifications, soil analysis, vegetation plot sampling, aerial and ground photographs, interviews, and historical documents. A sixth unit was added in 1984 (west of the walking trail from Carver Woods to the cemetery, currently part of Management Unit 4), with the intention of combining in with a larger unit as the restoration progressed (Jackson 1984).

Until 1989, GWCA had leased up to 93.5 acres of park land for agricultural use. It was decided in 1984 that the agricultural lease program was not achieving the management objective to "restore the historic scene to that of the Moses Carver Farm of the 1860's and 1870's." The two main reasons cited by Jackson (1984) were that 20th century agricultural practices were actually having a negative impact on historical interpretation and natural resources management. In addition, it was decided that exotic plant species would be easier to eradicate from the established prairie units without the agricultural plots. The agricultural lease program was to be phased out over five years, which created eight additional temporary prairie units numbered 7 through 14. These units and the existing six units were recombined into the 1990 Management Units (MU) 1-7 and Management Unit 8 in the current Harkins Woods, which was never managed as prairie and is now successional woodland. As of 2005, there were eight

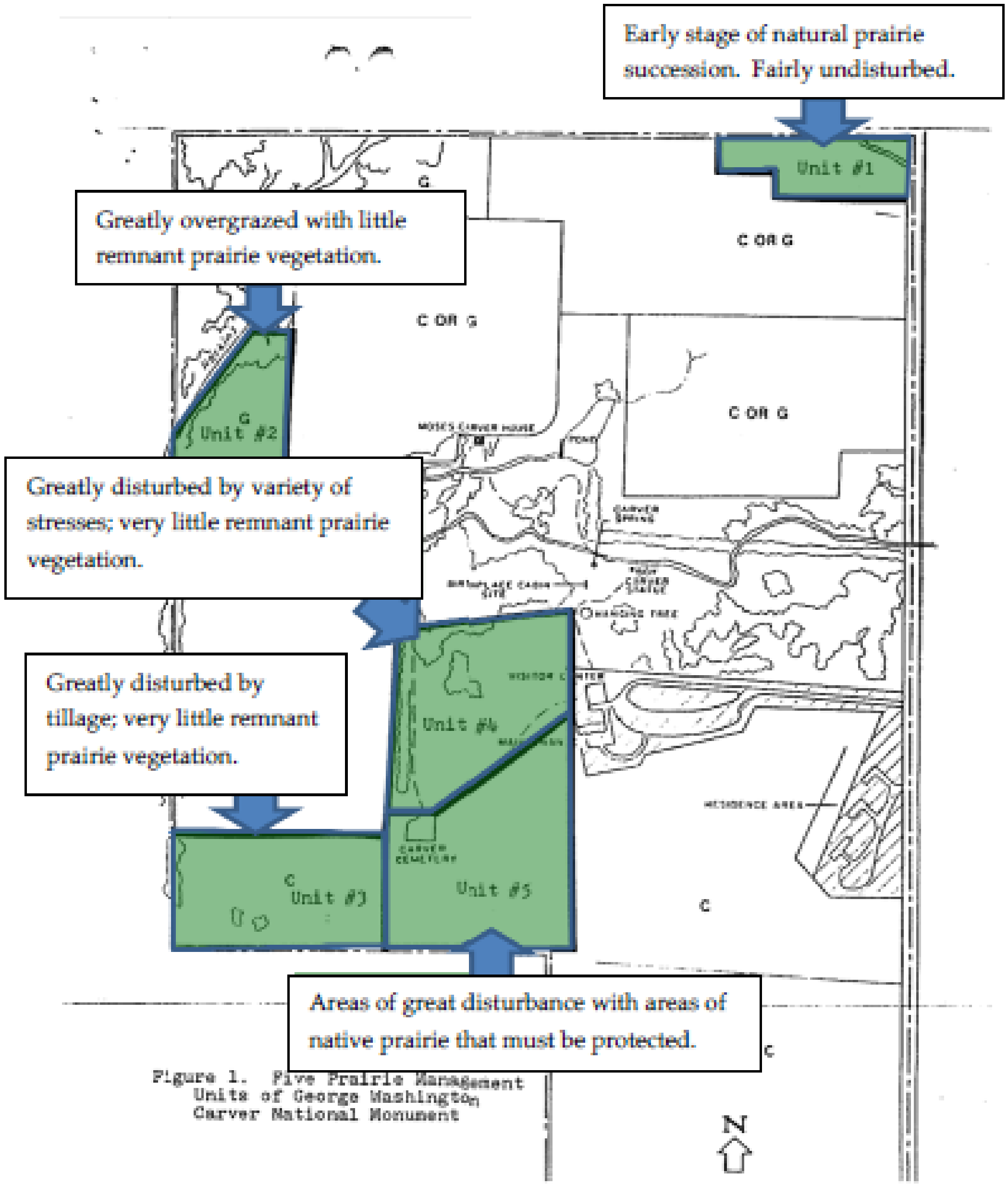


Figure 5: 1982 Map of the GWCA Prairie Management Units

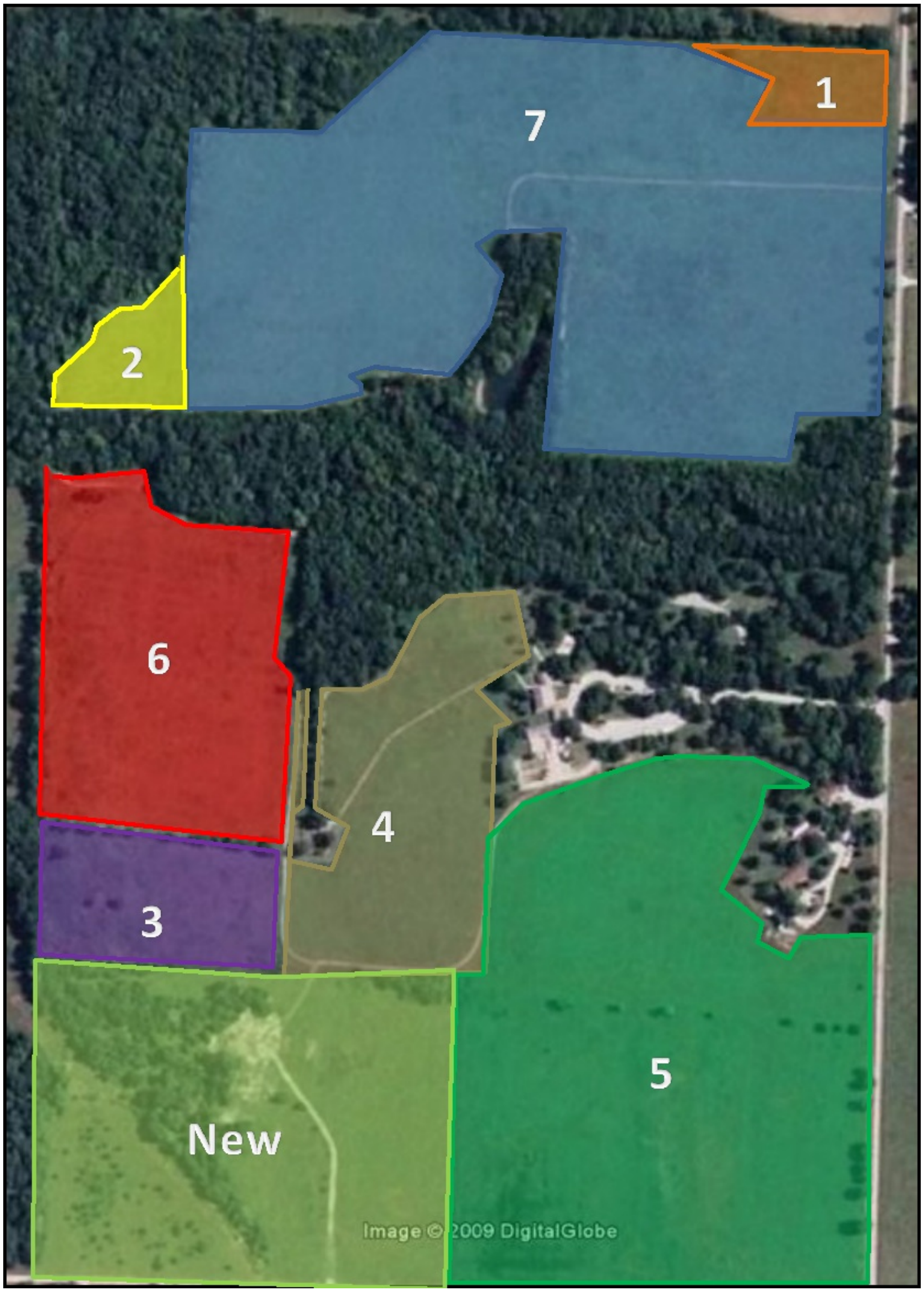


Figure 6: 1990 Map of the GWCA Prairie Management Units

prairie Management Units at GWCA, of which seven received regular management prescriptions. Unit 9 was acquired and designated in 2005, and is being evaluated for management potential. Zinc and lead ore mining operations were conducted on this unit in the 1930s. The tailings were cleared and the shafts sealed in 2004.

Proposed Realignment of Management Units

In order to consolidate management prescriptions, monitoring, and recordkeeping, we recommend that GWCA combine the current eight MUs into four new management "Zones" plus a zone for Carver Woods. The following would be the changes in unit designations:

- Units 1, 2, and 7 become **Zone 1** or **North Zone** (23 ha, 57 acres).
- Units 3, 4, 5, 6, and 9 become **Zone 2** or **South Zone** (48 ha, 119 acres).
- Carver Woods and Harkins Woods become **Zone 3** or **Carver Woodland/Savanna Zone** (18 ha, 45.5 acres).
- The "Development Subzone" including the Visitor Center, administration buildings, maintenance areas, apartments, driveways, and parking lots, plus the Carver Trail, Contemplative Loop, and Classified Structures (Figure 18) become **Zone 4** or the **Cultural Zone** (8 ha, 20 acres).
- There is also the possibility of establishing a **Demonstration Unit** in the southeast section of the Carver Woods near Carver Road.

In recent years, management actions have been prescribed by combining adjacent units. Prescribing management actions using the proposed realigned units allow for larger tracts of land with the same level of disturbance (one year after burning, two years after burning, etc.). GWCA could choose to prescribe management for specific areas of the zones.

Realignment would also provide for better HSI data collection. Three of the eight current units have only one or two HSI plots, and combining these with much larger units would make management prescriptions and subsequent monitoring more efficient. This realignment is logical because it keeps most of the outer boundaries of the previous units and allows for continuity in management decisions.

We also recommend that a “Visitor Viewshed” be developed in the areas immediately visible from the Carver Trail and Contemplative Loop. In the Viewshed, intensive prairie management will replace non-native and problematic species with a local mix of native warm season grasses and a 10 to 25 percent coverage with local native forb mix. The Viewshed would extend approximately 100 m into management zone in the areas shown in Figure 7. The intent of the Visitor Viewshed is to enhance the visitor experience with greater aesthetic value by improving habitat quality. Forbs would add color to the landscape and attract grassland wildlife, particularly birds, bees, and butterflies. GWCA could add a wildlife education feature to the trail with signage to identify plants and wildlife. The increased forb cover would also provide a seed bank for dispersal into more distant areas of the prairie zones.

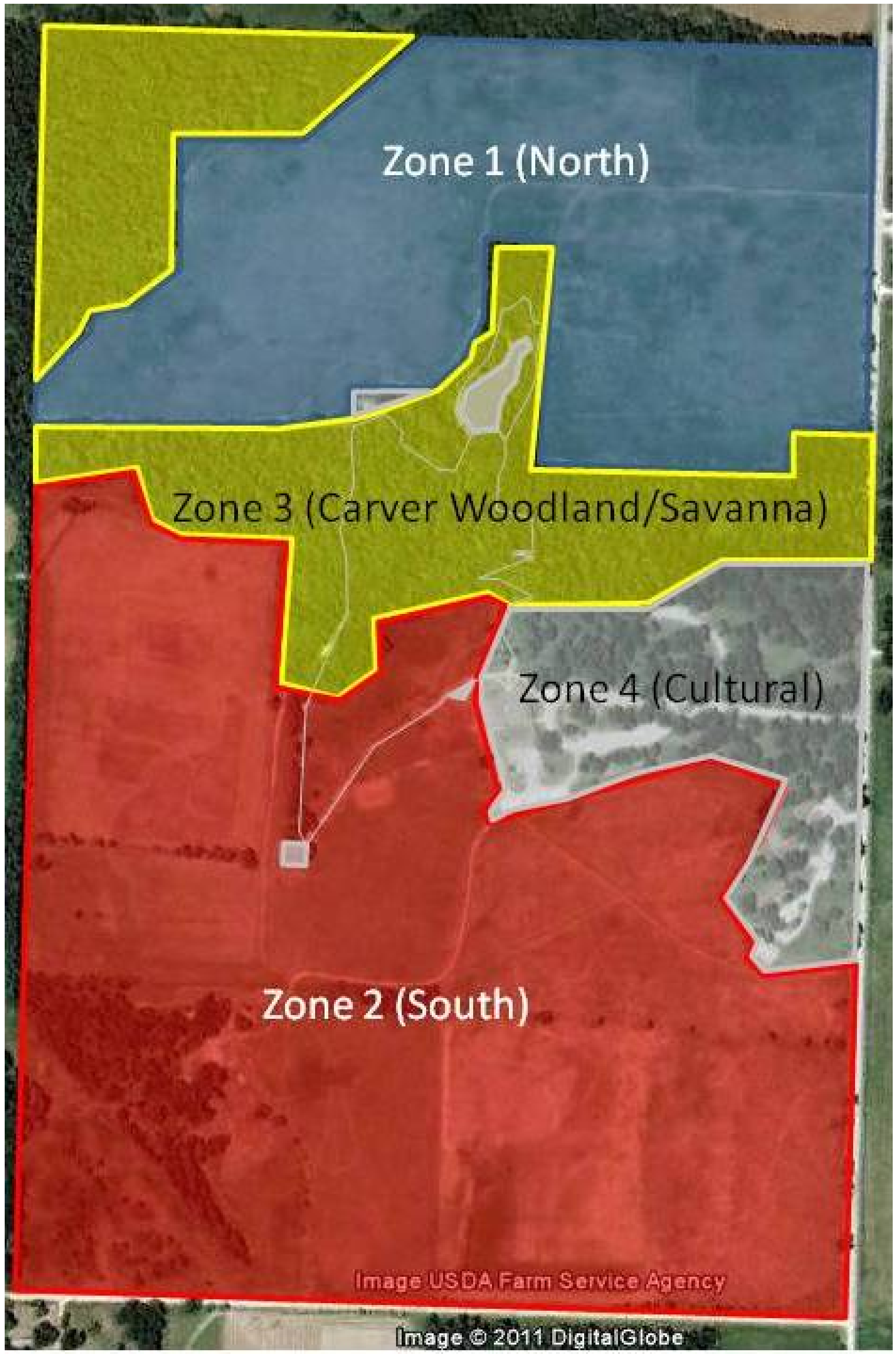


Figure 7: Recommended Management Zone Alignment at GWCA.

Prairie Management

The Heartland Inventory and Monitoring Network (HTLN) also monitors prairie conditions at GWCA. The mission of HTLN is to "acquire, manage, analyze, and distribute scientific information on the status and trends of specific park natural resources." HTLN has developed monitoring plans and inventories for a number of "Vital Signs" at its network of parks. Currently, HTLN inventories for GWCA include fish, herpetofauna, mammals, exotic plants, and vascular plants, with a corresponding geodatabase for each. This information is available to aid GWCA in management decisions, and HTLN occasionally will make recommendations to the park based on their findings. In 2010, HTLN instituted an Exotic Plant Management Team, which makes regular visits to the park to manually remove non-native species from the prairie and woodlands.

As we mentioned, the Missouri Resource Assessment Partnership (MoRAP) has developed two conceptual land cover maps for GWCA. The first shows expected pre-settlement vegetation communities based on soils data, and the second represents current ground cover.

The Volunteers In Parks (VIP) program and the Missouri Master Naturalists were very important labor sources for field work. Both organizations provided very motivated and reliable volunteers and could be depended upon for future field work. Some volunteers have already received training and/or have experience in various field methods.

Existing Conditions

Zone 1: North Zone (23 ha, 56.8 acres)

As noted in the GWCA 1994 Management Baseline and Monitoring Program (Wilson and Jackson 1994), Former MU 7 continues to show areas of superb restoration (Figure 8), while other areas are dominated by invasive or problematic species (Figure 9). The most affected part is just east of Williams' Pond, where there is surface water during winter and spring. In fact, there is an intermittent stream that required the construction of a small foot bridge where the stream enters the pond. This combined with wind dispersal from the woodland has likely contributed to the establishment of these problematic areas.

The northwest portion of the zone is probably the best representation of native prairie in the park. Unfortunately it is also one of the most remote. There is a healthy distribution of grasses, forbs, and shrubs. Across the northern section of the zone to the east the cover transitions to heavy sumac invasion. Blackberry (*Rubus* spp.) is widespread to the point of becoming problematic in some areas. Otherwise, there is a horseshoe-shape of native warm season grasses, interesting forbs, and fruit shrubs that stretches from the southwest to the north central region, then around to the southeast portion of Zone 1.

This zone is suffering from a heavy smooth sumac (*Rhus glabra*) invasion, and also contains a large tract of crown vetch (*Coronilla varia*) in the area of former MU 1

(Figure 10). Because this unit was considered to be one of the areas in the park that contained native vegetation, it should receive considerable attention.

Former MU 2 in the west end of Zone 1 remains diverse in plant species (Figure 11), but is being threatened by a major invasion of sericea lespedeza (*Lespedeza cuneata*). Pasturegard herbicide is being used to treat this invasion. There is a large patch of ashy sunflower (*Helianthus mollis*), which is native to Missouri. Overall, forb diversity is as good here as anywhere in the park, including a patch of royal catchfly (*Silene regia*). There is an American sycamore (*Platanus occidentalis*) invasion looming from the east. Though native to Missouri, blackberry covers a significant portion of the northern subzones and sycamore is primarily a woodland species that is escaping Zone 3 and colonizing.

Figure 8: Photo from HSI Plot 2 showing the condition of northwest Zone 1.

Figure 9: Photo from HSI Plot 14 showing the condition of Zone 1 east of Williams Pond.

Figure 10: Photo from HSI Plot 5 showing the condition of the northeast corner of Zone 1.

Figure 11: Photo from HSI Plot 11 showing the condition of the southwest end of Zone 1.

Zone 2: South Zone (48 ha, 119 acres)

There is a growing sumac invasion in Zone 2, primarily in former MU3 (Figure 12) and former MU4 (Figure 15), as well as several small colonies of sericea lespedeza. Sumac grows in natural non-invasive clumps in former MU 6. Blackberry is not as much a problem here as in Zone 1, but could potentially take over larger areas without proper management. The western edge of former MU3 closest to the adjacent woodland is an incline that is experiencing a substantial invasion of sumac and poison ivy (*Toxicodendron radicans*). Sericea lespedeza is also present in small patches throughout Zone 2. Interspersed with these invasive and problematic species is good native warm season grass cover, with an aesthetically pleasing cover of black-eyed susan (*Rudbeckia hurta*) that extends across the western half of former MU3. The northern section of the zone (former MU 6, Figure 13) is dominated by native warm season grasses, but would benefit greatly from greater forb cover and diversity. There is sporadic shrubby vegetation, which can be eradicated, tolerated, or encouraged depending on the species.

This zone exhibits very good native warm season grass cover, but shows areas of thinning where deep tire tracks from haying and mowing implements have disturbed the soil, even occasionally leaving bare patches. This prevents grass stands from reaching optimal health, particularly in the central portions of former MUs 5 and 6.

At this point, all former MUs are very different in species makeup and habitat quality. In the east portion of the zone (former MU 5, Figure 14), native warm season grass cover is reasonably good, but there are some areas in the northeast section of the zone that are completely dominated by Johnsongrass (*Sorghum halepense*). This was said to have happened because mowing implements that were not thoroughly cleaned dropped the seed while mowing. The southwest portion of former MU 5 is undergoing a substantial sumac invasion in the vicinity of an area that appears to be an intermittent wetland. In the northeast there is a healthy patch of blackberry and germander (*Teucrium canadense*), which also appear together in other areas of the park. Each of these areas is populated by bees regularly, and should be considered for preservation. Overall Zone 2 shows potential to become an even more aesthetically pleasing area without much effort. Increasing forb diversity and loosening the compacted soil, along with regular prescribed burns, may encourage an appreciated improvement in this zone.

Throughout prairie management history at GWCA, the southern half of former MU4 has been known as one of the best restoration successes in the program. Unfortunately the zone has recently been invaded by sumac in the southern section, and is beginning to be dominated by it in the northern section. Otherwise there is good native warm season grass cover in the southern section, and areas of amazing forb cover in the portion of the zone near the Carver cemetery.

The southwestern portion of the zone is the tract that was acquired by the park in 2005 (former MU 9, Figure 16). It remains largely covered in tall fescue (*Schedonorus phoenix*) and mixed woodland. There is a power line right-of-way in the southwest corner of the zone. No management has occurred on this section of the zone other than mowing and hand-pulling of invasive vegetation by an SCA intern in 2009. An interesting note is that native warm season grasses from the adjacent former MU 5 appear to be colonizing former MU 9 and should continue to do so as management is implemented.

Figure 12: Photo from HSI Plot 49 showing the condition of former MU3 in western Zone 2.

Figure 13: Photo from HSI Plot 36 showing the condition of former MU6 in northwestern Zone 2.

Figure 14: Photo from HSI Plot 65 showing the condition of former MU5 in eastern Zone 2.

Figure 15: Photo from HSI Plot 47 showing the condition of former MU4 in central Zone 2.

Figure 16: Photo from HSI Plot 59 showing the condition of former MU9 southwestern Zone 2.

Zone 3: Carver Woodland/Savanna (18 ha, 45.5 acres)

Over the course of this project, we collected data on the existing prairie management units, but not in the woodlands or developed zones. Upon observation of this zone, it is obvious that management actions should be prescribed to address Japanese bush honeysuckle (*Lonicera japonica*) and other invasive vegetation as outlined by HTLN (Cribbs et al. 2007). The woodland canopy is closed mainly due to colonizing trees growing in openings left by the tall hardwood canopy. The woodland areas at GWCA have been allowed to grow unchecked for decades and should be a candidate for a future study and management regime.

Figure 17: Photo showing the condition of Zone 3 near Carver Trail.

Zone 4: Cultural Zone (8 ha, 20 acres)

The Cultural Zone includes the driveway, parking lot, manicured public areas, the Visitor Center, administration buildings, the Carver Trail, the Moses Carver House, Williams Pond, the Contemplative Loop, and the Carver Cemetery. The Visitor Viewshed may also be recognized as part of Zone 4, but would be subject to management prescriptions of Zones 1, 2, and 3. The Carver Trail and the future Visitor Viewshed in their current conditions are not conducive to the Visitor Experience Objectives as laid out by the 2007 LRIP due to the presence of multiple invasive species and the disturbance of the woodland understory.

Figure 18: Photo showing the condition of Zone 4 near Carver Trail.

Figure 19: Photo showing Williams Pond and surrounding vegetation.

Figure 20: Photo showing the potential Visitor Viewshed north of the Moses Carver House.

Vegetation Management Alternatives

Alternative 1: Historical Vegetation Management

Restore the landscape of GWCA to a facsimile of the boyhood Carver Farm of the 1860s-1870s, based upon the Historic Base Map created in the 1999 Springs of Genius report (Harrington 1999; Figure 4) and data from the 2011 NRCA.

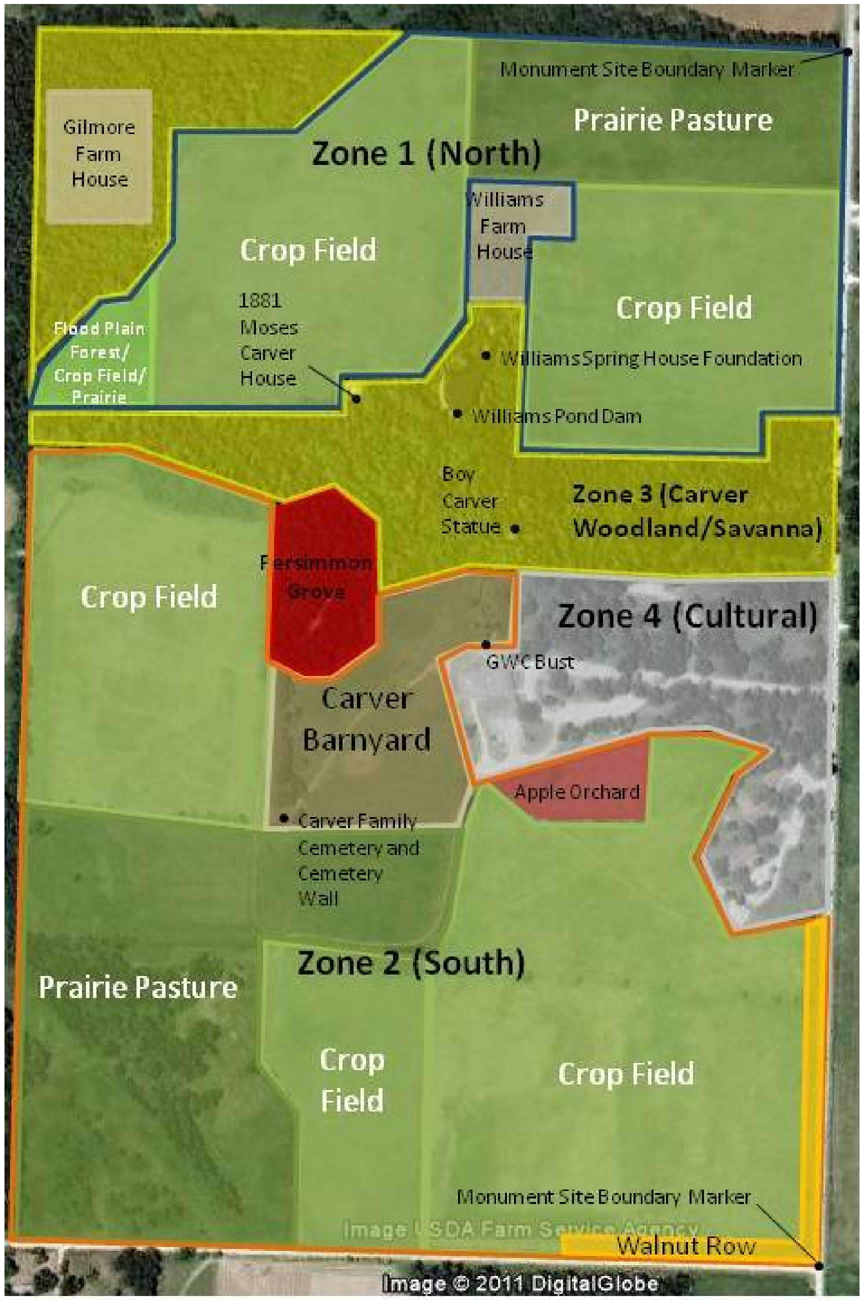


Figure 21: Alternative 1, Historic Vegetation Management

Zone 1 – North

23 ha (57 acres)

Description: Zone 1 is bordered on the north and east by the park's boundary, on the south by Zone 3 and Carver Branch, and on the west by the park boundary and Harkins Woods (Zone 3). The soil types for this zone are available in Appendix 3.

Most of Zone 1 was designated as a pair of 8.09 ha (20 acre) croplands. The Historic Base Map shows 6.07 ha (15 acres) in the northeast portion of this zone as being pastureland. Because Moses Carver settled the land his pasture likely was remnant unplowed prairie. Therefore, high quality restored prairie pasture would most accurately portray the cultural scene of the 1860s. Even if Moses had plowed his fields and allowed them to lie fallow, they would have eventually been recolonized by local native species. Non-native species would have been far less common in the 1860s. The former pasture area is currently plagued by sumac and crown vetch invasions. For this section of the zone, we have maximized our projected HSI scores.

The Historic Base Map does not clearly show whether former MU 2 was used for cropping, but it is located next to a 30-acre crop field. This section would have been bordered on the east by a north-south road to the Gilmore residence northwest of Harkins Branch. It is possible this area was left untouched by the Carvers and their residents, but not by later tenants as it was characterized as overgrazed by Jackson (1982). The soil profile is Secesh-cedargap complex, which according to MoRAP (2010) corresponds to white oak/bur oak-pecan, floodplain forest. However, because the imminent reestablishment of Harkins Woods as a cultural/historic interpretation zone is not likely, this road would not necessarily be reinstalled.

Goals: Restore Zone 1 to a replica of the 1860s-1870s Carver Farm to portray the boyhood home of George Washington Carver. Visitors would be provided with a landscape onsite that would recreate the many uses of GWCA land under the management of the Carvers and their extended family on the northern half of the property.

Recommendations: Re-establish two 20-acre cropfields to their designated locations on Figure 21. Continue restoration of the northeast prairie area, including eradication of crown vetch and sumac. GWCA may choose to fence off the prairie area for cattle grazing. Whether this plot is intended for use as a pasture, hayfield, or conservation area, it should be managed as prairie. Harrington (1999) characterizes prairie pasture as being up to 50% trees and shrubs to be managed by mowing, cutting, periodic prescribed burns, and grazing.

The area of former MU 2 could either be managed as a flood plain between the Harkins and Carver Branches or as an extension of the cropping zone. Because MU 2 was only 1.19 ha (2.94 acres) and due to its propensity for flooding, we assume that cropping ended at the Gilmore road. Another alternative for former MU 2 would be to leave it as it is now due to a strong presence of forbs.

Zone 2 – South

48 ha (119 acres)

Description: Zone 2 is bordered on the north by the Carver Branch and Zone 4, and on the west, south, and east by the park's boundary. The soil types for this zone are available in Appendix 3.

The Historic Base Map shows former MU 5 as two crop fields totaling 15.8 ha (39 acres). A drystone rock wall and an exterior row of walnut trees wrapped around the southeast corner of the property. A portion of Moses Carver's apple orchard would have been located on the north section of the unit. Former MU 6 (6.07 ha, 15 acres) is illustrated as cropland on the Historic Base Map, while former MU 3 (1.74 ha, 4.3 acres) is pasture. There were no historically significant features on either unit, though MU 3 would have been bordered on the south by a road to the Robinson residence.

Approximately two-thirds or 8.1 ha (20 acres) of former MU 9 would have been pasture, while the remaining 4.9 ha (12 acres) would have been a crop field. A road leading from the Carver homestead southwest off the property was located here. The Dry Branch enters the southern boundary of the zone and exits through the west boundary. Former MU 9 is currently fescue pasture with early successional woodland situated diagonally northwest to southeast.

Historically former MU 4 was used as a farm utility yard and pasture. The location of both the Carver and Shartel barns were here. The landscape likely featured a barnyard (presumably with horses) that led northwest to the persimmon grove, southwest to the Carver family cemetery, and southeast to the apple orchard near the current employee parking lot. To the northeast of this zone would have been the Carver residence, the cabin site where George Washington Carver was born, Carver spring, the legendary hanging tree, and the driveway out to what is now Carver Road.

Goals: Restore Zone 2 to a replica of the 1860s-1870s Carver Farm to portray the boyhood home of George Washington Carver. Visitors would be provided with a landscape onsite that would recreate the many uses of GWCA land under the management of the Carvers on the southern half of the property.

Recommendation: To properly represent the Historic Base Map, this Zone would need to be managed as a cropland on former MU 6 and a pasture in former MU 3. Former MU 5 and former MU 9 would be managed as cropland and pasture according to the Historic Base Map. Given that historic cropping methods have been deemed inefficient, modern methods may be used in all instances. The woodland on former MU 9 could remain open to grazing cattle if used, but a fence would need to be erected around the perimeter of the pasture. It is also recommended that fescue in former MU 9 be transitioned to restored native prairie.

Zone 4 would be managed as a barnyard, with or without livestock, but preferably with horses. A small pasture would be maintained to the south of the barnyard. It could be used as a “living” exhibit where the various trades of Moses Carver would be demonstrated with a predetermined level of visitor interaction. HSI scores have been adjusted accordingly to represent this unit’s value as wildlife habitat under this configuration. If this option is not viable for former MU 4, it would be best to continue restoration and plant with forbs as part of the Visitor Viewshed.

Zone 3 – Carver Woodland/Savanna

18 ha (45.5 acres)

Description: The Carver Woodland portion of Zone 3 is bordered by Zone 1 on the north, the park boundaries on the east and west, and Zones 2 and 4 on the south. The Harkins Woods portion is bordered by park boundaries on the north and west, and Zone 1 on the south and east. The soil types for this zone are available in Appendix 3.

The Historic Base Map shows the current Carver Woods area as a much narrower line of trees along either side of the Carver Branch. As noted by Jackson (1984), the native landscape likely had only 10 m of woodland on each bank of the stream. The Persimmon Grove would also have been located within this zone.

The Williams residence would have been located near the current day Williams Pond. The pond itself would not have been present historically, but should not be removed because of its importance to wildlife and as a visitor attraction.

The Harkins Woods were not previously woodland until ownership by the National Park Service. It was intended to be managed as a prairie management unit (MU 8) during the early restoration planning stages. At some point during the Carvers' occupation, the Gilmore Farm was located there.

Goals: Restore Zone 3 to a forest ecosystem that approximates a native riparian area. Trees should become more sparse as the vegetation approaches other management zones. Recreating a native hardwood riparian buffer along both Carver and Harkins Branches would add to the historic landscape as these creeks and their surrounding vegetation were virgin at the time Moses Carver settled the site. Establish the Persimmon Grove within Zone 3 (Figure 21).

Recommendations: Improve Indicator values for woodland habitat to Management Target levels while approximating the community description from the Woodland Reporting Unit (see Alternative 2 for more details). This may require much time and effort and additional planning from a forestry perspective. Establish the Persimmon Grove in the area indicated on Figure 21. According to Harrington (1999), persimmon trees should be planted in an open area with an old field for the understory. This would involve clearing the area intended for the Persimmon Grove, planting the trees, and allowing the understory to establish itself as a crop field lying fallow. Monitor the area for invasive species and other woody species that would be detrimental to the Grove.

<u>Zone 4 – Cultural Zone</u>

8 ha (20 acres)

Description: Zone 4 would have been the area occupied by the Carver homestead, including Carver Trail and the aforementioned historical landscape features.

Goals: Provide access to and interpretation of historic landscape features as outlined by GWCA's Long-Range Interpretation Plan. Maintain Carver Trail and all outdoor exhibits for aesthetic value, wildlife habitat, and long-term utility.

Recommendations: Manage modern landscaped areas as they are. The woodland that houses Carver Trail should be managed the same as adjacent areas of Zone 3.

<u>Evaluation Criteria</u>

1. **Impact in meeting the park's mission, purpose, and significance (enabling legislation, GMP – memorial concept)**

This alternative best fulfills the purpose of preserving the setting of the Moses Carver farm and the birthplace of George Washington Carver. It also meets the significance value of preserving George's birthplace and childhood home for the sake of understanding his later accomplishments. Many of the exhibits in the museum interpret the later life and accomplishments of George Washington Carver, and the Historic Base Map Restoration would re-create the scene that the Carvers would have experienced when George lived there.

2. **Impact in meeting interpretive and visitor experience objectives (LRIP)**

This alternative would help a visitor gain an understanding of the cultural environment around the farm in the 1860s, but it is not likely to illustrate the lack of opportunities Carver would have had interacting with people of his own race. The surrounding landscape has changed somewhat, though it is still an agrarian setting (GWCA 1997).

Recreating the Carver farm would limit the amount of spiritual inspiration a visitor would experience from nature. A visitor's experience would be primarily of an 1860's homestead.

Artistic interpretation in the landscape would also be limited in an agricultural setting. Carver would have found plants for his "Secret Garden" and his artwork on the property, but he may have ventured offsite for additional inspiration. Prior to development in the region, the Carver Farm was once part of the prairie that is now known as Diamond Grove Prairie, and there were likely inspirational natural areas within a short distance. George often traveled to nearby towns on errands for the Carvers, and may have taken a moment to reflect and gather specimens along the way (McMurray 1981). Moses Carver passed on to George the values of independent thought, frugal living, sustainability, and a love for music (Hersey 2011). Interesting questions to answer might be: 1) What about the Carver Farm would have inspired George? 2) Would farming practices have been intriguing, or was it his natural ability to raise plants and understand their maladies? 3) What would George have learned from Moses which may have influenced him to enter the field of agricultural science?

3. **Impact on preservation of cultural landscape features (identified in Cultural Landscape Inventory)**

There should be no negative impacts, as no cultural landscape features would be removed. Positive impacts would be understanding the day-to-day experiences of the Carvers, additional exhibitions of 1860s farming practices, and an image of how the Carver farm was laid out. If anything, this alternative would enhance these features and provide the opportunity for the rebuilding of historic buildings and roads, which could be used for visitor access to different sites.

4. Impact upon wildlife habitat based on Habitat Suitability Index Models

The following are the projected HSI model scores based on the vegetation management presented in this alternative:

Table 21: 2010 and Projected HSI model scores under recommended management for Alternative 1.

	Zone (2010)			Zone (Projected)	
Species	1	2	|	1	2
Prairie Vole	0.61	0.60	|	0.58	0.36
Ornate Box Turtle	0.75	0.68	|	0.49	0.46
Bobwhite Quail	0.78	0.67	|	0.56	0.53
Henslow's Sparrow	0.72	0.62	|	0.53	0.40

All Habitat Unit Values (HUVs) would decrease for each species in each zone. Prairie voles will be suited best in areas that feature native warm season grass and litter, primarily parts of Zone 1 and Zone 3. Bobwhite may prefer certain areas of the park that feature a diverse array of habitat types within close proximity to each other, but overall habitat quality would be negatively affected.

The main cause of the lower HSI scores in this alternative is the removal of the vegetation and physical structure associated with prairie habitat. Most of the prairie zone acreage would be converted from grassland of varying quality to row crops. In these areas, grass and forbs would be removed, which causes negative effects for each of the indicator species. Litter would be nonexistent in row crop areas. Diversity of food sources would be decreased, though bobwhite would benefit from crop fields and ornate box turtles would benefit from grazing on prairie pastures with cattle, where dung beetles would be abundant. Grassland nesting birds would be unlikely to use GWCA due to smaller units of grassland vegetation. They also would not have litter or standing grass for nest building, concealment, song perches, or food sources.

5. **Impact on the park's ability to manage the natural and cultural resources (resource needed, costs, impacts to existing landscape)**

This alternative was deemed inappropriate when Harrington (1999) presented it. In this case we are evaluating it based on its value as part of an integrated system. Prairie management is often a dynamic process, hence the need for an adaptive approach. Managing the landscape as described for Alternative 1 will cut down on that necessity somewhat by employing standard modern agricultural and landscaping techniques. GWCA would likely have to lease portions of the land again for cropping.

Under this alternative, the progress made since 1982 would be negated, and the park would require a great deal of additional resources to revert back to the landscape of 20-30 years ago. Additionally, farmland and pasture is abundant in the matrix surrounding the park, reducing their interpretive values within the park. In Alternative 3, we will discuss demonstrational farming plots that will illustrate the value of Carver's sustainable farming methods without large scale changes to the landscape or the need for additional resources.

Whether or not the pasture lands are to be used for grazing, they would be positioned distantly from the Visitor Center and Carver Trail, greatly reducing their value as an interpretive tool. Another issue is that the pasture lands would be too small to support many cattle. Fences would need to be constructed around prairie pastures. GWCA would have to refer to their previous agricultural lease program for leasing and management, use a protocol from a site with a similar purpose, or create a new process of managing these areas. If the property is not leased, GWCA would have to provide capital and labor. This alternative greatly cuts down the overall functionality of the landscape other than to show the working farm of the 1860s.

Alternative 2: Natural Resources Condition Assessment

Manage the landscape according to natural communities and features described in the 2011 GWCA Natural Resources Condition Assessment (NRCA).

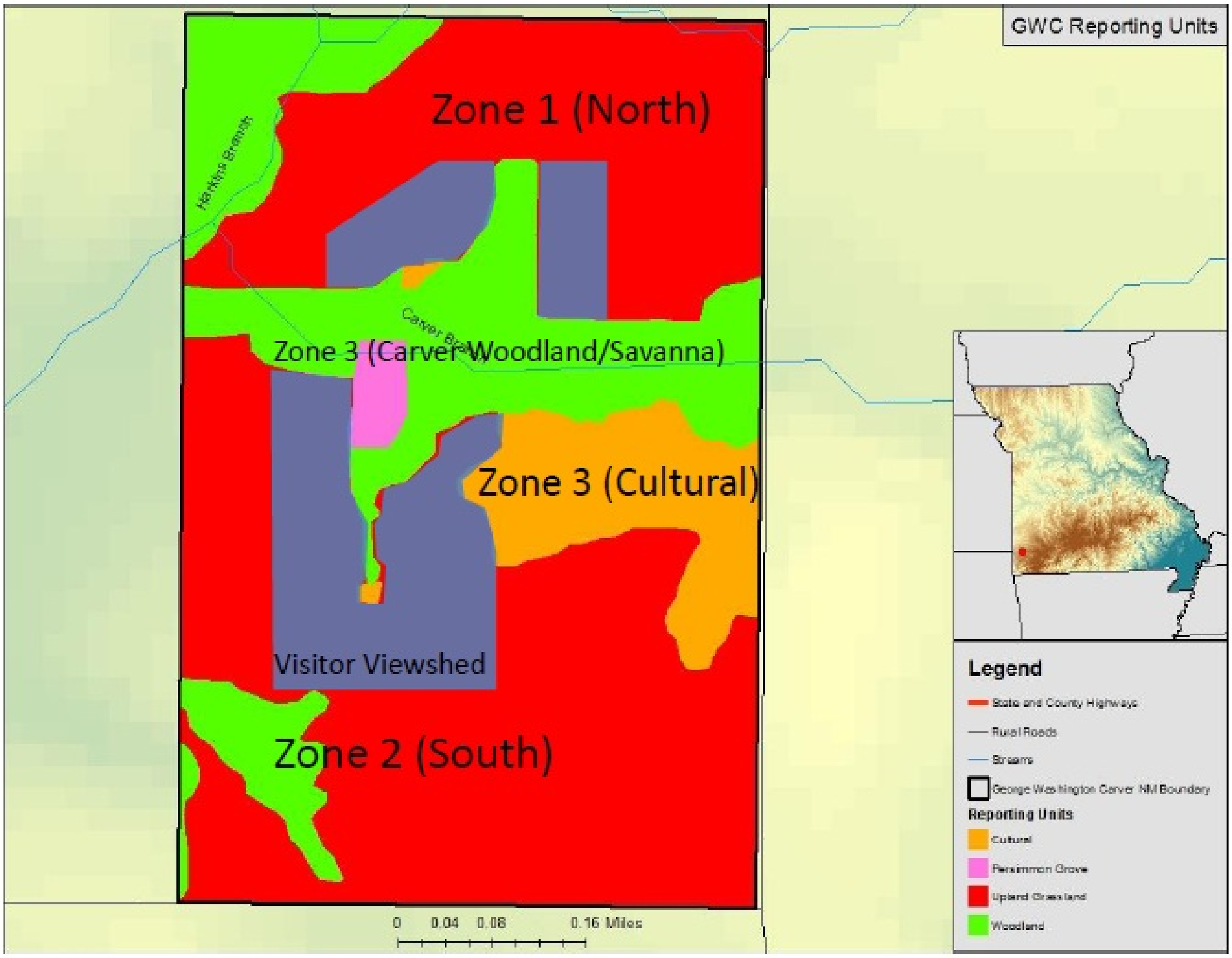


Figure 22: Alternative 2, Natural Resources Condition Assessment

This alternative is derived from the conceptual current vegetation map and vegetation descriptions from the George Washington Carver National Monument Natural Resources Condition Assessment (NRCA) conducted through the Heartland Network. This report assesses natural resource indicators for landscape types in the GWCA Reporting Units (Figure 22). It also provides descriptions of Pre-European natural vegetation communities, which would be the basis for natural area restoration under this alternative.

Zone 1 – North

23 ha (57 acres)

Description: Zone 1 is bordered on the north and east by the park's boundary, on the south by Zone 3 and the Carver Branch, and on the west by the park boundary and Harkins Woods (Zone 3). The soil types for this zone are available in Appendix 3.

The conceptual historic vegetation map (Appendix 1) illustrates Zone 1 as mesic tallgrass prairie, bluestem prairie, post oak-bluestem prairie or savanna, and floodplain forest (NRCA Appendix C).

The herbaceous cover of the mesic tallgrass prairie designation should be greater than 80%, while woody cover should be less than 10%.The dominant species in the community are big bluestem (*Andropogon gerardii*), prairie cordgrass (*Spartina pectinata*), and switchgrass (*Panicum virgatum*). Other native grasses, sedges, and forbs should also be present (see NRCA Appendix C).

The grass and forb cover of the bluestem prairie designation should be greater than 85%, while woody cover should be less than 10%.The dominant species in the community are little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), big bluestem (*Andropogon gerardii*), and prairie dropseed (*Spartina pectinata*). Other native grasses, sedges, and forbs should also be present to co-dominant. Forbs may have a cover of up to 40% (see NRCA Appendix C).

The canopy cover of the post oak-bluestem prairie/savanna designation should be less than 30%, and may be mostly absent altogether in patches of 50 ha or greater. The dominant overstory species in the community are post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), black oak (*Quercus velutina*), and black hickory (*Carya texana*). The herbaceous layer cover should be between 70-100% with dominant species of big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium soparium*). A sparse shrub layer of less than 25% may be present, including lead plant (*Amorpha canescens*), New Jersey tea (*Ceanothus americanus*), and pasture rose (*Rosa carolina*). Other native grasses, sedges, and forbs should also be present from the surrounding prairie (see NRCA Appendix C).

The canopy cover of the floodplain forest designation should be greater than 80% and up to or sometimes in excess of 70 feet tall. Overstory species basal area should be between 80-100 ft^2/acre. The dominant species in the community are bur oak (*Quercus macrocarpa*), pecan (*Carya illinoinensis*), shellbark hickory (*Carya laciniosa*), and American elm (*Ulmus Americana*). White oak (*Quercus alba*) may become more dominant at higher landscape positions. Other native trees, shrubs (30-60% cover), saplings of canopy and subcanopy species, and an open herbaceous layer (20-50% cover) should also be present (see NRCA Appendix C).

Goals: Manage resources so that Current Conditions of Indicators approach Management Targets as outlined in the NRCA. The Upland Grassland Resource Unit includes the following Attributes and Indicators:

Table 22: Attributes and Indicators for Grassland Reporting Units in GWCA NRCA.

Attributes	Indicators
Landscape Composition	Patch count
	Mean patch size (ha)
Land Use/Land Cover	Prairie (ha)
	Successional types (ha)
Diversity	Native species richness
	Total species richness
Herbaceous Guild Composition	Native grass (%)
	Native forbs (%)
	Native woody shrub and vine (%)

Recommendations: To increase the size and to decrease the number of patches in this reporting unit, prairie restoration should proceed with concentration on combining the species and cover levels outlined in the Description above. Managing for specific historic vegetation in the configuration illustrated in Appendix 1 could be accomplished, but for a park the size of GWCA, mixing these types across the landscape with a goal of meeting management targets should be sufficient. Many of the dominant grasses are currently present, though not in the ideal cover percentages. Additional forbs should be seeded to meet the bluestem prairie designation.

Zone 2 – South

48 ha (119 acres)

Description: Zone 2 is bordered on the north by the Carver Branch and Zone 4, and on the west, south, and east by the park's boundary. The soil types for this zone are available in Appendix 3.

The conceptual historic vegetation map (Appendix 1) illustrates Zone 2 as bluestem prairie, mesic tallgrass prairie, and post oak-bluestem prairie or savanna (NRCA Appendix C).

The grass and forb cover of the bluestem prairie designation should be greater than 85%, while woody cover should be less than 10%.The dominant species in the community are little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), big bluestem (*Andropogon gerardii*), and prairie dropseed (*Spartina pectinata*). Other native grasses, sedges, and forbs should also be present to co-dominant. Forbs may have a cover of up to 40% (see NRCA Appendix C).

The herbaceous cover of the mesic tallgrass prairie designation should be greater than 80%, while woody cover should be less than 10%.The dominant species in the community are big bluestem (*Andropogon gerardii*), prairie cordgrass (*Spartina pectinata*), and switchgrass (*Panicum virgatum*). Other native grasses, sedges, and forbs should also be present (see NRCA Appendix C).

The canopy cover of the post oak-bluestem prairie/savanna designation should be less than 30%, and may be mostly absent altogether in patches of 50 ha or greater. The dominant overstory species in the community are post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), black oak (*Quercus velutina*), and black hickory (*Carya texana*). The herbaceous layer cover should be between 70-100% with dominant species of big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium soparium*). A sparse shrub layer of less than 25% may be present, including lead plant (*Amorpha canescens*), New Jersey tea (*Ceanothus americanus*), and pasture rose (*Rosa carolina*). Other native grasses, sedges, and forbs should also be present from the surrounding prairie (see NRCA Appendix C).

Goals: Manage resources so that Current Conditions of Indicators approach Management Targets as outlined in the NRCA. The Upland Grassland Reporting Unit includes the following Attributes and Indicators:

Table 23: Attributes and Indicators for Grassland Reporting Units in GWCA NRCA.

Attributes	Indicators
Landscape Composition	Patch count
	Mean patch size (ha)
Land Use/Land Cover	Prairie (ha)
	Successional types (ha)
Diversity	Native species richness
	Total species richness
Herbaceous Guild Composition	Native grass (%)
	Native forbs (%)
	Native woody shrub and vine (%)

Recommendations: To increase the size and to decrease the number of patches in this reporting unit, prairie restoration should proceed with concentration on combining the species and cover levels outlined in the Description above. Managing for specific historic vegetation in the configuration illustrated in Appendix 1 could be accomplished, but for a park the size of GWCA, mixing these types across the landscape with a goal of meeting management targets should be sufficient. Many of the dominant grasses are currently present, though not in the ideal cover percentages. Additional forbs should be seeded to meet the bluestem prairie designation.

Zone 3 – Carver Woodland/Savanna

18 ha (45.5 acres)

Description: The Carver Woods section of Zone 3 is bordered on the north by Zone 1, on the west and east by the park boundary, south, and on the south by Zone 2 and Zone 4. It also houses Carver Branch, Carver Spring, Williams Spring, Williams Pond, Williams Branch, and numerous cultural interpretation wayside exhibits dedicated to George Washington Carver (see Alternative 1 for full list). The Harkins Woods section is bordered on the north and west by the park boundary, and on the south and east by Zone 1. The soil types for this zone are available in Appendix 3.

The conceptual historic vegetation map (Appendix 1) illustrates Zone 2 as floodplain forest (NRCA Appendix C).

The canopy cover of the floodplain forest designation should be greater than 80% and up to or sometimes in excess of 70 feet tall. Overstory species basal area should be between 80-100 ft^2/acre. The dominant species in the community are bur oak (*Quercus macrocarpa*), pecan (*Carya illinoinensis*), shellbark hickory (*Carya laciniosa*), and American elm (*Ulmus Americana*). White oak (*Quercus alba*) may become more dominant at higher landscape positions. Other native trees, shrubs (30-60% cover), saplings of canopy and subcanopy species, and an open herbaceous layer (20-50% cover) should also be present (see NRCA Appendix C).

Goals: Manage resources so that Current Conditions of Indicators approach Management Targets as outlined in the NRCA. The Woodland Resource Unit includes the following Attributes and Indicators:

Table 24: Attributes and Indicators for Woodland Reporting Units in GWCA NRCA.

Attributes	Indicators
Landscape Composition	Patch count
	Mean patch size (ha)
Land Use/Land Cover	Natural and semi-natural woodland (ha)
	Successional types (ha)
Structural Class	Hardwood canopy cover (%)
	Hardwood basal area (%)
	Density (stems/ha, trees >8 cm dbh)
Regeneration	Total hackberry relative density (% stems/ha, <8 cm dbh)
Herbaceous Guild Composition	Native grass (%)
	Native forbs (%)
	Native woody shrub (%)
Structure	Hardwood tree height (m)

Restore Zone 3 to a forest ecosystem that approximates a native riparian area. Trees should become more sparse as the vegetation approaches other management zones. Establish the Persimmon Grove within Zone 3 (Figure 22).

Recommendations: Improve Indicator values for woodland habitat to Management Target levels while approximating the community description from the Woodland Reporting Unit. This may require much time and effort and additional planning from a forestry perspective. Establish the Persimmon Grove in the area indicated on Figure 22. According to Harrington (1999), persimmon trees should be planted in an open area with an old field for the understory. This would involve clearing the area intended for the Persimmon Grove, planting the trees, and allowing the understory to establish itself as a crop field lying fallow. Monitor the area for invasive species and other woody species that would be detrimental to the Grove.

<u>Zone 4 – Cultural</u>

8 ha (20 acres)

Description: Zone 4 contains the Visitor Center, Administration buildings, Carver Trail, and classified structures.

While the Visitor Viewshed will be primarily located in the Prairie Management Zones, it will be considered part of the Cultural Zone. The Viewshed would provide increased aesthetic enjoyment, improved wildlife habitat, and a seed bank for surrounding areas within the park.

Goals: Provide access to and interpretation of historic landscape features as outlined by GWCA's Long-Range Interpretation Plan. Maintain Carver Trail and all outdoor exhibits for aesthetic value, wildlife habitat, and long-term utility.

Recommendations: Manage modern landscaped areas as they are. The woodland that houses Carver Trail should be managed the same as adjacent areas of Zone 3.

To establish the Visitor Viewshed, additional forbs as described in the NRCA would be seeded based on specific instructions for each species. In most areas it would be beneficial to increase HSI scores or reduce the gap between Current Conditions and Management Targets as outlined in the NRCA. This would ensure that aesthetics and wildlife habitat are improved and maintained.

Evaluation Criteria

1. **Impact in meeting the park's mission, purpose, and significance (enabling legislation, GMP – memorial concept)**

This alternative would add landscape features directly attributed to the memory of George Washington Carver. The prairie zones would add memorial value in that Carver experienced native prairie regularly in and around Diamond, and was inspired by its natural beauty. Also, he may have collected specimens for his Secret Garden from local prairie remnants.

2. **Impact in meeting interpretive and visitor experience objectives (LRIP)**

This alternative would provide no additional understanding of the cultural environment of the area during Carver's childhood. It should add a strong spiritual aspect to the outdoor natural areas of the park. The pre-European settlement appearance of the land would be represented most significantly. Visitors would be provided an opportunity to understand the native prairie landscape that would have dominated at the time Moses Carver settled his tract.

The native landscape likely also had some inspirational effect on George, especially in religion and art. Carver may have identified with native prairie as one of God's creations, and he often painted plants. However, in many biographical works about Carver, prairie is rarely, if ever, mentioned. Perhaps the most interesting question about Carver and prairies would be how could he interpret their value to mankind?

3. **Impact on preservation of cultural landscape features (identified in Cultural Landscape Inventory)**

This alternative actually fits quite well with concepts presented in the CLI. One major idea is that adjacent farmland contributes to the "setting, feeling, and association" of GWCA. For this reason, it does not appear necessary that agricultural areas be added to the park. The CLI also discusses the emphasis that GWCA has placed on vegetation to this point and how it has evolved, contrary to the development of most memorial parks. In this case, the re-establishment of historic vegetation communities serves the purpose of portraying the influence of the landscape on a young George Washington Carver.

4. Impact upon wildlife habitat based on Habitat Suitability Index Models

The following are the projected HSI model scores based on the vegetation management presented in this alternative:

Table 25: 2010 and Projected HSI model scores under recommended management for Alternative 2.

	Zone (2010)		Zone (Projected)	
Species	1	2	1	2
Prairie Vole	0.61	0.60	0.98	1.00
Ornate Box Turtle	0.75	0.68	0.89	0.93
Bobwhite Quail	0.78	0.67	0.87	0.79
Henslow's Sparrow	0.72	0.62	0.95	0.91

This alternative is designed to restore the zone to predetermined Management Targets and it assumes that prairie management will continue under the guidance of the NRCA, HSI models, and HTLN Inventory and Monitoring reports. In this alternative, the projected HSI scores reflect the maximum possible Habitat Unit Value based on optimum scores for each characteristic. This should lead to increased scores for each zone in the future, but reaching the projected scores is not likely due to variety in the habitat and due to the effects of management actions from year to year. Prescribed burns and haying may impact characteristics such as litter depth and vegetation height.

Projected improvements in HSI scores for Alternative 2 are mainly due to continuing prairie restoration. The alternative assumes that characteristic scores will approach maximum possible scores in each unit. Characteristics affected by this include those related to grass and forb cover, vegetation height, shade producing woody invasion, average litter depth, food plant species diversity, thermoregulatory cover, grasses for nesting and concealment, and habitat edge. Each of these characteristics would benefit from management proposed under this alternative

5. **Impact on the park's ability to manage the natural and cultural resources (resource needed, costs, impacts to existing landscape)**

Areas that currently require full restoration (former MU9, Zone 1 north of Carver House and east of Williams Pond, wooded areas) will involve greater resources than other areas where prairie restoration would continue under regular conditions. However, the areas that require additional resources have been allowed to fall into disrepair either due to lack of management emphasis or in the case of the former Unit 9, the previous ownership's management. These wholesale changes to the landscape would entail planning, initial costs for labor and material, and intense monitoring and management until the desired plant communities are re-colonized. HTLN would be a valuable resource for monitoring the species makeup of the new plantings, and HSI models will ensure that the physical development of the areas as viable wildlife habitat is progressing. The Exotic Plant Management Team (EPMT) would have a great deal of responsibility as it relates to watch list species (see Cribbs et al. 2007) and eradicating any new invasions.

GWCA has also shown some interest in grazing and patch-burn grazing techniques in the prairie management zones. These regimes are not terribly difficult to establish, but they must fit in with the other management techniques the park currently uses. Startup costs would include erecting fences around the management zones. The park may be able to offset losses in revenue from reduced haying with leases from cattle farmers. GWCA would have to refer to their previous agricultural lease program for leasing and management, use a protocol from a site with a similar purpose, or create a new process of managing these areas. If the property is not leased, GWCA would have to provide capital and labor.

Alternative 3: Integrated Cultural/Natural Vegetation Management

Manage the cultural landscape to meet the desired conditions identified in the 2005 Integrated Cultural/Natural Resources Management Workshop in Omaha, Nebraska. A document entitled Managing the Park's Cultural and Natural Resources in Accordance with the Enabling Legislation *(GWCA 2005) was created at this meeting and outlines the concepts.*

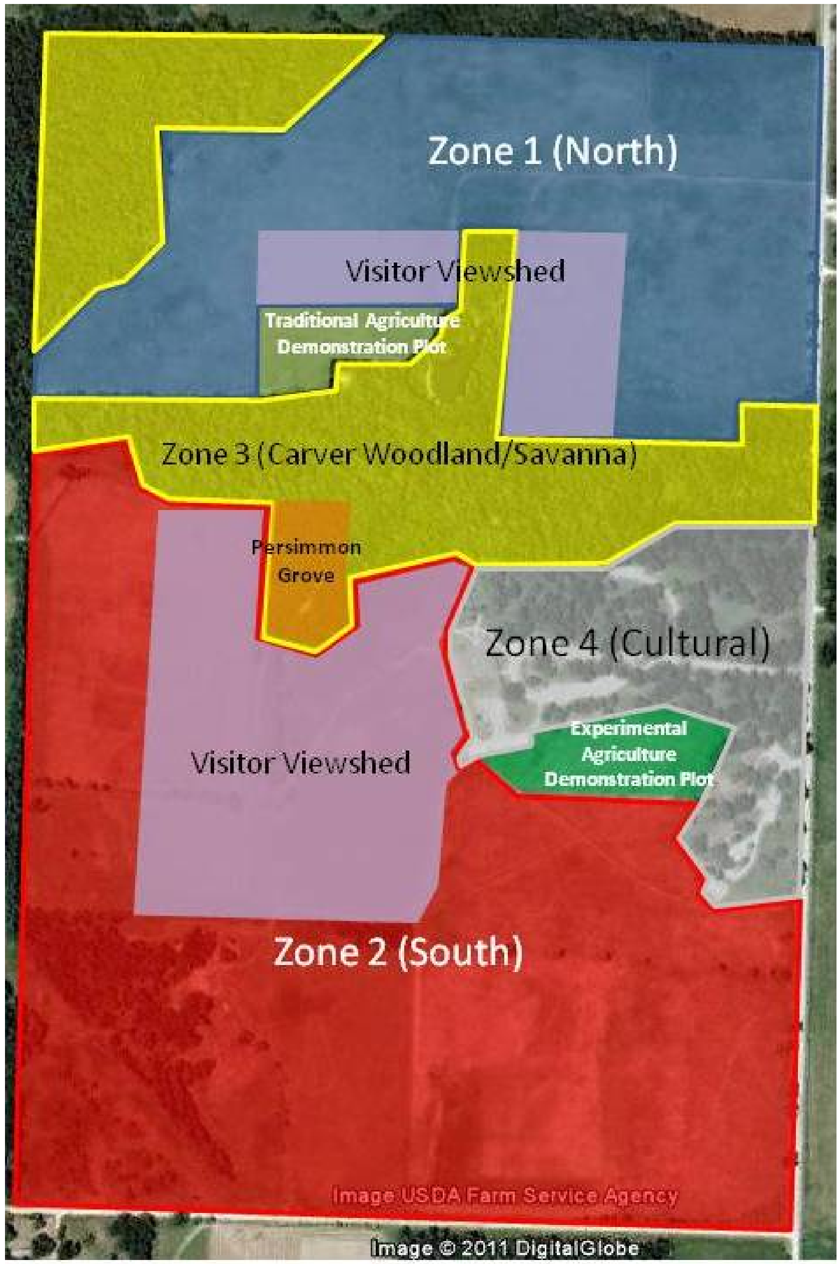


Figure 23: Alternative 3, Integrated Cultural/Natural Vegetation Management.

Under this configuration, prairie zones would be used to memorialize George Washington Carver as a youth and as a professional, as well as improving the physical structure of prairie habitat using HSI models. Prairie pastures on site during Carver's youth would have been used as forage for livestock, especially in low-lying areas that were too wet to crop. Prairie zones would also be used to memorialize Carver's later experiences as a naturalist, artist, and scientist. They would represent his love of plant collecting, plant identification, artwork of natural plants, and his herbarium collections. Additionally they could be used to demonstrate his work as a mycologist and horticulturalist.

Experimental plots for agricultural crops would be created to memorialize George Washington Carver's efforts as a researcher, educator, humanitarian, scientist, and agronomist. This would demonstrate how the Carver legacy lives on as agricultural research continues to make advancements.

This alternative would also install "traditional" row crops using methods from the 1860s-1870s in suitable areas near the Moses Carver House. Crops known to have been grown on the Carver farm would be selected for this area.

<u>Zone 1 – North</u>

23 ha (57 acres)

Description: Zone 1 is bordered on the north and east by the park's boundary, on the south by Zone 3 and the Carver Branch, and on the west by the park boundary and Harkins Woods (Zone 3). The soil types for this zone are available in Appendix 3.

This alternative combines land use and prairie management history at GWCA, inventory and monitoring data from HTLN, the 2011 GWCA NRCA, MoRAP vegetation maps, HSI models, and cultural landscape planning materials developed by the park.

Goals: Continue restoration of the natural landscape of GWCA using available resources while integrating landscape management with cultural and historical interpretation objectives.

Recommendations: This zone would primarily remain under prairie management under this alternative, guided by NRCA Management Targets and HSI models. Approximately 1 ha (2.44 acres) of traditional row crops would be installed immediately north of the 1881 Moses Carver House (Figure 23). Adding crops in this location would also put them in direct view of visitors entering from Williams Pond on the Carver Trail. Converting this location to cropland would create a suite of interpretive sites including the Moses Carver House, Williams Pond, Williams Spring, the Williams Cabin Site, the Contemplative Loop, approximately half of the Carver Trail, Williams and Carver Branches, Carver Spring, the Birthplace Cabin, and the Boy Carver Statue. The re-established Persimmon Grove would also be located nearby.

There are major invasions of sericea lespedeza (*lespedeza cuneata*), tall fescue (*Schedonorus phoenix*), and brome (*Bromus* spp.) immediately to the north of the Moses Carver House, most which would be replaced by agricultural plots.

Zone 2 – South

48 ha (119 acres)

Description: Zone 2 is bordered on the north by the Carver Branch and Zone 4, and on the west, south, and east by the park's boundary. The soil types for this zone are available in Appendix 3.

This alternative combines land use and prairie management history at GWCA, inventory and monitoring data from HTLN, the 2011 GWCA NRCA, MoRAP vegetation maps, HSI models, and cultural landscape planning materials developed by the park.

Zone 2 was historically cropland according to the Historic Base Map, but at this point provides strong aesthetic values and important connectivity in wildlife habitat, and it also contains low-lying areas that are prone to standing water. As the cemetery is considered an area of reflection, and the Carver Trail opens to this zone, native prairie is likely more effective than row crops in providing a serene and reflective environment.

This alternative creates an opportunity to use former MU 4 as a memorial unit. After visitors complete Carver Trail and experience the cemetery, the walk back to the Visitor Center and parking lot would be enhanced by the Visitor Viewshed. The area near the opening of the cemetery wall features several wildflowers, and if prairie management continues with an emphasis on aesthetic improvements and attracting wildlife, it could serve as a symbolic "Secret Garden" to memorialize Carver's initial inspiration.

Goals: Continue restoration of the natural landscape of GWCA using available resources while integrating landscape management with cultural and historical interpretation objectives

Recommendation: If experimental agricultural plots (1.56 ha, ~4 acres) are to be developed, it would likely be best to situate them in the north end of former MU5. For maximum visibility, maintained habitat connectivity, and ease of access, the best place to place these plots would be the north end of this zone. Another potential location would be in the fescue fields of former Unit 9. As in Zone 1, these locations would allow conversion of some of the poorest prairie habitat in the park to serve interpretive purposes. They would also be visible from the Visitor Center. It is recommended that a pedestrian path be developed for increased access to these plots. Care should be taken that these plots do not directly reproduce the George Washington Carver Agricultural Experiment Station Plots at Tuskegee, per the *Managing the Park's Cultural and Natural Resources in Accordance with the Enabling Legislation* document (GWCA 2005). The majority of the southern section of former Unit 5 should remain intact as prairie because of its interior habitat, and restoration should continue.

HTLN has expressed an interest in managing for northern bobwhite quail (*Colinus virginianus*) at GWCA. Bobwhite are currently present near the woodland in this zone, and would further benefit from focused management. Successional woodland currently resides on former MU9 and could be managed for the post oak-bluestem prairie/savanna community type described in the NRCA. This would also require that native warm season grass (NWSG) and forb cover replace the current fescue grassland that exists there now. HSI models can also be used to identify specific physical habitat features to increase habitat value. Quail require several habitat types in a proximate matrix ranging from bare ground to woodland. Fescue grows thick at its base and does not allow for movement or foraging. NWSGs allow for space and bare ground between clumps, and access roads allow foraging. The current woodland should be managed for native hardwood trees while bush honeysuckle and other invasive species are minimized. Trees could be planted according to the guidelines of the post oak-bluestem prairie/savanna community type with bur oaks in more secluded areas.

Zone 3 – Carver Woodland/Savanna

Description: As we discussed in the Zone 1 recommendations, the Carver Woodland contains a suite of interpretive features. MoRAP (2010) determined that the soil in this zone is best suited for bottomland hardwood, and a riparian buffer-type habitat should be the basis for restoration in this zone. The width of the woodland from the stream banks should be narrowed, especially on the eastern and western ends. The area could be managed as a savanna in some places as well. This alternative would allow for visual and habitat connectivity between the north and south prairie units. Finally, the Persimmon Grove could be re-established, potentially as a stand-alone area separate from the Carver Woodland.

Goals: Enhance visitor aesthetics and improve wildlife habitat in Carver Woods while providing additional educational opportunities. Restore Zone 3 to a forest ecosystem that approximates a native riparian area. Trees should become more sparse as the vegetation approaches other management zones. Recreating a native hardwood riparian buffer along both Carver and Harkins Branches would add to the historic landscape as these creeks and their surrounding vegetation were virgin at the time Moses Carver settled the site. Establish the Persimmon Grove within Zone 3 (Figure 23).

Recommendation: Continue emphasis on cultural materials along Carver Trail. Add signage explaining natural features (prairie and woodland management, species guides, what these things would mean to Carver, etc.) and possibly a lookout point boardwalk to the highest point in former MU4. Carver Trail and the rest of the Carver Woodland should undergo a clearing of understory through prescribed burns, manual removal, and herbicide treatment.

Improve Indicator values for woodland habitat to Management Target levels while approximating the community description from the Woodland Reporting Unit. This may require much time and effort and additional planning from a forestry perspective. Establish the Persimmon Grove in the area indicated on Figure 23. According to Harrington (1999), persimmon trees should be planted in an open area with an old field for the understory. This would involve clearing the area intended for the Persimmon Grove, planting the trees, and allowing the understory to establish itself as a crop field lying fallow. Monitor the area for invasive species and other woody species that would be detrimental to the Grove.

<u>Zone 4 – Cultural</u>

Description: Zone 4 contains the Visitor Center, Administration buildings, Carver Trail, and classified structures.

While the Visitor Viewshed will be primarily located in the Prairie Management Zones, it will be considered part of the Cultural Zone. The Viewshed would provide increased aesthetic enjoyment, improved wildlife habitat, and a seed bank for surrounding areas within the park.

Goals: Provide access to and interpretation of historic landscape features as outlined by GWCA's Long-Range Interpretation Plan. Maintain Carver Trail and all outdoor exhibits for aesthetic value, wildlife habitat, and long-term utility.

Recommendations: Manage modern landscaped areas as they are. The woodland that houses Carver Trail should be managed the same as adjacent areas of Zone 3.

To establish the Visitor Viewshed, additional forbs as described in the NRCA would be seeded based on specific instructions for each species. In most areas it would be beneficial to increase HSI scores or reduce the gap between Current Conditions and Management Targets as outlined in the NRCA. This would ensure that aesthetics and wildlife habitat are improved and maintained.

Evaluation Criteria

1. **Impact in meeting the park's mission, purpose, and significance (enabling legislation, GMP – memorial concept)**

This alternative would serve well to "maintain, preserve, and interpret" George Washington Carver's life and accomplishments. First, it portrays an image of the boyhood scene through recreating aspects of life on the farm. Despite being an anomaly to George's residence on site, the Moses Carver House exhibits provide examples of self-sufficient techniques that George would have embraced. Adding traditional agricultural plots that employ 19th century farming techniques would create an intimate contemporary scene in that portion of the park. However, in order to best portray the historic scene, forest and prairie management must continue, as these landscapes would have been nearly pristine when George lived on site, and would best represent Carver's interest in nature.

Alternative 2 also works well in maintaining and preserving Carver's accomplishments. Agricultural demonstration plots could be used to re-create some of George's historical experiments at Tuskegee and allow visitors to see his methods first hand. It would also give the park the opportunity to participate in sustainable agriculture research or experimentation through local educational institutions and the VIP program. This combination of demonstrational techniques would both preserve and maintain Carver's legacy while continuing his vision on the site where it began.

2. Impact in meeting interpretive and visitor experience objectives (LRIP)

This alternative combines natural, cultural, and historical interpretation opportunities with a stronger educational focus, which would greatly represent Carver's interests. It would recreate some of the cultural landscape near the Moses Carver House.

This alternative also combines the spiritual aspect of the landscape with the science that Carver worked to improve. Much of the research and experimentation that Carver was pushing early in the 20th century could be very important to our own society moving forward, mainly as they pertain to sustainability of natural resources.

There is more of an emphasis on preserving nature in this alternative compared to the first, and visitors will have a better opportunity to interact with nature due to the layout of the park. The agricultural plots will be large enough to be effective for interpretation purposes, but will not take up significant wildlife habitat. The clearing of the forest understory and management as a bottomland hardwood forest/riparian buffer will enhance the visitor experience by creating a more inspiring atmosphere and providing more opportunities to view wildlife. The Visitor Viewshed will attract butterflies and birds among other species of charismatic wildlife and offer more artistic landscapes.

Finally, this layout provides additional educational opportunities due to the diversity of the landscape. Prairie and woodland ecosystem concepts could be included in the visitor experience through tours and literature, inspiring visitors to see Carver's vision that all of nature serves a purpose and that people should approach their lives with an eye toward conservation, thus further preserving Carver's vision. Students and volunteers could participate in prairie management and in the administration of the traditional and experimental agriculture plots.

3. Impact on preservation of cultural landscape features (identified in Cultural Landscape Inventory)

Again, no current cultural landscape features will be removed, only enhanced. It will also keep intact the chronological order of the Carver Trail as explained in the Cultural Landscape Inventory (CLI). In this case it would add to the time period experience near the Carver House and add a memorial aspect to the vegetation on Carver Trail in the woodland and near the Visitor Center. While not necessarily a cultural landscape feature, the Demonstration Plots would provide a "suitable and enduring" memorial to Carver's achievements.

4. Impact upon wildlife habitat based on Habitat Suitability Index Models

The following are the projected HSI model scores based on the vegetation management presented in this alternative:

Table 26: 2010 and Projected HSI model scores under recommended management for Alternative 3.

	Zone (2010)			Zone (Projected)	
Species	1	2	|	1	2
Prairie Vole	0.61	0.60	|	0.87	0.87
Ornate Box Turtle	0.75	0.68	|	0.78	0.81
Bobwhite Quail	0.78	0.67	|	0.81	0.76
Henslow's Sparrow	0.72	0.62	|	0.92	0.86

This alternative assumes that prairie management will continue under the guidance of the *HSI Guidebook*, NRCA Management Targets, and HTLN Inventory and Monitoring invasive species reports. In that case, overall HSI scores for each zone should rise until they reach the projected levels. Based on 2010 and projected data, all HSI scores would be expected to rise. The projected scores are based on prairie management meeting the optimal levels possible in each zone. Not all characteristic scores will be at the maximum due to variety in the habitat, and the projected scores take this into account. Also, management actions from year to year such as prescribed burns and haying may impact characteristics such as litter depth and vegetation height. In years following management actions, additional inconsistencies can be expected.

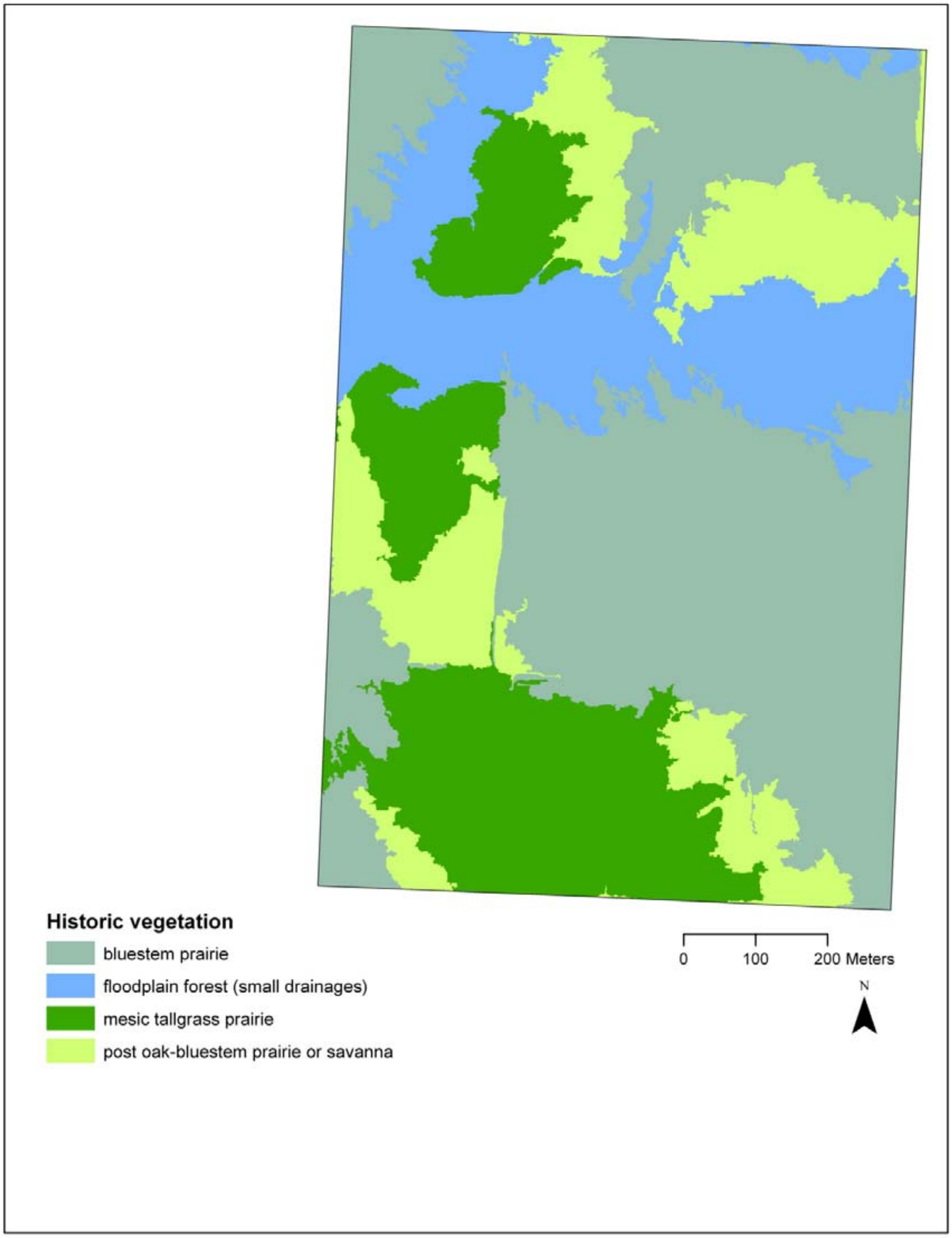
Projected improvements in HSI scores for Alternative 3 are mainly due to continuing prairie restoration. The alternative assumes that characteristic scores will approach maximum possible scores in each unit. Characteristics affected by this include those related to grass and forb cover, vegetation height, shade producing woody invasion, average litter depth, food plant species diversity, thermoregulatory cover, grasses for nesting and concealment, and habitat edge. Each of these characteristics would benefit from management proposed under this alternative. The addition of agricultural plots as shown in Figure 23 would have minimal impact on their respective management zones. Both are large enough that they would not fall below thresholds for home ranges for indicator species.

5. **Impact on the park's ability to manage the natural and cultural resources (resource needed, costs, impacts to existing landscape)**

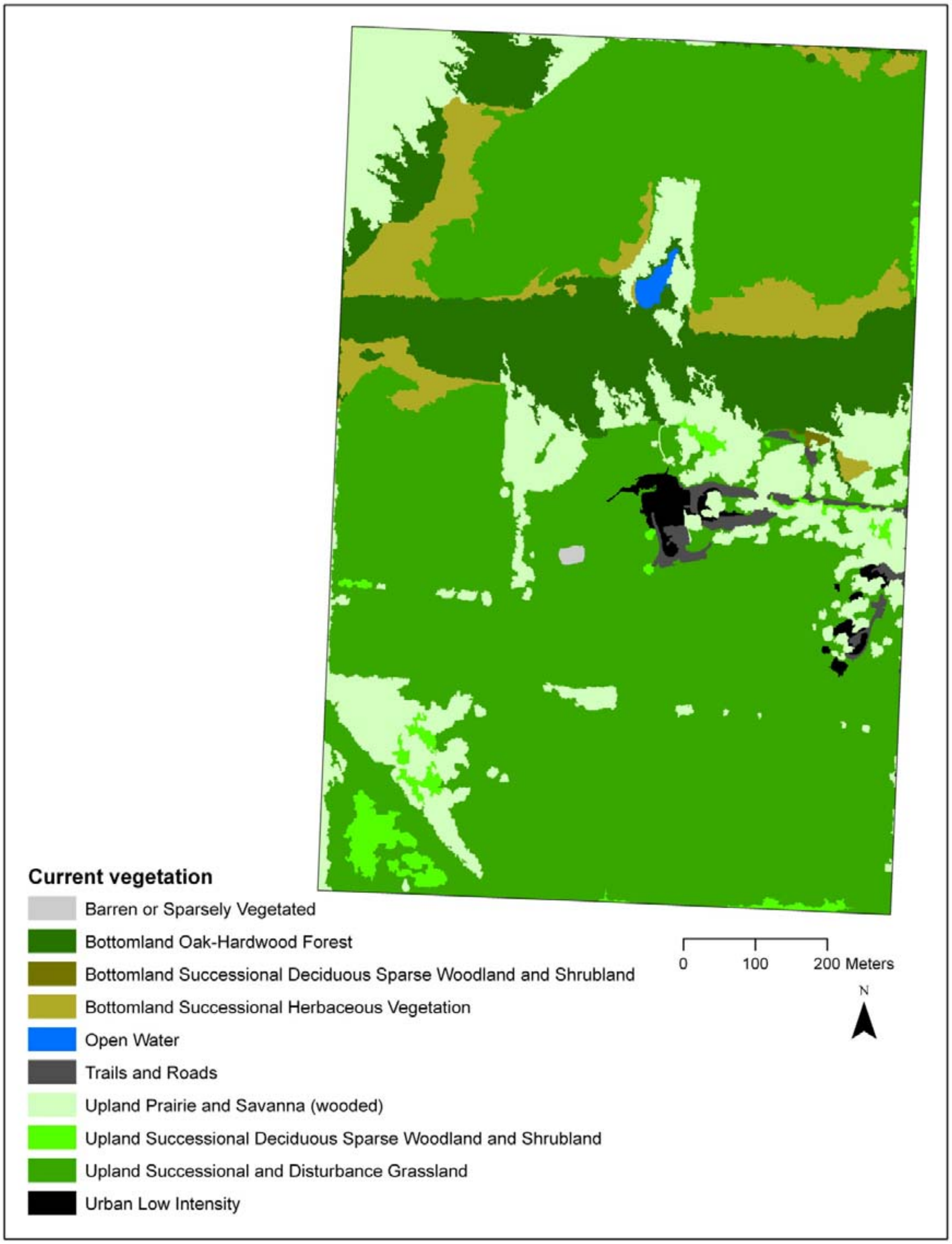
Much of the land management under this alternative would proceed as normal, but additional equipment and possibly improved access roads may be necessary. Constructing the traditional and demonstration agricultural plots would require startup costs for plowing, planting, and maintaining them. Caution would be required to ensure that bare ground would not accommodate undesired weeds and non-native plants. In addition, some type of barrier should be erected to prevent wildlife from damaging the plots. (An interesting note: If box turtles are able to enter the plots, it will provide them with thermoregulatory cover and an additional food source without damaging crops, and visitors would likely enjoy seeing them.) Given that the plots are relatively small, they could be maintained by park staff and volunteers.

GWCA has also shown some interest in grazing and patch-burn grazing techniques in the prairie management zones. These regimes are not terribly difficult to establish, but they must fit in with the other management techniques the park currently uses. Startup costs would include erecting fences around the management zones. The park may be able to offset losses in revenue from reduced haying with leases from cattle farmers. GWCA would have to refer to their previous agricultural lease program for leasing and management, use a protocol from a site with a similar purpose, or create a new process of managing these areas. If the property is not leased, GWCA would have to provide capital and labor.

Appendix 1: GWCA Historic Soil Compatibility Vegetation Map (MoRAP 2011).



Appendix 2: GWCA Current Vegetation Map (MoRAP 2011).



Appendix 3: CARES Soil Type Map for GWCA

Soil Map—Newton County, Missouri
(Soil Type Map for George Washington Carver National Monument, Diamond, MO)

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Federal Land
- National Park Service

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:7,230 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 15N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Newton County, Missouri
Survey Area Data: Version 10, Jun 3, 2009

Date(s) aerial images were photographed: 8/6/2007

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Newton County, Missouri (MO145)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
40043	Carytown silt loam, 0 to 2 percent slopes	59.6	20.4%
70012	Hoberg silt loam, 2 to 5 percent slopes	14.1	4.8%
70045	Keeno gravelly silt loam, 3 to 8 percent slopes	118.4	40.5%
70047	Wanda silt loam, 2 to 5 percent slopes	42.5	14.6%
71758	Secesh-Cedargap complex, 0 to 3 percent slopes, frequently flooded	57.6	19.7%
Totals for Area of Interest		**292.3**	**100.0%**

CHAPTER 5: GEORGE WASHINGTON CARVER NATIONAL MONUMENT PRAIRIE MANAGEMENT GUIDEBOOK: USING HABITAT SUITABILITY INDEX MODELS

HSI Guidebook

The HSI Guidebook is a document that outlines what a habitat suitability index (HSI) is and how it is being used as a management tool at George Washington Carver National Monument (GWCA). It describes step-by-step the methods I used to collect, analyze, and apply HSI data. Park staff will use the procedures in this guidebook to collect HSI data and make prairie management decisions.

Introduction

The purpose of this Prairie Management Guidebook is to describe Habitat Suitability Index (HSI) models, describes methods for collecting and analyzing data using HSI models, and describe a procedure for determining actions needed to address limiting features. HSI models will assist park staff in assessing the existing structure of prairie vegetation and wildlife habitat and in making informed decisions on park management.

Definition of Habitat Suitability Index Models

Burgman et al. (2001) defined a habitat suitability index as:

> An HSI measures a set of variables that relate to the suitability of a particular site for the species in question, based on reviews of literature pertaining to the ecology and habitat requirements of the target species. Higher HSI scores are typically indicative of habitat that promotes reproductive success and survivorship. The dynamic contrast of varying levels of habitat quality can also be measured using this method.

The variables in HSI models are habitat characteristics that represent the basic needs of the target species. These variables include water, materials for protective and/or reproductive shelter, food sources, etc. Characteristics are chosen based on findings in peer-reviewed and technical literature that describe the requirements of the target species. Each target species is chosen based on its ability to represent the habitat being managed. In this case, the characteristics represent prairie habitat. Each characteristic is scored on an ascending 5- or 10-point scale related to the level of quality of that characteristic.

The models incorporate a ranking scale for each habitat characteristic where the highest score is considered the optimal level for the associated requirement. After the characteristics are measured and scored in the field, the individual scores are added together, averaged, and divided by the maximum possible score to provide an overall Habitat Unit Value (HUV) on a scale of 0.00 to 1.00. The HUV relates the observed habitat quality to what would be considered optimum habitat. The higher the score, the better the unit is as potential habitat for a target species.

The "dynamic contrast of varying levels of habitat quality" tells us that while each management unit receives its own score, the characteristic scores that contribute to the overall score can be different for each unit. For instance, two units with the same HUV are unlikely to have the same characteristic scores. Also, if a unit has a different score from one year to the next, a closer look at the individual characteristics should indicate to park staff what caused the difference.

HSI Data Collection and Analysis Methods

The locations of HSI plots are the same as the bird count plots used by Volunteers in Parks (VIP) surveyors, as described in the Heartland Network's Breeding Bird Monitoring Protocol (Pietz et al. 2008). HSI data collection is estimated to take two to three weeks with two employees together for up to four hours a day. There are a total of 53 plots for 150 acres of grassland habitat. These plots were chosen to maximize coverage of park grounds and to maintain continuity with Heartland Network Inventory and Monitoring (HTLN) reports. All waypoint coordinates are entered into an HTLN-owned GPS unit, which should be available at the park for the VIP surveys.

HSI Model Data Collection

Materials:

- GPS unit with preloaded HTLN Bird Survey waypoints
- Plot marker (Wooden stake with brightly colored flag to mark center of plot)
- Hammer, for driving stake into the ground
- 10 cm string, to mark plot radius
- HSI model data sheets
- Clipboard
- Digital camera
- Tape measure or meter stick
- Safety materials (long pants, gloves, wide-brimmed hat, sunglasses, sunblock, insect repellant, poison ivy repellant and cleaner, first aid kit)

Instructions:

1. Use a GPS unit with pre-loaded HSI plots. If a pre-loaded GPS is not available, or if the park acquires its own GPS unit, load the waypoints listed in the Bird Monitoring at George Washington Carver National Monument 2008 Status Report (Pietz 2009, pages 4-5).

2. Determine if any management actions have been prescribed for the current year that may occur during HSI sampling.

3. Make a schedule outlining which units are to be done on what days. The schedule should be designed so that data is collected prior to any planned management actions. For simplicity, plan to sample from north to south (low plot numbers to high). Sampling 5-6 plots per day will complete sampling in ten work days. Each plot requires 20-30 minutes for travel and data collection. Outdoor temperatures can be very hot in the summer time. Plan for early morning hours and finish sampling by mid-day.

4. Use the GPS unit to locate the plot to be sampled. Follow established service roads if using a vehicle, then walk to the plot through the prairie management.

5. At the location of the waypoint, drive the marker into the ground.

6. Loop one end of the 10 m string over the top of the marker.

7. Walk directly north while unraveling the string until the full length of the string is reached.

8. Take two steps back from the end of the string, and take a picture of the plot, facing directly south.

9. At the top of each sheet, be sure to write down the Unit number, the plot number, the date, and the time.

10. On the Henslow's sparrow HSI Data Sheet or in a separate notebook make notes on each of the following (See Appendix III): Problematic Species, Invasive Species, Forb Cover, and Native Warm Season Grass (NWSG) Cover. (I also noted what species of forbs were present in each plot, which helps to identify conservative vs. pioneer species.)

11. Begin taking measurements and observations on the HSI model characteristics that can be measured in the field. (I have found the best order for collecting data to be Henslow's sparrow → prairie vole → ornate box turtle → northern bobwhite.) Take pictures of any notable features, such as plant species for identification or watch-list invasive species. Some characteristics are best evaluated when viewing aerial photos or maps of the park. These map or photo based variables should be measured using an HSI

plot map with a scale to evaluate the distance between the plot and the object. They may also be measured using geographic information system (GIS) software.

12. When all measurements are complete and observations have been recorded, wind up the 10 m string and collect all materials.

13. Locate the next HSI plot in the GPS and travel to the waypoint.

HSI Model Data Analysis

Materials:

- Computer with Microsoft Excel
- HSI Model Data Sheets

Instructions:

1. Sort the HSI Data Sheets by indicator species. Then place the sheets in order by plot number.

2. Create a new Microsoft Excel spreadsheet or “Workbook” where the data are to be saved. Save and choose a file name that is easy to remember and locate, such as “HSI Scores 20xx”. The first two years of data collection are named “HSI Scores 2009” and “HSI Scores 2010”, and should be available on the park network.

3. There is a separate tab or "Worksheet" on the spreadsheet for each of the four indicator species. A new Excel spreadsheet will have three tabs (Sheet 1, Sheet 2, and Sheet 3), so you will need to create a new one. (To create a new tab in Excel 2007 or newer, simply click the rightmost tab, which has an illustration of a "sparkly new" spreadsheet page. You can also right click, then select "Insert…" and "Worksheet", then click "OK.") Rename tabs 1-4 (by double-clicking name of the tab and typing) with the four species names: Henslow's Sparrow (HESP), Prairie Vole (PV), Ornate Box Turtle (OBT), and Northern Bobwhite (NOBO). Each management unit on the species' pages is color-coded for ease of reference.

4. Open the most recent version of "HSI Scores 20xx", and copy and paste each tab in the spreadsheet onto the corresponding tabs in the new spreadsheet.

5. Zero out the scores under the columns that are not permanent scores. Permanent score columns are designated by a thick black outline. Columns for scores that will be changed are designated by a thin black line. All other columns are for calculations.

6. Under each unit, the plots should be listed in numerical order. In the next two columns, enter the date and the time.

7. Enter the characteristic score under its corresponding column across the row. The HSI score for the plot will be calculated automatically.

8. When all data has been entered, several important calculations will be done automatically by the spreadsheet (all will be **bold** in the spreadsheet):

a. The final column for each Unit will show the calculated HSI value for each plot.

b. The final row for each Unit will show the calculated HSI value for each characteristic.

c. The cell where the final row and column intersect for each unit is the Habitat Unit Value or HUV for the entire unit.

9. To select management actions, identify **Limiting Factors**. To do this, look at the individual characteristic scores listed in the last row for each plot. Scores below 0.50 are the **Limiting Factors**.

Appendix I: Glossary of Terms

Characteristic (of habitat): Attributes of the habitat that may be critical to the survival, perpetuation, and abundance of an animal species (Baskett et al. 1980).

Cover: Vegetation or other shelter providing protection for wildlife from weather or predators.

Forb: Broad-leaved non-woody prairie plant that is not grass or grass-like (i.e. wildflower).

Habitat Edge (or Ecotone): Transition zone between distinctly different habitats having some characteristics of each; or a narrow zone between habitat types with vegetation characteristics markedly different from each (Baskett et al. 1980).

Habitat Suitability Index (HSI) Model: measures a set of variables that relate to the suitability of a particular site for the species in question, based on reviews of literature pertaining to the ecology and habitat requirements of the target species. Higher HSI scores are typically indicative of habitat that promotes reproductive success and survivorship (Burgman et al. 2001).

Indicator Species: A species whose presence, absence, or relative well-being in a given environment is a sign of the overall health of its ecosystem. By monitoring the condition and behavior of an indicator species, scientists can determine how changes in the environment are likely to affect other species that are more difficult to study.

Litter (or Litter Layer): Dead vegetation from previous year(s) growth in prairies that provides wildlife cover and nest-building materials.

Native Plant: Plant that occurs naturally in a particular region, state, ecosystem, and habitat without direct or indirect human actions (Federal Native Plant Committee).

Native Warm Season Grasses: Native grasses that grow and flower during the warm season of the year (June – September 1) and remain dormant during cooler weather (mdc.mo.gov)

Non-native (Invasive or Exotic) Plant: Species that have become able to survive and reproduce outside the habitats where they evolved or spread naturally (Environmental Protection Agency).

Plot: Pre-chosen grid locations where HSI measurements are taken. Each HSI plot covers an area of approximately 3,380 ft^2 (314 m^2). This is an area equal to 0.08 acres (0.03 ha).

Unit: The Management Unit where the HSI plot is located. These units are numbered 1, 2, 3, 4, 5, 6, 7, and 9.

Appendix II: Descriptions of Characteristics

Prairie Vole (*Microtus ochrogaster*)

Schwartz and Schwartz 2001 describe the prairie vole as "a small, stocky rodent with a large head, short legs, and a short tail. The tail is moderately furred and is slightly less than twice the length of the hind foot. The black eyes are small and beady, and the well-furred ears project only slightly beyond the body fur … The long, loose body fur is glossy, course, and grizzled … The upper parts … are grayish to blackish brown, mixed with whitish, yellowish, or rusty, imparting a grizzled appearance; the color at the base of the hairs is dark gray."

I. Grass and Forb Cover refers to the percentage of the area covered by grasses and forbs in the plot. Both grasses and forbs are important food species for prairie voles (Schwartz and Schwartz 2001).

II. Shade Producing Woody Invasion indicates the level of invasion of sumac (*Rhus* spp.) or another woody species within the area described on the form. Prairie voles avoid woody vegetation (Schwartz and Schwartz 2001).

III. Average litter depth indicates the thickness of the litter layer available for building runways and nests. It is also important for nutrient cycling.

IV. Size of Grassland refers to the available area on which prairie voles can establish home ranges.

V. Number of Important Food Plant Species is an indicator of vegetative diversity (i.e. the number of different grasses, forbs, etc.). The food species of interest are listed on the form.

VI. Soil Texture indicates that proper soils are available for water drainage and digging networks of runways for protection and reproduction.

Ornate Box Turtle (*Terrapene ornata ornata*)

Redder et al. (2006) provide the following description of the ornate box turtle: "The ornate box turtle is a small terrestrial turtle with an adult carapace length between 95 and 154 mm. Males are usually smaller than females. The carapace varies in color from black to dark gray to reddish brown, with yellow lines radiating from the center of every pleural scute. Central scutes have yellow dashes and form a discontinuous mid-dorsal line. The carapace has an oval outline and a domed and dorsally flattened shape resembling a box, with little or no mid-dorsal keel. The plastron is hinged between the hyoplastral and hypoplastral bones (at the joint between the pectoral and abdominal scutes), and it can be completely closed against the carapace, allowing box turtles to completely withdraw their head and feet. All plastral scutes have yellow streaks. The skin is brown with yellow spots. There are four toes (rarely three) on each hind foot." In addition, males can be distinguished from females via an enlarged, recurved inner claw on the hind feet used during copulation, a concave plastron, a red iris versus yellow in *females, a more posterior cloacal opening, a longer and thicker tail, and red coloration on the legs and jaw.*

Threats to this species include destruction, degradation, and fragmentation of grassland habitats and collection for domestic and international pet trade (Redder et al. 2006). Included in these threats are road mortality and other man-made effects.

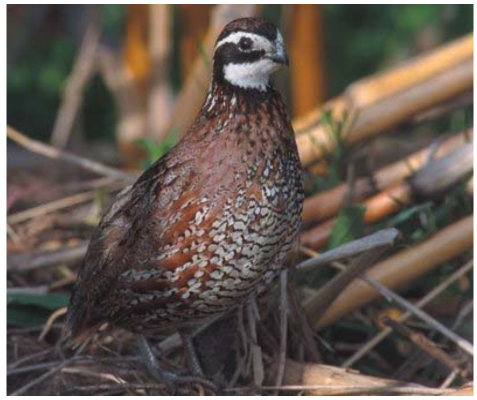
I. Availability of thermoregulatory indicates the presence of three important habitat features for turtles to use for shade during the day. The three features are native grasses, shrubs, and litter.

II. Available food groups are an indicator of biodiversity. This characteristic includes several food sources (grasses, legumes, fruit, etc.) due to the omnivorous nature of this species.

III. Soil Types indicates that proper soils are available for water drainage and digging of forms (underground burrows) for thermoregulation, protection, reproduction, and hibernation.

IV. Distance to water cannot be altered, but is included for assessing habitat quality.

Northern Bobwhite Quail (*Colinus virginianus*)



The Northern Bobwhite has been an important game species in the United States since colonization. Populations across its range reached a high point between 1900 and the 1950s. This was attributed to diverse land use practices. Monotypic land use and developments in technology contributed to the decline in bobwhite habitat quality in three-fourths of its range across the country. Over the last 30 years, the species has experienced a decline of over 70% in its Missouri populations. The yearly rate of decline in Missouri is 5%. The high nesting potential of northern bobwhite makes them likely to respond to habitat restoration (Pierce and Gallagher 2005).

Threats to C. virginianus range from natural to anthropogenic factors. Natural threats include advanced natural succession, predators, and pathogens. Anthropogenic factors include large tracts of monoculture (less, but larger farms), reduced prescribed fire use, extensive use of non-native grasses, urban sprawl, and pesticides (Pierce and Gallagher 2005). The IUCN lists C. virginianus as "Near Threatened" as of their Version 3.1 Assessment in 2008 (BirdLife International 2008).

I. Distance from Center of Plot to Nearest Bare or Sparsely Vegetated Ground refers to the distance from the HSI plot to bare or sparsely vegetated ground used for foraging and escape routes.

II. Nesting Cover Quantity indicates the percentage of native warm season grass cover in the unit, and is affected by woody or non-native plant invasion.

III. Grassland Management assesses the physical structure of grasses and forbs, which provide cover and food for this species.

IV. Habitat Edge width and perimeter refers to the width of transitional edge habitat between different habitat types, and how much of the contiguous prairie is surrounded by edge habitat.

V. Vegetative Escape and Concealment Cover indicates that an adequate amount of vegetative cover is available for developing coveys and concealment from predators.

VI. Distance to Cropland cannot be altered within GWCA unless cropland is added. Cropland is an important food source for bobwhite.

VII. Distance to Water indicates the distance of the plot from a viable, consistent water source.

VIII. Distance to Forest is not expected to change unless woodland areas are added or removed from GWCA.

IX. Distance to Oldfield is not expected to change unless an oldfield area is added to correspond with the proposed Persimmon Grove in Carver Woods.

Henslow's Sparrow (***Ammodramus henslowii***)

The Henslow's sparrow is a grassland nesting bird. It is described by Smith (1992) as "characterized by a large flat head, large gray bill, and short tail. The head, nape, and most of the central crown strip are olive-colored, with the wings extensively dark chestnut. The breast is finely streaked." Males and females of this species look very similar. It can typically only be detected by ear due to its secretive behavior (Burhans 2002).

Henslow's sparrows have shown the strongest decline among migrant songbirds in the United States. The average population decline is calculated as 7.7% per year across its range (Burhans 2002). The Missouri Department of Conservation reports that individuals of this species are regularly encountered at Diamond Grove Prairie near GWCA. We confirmed their presence there in 2010. Threats to this species include breeding and non-breeding habitat loss due to wetland draining, fire suppression, *agricultural development, nest predation, and habitat fragmentation (Burhans 2002, BirdLife 2008a)*.

I. Average Height of Vegetation indicates whether prairie vegetation has reached an adequate height for use as habitat by grassland nesting birds. Henslow's sparrows prefer tall, dense native warm season grass vegetation.

II. Diversity of Vegetation Heights refers to diversity of actual vegetation and the availability of forbs, stems from previous years' grass growth, and woody shrubs for song perches.

III. Shade Producing Woody Invasion indicates the level of invasion of sumac (*Rhus* spp.) or another woody species within the area described on the form.

IV. Average Litter Depth indicates the thickness of the litter layer available, which is important for nutrient cycling and nest building.

V. Forb Canopy Cover refers to the percentage of the plot covered in forbs. This indicates the quality of food sources and the availability of song perches for courtship.

VI. Distance to Water indicates the distance of the plot from a viable, consistent water source.

Appendix III: Problematic and Invasive Species

Examples of Problematic Species Found 2009-2010

Ash (*Fraxinus* spp.)

Blackberry (*Rubus* spp.)

Poison Ivy (*Toxicodendron radicans*)

Sumac (Smooth *Rhus glabra* and Winged *Rhus copallinum*)

Examples of Invasive Species Found 2009-2010

Brome (*Bromus* spp.)


Crown Vetch (*Coronilla varia*)


Johnsongrass (*Sorghum halepense*)

Musk Thistle (*Carduus nutans*)

Sericea Lespedeza (*Lespedeza cuneata*)

Sweet Clover (White *Melilotus alba* and Yellow *M. officinalis*)

Tall Fescue (*Schedonorus phoenix*)

Appendix IV: HSI Model Data Sheets

Prairie Vole *Microtus ochrogaster* Unit ________ Plot ________

CHARACTERISTIC	POSSIBLE SCORE	ACTUAL SCORE
I. Grass and Forb Cover (Subtract 1 for non-native species)		
1. Covers more than 70% of ground	8 - 10	
2. Covers 30-70%	4 - 7	
3. Covers less than 30%	1 - 2	
II. Shade Producing Woody Invasion (average number of trees and clumps of shrubs per 50 m^2)		
1. Less than 3	8 - 10	
2. 3 - 6	3 - 7	
3. More than 6	1 - 2	

(NOTE: If tree canopy diameters or shrub clumps exceed 5 m, decrease value of Characteristic II.)

CHARACTERISTIC	POSSIBLE SCORE	ACTUAL SCORE
III. Average Litter Depth (cm)		
1. 4 - 12	8 - 10	
2. More than 12	5 - 7	
3. Less than 4	1 - 4	
IV. Size of Old Field/Grassland (ha)		
1. More than 0.6	5	
2. 0.2 - 0.6	3 - 4	
3. Less than 0.2	1 - 2	
V. Number of important food plant species comprising more than 1% of total plants present		
1. More than 12	5	
2. 7 - 12	3 - 4	
3. Less than 7	1 - 2	
VI. Soil Texture: Internal Drainage		
1. Sandy Loam or loam	5	
2. Clay loam or silty clay loam	3 - 4	
3. Clay or Silty Clay	1 - 2	

NOTES: 1. If characteristic is not applicable, enter NA and do not count.
2. If all characteristics are scored as 1, disregard computations below and enter 1 on line (5) as habitat unit value.

1	Maximum possible score for form:	45
2	Total maximum possible score(s) for characteristic(s) tallied as NA:	
3	Corrected maximum possible score, (1) - (2):	
4	Total actual scores:	
5	(4) / (3) x 10 = **HABITAT UNIT VALUE:**	

Important Food Species

White clover	Kentucky blue grass	Fescue	Pokeweed
Alfalfa	Timothy	Big bluestem	Blackberries
Red clover	Smooth brome	Sedges	Giant ragweed
Dandelion	Foxtails	Spike rush	
Horsetails	Quack grass	Goldenrods	
Horse nettle	Reed canary grass	Little bluestem	

Ornate Box Turtle *Terrapene ornata ornata* Unit ________ Plot ________

CHARACTERISTIC	POSSIBLE SCORE	ACTUAL SCORE
I. Availability of Thermoregulatory Cover		
1. Shrubs, native warm season grass, litter	8-10	
2. Native warm season grass, litter	6-7	
3. Patchy vegetation, some litter	3-5	
4. Bare ground, some vegetation	1-2	
II. Number of Available Food Groups within 100 m (from compiled list below)		
1. 6 - 8 (or within 100 m of cattle dung)	8-10	
2. 4 - 5	5-7	
3. 3	3	
4. 1 - 2	1-2	

To be evaluated from previous studies:

III. Soil Types		
1. Sandy Loam or Loam	7-10	
2. Clay Loam or Silty Clay Loam	3-6	
3. Clay or Silty Clay	1-2	

To be evaluated from aerial photographs:

IV. Distance to Water		
1. 100 m or less	3-5	
2. More than 100 m	1-2	

NOTES:

1. If characteristic is not applicable, enter NA and do not count.
2. If all characteristics are scored as 1, disregard computations below and enter 1 on line (5) as habitat unit value.

1	Maximum possible score for form:	35
2	Total maximum possible score(s) for characteristic(s) tallied as NA:	
3	Corrected maximum possible score, (1) - (2):	
4	Total actual scores:	
5	(4) / (3) x 10 = **HABITAT UNIT VALUE**:	

Food Groups

Insects and Invertebrates (10 if dung beetles present)
Fruit
Legumes
Vegetables
Carrion
Grass
Groundnesting Bird Eggs
Mushrooms

Northern Bobwhite *Colinus virginianus* Unit ________ Plot ________

CHARACTERISTIC POSSIBLE SCORE ACTUAL SCORE

I. Distance (km) from center of plot to nearest bare or sparsely vegetated ground.

1. Less than 0.4	7 - 10	
2. 0.4 - 0.8	3 - 6	
3. More than 0.8	1 - 2	

(NOTE: If Characteristic I is scored as 1, disregard other criteria, and enter 1 on line (8) as Habitat Unit Value.

II. Nesting Cover Quantity

1. 30-50% or more preferred grasses within plot	8 - 10	
2. 20-30% preferred grasses within plot	5 - 7	
3. 10-20% preferred grasses within plot	3 - 4	
4. 1-10% preferred grasses within plot	2	
3. No preferred grasses within plot	1	

III. Grassland Management Practices

1. More than 50% grasses and forbs; lightly cropped	8 - 10	
2. 25 - 50% grasses and forbs; lightly cropped	5 - 7	
3. Less than 25% grasses and forbs; heavily cropped	1 - 4	

IV. Habitat Edge (width and extent of ecotone)

A. Average Width (m) of habitat edge

1. More than 15	5	
2. 10 - 15	3 - 4	
3. 5 - 9	2	
4. Less than 5	1	

B. Habitat Edge (identifiable ecotone) surrounds:

1. Entire site evaluated	5	
2. 3/4 of site	3 - 4	
3. 1/2 of site	2 - 3	
4. 1/4 of site	1 - 2	
5. Less than 1/4 of site	1	

(NOTE: Add A and B to obtain value for Characteristic IV)

V. Vegetative Escape and Concealment Cover: Shrubs and Herbs (vegetation not cropped in hayland)

1. Covers more than 20% of ground	5	
2. Covers 5 - 20% of ground	2 - 4	
3. Covers less than 5% of ground	1	

To Be Evaluated From Aerial Photographs:

VI. Distance to Cropland (km)

1. Less than 0.4	7 - 10	
2. 0.4 - 0.8	4 - 6	
3. More than 0.8	1 - 3	

VII. Distance to Water (km)

1. Less than 0.4	5	
2. 0.4 - 0.8	3 - 4	
3. More than 0.8	1 - 2	

VIII. Distance to Forest (km)

1. Less than 0.4	5	
2. 0.4 - 0.8	3 - 4	
3. More than 0.8	1 - 2	

IX. Distance to Old Field (km)

1. Less than 0.4	5	
2. 0.4 - 0.8	3 - 4	
3. More than 0.8	1 - 2	

NOTES: 1. If characteristic is not applicable, enter NA and do not count.
2. If all characteristics are scored as 1, disregard computations below and enter 1 on line (5) as habitat unit value.

1	Maximum possible score for form:	70
2	Total maximum possible score(s) for characteristic(s) tallied as NA:	
3	Corrected maximum possible score, (1) - (2):	
4	Total actual scores:	
5	(4) / (3) x 10 = **HABITAT UNIT VALUE:**	

Henslow's Sparrow *Ammodramus Henslowii* Unit________ Plot________

CHARACTERISTIC	POSSIBLE SCORE	ACTUAL SCORE
I. Average Height of Vegetation (cm)		
1. More than 30	8-10	
2. 20 - 30	6-7	
3. 10 - 19	3-5	
4. Less than 10	1-2	

NOTE: If average height of vegetation in characteristic (I) is less than 10 cm, enter 1 for characteristic (II) and go directly to (III).

II. Diversity of Vegetation Heights

1. Not uniform: height of less than 50% of vegetation within 10 cm of the average height.	4-5	
2. Uniform: height of more than 50% of vegetation within 10 cm of the average height.	1-3	

III. Shade Producing Woody Invasion (average number of trees and clumps of shrubs per 50 m^2)

1. Less than 3	8-10	
2. 3 - 6	3-7	
3. More than 6	1-2	

IV. Average Litter Depth (cm)

1. 2 - 4	4-5	
2. Less than 2, or more than 4	1-3	

V. Forb Canopy

1. Covers 10-25% of ground	5	
2. Covers 26-50% of ground	3-4	
3. Covers less than 10% or more than 50% of ground	1-2	

To be evaluated from aerial photographs:

VI. Distance to Water (km)

1. 0.25 or less	3-5	
2. More than 0.25	1-2	

NOTES: 1. If characteristic is not applicable, enter NA and do not count.
2. If all characteristics are scored as 1, disregard computations below and enter 1 on line (5) as habitat unit value.

1	Maximum possible score for form:	40
2	Total maximum possible score(s) for characteristic(s) tallied as NA:	
3	Corrected maximum possible score, (1) - (2):	
4	Total actual scores:	
5	(4) / (3) x 10 = **HABITAT UNIT VALUE**:	

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