GUIDE TO SUSTAINABLE EARTHWORKS MANAGEMENT
90% DRAFT

NATIONAL PARK SERVICE
IN ASSOCIATION WITH THE
GEORGIA TRUST FOR HISTORIC PRESERVATION
1998
GUIDE TO SUSTAINABLE EARTHWORKS MANAGEMENT

90% DRAFT

NATIONAL PARK SERVICE
IN ASSOCIATION WITH THE
GEORGIA TRUST FOR HISTORIC PRESERVATION

1998
CONTENTS

List of Illustrations: v
Forward: vii
Acknowledgements: viii
Introduction: ix

CHAPTER 1 A HISTORY OF EARTHWORKS IN THE UNITED STATES: 1
Fortifications and Military Theory in Europe 1500-1800
The Evolution of American Earthwork Fortification through the War of 1812
Fortification and Military Theory in the United States through the Civil War
The Construction of Earthworks
Existing Conditions of Earthworks

CHAPTER 2 EARTHWORKS LANDSCAPE MANAGEMENT PRINCIPLES: 17
Protection/ Preservation
Sustainability in Earthworks Management Practices
Legibility and Aesthetic Acceptability
Conclusion/ Synthesis

CHAPTER 3 MANAGING EARTHWORKS UNDER FOREST COVER: 27
Ecological Processes
Forest Cover Conditions
Earthworks Under Full Canopy
Earthworks Under Partial Canopy
Hazard Tree Management
Thinning the Overstory in Earthworks Areas

CHAPTER 4 MANAGING EARTHWORKS IN OPEN CONDITIONS: 37
Grass Community Ecology and Physiology
Open Conditions Management
Mowing
Prescribed Burning
Herbicide Treatment

CHAPTER 5 A PROCESS FOR EARTHWORKS MANAGEMENT: 45
Defining the Management Area
Identifying the Resource
Establishing Management Objectives
Describing Management Strategies
Developing Implementation and Maintenance Plans
Developing Good Records
Monitoring and Evaluating Earthworks Management
CHAPTER 6  EARTHWORKS MANAGEMENT SAMPLE STRATEGIES: 53

1. Maintaining earthworks under full forest cover: 55
2. Creating viewing opportunities through selective forest thinning: 57
3. Enhancing earthworks legibility through selective forest thinning: 59
4. Maintaining an open understory to allow viewing of earthworks: 61
5. Establishing native herbaceous cover in a semi-shaded environment: 63
6. Developing mixed native grasses on a site with invading woody species: 65
7. Establishing immediate, long-term herbaceous cover: 68
8. Enriching native species: 70
9. Converting exotic turf to native tallgrass cover: 73
10. Enhancing legibility of fortifications through planting and mowing: 76

CHAPTER 7  TECHNICAL SUPPORT TOPICS: 79

1. Glossary of Earthworks Terminology: 79
2. Field Forms: 91
3. GPS Mapping Methodology: 97
4. Sustainable Plant Species for Earthworks Management: 109
5. Suppliers of Native Seeds and Plants: 113
6. Establishment and Managing Native Grasses: 115
7. Invasive Plant Species and Control Measures: 119
8. Supplies and Equipment Costs: 123
9. References for Vegetation Management: 125
10. Preservation of Archeological Resources: 127

Bibliography: 131

Appendices

A: Background Information on the Guide: 133
B: Review and Evaluation of the Manual: 143
LIST OF ILLUSTRATIONS

1.1. Earthworks and clearcut forest near Bermuda Hundred, Virginia, 1864 / 5
1.2. Timeline showing the use of earthworks in the U. S. / 6
1.3. Profile of field fortification, and fortification forms / 8a
1.4. Ditch-in-rear construction, Petersburg, Virginia, 1865 / 11
1.5. Existing conditions sample / 13
1.6. Existing conditions sample / 13
1.7. Existing conditions sample / 13
1.8. Existing conditions sample / 14
1.9. Existing conditions sample / 14

2.1. Wind-fall damage at Kennesaw Mountain NBP, Georgia / 22
2.2. Tall native grasses growing on earthworks at Colonial NHP, Virginia / 25

3.1. Forest Succession on an open field at Fredericksburg NMP / 28
3.2. Damage to earthwork due to bicycle use at Colonial NHP / 30
3.3. Protected earthwork under full forest cover at Petersburg NBP / 31
3.4. Intermediately managed earthworks at Richmond NBP / 32
3.5. Uprooted tree adjacent to an earthwork at Colonial NHP / 34

4.1. Mixed grasses on Prospect Hill at Fredericksburg NMP, Virginia / 38
4.2. Poor coverage of grasses on earthworks at Colonial NHP, Virginia / 41

5.1. Sample field form for documenting point features / 47
5.2. Detail from GPS survey map of Camp Davies, Corinth, Mississippi / 49
5.3. Sample field form for documenting maintenance data / 52

6.1. Earthworks in a remote area of Colonial NHP, Virginia / 55
6.2. Earthworks on Little Kennesaw Mountain, Kennesaw Mountain NBP / 57
6.3. Fort Conahey, Petersburg National Battlefield Park, Virginia / 59
6.4. Low earthworks at Kennesaw Mountain NBP, Georgia / 61
6.5. Small circular earthwork at Kennesaw Mountain NBP, Georgia / 63
6.6. Fort Harrison, Richmond National Battlefield Park, Virginia / 65
6.7. Redoubt Brannan, Stones River National Battlefield, Tennessee / 68
6.8. Battery Five, Petersburg National Battlefield Park, Virginia / 70
6.9. Prospect Hill, Fredericksburg-Spotsylvania NMP, Virginia / 73
6.10. Star Fort, Ninety-Six National Historic Site, South Carolina / 76

7.1.1. Bastioned Fort / 80
7.1.2. Fortification Terminology / 81
7.1.3. Cremaillere or Indented Line / 83
7.1.4. Star Fort / 85
7.1.5. Lunette / 86
7.1.6. Redan / 88
7.1.7. Redoubt / 88
7.1.8. Stockade / 89
7.3.1. Fort Marcy, Arlington, Virginia / 98
7.3.2. Rifle Trench, Ditch-in-Rear Construction / 100
7.3.3. Field Fortification, Ditch-in-Front Construction / 100
7.3.4. Profile of Fieldwork, Showing Relief and Width / 101

A.1. Vegetation sampling, Ninety-Six NHS, South Carolina / 134
B.1. Prospect Hill, Fredericksburg-Spotsylvania NMP, Virginia / 146
B.2. Yorktown Visitor Center, Colonial NHP, Virginia / 147
FORWORD

(To be included in the completed document)
ACKNOWLEDGMENTS

(To be included in the completed document)
INTRODUCTION

Earthworks Management in the National Park Service

Earthworks, also known as fieldworks or earthen fortifications, have been used throughout American military history as a form of defense. The basic function of earthworks is relatively simple - to place a barrier between an army and its enemy. Earthworks took on many different forms and levels of complexity depending on the circumstances, the military strategy, and the particular requirements. Today, hundreds of linear miles of battle earthworks survive in landscapes east of the Mississippi River, although they are often only a fraction of their original size and extent. Protecting and interpreting earthworks has been a major concern of the National Park Service since becoming steward of some of the most significant American battlefields over sixty years ago. While management strategies have evolved through the years, the basic threats to earthworks have remained constant. The effects of natural processes, primarily erosion, have been overlain by the consequences of human activity, which ranges from the indirect results of urbanization in the vicinity of earthworks to the direct impacts of interpretive, recreational, and landscape maintenance activities. These threats place many earthworks in danger of degradation or loss over time. They are magnified by an uncertain future of financial, material, and human resources required that are to adequately preserve these fragile structures.

Earthworks Landscape Management Manual

The need for guidance to appropriately manage earthworks led to the development of the Earthworks Landscape Management Manual, developed in 1989 by Andropogon Associates for the National Park Service. This was completed to provide an evaluation of then-current management practices and to provide recommendations for alternative management approaches. The parks emphasized in that study were four Virginia, Civil and Revolutionary War battlefield parks. The Manual provided guidelines for managing various vegetative cover types ranging from forest to native tall grasses, and for stabilization and revegetation of damaged ground surfaces through various methods, including bioengineering techniques. Some of the recommended practices have since been implemented or partially implemented with varying degrees of success. From its inception, the Manual was considered to be a first step in developing the art and science of earthworks landscape management. Some of the methods proposed in the Manual were considered experimental in nature, subject to evaluation and
re-evaluation over time, as well as refinement and revision as more experience and information is accumulated both from the management applications in the parks themselves and more generally from the growing body of literature on landscape management and restoration.

**Guide to Sustainable Earthworks Management.**

The current project represents the first such evaluation, refinement, and expansion of the 1989 *Earthworks Landscape Management Manual*. Begun in the summer of 1995 with field assessments of earthworks and earthworks management practices in seven parks in the Middle Atlantic and Southeastern states, the project has culminated in the development of the *Guide to Sustainable Earthworks Management*. The *Guide* includes specific information on managing earthworks in the two most typical conditions in which they are found: under forest cover and in open conditions. The *Guide* draws upon information we have learned since the last exploration; the basis for this new work is a clear management process that considers sustainability to be the foundation for preserving and interpreting these resources.

This current work has been completed by the NPS Northeast Region, NPS Southeast Region, and the NPS Battlefield Protection Program in partnership with the Georgia Trust for Historic Preservation. It draws upon the work of several professionals including Darrel Morrison, Professor of Landscape Architecture at the University of Georgia, Dr. James Johnson, Forester with Virginia Polytechnic Institute and State University, Paul Hawke, Historian, Shiloh National Military Park, David Lowe, Historian, National Park Service, and Allen Cooper, Archaeologist, National Park Service. It has also been informed by current earthworks management philosophies in the seven parks that are the focus of this study: Colonial NHP, Fredericksburg NMP, Kennesaw Mountain NBP, Ninety Six NHS, Petersburg NB, Richmond NBP, and Stones River NB. Chapter One, written by Paul Hawke, provides an historical context for American earthworks associated for the most part with the Revolutionary and Civil Wars. This chapter includes a concise history of these structures as well as a discussion of their significance along with images illustrating the historic and current appearance of typical earthworks. A glossary of terms, identifying the various types of earthworks, with written and graphic portrayals of characteristic earthwork forms, is included as Technical Support Topic #1 in chapter seven. Chapter Two expands on three central principles of earthworks management. Chapters
Three and Four provide concise information about applying these principles to managing earthworks under forest cover and in open conditions. Chapter Five defines a step by step process for earthworks management and Chapter Six provides sample management strategies ranging from establishing a long term native grass cover to enhancing legibility of earthworks for interpretation. Chapter Seven contains a series of technical support topics including such topics as a glossary of earthworks terms and a list of nurseries that supply native seeds. The purpose of this chapter is to provide field-specific information on managing earthworks; additional technical support topics will be developed. The Guide appendices contain critical information on the methodology for this project, the evaluation of the Earthworks Landscape Management Manual, and a copy of the Earthworks Landscape Management Manual.

The Guide to Sustainable Earthworks Management is intended to be a living document that is revised and expanded as more data is collected on successful earthworks management strategies.
INTRODUCTION

Earthen fortifications have played a role throughout American military history. Earthworks of varying size and complexity dot our battlefields and military sites and their identification can be challenging. Time, erosion, weathering, and human disturbances have modified most earthen fortifications to a degree that specialists are required to identify their type and function from what remains. The best way to determine an earthen fortification's function, its original extent or appearance at any given time, is to do research. Finding written accounts, maps, or photographs of a fortification at the time of its construction can go a long way in answering many questions a contemporary manager would ask. From this information, it becomes relatively easy to compare the surviving remnant with what was originally constructed. In many instances, however, historical information is not available and the only recourse is to make an educated guess based upon existing site features.

In the cases where historical documentation is inconclusive, identification of earthworks is first a process of eliminating all possible modern earthen structures from consideration, such as agricultural terraces or landscape berms. Once those possibilities have been discarded, a series of questions can be asked to narrow the field of possibilities. First, one needs to ask at what stage in the design evolution of earthen fortifications do these examples represent and what formal training or influences the military personnel might have had who constructed them? Second, what purpose did these earthen fortifications serve and under what circumstances were they constructed? Third, how would these earthen fortifications have looked, not only at the time of their construction and use, but post-battle, when agriculture resumed or the site was abandoned? In order to answer these questions, it is essential to become familiar with the period literature, both in Europe and America, that shaped military thought and design, as well as to understand the action and personnel of the battle and the post-battle land use changes.

This chapter includes a discussion of the evolution of fortification design as it originated in Europe and was practiced in the colonies and United States up through the Civil War. While it emphasizes the design and use of earthen fieldworks, a discussion of permanent masonry fortifications is required because they evolve from the same design theories. Two basic types of fortifications were erected in the United States during the eighteenth and
nineteenth centuries. One was masonry fortification—a permanent type, usually constructed along the seacoast. The second was earthen fortification—usually built for more temporary reasons and most often constructed in the field of battle. As the technology of war evolved, the methods and styles of waging war changed with the technology. In the case of weaponry design, the introduction of rifled artillery during the Civil War, with its ability to crumble stone and brick, heralded the obsolescence of masonry fortifications. Whereas, earthen fortifications and their ability to absorb the impact of rifled artillery, made them essential features for withstanding an enemy's attack. Therefore, as an adaptation of the masonry form, it is extremely important for those attempting to identify features of earthen fortifications to have an understanding of the design principles, teachings, and guidelines used to create masonry fortifications because the references are the same.

FORTIFICATION AND MILITARY THEORY IN EUROPE 1500-1800

The art of fortification was refined by European theorists between the fourteenth and eighteenth centuries. One theorist, a seventeenth-century French engineer—Sebastien le Prestre de Vauban,—standardized a design of fortification based on a series of geometrical shapes and angles allowing fields of fire to cover all approaches to a fort. Vauban's principles revolutionized fortification construction, which in turn dictated new strategies for capturing these forts. A well-trained offensive force, for example, could predict the number of hours needed to capture a Vauban inspired fort by applying the same principles of parallels and zigzags to the attack. At this time, the art of fortification in Europe, and European fortifications in the New World, were centered on large permanent forts protecting cities and strategic locales. In the seventeenth century, earthen fortifications were rarely used, and then only as a last resort for retreating armies in the field.

Two wars during the eighteenth and early nineteenth centuries greatly influenced military thought well into the mid-nineteenth century. These were the Seven Years War (1756-63) and its American counterpart, the French and Indian War (1754-63), the other was the Napoleonic Wars (1803-15). During these conflicts, the primary weapons were the smooth bore musket, which had an effective range of 50 to 75 yards, and smoothbore limited range artillery. The smoothbore technology resulted in tactics that were based on linear, massed, open field formations and movements. These wars, particularly the Seven Years war, were considered the last of the gentleman's wars waged by professional armies.¹

In Europe at this same time, special schools were being developed to teach military disciplines. Napoleon established the Ecole Polytechnique to train the elite, especially engineers, of the French military. Baron Simon Francois Gay de Vernon, as one of the first professors to teach fortification and the
art of war, published a textbook in 1805 for use in his classes. The book, *A Treatise on the Science of War and Fortification*, became the standard text for instruction in the art of fortification in France through the first quarter of the nineteenth century and was used as the chief source for American military educators as well.

**THE EVOLUTION OF AMERICAN EARTHWORK FORTIFICATION THROUGH THE WAR OF 1812**

Although Native American populations used various forms of fortification for thousands of years prior to European colonization, the development of military fortifications used in the United States in the eighteenth and nineteenth centuries, was of European origin. European military strategists had studied and refined the art of fortification for several centuries prior to applying its use in American conflicts.

The use of field fortifications followed several lines of development during the course of American military history. Prior to the American Revolution, the use of fortification was relatively primitive. European professional armies operating in the colonies built large permanent fortifications, usually at important seaports, using the most advanced principles available to them. However, it was not common for opposing professional armies to construct field fortifications on a large scale because of the type of open field massed movements, the rigid regulations of the armies, and the sense of duty and propriety professional soldiers extended to each other.

In contrast, frontier defenses constructed by settlers and militia units, consisted of wooden structures such as log blockhouses, fortified homesteads, and palisade log forts which were often supported with earth buttressing. At times, these fortifications were hastily built defenses. At Bushy Run during Pontiac's Rebellion in Pennsylvania, for example, English regulars built fortifications with flour bags from the supply train rather than dig earthworks.

At the beginning of the French and Indian war, George Washington and his force of Virginia Militia became surrounded at Great Meadows, Pennsylvania, and built Fort Necessity. It was not constructed using the principles of fortification as practiced in the eighteenth century, but hastily constructed for survival. The fort consisted of a log palisade built upon an earthen mound surrounding a log cabin, with an encircling ditch in front. Having no time to plan, the fort was poorly situated in a valley where enemy fire made the location untenable, and without much effort, the attacking force compelled Washington to surrender.

Later, during the American Revolution and the War of 1812, earthworks were employed primarily as defenses for garrisoned areas or as positions from which a defense could be maintained against greatly superior numbers. In many cases, earthen field fortifications became the best way to equalize the disparity between the large, well equipped, disciplined English army and
the small, poorly equipped, untrained Colonial army. Surviving examples of Revolutionary War earthen fortifications are the Star Fort at Ninty-Six, South Carolina, and the siege lines at Yorktown, Virginia.

Field fortifications constructed during the Revolution were often based on European design (usually Vauban), and incorporated most of the basic principles of fortification as practiced in Europe. Just as often, however, the earthworks and forts were crude and not as intricate or precise as European standards would propose. Throughout the Revolutionary War, the Americans were thwarted by the lack of trained or experienced leaders to teach the art of war and fortification to their inexperienced militia. Valuable knowledge about military theory and training was brought to America during the Revolution by trained European mercenaries and many of the fortifications were designed and constructed by them or by Americans they trained. Among the most notable examples are the defenses designed by Tadeusz Kosciuszko, a Polish mercenary, at Saratoga, New York, and Charleston, South Carolina, as well as other fortifications for the Continental Army. France’s growing involvement in the Revolution brought French military leaders and advisors into the war on the side of the Americans and they passed on the latest principles of fortification to the American commanders. Despite these efforts, American military leaders had more to learn. Following the end of the war in 1781, they went to Europe to study the works of the great European theorists first hand.

The War of 1812 found America without the great influx of European mercenaries the Revolution enjoyed. The art of fortification fell on the shoulders of American officers and earthen field fortifications reflected the varied training and discipline of the volunteers. The best example of this was at New Orleans, where Andrew Jackson commanded a diverse group of citizen volunteer soldiers, which included landed gentry, slaves, tradesmen, Creoles, Indians, and pirates. Their military experience, training, and discipline was equally mixed and the fortifications they constructed reflected this diversity. The defense line consisted of a parapet wall along an existing drainage ditch, with cotton bales, wagons, and whatever else was available, used in its construction. However, Jackson’s ragtag force and their makeshift fortifications held, and the beaten English withdrew.

**FORTIFICATION AND MILITARY THEORY IN THE UNITED STATES THROUGH THE CIVIL WAR**

With the English barely beaten, the new nation recognized the need for a formerly trained army and established the United States Military Academy at West Point, New York, 1802. This institution was a copy of the French military school, the Ecole Polytechnique, and its first textbooks were French translations. In 1817, John Michael O’Conner not only translated Gay de Vernon’s *Treatise*, but realizing the need to combine strategy, tactics, and
fortification, O'Conner enhanced Gay de Vernon's book by adding a one hundred page appendix, which was a summary of Jomini's *Traite des Grandes Operations Militaires*.³ O'Conner's translations remained the standard at West Point for a generation, when in 1836, it was replaced by a new publication by Dennis Hart Mahan.

A graduate of West Point, Dennis Hart Mahan went on to teach engineering from 1824 until 1871 thereby influencing almost every American military leader, West Point graduate or not, who served in the War with Mexico, the Civil War, or the numerous Indian Wars of the nineteenth century, through his teachings and writings.⁴ At the beginning of his career, Mahan relied on the standard West Point texts, which for fortifications was O'Conner's translation. Mahan himself became very familiar with the works of Gay de Vernon and of the master engineer Vauban, as well as the newer theories being considered in Europe.⁵ As he gained experience, Mahan found the translations inadequate in meeting the needs of the average American soldier
Events Effecting the Use of Earthen Fortifications in the United States

1750
French & Indian War (Seven Years War) 1755-63

U.S. Secretary of War Dearborn orders all cannon to be cast of iron. 1800

United States Military Academy established at West Point, New York 1802

O'Conner translates Gay de Vernon's "Treatise" for use at West Point 1817

Mahan publishes the first edition of his "Treatise" 1836

The U.S. Army begins the rifling of its smoothbore muskets. 1857

Mahan publishes the third edition of his "Treatise" 1861

Chief Joseph and his men utilize rifle pits at Bear Paw, Montana during the "Nez Perce War" 1877

1775
American Revolution 1775-83

French Revolution 1789-99

1800
War of 1812 1812-14

By the early 1800s artillery had come into its own as a mobile supporting force in warfare.

Colonel Wadsworth issues orders to create the first complete U.S. system of artillery. 1816

Clausewitz's "On War" is posthumously published. 1833

1825
Mexican War 1846-48

U.S. military produces the "Napoleon", modeled after the light field artillery developed by the French under Napoleon III. 1857

1850
American Civil War 1861-65

U.S. military produces the "Napoleon", modeled after the light field artillery developed by the French under Napoleon III. 1857

Captain Jack and his Modoc tribesmen construct defenses in lava beds during the "Modoc War" 1872-73

1875
and replaced O'Connor's translation with a series of his own writings. These later evolved into his seminal 1936 publication, *A Complete Treatise on Field Fortification, with the General Outlines of the Principles Regulating the Arrangement, the Attack, and the Defense of Permanent Works*.

Mahan's works advocated the use of field works to provide an edge to the often poorly trained and equipped militias of the United States in the face of more highly trained regulars of European armies. The target audience of *Field Fortification* was the junior officer, West Point trained or not. His book was written, "in a manner to be within the comprehension of any person of ordinary intelligence." The art of field fortification was spelled out in specific detail so that a novice could pick up the book and, if literate, design and build an earthwork that would suit his needs.

The first edition contained eleven chapters dealing with the basic elements of fortification in the field. Prior to the Civil War, two more editions of *Field Fortification* were published. A third edition published in 1861, included a new introduction and three new chapters: permanent fortifications, military bridging, and military reconnaissance. The introduction, which described the effects of musket fire, rifle fire, and artillery, ironically foretold lessons that four long years of bloody conflict made common knowledge; modern weapons were changing the face of war. With the introduction of rifled artillery, soldiers required the protection of earthen field fortifications in order to survive.

By the mid-1840s and the war with Mexico, West Point—through the work of Dennis Hart Mahan— influenced the use of field fortifications. Years of study, in addition to three periods of seacoast masonry fortification development, gave American officers a better foundation in the application of basic fortification principles. Field fortifications used during the Mexican War (1846-48) were based on the same theories and designs that prevailed during preceding periods, but because American forces were on the offensive most of the time, the use of field fortifications had minimal effect.

At the outbreak of the American Civil War, most regular officers of the United States Army had studied Mahan's *Field Fortification*. Officers who had not attended West Point, quickly became familiar with it because of the necessity of applying its teachings. Although there were other published works that contained some information on field fortification, Mahan's book was considered the best.

The use of earthen field fortifications reached a zenith during the American Civil War. As Mahan foreshadowed, the use of rifled weapons changed the face of war forever. Field fortifications, in one form or another, were utilized by both sides during most operations from the outset of the war. In April 1862, when rifled artillery attack left Fort Pulaski in ruins, the armies had proof that masonry fortification could not withstand the new weaponry.
Earthen fortifications, by absorbing the rifled artillery fire, stood a much better chance of withstanding an attack by rifled guns. Therefore by 1864, every movement and every position of both the northern and southern armies, were usually covered by field fortifications. In addition, earthen fortifications were used to protect cities, supply depots, railroad bridges, and to cover roads and river access. The remnants of one of the largest earthen fortifications built during the Civil War is Fortress Rosecrans at Murfreesboro, Tennessee.

Mahan continually revised and released editions of Field Fortification after the Civil War, making changes as needed to keep abreast of the latest technological advances. Throughout the rest of the nineteenth century, Mahan’s Field Fortification stood as the principle reference on fieldwork construction.

In addition to the Mexican War and the Civil War, American soldiers were involved in a series of conflicts throughout the nineteenth century in their efforts to push Native Americans from land coveted by white settlers. Basic forms of fortifications were used by the soldiers, but the art of fortification employed against Native Americans, never reached the level of sophistication used during the Civil War. However, simple rifle pits, battery positions, and breastworks construction were common. Native American’s also made use of simple fortifications and defenses of convenience. Noteworthy are the lava bed defenses of Captain Jack and his Modoc tribesmen in northern California, and the rifle pits of the Chief Joseph’s Nez Perce at Bear Paw, Montana.

**THE CONSTRUCTION OF EARTHWORKS**

The construction of earthworks remained consistent throughout their history. The basic technique involved piling dirt, excavated from a ditch, against a revetment, which was made from available wood or stone. As a general rule, earthworks constructed by trained soldiers almost always conformed to the principles of construction as dictated by the various manuals in use at the time. However, several interrelated factors effected the form and appearance of fortifications. These included the expected duration of use, the training of those constructing the works, the conditions under which they were constructed, and their position in the landscape and the relation to other earthworks.

By the mid-nineteenth century, earthworks were generally categorized as either hasty entrenchments or provisional fortifications, depending on their use. Earthworks constructed in the field for immediate, short-term use during tactical combat situations were referred to as hasty entrenchments because they could be constructed in a day or overnight. Because of their “hasty” construction, it is sometimes difficult to ascertain from which manual, or from whose imagination the forms derived. The raw dirt slopes and limited
design of hasty entrenchments were often improved when soldiers occupied the position for several days or more. When this occurred, positions were formalized and earthworks often gained a more “text book” appearance.

More permanent fortifications, both masonry and earthen, were referred to as provisional. In these cases, it was not uncommon for the slopes of earthen fortifications to have sod laid on them to prevent erosion and make the earthworks easier to maintain. As the use of rifled artillery increased during the Civil War, more substantial earthen fortifications were built to counter the impact of the new weaponry. Built to replace the now obsolete masonry fortifications type, provisional earthen fortifications were expected to last the duration of the war or for an extended occupation of a particular place.

A third type of fortification was constructed under specific field conditions where pre-battle landscape features existed such as stone walls, railroad embankments, or felled trees. In these cases, earthworks could be built to reinforce the man-made or natural feature in order to establish a defensive position. The sunken roads at Antietam and Shiloh battlefields are good examples of this fortification type.

Under ideal conditions, an engineer officer directed the construction of earthworks. After selecting and surveying a site, an engineer officer would mark out the positions for specific fortification features. Groups of soldiers, sometimes specially trained for this type of construction, or conscripted laborers would then carefully fill in the well marked areas with excavated dirt. The effort described here was usually associated with provisional works or those earthworks far enough from the front lines that laborers were not under direct enemy fire. The availability of an engineer officer had a marked effect on the quality of fieldworks construction. Although few officers were classified as trained engineer officers, many had some training, if not at West Point, then at another military academy. Many had a basic understanding of what to do when constructing earthworks and had access to a fortification manual such as Mahan’s Field Fortification. Every soldier who saw action understood the basic principle of a protective shield between himself and the enemy. On many battlefields, enemy fire, poor conditions, as well as the lack of engineer officers and digging implements, hampered the construction of fortifications. Where picks, shovels, and well marked lines were unavailable luxuries, the design and construction of fieldworks fell upon the individual soldiers and the non-commissioned officers to achieve. Each man dug the best he could with what he had—a canteen, bayonet, cup, or his hands.

The first priority in the construction of earthworks was to choose a defensible position. The success of a fortification often depended on the ground it occupied. High ground was preferable to low. The military crest—the line on a hill or ridge just below the summit—provided better protection than the hilltop. Here a soldier was not exposed against the sky. Fortifications
built on the opposite crest of the hill would have their field of fire obstructed, preventing accurate defensive coverage. A defensive fortification positioned poorly was perceived to be a weak point and became a target for assault.

Once a defensive position was selected, the next priority was the location of the ditch. The primary purpose of the ditch was to provide dirt for the fieldwork. The most basic construction of an earthwork consisted of dirt from the ditch being thrown into a pile called a parapet. The parapet wall was usually supported by a wall of hard material called a revetment. The revetment gave support to the earth and added protection from projectiles penetrating the earth. The revetment was usually made from wood, but stone, brick, or sandbags were also used. Wood used in revetment included logs, board, small saplings or twigs woven into a garrison, or small saplings bundled into a facine. Three techniques of construction were used: ditch in front, ditch in rear, and ditch on both sides.

The simplest and most common method of construction was to line soldiers up along the intended course of the work and for them to dig with shovels and picks. If the earthworks was constructed while under fire, the soldiers utilized a back ditch approach, throwing the excavated earth to their front to provide a barrier of earth between themselves and the enemy. Earth was thrown onto existing piles of logs or fence rails to act as a revetment by increasing the bulk of the parapet and its thereby its ability to absorb bullets. When time and need permitted, the trench would be deepened, and the back side of the parapet revetted or reinforced with logs, braided branches, or sandbags. Soldiers often added head logs—logs spaced lengthwise along the top of the parapet—from beneath which the soldiers could fire. This type of field fortification, commonly known as a rifle trench or rifle pit provided basic shelter for infantrymen. The size of this type of earthworks averaged four to five feet in relief. Ditch in rear construction was employed when the slope of the ground did not allow for the construction of a front ditch. In this case a back ditch provided added protection by the creating a low place for cover.

The second technique used to construct field fortifications was to excavate a ditch in front of the parapet. The soldiers first constructed a revetment, then lined up in front of it and dug a trench, piling the dirt against a revetment. Front ditches were generally prescribed to be 8'-12' wide and 4'-6' deep. The extra earth made the parapet correspondingly thicker and stronger. A front ditch was desirable because it added another obstacle for attacking enemy troops to overcome. As an assaulting enemy entered the ditch, the added height of the parapet slope made the final push even more difficult. Such works typically were used in semi-permanent fortifications, to shelter artillery batteries, or to provide extra protection for infantry from incoming
enemy artillery fire. Detached works, such as redans, lunettes, and redoubts, were built this way, often under the direct supervision of a military engineer. Long, straight segments of ditch-in-front entrenchments connecting artillery strong points were called “parallels.”

![Figure 1.4](image)

Figure 1.4. This photograph taken in 1865 shows an example of ditch-in-rear construction, using a log revetment, along a federal line near Fort Morton, Petersburg, Virginia.

The third type of entrenchment was built with a ditch on both sides of the parapet. Ditch-on-both-sides construction was often employed as an ad hoc measure to strengthen a section of parapet, to adapt to shallow topsoil, or to respond to uneven terrain. This technique was sometimes used to deepen a wagon road or protect a covered way that ran behind the parapet. Ditch-on-both-sides also occurred when trench segments were captured and refaced or “turned” to face the opposite direction. It is possible to see all three forms of ditches in an area or even in a single line.9
In order to facilitate firing at the enemy, several features were added to the basic ditch and parapet fortification. A firing step, also called a banquette, allowed soldiers to step up to the revetment and fire over a high parapet wall. Sometimes the construction of the earthworks, also known as breastworks, only allowed for the height of the parapet to cover a portion of a man standing behind it roughly breast high (five feet). No banquette was needed and defenders would often kneel to fire over them. The most elaborate fortifications had the parapet wall and banquette on a platform called a rampart. Most of the time ramparts were not included in field fortifications, but many provisional and more elaborate field fortifications did include this feature.

Like the banquette, which allowed riflemen to fire over the parapet, gun platforms were constructed to provide stability and maneuverability for artillery pieces. The gun could fire over the parapet in one of two ways. The most common is the embrasure. An embrasure was a slit in the parapet, usually protected by log, plank, or gabion revetment, though which guns could fire. The gun and crew were protected by the parapet wall and only exposed through the slim cut of the embrasure. Often, a gun platform would have two or more embrasures to service one gun. This allowed for an increased angle of fire for each gun, while minimizing exposure of the soldiers. “En barbette” positions placed the gun platform so that the barrel of the gun was above the crest of the parapet and, therefore, able to fire from any point along the parapet wall where a gun platform allowed it.

In front of the main line of fortifications were a series of advanced works. These works included ditches, parapets, covered ways, and rifle pits. Such fortifications provided protection to pickets—a detached body of soldiers serving to guard the army from surprise—while on duty in the exposed front areas of the position. In appearance they were very similar to the main line but built on a much smaller scale.

Examples of these distinct earthworks features can be seen, in various conditions, at National Park Service battlefields. Questions concerning the identification of earthworks in private or public ownership, can be directed to the National Park Service.

EXISTING CONDITIONS

Identifying the historic functions of existing earthworks can be a challenging task for even the most experienced military historian. Most earthworks are only a fraction of their historic height and width. The following series of figures will help to illustrate how various earthwork structures appear today and will name the various parts where possible. The photographs were taken between 1995 and 1998.
Note: This section is currently being developed by Paul Hawke, Historian at Shiloh NMP. When completed, it will identify structural parts of earthworks as they appear today.

Figure 1.5. Fort Wadsworth at Petersburg National Battlefield

Figure 1.6. Colonial NMP before the August mowing

Figure 1.7. Fort Wadsworth at Petersburg National Battlefield
Figure 1.8. Prospect Hill at Fredericksburg National Military Park

Figure 1.9. Battery #5 at Petersburg National Battlefield
Notes on Chapter One

1 The French army in the Napoleonic Wars are usually credited with being the first nationalistic “volunteer” army.

2 Although the finer details of military thought are not evident, many of the principles used in the construction of ancient American fortifications are the same. These ancient fortifications are still historic structures, with historic features, and should be treated just as delicately as a Civil War or Revolutionary War earthwork; possibly even more delicately since they are literally thousands of years old. Many of these fortifications of ancient America are still evident.

3 The role of military theorists Jomini and Loyd in the development of American Nineteenth Century military thought has been discussed among intellectual military historians for years. There are several books and many articles relating to the influence of these two theorists, particularly on the American Civil War. A third theorist, Karl von Clausewitz, has also been added to the mix. Particularly since his view embodied the realistic assessment of the nature of war and the impact of technology as it was being fought in the early to mid-Nineteenth Centuries.

Jomini, served as a staff officer with Napoleon late in the Wars for Empire. It is said that he was so appalled by the savagery and horror of the conflict he witnessed that his writings tried to influence military doctrine to return back to a time of more gentlemanly conflict, that of Frederick the Great. His works served as the bases of many texts and lectures in military science in Europe and the United States during the early Nineteenth Century. Several of his early writings were direct plagiarisms from the English biographer of Frederick the Great, Henri Loyd (especially Loyd’s 1790 work The History of the Late War in Germany: Between the King of Prussia and the Empress of Germany and Her Allies).

The German, Karl Von Clausewitz, on the other hand, saw the beginnings of total war being waged for political objectives. His work, On War, was not popular in Europe until the 1870’s. It seems that a war weary, shell-shocked (or post traumatic stress syndromed) continent shared Jomini’s desires. However, this does not mean that Clausewitz did not have students of his ideas in the United States. Henry W. Halleck’s Element’s of Military Art and Science, published in 1846, gives reference to Clausewitz. It is not implausible that Mahan reviewed Clausewitz’s work, or discussed it with his peers or students, with a view of applying the German’s principles to American needs.

4 Of Confederate Generals who attended West Point only Robert E. Lee, Joseph E. Johnston (Class of 1829), and Albert Sydney Johnston (Class of 1826) did not attend classes when Mahan was head of the Engineering Department. Jefferson Davis, President of the Confederacy (Class of 1828) also missed out on Mahan’s influence as a department head. However, it is safe to assume Mahan still would have had an influence on these Generals through association and professional development during their careers in the Regular Army.
Between 1825 and 1830, Mahan took a leave of absence from his teachings to study fortifications, military engineering, bridging, and public works in Europe. He attended the French school of Application for Artillery and Engineering at Metz. The Metz school was the post graduate course for the graduates of the Ecole Polytechnique who were in line for positions as Engineers or the artillery. Mahan's teachings and writings were based on his studies as a cadet and the four years he spent in Europe. At the Metz school he took copious notes. It was from these notes that many of his lectures were derived.

Dennis Hart Mahan, *A Treatise on Field Fortification, Containing Instructions on the Methods of Laying Out, Constructing, Defending, and Attacking Intrenchments, with the General Outlines also of the Arrangement, the Attack and Defense of Permanent Fortifications*, (New York: John Wiley, 1861), p. v

Information for this introduction was derived from experiments conducted in Europe on some of the new weapons being produced. Mahan included rates of fire, range, and accuracy for each weapon.

During the Crimean War several officers went to observe the conflict. Richard Delafield examined the fortifications of the Crimea and submitted a report to the Secretary of War. It provided a view of how fortification was accomplished in Europe during the 1850's. But it still was not the how-to *Field Fortification.*
Field Fortifications
adapted from Griffith, 1989

Fortification Forms
adapted from Mahan, 1836
INTRODUCTION

Earthworks are historic structures which are often the only visible remnants of an important military event. Earthworks, which can form vast networks, have often evolved to be functioning parts of broader ecological systems. Earthworks management, therefore, integrates in a unique and sometimes complex way, natural and cultural resource management values. Within this integrated landscape philosophy, three general principles for earthworks management emerge that address protection, sustainability, and interpretation:

1. Historic earthworks are protected and preserved.
2. Historic earthworks are managed using sustainable practices that consider the associated ecological system.
3. Historic earthworks that are presented to the public are legible.

The rationale supporting these principles of earthworks management is advanced in this chapter along with a discussion of the earthworks management components embodied in each of them.

PROTECTION/PRESERVATION

The mandate for preservation of earthworks is stated strongly and clearly in legislation that established national battlefield parks. An example is provided in the U.S. Congress declaration of July 3, 1926, designating the Petersburg National Battlefield:

In order to commemorate the campaign and siege and defense of Petersburg, Virginia in 1864 and 1865 and to preserve for historical purposes the breastworks, earthworks, walls, and other defenses or shelters used by the armies therein, the battle fields of Petersburg, in the State of Virginia, are declared a national battlefield...

Like Petersburg, many battlefield parks recognize the preservation and protection of the earthworks as the highest management priority. This in no way however precludes the possibility of letting people see them, or of interpreting them to the public. It simply makes clear that interpretation and appreciation of these sites not be at the expense of the protection of these irreplaceable structures.
There are three major management components embodied in the principle of earthworks preservation/protection:

a. Perpetuate and/or establish a vegetative cover that stabilizes the soil and protects the earthworks from the direct impacts of wind and water erosion;

b. Minimize the impact of human activities on the earthworks, whether they result from recreational, interpretive, or actual landscape maintenance and management activities;

c. Minimize the deleterious action of natural phenomena on the earthworks, e.g., windthrow of trees, burrowing of animals, or invasion of plant species that reduce natural diversity and erosion-controlling cover.

Perpetuate or Establish a Vegetative Cover

Perpetuating vegetative cover on earthworks involves one of two basic scenarios: earthworks are either in open (grassed) conditions and are actively maintained, or earthworks are in forested conditions and are minimally maintained. The critical difference is that forests and grasslands function differently to protect the earthworks and therefore require individualized management planning strategies to be successful. Under forest cover, it is the forest floor—layers of leaf litter built up over many years—that prevents erosion. In a grass/herbaceous condition, it is the network of roots and living leaf cover that reduces erosion. Each scenario can successfully protect the earthworks from wind and water erosion but each requires its own management strategy and associated tools and techniques. The tools and techniques associated with open and forested conditions will be discussed in detail in the following chapters.

The greatest challenge is establishing a functioning, erosion-controlling grass/herbaceous cover on earthworks that have been cleared of trees. Earthworks are generally cleared for one or more of the following reasons: (a) to be more visible for interpretive opportunities, (b) to maintain the public perception of being well maintained, and (c) to more closely resemble the historic scene.

The logical vegetative cover to establish on sites that have been cleared is a diverse herbaceous mix in which native grasses predominate. Native grasses as a group are probably the most effective plants for protecting soils from runoff and erosion. Moreover, once native grasses are established, they require less intensive maintenance than most exotic grass species. This lessens the chance of adversely impacting earthworks during routine maintenance activities. There is a growing number of successful examples of the use of native prairie grasses and other types of cover to protect sites from erosion.
In Georgia, the Oglethorpe Power Corporation conducted experimental planting of native grass species in test plots between 1987 and 1992. In October of 1990, based on this experimental work, a power line right-of-way in Smarr, Georgia, adjacent to Interstate Highway 75, was planted with a mix of Little Bluestem, Indiangrass, Switchgrass, Blackeyed Susan and Lanceleaf Coreopsis with a cover crop of annual ryegrass. In May of 1992, this planting was reported as providing greater than 80% cover. In July, 1996, Mr. Vince Howard Environmental Specialist at OPC, Atlanta, reported the continuing success of this planting in terms of cover and erosion control.

In another example initiated in the spring of 1994, a mix of native grasses and the legume partridge pea, were installed at Ninety-Six National Historic Site at Ninety-Six, South Carolina. By September of 1995, staff members at Ninety-Six reported the best cover of the earthworks, including the Star Fort, in memory. Quantitative sampling at that time revealed an average cover on the Star Fort of over 82%, almost entirely provided by grasses. The berm surfaces there had been mowed to a height of 5"-6" monthly during the 1995 growing season, and demonstrated a refined aesthetic effect.

At Cades Cove in the Great Smoky Mountains National Park, restoration of native meadows has been underway since spring of 1995. A preliminary report in April of 1996 documents a successful initiation in terms of increasing natural diversity in restoration sites. Dana Soehn, coordinator of the Cades Cove restoration, in a letter dated July 27, 1996, makes the following observation: "In restoring these areas, we have worked in cooperation with our cultural resources division within the Park. Overall, the Park historian has been receptive to the native meadows and the eradication of grasses which were planted in the 1930s and later, such as tall fescue." The project more generally provides a demonstration of cooperation and collaboration as well, with several federal agencies cooperating, and with volunteers, mainly students, donating over 1400 hours' work on such tasks as extensive seed-collecting from unmown field within the cove.

Brian Lambert, Natural Resources Specialist at Valley Forge National Historical Park, Pennsylvania initiated a tallgrass meadow project in that park in 1991; it has in 1996 been expanded from 200 to 700 acres. Included within the meadow areas are several redoubts. The former turf has been successfully converted from turf to a mix of tall grasses and forbs which provide very effective erosion control on the redoubts. No planting has been done in this case; the management program includes an annual mowing, usually in late March, with selective spot application of glyphosate herbicide to treat invasive woody plants such as Multiflora Rose and Asian Bittersweet. While the grasses that have developed under this program include exotic grasses such as Orchard Grass, there is a large component of Little Bluestem and Purpletop present. The only short mowing done under this program occurs on pathways leading from parking lots to the redoubts, and a path around the base of the earthworks, successfully keeping visitors off.
response to the tall grass meadow is overwhelmingly positive, according to Mr. Lambert, who estimates nine positive reactions to one negative.

While these examples provide evidence of the potential for establishing native grasses on sites in the eastern United States, the most convincing evidence is in a number of sites within the seven parks in this study. Where mowing has been reduced to once or twice a year, richly diverse stands of predominantly native grasses appear, presumably from propagules present in the soil. These same stands provide an ideal source of seed to introduce on earthworks.

**Minimizing the Impact of Human Activities On the Earthworks**

There is a strong attraction for visitors to walk on or over earthworks in battlefield parks. The earthworks are typically higher than their surroundings and provide a vantage point from which to view the landscape. Some also enjoy recreating the battle scene from this vantage point. Children especially enjoy the experience of climbing on earthworks because the view attained and the physical challenge. Adolescents and adults, attracted to the topographic challenges presented by earthworks, may cause irreparable damage by riding mountain bikes and other recreational vehicles on earthworks. Still another detrimental recreational use is associated with equestrian activities. All these recreational activities are clearly in conflict with the goal of earthwork preservation. A variety of policies and practices can be adopted to reduce visitor abuse of these resources.

Walkways or mowed pathways that lead people along the base of earthworks generally need to be eliminated. Educational programs remind people of the fragility of earthworks but where signs prohibiting visitor trampling are in place, they are often ineffective. A program of signs, pamphlets, and instructive reminders from park staff may be the most effective way to deter visitors from harming earthworks. Parks that provide viewing platforms, such as those at Fortress Rosecrans, Stones River National Battlefield, Murfreesboro, Tennessee, or at Cold Harbor at Richmond Battlefield Park, give visitors the opportunity to experience the height of the earthworks while making it clear that earthworks are not to be trampled.

One could argue that visitors walking over reconstructed earthworks is acceptable because they are not original structures. However, there are two counter-arguments suggesting that even this is not a good practice, namely that (a) the public generally can not differentiate between original and reconstructed earthworks; and that (b) some reconstructed earthworks themselves now have historic value, and therefore are worthy of protection and preservation. An exception to this might be where “demonstration” earthworks are constructed, in an inconspicuous and nonhistoric location, to interpret to the public the likely condition of earthworks at the time of the battle. Both Fredricksburg and Petersburg have constructed such features with some success. Parks should promote appropriate access and use by visitors.
Vegetation can be used in various ways to discourage recreational activity on earthworks. At an open site, grasses left to grow taller than six inches can deter trampling; taller grasses are even more effective. Another example is where a mowed “interior” of an earthwork is surrounded by a tallgrass cover on the berms, such as the treatment at Battery Five at Petersburg National Battlefield. The taller grasses in these cases discourage trampling. In a wooded setting, a shrub cover of one to three feet in height could be effective. In parks that are adjacent to urban residential developments, more impenetrable barriers may be necessary at access points: logs or fallen trees; thorny shrubs and vines (e.g., blackberry and greenbrier); or in some cases, fences (ranging from split rail fences judiciously placed, as at Chancellorsville, to various heights and types of wire fencing in combination with dense vegetation) might be used.

Other activities that are often overlooked for their effect on earthworks are maintenance practices themselves. Maintenance and management activities, particularly mowing, have the potential to contribute to erosion and gradual degradation of the earthworks. With every pass of the mowing machinery, the potential for damage increases. If the mowing height is short—one or two inches—the potential for gouging the surface is increased. Hence, from the standpoint of erosion protection, the fewer mowings and the higher the mowing height the better because opportunities to gouge the surface of the earthworks is reduced.

Techniques to establish vegetation on earthworks can also damage the resources. Planting grass and shrub seedlings requires digging as well as considerable direct human trampling. This may be damaging to earthwork structures and any associated archeological resources. Wherever possible, planting techniques that require the least disturbance to the soil layer should be adopted.

**Minimizing the Deleterious Action of Natural Phenomena**

Natural phenomena can also greatly contribute to the destruction of earthworks. Three primary sources of damage are the windthrow of large canopy trees, the colonization of earthworks by undesirable plant species, and the burrowing of animals, particularly groundhogs.

The most dramatic of these natural processes that contributes to erosion and seriously damages earthworks, is the windthrow of large canopy trees. If a blown-down tree was growing on the earthworks, it pulls away layers of earth and rock that constitute the resource. Trees thrown down upon the earthworks can gouge out sections and expose bare earth to the process of erosion. Damage that resulted from a major windstorm was observed at Kennesaw Mountain National Battlefield Park. Here blown-down species of trees included mature oaks, hickories and blackgum. Fallen trees were pointed out at other parks in the study as well, which suggests that this is a recurring phenomenon.
Despite the damage that may result from major wind events, removal of all trees on earthworks in anticipation of a major storm is not a practical solution for a variety of reasons. Isolated mature trees growing directly on earthwork structures, however, may be targeted for gradual removal over time. Another solution may be a management program that removes saplings on the earthworks, which will prevent them from becoming major threats in the long run. Trees not growing directly on the earthworks should remain, with their canopies extending over the earthworks, perpetuating the forest floor and providing the general protective cover of a forest environment. (Management of earthworks in a forest environment is covered in more detail in Chapter 3.)

Figure 2.1. Damage resulting from the wind-fall of a large hickory tree at Kennesaw Mountain National Battlefield Park, Georgia.

A second natural phenomenon that diminishes the erosion-controlling capability of an herbaceous cover on cleared earthworks is the colonization of undesirable woody plant species. Two problems associated with this condition are: (a) the undesirable woody species do not provide good year-round erosion control; and (b) woody species shade out many of the desirable grasses and forbs. The most pernicious woody plant observed in many parks is Japanese Honeysuckle (*Lonicera japonica*). (See Figure 3.3) This invasive exotic plant spreads by way of trailing stems that sporadically root as well as through germination of its abundant seeds, which are eaten and eliminated by birds and small mammals. Blackberry (*Rubus allegheniensis*) may similarly invade a predominantly herbaceous cover and spread rapidly.
outward through sprouts, layers, underground stems, and seeds. Like the Japanese Honeysuckle, Blackberry shades out low-growing herbaceous plants, exposing bare earth beneath its arching canes.

Chinese Privet (*Ligustrum sinense*) has a more upright growth form, but it too may effectively eliminate most other species in its path. Privet has a very high stem density, which prevents other herbaceous plants from competing for light and moisture. Furthermore, it is able to grow in conditions ranging from full sun to full shade, and from dry-mesic sites to floodplains with periodic inundation.

Management programs to inhibit the colonization and spread of these and other invasive species are necessary in order to promote the highest degree of protection for earthworks from erosion. Technical Support Topic #7, *Invasive Plant Species and Control Measures*, provides a summary of current knowledge on the control of these and other invasive species that tend to diminish the plant diversity once they are established.

Finally, another naturally-occurring phenomenon that represents a threat to earthworks is the burrowing of groundhogs. During this study, groundhog burrows, with their identifiable mounds of compacted earth at the entrance to the burrow, were observed on all types of sites—open sites with frequent visitation, wooded sites where visitors rarely go and even sites that had recently been cleared of Kudzu. To date, the preferred management recommendations regarding the problem of burrowing animals are: (a) trapping and removal; or (b) extermination.

**SUSTAINABILITY IN EARTHWORKS MANAGEMENT PRACTICES**

The National Park Service’s own 1993 publication, Guiding Principles of Sustainable Design, states that “cultural resource treatment and maintenance methods should be both environmentally and culturally sensitive and sustainable over the long term” (p. 31). There are several components implicit to the principle of sustainability as it applies to earthworks management:

- a. Minimize the expenditure of energy resources required such as the number of mowings or other maintenance treatments requiring motorized equipment.
- b. Restrict the need for irrigation to small areas or rare occasions such as extreme droughts or plant establishment periods.
- c. Minimize the need for soil amendments such as chemical fertilizers and lime through the use of plant species that are naturally adapted to the site conditions.
- d. Minimize labor-intensive practices of plant establishment such as planting grass seedlings by hand.
e. Employ natural processes whenever possible to help rejuvenate and revegetate the site.

f. Minimize the use of pesticides and herbicides, consistent with the National Park Service Integrated Pest Management (IPM) guidelines.

A key consideration in the development of sustainable management practices for vegetation on earthworks is the use of a diversity of species predominantly native to the site. As noted in the discussion of earthworks protection/preservation, a management strategy that favors a diverse cover will lead to a complex mix of vegetation that will be adaptable to the heterogeneous environment of earthworks. A diverse mix of species will be resilient to climatic fluctuations, such as periods of heat and drought, or to infestations of a disease or insect. Plants native to a region, which have been observed on earthworks or on similar sites in the area, provide a logical pool of species to draw from when revegetation is necessary. Plant species that have persisted for centuries in a particular area are adapted to the climatic vagaries of that zone. Stands of native species are not management-free, however. Management practices associated with perpetuating diverse grass/herbaceous stands relate to arresting succession and suppressing diversity-diminishing invasive species. When herbicide treatment is necessary to suppress invasive species, targeted application through the use of a wick applicator or paintbrush is recommended over broadcast spraying. A diverse stand of forest also requires some maintenance to ensure that hazardous trees will not damage earthworks.

LEGIBILITY AND AESTHETIC ACCEPTABILITY

There is a wide range of opinion among site managers as to what constitutes acceptable aesthetic standards for earthworks vegetation. Opinions also vary on the degree of visual refinement of earthworks necessary as it relates to the degree of interpretation. For example, one school of thought puts earthworks that are key interpretive points in an open condition under a monoculture of turf. It is therefore useful to develop a range of acceptable aesthetic standards or goals for the range of conditions: from open, non-forested, highly-interpreted earthworks, to forested, minimally-interpreted examples.

In cases when earthworks were hastily constructed at the time of the battle, they were bare earth or mud, with timber components in some situations for reinforcement. For these types of earthworks, the recreation of an authentic historic scene is not a viable option. Earthworks kept in such a condition would soon erode out of existence. As an alternative to bare earth, the establishment and perpetuation of a vegetative cover that might naturally have colonized in the years following the battle is appropriate. This "natural
look" is a complex of vegetation and can be a logical management goal. The natural evolution for most abandoned sites in the southeast begins with a community of herbaceous plants and evolves slowly to a mixed hardwood forest with multiple layers of vegetation. Between the extremes of this evolutionary continuum, there is a period when the vegetation seems an inconsistent and chaotic mix of grasses, broad-leaved herbaceous plants, vines, brambles, and tree seedlings and saplings. In the period soon after the Revolutionary or Civil Wars, it is important to note that there would have been less likelihood than there is today of invasive exotic species dominating the vegetation at any stage, since many of them were not yet so pervasive as they are today.

![Image of natural vegetation](image)

**Figure 2.2.** A mixed stand of tall native grasses provides excellent legibility as well as erosion control benefits as in this example at Colonial National Historical Park, Virginia.

Documentation shows that earthworks built to last for a period longer than the battle were often "sodded" with field grasses for the same reason that earthworks are vegetated today: to prevent erosion. In the case of sodded earthworks, plant succession, once the earthworks were abandoned, was the same as in the bare earth scenario, only proceeding more rapidly because of the head start that sodding provided.

For highly-interpreted sites, the early-successional "look" could be reasonably and successfully achieved by a mix of native grasses, given their fine texture and average two- to three-foot mature height. Notwithstanding the desirability of species diversity for sustainable reasons, too much visual
diversity, as represented by a variety of growth forms (e.g., grasses, forbs, vines, shrubs, and saplings) leads to visual chaos and a loss of earthworks legibility. A management goal in this situation would be to perpetuate the dominance of the fine-textured grasses.

For earthworks that are only minimally interpreted, or where the interpretive message includes the story of successional change from open field to a mature forest, the central visual goal will be to maintain legibility of the earthworks, by reducing the number of different growth forms in the understory and groundlayer. This can be done by encouraging relatively low plant cover on the earthworks themselves.

To facilitate the public’s appreciation of the “new aesthetic” of tall grasses where previously there was a highly-manicured turf, two strategies may be useful:

a. Some manicured turf cover may be perpetuated in selected zones. Examples include maintaining turf on the interior of a fort or battery, such as Battery Five at Petersburg, or in bands alongside trails to diminish the perception of neglect, which some people associate with native tall grasses.

b. During a transitional period, a mowing frequency of once every four to five weeks during the growing season, at a height of five to six inches, will gradually prepare people, for a mowing frequency of only once a year, and an average grass height of 18"-36".

**CONCLUSION/ SYNTHESIS**

By examining these three principles it can be concluded that they are compatible with one another. For example, the establishment of a diverse cover of herbaceous vegetation dominated by grasses in open, sunny situations represents one of the best possible means of providing erosion control. At the same time, a diverse cover of herbaceous vegetation can be perpetuated through management as simple as annual or semiannual mowing to a height of five or six inches. The visual effect of infrequent mowing permits the visitor to understand the earthwork form, but without the temptation to walk over it. Aesthetically, the effect of a fine-textured grass cover, increasing in height as the growing season progresses, and changing to warm color tones during the fall and winter, is a positive prospect.

Earthworks existing under forest conditions can exceed the protection offered by an established herbaceous cover if an intact forest floor is perpetuated. The only maintenance required in a forested condition is the removal of hazardous tree. In the following chapters, the application of these principles to the management of earthworks in both forested and open conditions is explored and technical information is provided that will assist in implementing a management plan for earthworks.
INTRODUCTION

Earthworks under forest cover represent a typical condition throughout the battlefield parks. This condition results from an area's release from active management, which allows natural plant succession to occur. As noted in the history section, earthworks at the time of construction were in open situations that allowed for a clear field of fire, even if that meant the soldiers cut down the forest themselves. Following the war, earthworks were either kept open with the resumption of agricultural use, or reverted to forest because the land was undesirable for development. Even after earthworks were collected into battlefield parks, earthworks that were not considered primary interpretive features, were released from active management and woodlands allowed to return. Existing earthworks under forest cover are comprised of second-generation stands of trees dating to the area's release.

ECOLOGICAL PROCESSES

Before discussing management tools and techniques for earthworks under forest cover, it is important to have a basic understanding of forest ecology. Ecology is the field of study that relates to the interaction of living organisms with their biotic and abiotic environments. Forest ecology is simply a special case that includes forest environments. Numerous forest ecology textbooks are available that describe the full body of natural processes that occur in various forest ecosystems, however, two will be mentioned here because of their direct relationship to earthwork: forest succession and forest soil erosion.

Forest Succession

Forest succession is the process by which one plant community is replaced by another, over time (West and others 1981). When bare soil is abandoned, such as after plowing a field or constructing earthworks, the process of succession begins immediately. Seeds already present in the soil will germinate as soon as conditions permit. Wind-disseminated seeds dispersed over an area, will readily germinate. This first plant community generally consists of herbaceous plants, which add organic matter and nutrients to the surface soil. These plants increase the water-holding capacity of the soil, and generally increase the soil's productive potential. Woody shrubs and trees next invade the site, and gradually they shade out the shorter herbaceous plants. These trees are generally fast-growing and shade-intolerant. Over time, a litter layer builds to become the forest floor, which is one of the defining characteristics of an intact, functioning forest ecosystem. The shady,
forest environment provides a site for trees and shrubs that germinate and grow in this condition. Over time, shade-tolerant trees will eventually occupy the overstory canopy, and create a climax forest condition. Usually, however, continued natural or man-caused disturbance prohibits a climax forest from developing or persisting for very long.

![Forest succession in action](image)

*Figure 3.1. Field created to establish an authentic historical scene at Fredericksburg National Military Park. Forest succession is rapidly progressing with yellow-poplar, sweetgum, and other fast-growing tree species invading the site.*

It is important for park managers to understand this natural process of succession, and the plant species that are most common to the various stages. Any vegetation management done in the forest is really an attempt to manipulate this process of succession in some way. Establishing and maintaining a field, for example, is a direct attempt to keep an early successional stage, or sere, in place (Figure 3.1). It cannot be done without a continued investment of time and money, because the natural process in the Eastern Woodlands is to replace the herbaceous vegetation with taller woody shrubs and trees. The stronger the tendency for succession to proceed, the more time and money must be spent on manipulations. For example, attempting to maintain a monoculture of any species, be it grass, shrub, or tree, is in direct conflict with natural succession, and can only be achieved with great time and expense. Manipulating forest vegetation is something foresters have been doing for a hundred years. Success is measured by working with nature as much as possible to achieve the desired condition at the least expense.
Forest Soil Erosion

Like succession, forest soil erosion is also a natural process. Soil erosion will always occur, however, in undisturbed forest ecosystems it is minimal. The U.S. Forest Service estimates that erosion rates in undisturbed eastern deciduous forests are 0.05 to 0.10 tons/ac/yr (Patric 1976). However, erosion rates on agricultural lands are typically 3 to 5 tons/ac/yr.

Erosion is a two step process. In the first step soil particles are detached, usually from the impact of falling raindrops. In the second step the soil particles are transported, either to a lower slope position or to a stream channel, where they are deposited as sediment. To halt or slow erosion, one or both of these steps must be interrupted. This can be done in a variety of ways, the most common is to maintain a cover crop over the bare soil. The canopy and stalks of the plants disrupt the impact of falling raindrops, and the roots tend to hold the soil in place, preventing transport. Obviously, the more complete the plant cover, the more effective the erosion control. Establishing plant cover is the most common soil erosion control method on disturbed lands be they agricultural fields, roadbank cuts, or earthworks.

There are, however, some very dramatic differences between erosion potential on open bare land and in a forest environment. In a fully-stocked forest the soil surface is covered with a built-in mulch blanket called the forest floor. Also, the multi-storied canopy common in most eastern deciduous forests greatly reduces the impact of falling raindrops. Separation and transport of soil particles are greatly hampered in this condition, and thus erosion from undisturbed forests is nil. Where the forest is relatively undisturbed, stream sediment comes from the cut banks of the stream itself, not from eroded soil in the watershed.

It is very important for park managers to understand this unique feature of erosion in the forest. By far the most critical element to arresting erosion is the forest floor. Soil erosion rates in agriculture are commonly estimated using the Universal Soil Loss Equation (USLE) developed by the U.S. Department of Agriculture. The USLE has been modified for use on forest lands by the inclusion of nine sub-factors that collectively account for the many differences between agricultural and forest systems (Dissmeyer and Foster 1981, 1984). One of the most important sub-factors is the presence of an intact forest floor. In fact, if an intact forest floor is present—potential soil erosion is zero! Therefore, the most critical factor to reducing erosion under forest cover is maintaining the integrity of the forest floor. Even if the entire forest overstory and understory is removed, erosion will still be zero as long as the forest floor remains intact. Of course, it is the overstory that keeps the forest floor replenished with litter each year, so the forest’s complete removal hardly makes sense. However, controlling erosion on earthworks in the forest is largely a matter of managing the forest floor, rather than manipulating vegetation. The most important consideration is
maintaining enough forest cover so that the forest floor does not become diminished over time. Maintaining a fully-stocked stand condition will generally insure this.

Overall, forest cover represents the safest, most natural, most effective, and most cost-efficient means of protecting earthworks (Helm and Johnson 1995). In general, earthworks under forest cover are well-preserved and protected, with some exceptions. Occasionally the forest floor is diminished because of disturbances like hiking trails and excessive bicycle use (Figure 3.2). While overstory forest cover will slow down the impact of falling rain (the first step in the erosion process), the lack of a forest floor will allow the second step, transport of soil particles, to occur unimpeded. Under heavy storm conditions this will undoubtedly result in serious erosion. Other disturbances like ground hog dens and tree tips are also a problem, though not on a wide scale. With these exceptions, most park natural resource managers agree that most earthworks should remain under forest cover for greatest long term protection.

Figure 3.2. Earthwork under forest cover at Yorktown Unit of Colonial National Historical Park. Forest floor has been removed due to excessive bicycle use, creating ideal conditions for erosion and subsequent degradation.

FOREST COVER CONDITIONS

With earthwork management there are really two objectives to achieve, and at times they may conflict. The first is to preserve the integrity of the earthworks themselves, the second is to display the earthworks in an historically accurate setting. The best strategy for preservation may not be
the best for display, and vice versa. Earthworks in an historically accurate setting means, for most situations, cleared earthworks and that is covered in the preceding chapter. Therefore, the following discussion will only deal with earthworks in two different conditions: 1) full canopy and 2) partial canopy.

**Earthworks Under Full Canopy**

A full canopy often represents the most cost efficient condition for earthworks because it requires almost no maintenance. It is ironic that while representing the least effort a park can afford, a full forest canopy also represents the highest level of protection. With limited budgets, this condition may be the only or, at least, the default strategy available to parks. Because earthworks under continuous forest cover occur most often in out-lying areas of the park, they may for that reason be considered as having a low interpretive value (Figure 3.3). Overall, most earthworks in a given park are likely to fall in this category. Suggested management practices for these earthworks include the following:

1. identify and map the earthworks;
2. inventory the area for current condition and hazard trees;
3. remove hazard trees as budget permits;
4. monitor the earthworks biennially.

![Figure 3.3. Protected earthwork on Main Unit of Petersburg National Battlefield. Forest canopy is closed and forest floor is intact, providing ideal protection. Erosion is nonexistent.](image-url)
Over time, there should be a commitment to removing large trees from the earthworks themselves because of the potential for damage if they fall naturally. Obviously, the first trees to remove are those that are most hazardous because of disease or location. However, a long term goal should be to maintain a forest cover over the earthworks, with the largest trees being near but not one the earthworks.

**Earthworks Under Partial Canopy**

Where forested earthworks have intermediate interpretive value, either because they are situated where some significant event in the battle occurred, or they happen to be close to a road, or trail, it may be desirable for the park to pursue a partial canopy strategy. Preservation is still critical to these earthworks, but there is a dual objective of displaying them for visitor viewing (Figure 3.4). For these earthworks, the expense of clearing the forest is not warranted nor is establishing and maintaining early successional, herbaceous vegetation. However, these earthworks could be exposed for viewing, which entails removal of the woody understory. In many cases, only a section of earthworks should be opened up, which satisfies the interpretive objective without the expense of maintaining an open condition over a large area. For example, an earthwork may extend a half-mile along a trail, but it may only need the understory removed in a couple of 100 yard sections to satisfy the viewing public. The remainder of the earthwork line can remain in a protected condition.

![Figure 3.4. Intermediately-managed earthworks at Richmond National Battlefield Park. Ground vegetation and forest floor provide protection, while understory removal opens up the earthworks for viewing.](image)
For intermediately-managed earthworks the following management practices apply:

1. identify and map the earthworks;
2. inventory the area for current condition and hazard trees;
3. remove trees hazardous to visitors in the area;
4. remove all dead and downed logs on earthworks;
5. selectively thin earthworks trees that may become hazardous
6. selectively remove understory trees and shrubs
7. treat cut stumps that are prone to rootsprout with herbicides (optional);
8. cut understory annually or biennially;
9. monitor annually.

HAZARD TREE MANAGEMENT

There are two types of hazardous trees in parks—those that pose a threat to visitors or property and those that pose a threat to cultural resources such as earthworks. Clearly the human safety issues take precedent, and all attraction areas such as along trails, picnic grounds, parking lots, and near interpretative signs, should be checked annually. All hazardous trees and limbs should be removed. Likewise, hazardous trees near the park boundary that threaten neighbors and their property should also be removed. The NPS-Natural Resources Management Manual (NPS-77, pages 349-358) contains guidelines for inspection, classification, and rating of hazardous trees that pose a threat to visitors or property. What is missing, however, are specific descriptions of trees that may be hazardous to earthworks.

Assessing Potential Hazard Trees

The greatest concern with hazardous trees on earthworks is the threat of windthrow or tree uprooting, and the associated removal of soil from the earthwork in the form of a root ball (Figure 4.5). Tree uprooting is a natural process in forests throughout the eastern U.S. (Shaetzl and others, 1989a, 1989b). However, it is very difficult to predict whether or not a given tree will be uprooted. Many factors influence the process, including wind speed and direction; tree size, crown shape and position on a slope; soil depth and wetness; and tree rooting habit and presence of root pathogens. It is clear, however, that larger trees are more at risk than smaller trees, and shallow-rooted trees growing in wet soils with restricted rooting depth have a greater likelihood of being uprooted.
Figure 3.5. Tree blowdown and uprooting adjacent to an earthwork at the Yorktown Unit of the Colonial National Historical Park.

Generally, earthworks represent well-drained soil conditions without restrictive soil layers. However, based on root zone geography, it is possible to determine where on the earthworks's structure would trees be most weakly anchored and therefore more susceptible to being windthrown. If tree roots can grow in four cardinal directions in the horizontal dimension and one direction (down into the soil) in the vertical direction, then the most secure location would be in a flat area where roots can grow out and down freely. But earthworks consist of long mounds. Trees that are located on the nose slope, or end of an earthwork can send roots only in two directions, down and back into the earthwork. This area of the earthwork is at the greatest risk for tree fall damage. Trees growing on the top of the earthworks can send roots in three directions, down into the soil and out into the earthwork on either side. They are the second greatest risk. Finally, trees growing on the side slope of earthworks can send roots in four directions, down, or back into the earthwork, in three directions. These are the least susceptible.

Generally, trees develop windfirmness against the prevailing winds, but become especially susceptible to blow down when strong winds occur from the other directions. For example, assume the prevailing winds in an area are from the west. A storm out of the northeast with strong, gusty winds may cause more severe blow down, especially if the soil is wet.
Large trees with heavy crowns catch more wind and are much more susceptible to blow down (Shaetzl and others 1989a). While there is no magic measurement for the tree size, foresters have observed that tree seedlings, saplings, and poles rarely blow down and uproot. This is normally an affliction of "sawtimber" trees, which have a diameter at breast height (dbh) of 12 inches or greater. When identifying trees at risk of uprooting, 12 inches dbh may be considered a lower threshold.

Removal of Hazardous Trees

The simplest way of removing hazardous trees is to cut them with a chain saw, directionally-felling them away from earthworks. If earthworks are in isolated areas away from trails, the cut stems can simply remain in place to decompose. Where earthworks are near trails or interpretive zones, the cut stems should be removed. Cut stumps may be treated with a labeled herbicide to prevent resprouting of deciduous trees (this is unnecessary with coniferous trees, since they generally do not sprout from the stump). An option only in isolated areas where visitors rarely venture, is to girdle the hazardous trees rather than cutting them. Girdled trees die slowly over the growing season and, once dead, the crown begins to break up and fall down in pieces. This is cheaper and easier than cutting, and less obtrusive. The girdled trees also become attractive to wildlife. A couple of precautions are necessary:

1. girdling must be complete all around the tree, and must sever the vascular cambium and phloem tissue.

2. girdling coupled with a herbicide application insures tree death and also kills the roots, eliminating sprouting.

3. girdling is not a possibility in areas with regular visitation, because it effectively creates a tree that is hazardous to visitors.

4. girdling should not be used in areas where there is a large pine component in the overstory. Girdling creates stressed and dying trees that may be attractive to the southern pine beetle—a serious pest in southern pine forests.

Even under the best management scenario, some trees will blow down and uproot, breaking out sections of earthworks. Such trees should be cut off leaving a minimal stump. If cut soon after blowdown, the stump will occasionally spring back into place as soon as the tree is severed. Caution should be taken that no one is standing next to the root wad when it springs back into place. If the stump doesn’t spring back, the stump can be grubbed out with hand tools and removed or left in place to decay over time. An attempt should be made to spread out the soil and smooth the surface, then cover all exposed soil with organic matter from the site. Chipped limbs would ideally suit this purpose.
THINNING THE OVERSTORY IN EARTHWORKS AREAS

Thinning the overstory to achieve a partial canopy is a recommended management strategy. The first trees to remove are those hazardous to visitors and to the earthworks themselves. Additional thinning may be done, if desired, to improve visibility of the earthworks. It is important, however, to maintain a fully-stocked stand condition so that leaf litter buildup is heavy enough to replenish the forest floor. Also, under fully-stocked conditions light reaching through the canopy is reduced, which cuts down on understory growth. There are several ways to estimate stocking levels, but foresters typically use basal area. A rule of thumb is that in deciduous forests the lower limit of full stocking is around 60 square feet of basal area per acre, while in pine and pine-hardwood forests it is 80 square feet per acre. Basal area can be estimated quickly and easily using a 10 factor wedge prism. If removing all hazardous trees reduces the basal area below the recommended level, some of the hazardous trees should remain in place. When trees are thinned, the slash (branches and twigs) should be chipped and left on the site, or used to cover bare soil wherever it occurs.

Understory trees and shrubs should likewise be cut and chipped in areas with a partial canopy. Tree regeneration and the development of a shade-tolerant shrub layer is part of the natural succession process. Retarding that process is possible, but it will take continual effort. Brush cutting and weed whacking at least every other year will be necessary. As long as the forest floor remains intact, neither the understory shrubs and trees nor the ground vegetation play a significant role in arresting soil erosion. Removing this layer may, however, play a role in encouraging visitors from walking on the earthworks.
INTRODUCTION

For the purposes of this handbook, an open condition is defined as a site where little or no canopy of trees exists on or near the earthworks and a native grass-dominated plant community is present. An open condition is selected when interpretation of the earthworks is of primary interest and/or the earthworks have historically been in an open condition. Because of the body of knowledge that is already available on turf grass management, parks that manage earthworks in a monoculture of turf grass are not addressed at length by this chapter.

GRASS COMMUNITY ECOLOGY AND PHYSIOLOGY

A grass-dominated ecosystem is not a stable plant community in the Eastern United States. In natural succession processes, meadows or grasslands develop during the early stages (years) of succession on bare, sunny sites. Left unmanaged, however, natural succession will continue and a mixed hardwood forest will result in most environments.

Like the prairies of the Midwest, in which grasses and herbs represent a climax community, the grass stage in the East is comprised of a diversity of species. It is a long-accepted precept that a certain amount of species diversity contributes to the efficiency and resiliency of natural ecosystems. In the heterogeneous environments that are characteristic of earthworks, there is particular value in having a variety of species. Greater numbers of species increase opportunities for adaptation to the variable microhabitats: tops of slopes that are characteristically drier than the bases of slopes; south- and west-facing slopes that are hotter and drier than north- and east-facing slopes; and soil textures and nutrient levels that may be highly variable. Hence, the establishment and management of an array of plant species with slightly different ranges of environmental tolerances increase the likelihood that there will be at least one species successfully colonizing in each of several different microhabitats.

In addition to understanding the importance of species composition, one must also understand the basic physiology and life cycle of several categories of grasses that are important to this project including: annual grasses; short-lived perennial grasses; and long-lived perennial grasses.
Annual grasses, such as the native Foxtail (Setaria sp.) germinate, grow to maturity, and produce seed in one growing season. Because of the seed's ability to colonize on bare soil, it is desirable to include these species in a seed mix for unvegetated sites. Although the annual grasses will fade as perennial grasses take hold, seeds will continue to germinate wherever they come into contact with bare soil.

Short-lived perennial grasses, such as Wild Rye (Elymus virginicus), are similar to the annual grasses in that they also tend to colonize well on bare soil, but short-lived perennials will gradually phase out as long-lived perennial species take hold and spread. What distinguishes perennial from annual grass species is the multi-year life span of the perennials. The stems of both short-lived and long-lived perennial grasses die back to the base each year in the Mid-Atlantic and Southeastern climatic zones, but in the basal part of the stem, there are a number of nodes or "growing tips" capable of producing new growth the following year. If permitted to grow to maturity, perennial grasses also produce seed that would be available for germination the following growing season.

In addition to life cycle, the different species of grasses also differ in their temperature needs for growth. Depending on these requirements, they are categorized either as "cool-season" or "warm-season" grasses. Cool-season grasses grow most actively in late fall and early spring, i.e., with a minimum
daily temperature of 40° to 45°F. Cool-season grasses typically produce their seed by May or June, before going dormant for the summer. Warm-season grasses, on the other hand, start growth only when the minimum daily temperature reaches 60° to 65°F, which means they are dormant during late fall, winter, and early spring. Warm-season grasses bloom and typically set seed in late summer with seeds maturing by October.

One additional distinction between grasses relates to their growth form. There are species, such as little bluestem (Schizachyrium scoparium) that form "clumps" of stems from a central point. These clumps grow outward over time, and the growing tips tend to be mounded, i.e., higher in the center of the clump than at the edges. The clump-forming grasses, or bunch grasses, generally have bare earth surrounding each clump. There are other species that produce rhizomes that spread laterally, such as sideoats grama grass (Bouteloua curtipendula) and effectively form a dense sod without visible open soil between plants. For erosion-control purposes, the inclusion of some sod-forming species in a seed mix is important.

**OPEN CONDITIONS MANAGEMENT**

If an open condition that is dominated by native grasses is the proposed or existing setting for an earthworks site in the Eastern, United States—where succession to a mixed hardwood forest is the norm—some level of hands-on landscape management will be required to achieve that goal. Before deciding the most effective way to establish or perpetuate a grass-dominated condition, park managers must first understand the existing plant community and what tools and techniques are necessary to achieve a native grass community. The following statements describe three basic management scenarios:

1. **Decelerate succession or stabilize the vegetation at a particular stage of succession.** This scenario implies the existence of an acceptable grass-dominated cover on earthworks and the goal is to inhibit the establishment of trees and shrubs.

2. **Accelerate succession in order to achieve greater native grass cover, or to advance to a later stage of succession.** This scenario implies that a bare site is being revegetated with perennial grasses and herbs and there is the need to enhance that process.

3. **Modify species composition.** This scenario implies that native grasses and herbs are present but do not dominate because they are competing with other less desirable species (trees, shrubs, or invasive exotics). To achieve the grass-dominated condition, removal or suppression of selected species and/or the active reintroduction of native grasses and herbs, or the creation of conditions that releases existing native suppressed species is necessary.
Once an existing condition is understood in terms of one of these scenarios, the tools and techniques for achieving the goal of a grass-dominated open condition must be considered. There are various tools for achieving and maintaining an open site. The following is a discussion of three tools and associated techniques and how they might be applied in carrying out an open conditions scenario. The tools are: (1) mowing, (2) prescribed burning, and (3) herbicide treatment. The labor/cost associated with implementing any selected tool is an important factor to consider, and while not discussed in this chapter, costs associated with park case studies are included in Chapter 7, Technical Support Topic 8.

**Mowing**

Mowing is defined by mechanical grass cutting on a predetermined regime to achieve a particular strategy. Three characteristics of a mowing regime that can be manipulated to affect the species composition of a particular site over time are: (a) the frequency of mowing, (b) the date(s) of mowing, and (c) the height of mowing.

**Frequency of Mowing**

Mowing frequency is a relevant characteristic to consider because, as noted earlier, the erosion-controlling capability of grasses overall is based on the rainfall-interception capacity of the leaves combined with the soil-holding potential of the dense root system. Mowing has a direct effect on the amount of leaf surface area above ground and an indirect effect on the root development. In the USDA Agriculture Handbook No. 389, 100 Native Forage Grasses in 11 Southern States, authors Horace L. Leithead, Lewis L. Yarlett and Thomas Shiflet discuss the relationship of top removal to root development. They note that 50% of the leaf surface of grasses may be removed by grazing or mowing with no appreciable effect on root growth. If 70% of the leaf surface is removed, 50% of the roots stop growing for 17 days. If 90% of the top growth is removed, for example by mowing to a height of two inches, all root growth stops for a period of 17 days. Repeated removal of leaf surface has a cumulative effect of decreasing plant vigor and ultimately senescence (death) of the plant. Root development of most grass species is fibrous and dense and is, therefore, to be encouraged. Not only is this root network useful in holding soil in place, but the fine roots ultimately improve soil texture. If grass roots die, their decomposition improves the soil nutrient level, although the plants themselves, in most cases, would require replacement.

**Dates of Mowing**

Mowing dates have a pronounced effect on the growth of different grasses. Neither cool-season nor warm-season grasses are damaged by an early spring mowing, assuming the cut is higher than the bunch grasses’ growing tips.
Figure 4.2. Mowing too closely or at the wrong time of the year can lead to poor coverage as in this example from Colonial National Historic Park in Virginia. This can be especially problematic on slopes which are prone to drier conditions and vulnerable to erosion.

(approximately 4"-6"). Mowing at that time lays down an organic mulch in the form of grass clippings, which helps in erosion control. Such a mowing might be timed for February-March in the regions of this study (February in South Carolina, Tennessee, and Georgia, and March in Virginia, during most years). If there are desirable cool-season grasses at a site, the next logical mowing date is after those species have flowered and set seed (June, in most places). If, on the other hand, there are undesirable cool-season species present, they may be cut in April or May as a means of suppressing them. Sites that are covered predominantly by warm-season grasses should not be cut after early to mid-July, in order to permit full development of their leaves, flowering stalks, and the maturing of their seed (typically in October). If, for aesthetic or interpretive purposes, it is deemed that mowing of warm-season grasses must be performed after July 15, there should be an effort made to introduce sod-forming increaser species into such sites. For the health and longevity of the warm-season grasses in general, mowing height should be kept at five to six inches at a minimum.
**Height of Mowing**

Much of the effect of mowing height is covered by frequency of mowing: if the leaves of the plant are kept short, photosynthesis will not feed the roots. However, there is a differential response to mowing between bunch grasses and rhizomatous sod-forming species. Short mowing is more damaging to clump-forming grasses because mowing tends to gouge the higher centers of the clumps, which kills the growing tips. Weaver, in extensive prairie studies, noted that there is a tendency for bunch grasses to be decreasers under short mowing regimes, whereas rhizomatous sod-formers tend to be increasers under the same treatment (See Chapter 7, Technical Support Topic 7).

Mowing can also be an effective tool for the suppression of woody species in a grassland. Trees such as pine species; sweetgum, tulip poplar, and black cherry will be eliminated through once-a-year mowing. Mat-forming shrubs such as Japanese honeysuckle and blackberry, once established, are not as readily eliminated by mowing because of their ability to root along stems (or canes) that lie near the ground. Multiple cuttings during one year, however, have proven effective in preventing the spread of Japanese honeysuckle. An Ohio study cut honeysuckle on or about July 15 and September 15 and by doing so, prevented its spread (reported on by James E. Evans in Compendium on Exotic Species, published by the Natural Areas Association, 1992).

**Prescribed Burning**

Prescribed burning is a landscape management tool gaining in popularity, which uses fire to achieve predetermined objectives. Fire, as a natural phenomenon has been an integral part of many native plant communities including the Midwestern prairie and the Southeastern Longleaf Pine/Wiregrass ecosystems. Early use of fire has a cultural tool includes use by Native Americans fire in pre-European settlement landscapes for agricultural, transportation, warfare and hunting purposes. Euro-American settlers often used fire to clear agricultural land, but as land-use patterns became increasingly more complex, naturally-occurring fires, which had once burned over large areas of land, were actively suppressed. In this country, the long-held view of fire only as a destructive force has in recent years been revised by ecological research. It has been proved that, not only is fire an essential natural phenomenon to sustain certain plant communities, but fire has beneficial effects, especially in natural area management.

Earthworks covered by a mix of predominantly warm-season grasses could be effectively managed with prescribed burns. The burning process is beneficial to fire-tolerant plants in several ways. It returns nutrients to the soil in a usable form; it stimulates growth and seed production of many native
warm-season grasses; and properly timed, it can suppress undesirable cool- 
season plant species, most notably, a number of woody species. If 
accomplished in early- to mid-spring, a prescribed burn facilitates an earlier 
 warming-up of the soil than occurs on unburned areas because a higher rate 
of sunlight is absorbed on the exposed, charred earth. An additional benefit 
to burning is that an open condition can be accomplished without the impact 
of mowing machinery on the earthworks.

Prescribed burns could be conducted on many earthworks in open, non-
canopied environments with a minimum of complication. A park’s fire 
management plan can be modified to describe prescribed burns for natural 
and cultural sites. A prescribed burning plan locates firebreaks of ten feet or 
more in width, which at the time of the burn, are mowed to a height of two 
inches and wet down. Prescribed burning uses wind direction and slope to 
control the speed and heat of the burn. For example, burning against the 
wind and/or downslope will produce a slower-burning fire, which is a 
desirable attribute if a goal is to suppress Japanese honeysuckle or other 
woody species.

To date, park managers have made limited use of prescribed fire to manage 
earthworks vegetation. The one example in this study where prescribed fire 
is being used is at Fort Harrison, Richmond National Battlefield. As part of 
their approved fire management plan, burns were conducted at Fort Harrison 
in April of 1995 and April of 1996. Other park managers have noted that 
prescribed burns may not be a practical solution because of the NPS’s self-
imposed personnel requirements and restrictions as well as the restrictions 
that result from the urban/suburban environment that now surround most 
battlefield sites. In view of the fact that prescribed burns on many non-
canopied, grass-covered earthworks sites could be controlled and managed 
with relative ease, it would seem appropriate for those parks to pursue fire 
management plans that address their management needs. Further, there is 
evidence that cooperating agencies such as the Virginia Fish and Game 
Department (for Virginia sites), local fire departments, and Nature 
Conservancy chapters would assist in fire management.

One disadvantage of burning the steep slopes of earthworks must be 
acknowledged: the removal of leaf litter, which potentially results in bare 
soil and the possibility of erosion in the first growing season after a burn. 
Vegetation sampling in the burned areas of Fort Harrison in August of 1995 
found an average of 30% bare soil from the prescribed burn conducted in 
April of that year. To offset this negative effect, a thin mulching with oat or 
wheat straw, or native grass hay, could have been applied to the steep slopes 
after a burn. Because the application of mulch will offset the benefit of early 
soil warming, the potential for soil erosion should be weighed against 
improved seed germination.
**Herbicide treatment**

The NPS’s Integrated Pest Management (IPM) program, as well as its policy of promoting sustainable landscape practices, suggests minimum application of herbicides for removal or suppression of invasive plant species. In some cases, however, when invasive species gain a foothold and are suppressing the development of a diverse native cover, herbicide application may be the only practical method of eradication. The selective and limited use of glyphosate herbicides is considered acceptable for eradication of plant species that cannot be controlled through a mowing or burning program. Blanket applications (i.e., spraying) of such substances should only be done when there is a solid stand of an undesirable species. More often, herbicides should be selectively applied with spot treatments, spraying specific small problem areas, or applying herbicide to individual plants with a wick applicator. A number of woody species, such as privet (*Ligustrum* sp.), autumn olive (*Elaeaganus umbellata*), and some honeysuckles have been effectively eliminated. An 80%-90% success rate results when herbicide is applied the growing season through the process of cutting, and then applying a solution of 10%-20% glyphosate in water onto freshly-cut stumps with a sponge-type paint applicator (See Chapter 7, Technical Support Topic 6 for more information on invasive species control).
A PROCESS FOR EARTHWORKS MANAGEMENT

INTRODUCTION

Successful earthworks management depends on an approach that balances careful resource management with maintenance and interpretation goals. Within the current environment of uncertain funding levels for earthworks landscape management, it is more critical than ever that each manager develop comprehensive earthworks planning, which establish clear priorities. While management must be tailored to meet the unique needs of each park or organization, there are several basic components that should be present in any approach. In this section, a process for earthworks management that includes these basic components is proposed. The following seven steps are recommended:

1. Define the management area
2. Identify the resource
3. Establish management objectives
4. Describe management strategies
5. Develop implementation and maintenance plans
6. Develop good records
7. Monitor and evaluate earthworks management

1. DEFINING THE MANAGEMENT AREA

Identifying the boundaries of the area of earthworks that will be managed is an important early step in the planning process. A management area is a zone that includes the earthworks or system of earthworks that will be managed. Defining a management area(s) for earthworks helps organize and focus management efforts. How an area is identified depends on the complexity and size of the resource and ultimately the management approach. The boundary of the management area may be selected because it is the historic boundary of a battlefield or because it defines a unified concentration of related earthworks structures, such as an individual fort within a system of forts.
Within an earthworks management area, there may be several sub-areas based on management objectives and associated strategies. A management sub-area is a discrete part of a larger management area. These may include areas that require different levels of maintenance or have a different interpretive approach. The management area(s) and sub-areas should be clearly identified on a basemap. Boundaries may be modified as the process of management planning progresses and more information is collected. It is important, however, to establish the general area that is likely to be managed to focus early research and inventory efforts.

2. **IDENTIFYING THE RESOURCE**

Successful earthworks management depends upon a clear understanding of what the resource is, including its location, extent, type, and condition. This is accomplished through a combination of historical research, field inventory, and mapping.

*Historical Research*

Historical research helps a manager understand the significance of the earthworks and the role they played in a particular military event. Research should establish the types of earthworks and particular structural features that may have been built in the area. Views and vistas critical to the military strategy along with the general character of the area also may be identified during the research phase. Historical research is best completed by a qualified historian who is familiar with the resource and the material available. Typical resources to consult when completing a history of the an earthworks management area include battle histories, first hand military accounts, troop movement maps, soldiers’ diaries, and historic photographs. This information may guide ultimate treatment decisions for the earthworks.

*Field Inventory*

Field inventory is essential to understand the location and extent of the resource, identify various earthworks types and their parts, and assess current condition. Include general contextual information as well as specific information. Collecting general field information helps establish the broad picture of what kinds of earthworks exist in a management area and in what general condition they may be found. Collecting specific information about individual point and line features gives a clearer picture of the condition of the resource and the level of effort needed for its maintenance. The following information should be collected to provide a complete picture of the resource:

1. quantity and location of line and point features,
2. type of each point and line feature,
3. type of construction for each point and line feature,
4. condition of each point and line feature,
5. the ground cover (vegetation and/or litter),
6. the current type and level of management for the general area as well as each point and line feature.

Specialists in natural resources, archeology, and historical landscape architecture may be needed to assist with this phase. (Technical Support Topic #3 - GPS Mapping Methodology for Earthworks contains a detailed dictionary of data that should be collected during the inventory phase -See Technical Support Topic #2 - Field Forms for ways of organizing this information). All field data should be keyed to a map drawn to an accurate scale. This map can be developed by hand or computer from current existing conditions maps or it can be generated using more sophisticated mapping technologies.

Figure 5.1. A sample of the field forms for documenting features found in Chapter 7: Technical Support Topics.

<table>
<thead>
<tr>
<th>RESOURCE IDENTIFICATION: POINT FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Site: _________________________</td>
</tr>
<tr>
<td>Recorder: ____________________________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Point Feature</th>
<th>Feature#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature Name</td>
<td>Feature#</td>
</tr>
<tr>
<td>Feature Type</td>
<td>Break in Parapet</td>
</tr>
<tr>
<td>gun platform</td>
<td>engineered outlet</td>
</tr>
<tr>
<td>embrasure</td>
<td>stream/ gully</td>
</tr>
<tr>
<td>hole/ dugout</td>
<td>intrusion</td>
</tr>
<tr>
<td>hump/ traverse</td>
<td>erosion</td>
</tr>
<tr>
<td>other</td>
<td></td>
</tr>
</tbody>
</table>

Measurements
- height
- width
- area

Area Ground Cover
- evergreen forest
- mixed forest
- deciduous forest
- meadow/pasture/grassland
- marsh/ wetland
- scrub/ regrowth
- maintained cover
- other

<table>
<thead>
<tr>
<th>Current Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
</tr>
<tr>
<td>high</td>
</tr>
<tr>
<td>high</td>
</tr>
<tr>
<td>high</td>
</tr>
<tr>
<td>high</td>
</tr>
<tr>
<td>high</td>
</tr>
<tr>
<td>high</td>
</tr>
</tbody>
</table>

Major Impacts
- visitor use (erosion, trails)
- animal burrowing
- erosion (natural, exposed)
- mechanical damage

Guide to Sustainable Earthworks Management - 90% Draft
Mapping

Mapping is important tool in earthworks management. A clear, scaled, existing conditions basemap graphically portrays the earthworks system and locates it within a regional and local context. This map should be developed early in the research and inventory phase. Roads, natural systems, topography, current vegetation cover, urban and suburban development are all important related features that help put earthworks into context. All data collected on earthworks is keyed to this map with an identifying number (current or proposed) or name (see field forms and maps for examples). There are three basic techniques for mapping earthworks; each technique has different advantages. The choice of mapping technique should be based on the extent of the earthworks system, management objectives, available resources, and cost. The critical characteristic of all maps is that they accurately show the location and extent of the resource in relation to other natural and manmade features.

Mapping Techniques

1. GPS Mapping
2. Hand-drawn or computer-aided map
3. Professionally surveyed map

GPS/GIS (Geographic Positioning System/ Geographic Information System) mapping provides an ideal framework for plotting the inventory data. Critical information regarding earthworks can be gathered in the field using a GPS unit; this information is then downloaded into a GIS computer program and made into a basemap with attached data information. The advantage of GPS/GIS technology is that it can collect data relatively quickly and easily for earthworks within a particular area. In fact, this technology has been determined to be the most cost effective, efficient means of collecting data on large systems of earthworks. (See Technical Support Topic #3 - GPS Mapping Methodology)

In the absence of such technology, computer-aided or hand-drawn diagram maps can be developed to create an adequate working basemap. Both GPS generated maps and hand drawn diagrams are most useful as a planning tool for earthworks management.

A professionally surveyed map uses a transit or total station technology to accurately locate landscape features and collect topographic information. Professionally surveyed maps are required for any earthworks management plan that includes extensive intervention, such as large scale clearing or construction of a path system. Maps generated from GPS data and hand drawn/computer generated maps are extremely useful for planning, but they
may not have the accuracy necessary for construction projects.

3. ESTABLISHING MANAGEMENT OBJECTIVES

Management objectives state the desired results and provide the basic framework for establishing a management strategy described in Part 4 below. Once historical research has been completed and inventory data is portrayed on maps, objectives for earthworks management may be established. This is
best done by a team that includes historians, interpretive staff, historical landscape architects, natural resource specialists, and maintenance personnel. Objectives for management should reflect the three over-arching principles of earthworks management explained in Chapter Two:

1. The management approach should protect and preserve the resource
2. The management approach should be sustainable
3. The management approach should consider earthworks' legibility and aesthetic qualities with interpretation goals.

Within a management area, there may be several objectives - some that relate to the whole resource and some that relate to individual sub-areas. For example, the objective to preserve and protect earthworks by nurturing a healthy, vegetative cover may apply to an entire management area. The objective to interpret earthworks to the public through programs and waysides may apply to discrete sub-areas only.

4. DEVELOPING MANAGEMENT STRATEGIES

Once objectives are established, an earthworks landscape management strategy may be developed for the area and sub-areas. The strategy describes the physical treatment the management area will receive to achieve the stated objectives. Strategies may range from very low impact approaches, such as maintaining an established forest cover intact to high intervention approaches such as clearing forest cover to establish an open condition with a circulation system of wooden boardwalks. The following provides an example of a simple management strategy for a system of breastworks and six forts currently under forest cover.

**Objectives:**

- To preserve and protect system of earthworks through low maintenance vegetation management.
- To provide public access and interpretation to the two principal forts within the system.

**Management Strategy:**

- Manage breastworks and non-interpreted forts in forest cover while removing all large canopy trees growing directly on the structures.
- Manage open condition at identified forts by removing forest cover using low impact tree removal techniques. Plant sustainable grass cover to prevent erosion and enhance visibility and legibility of fort structures.
- Develop perimeter pedestrian trail system with wooden viewing platforms at forts.
Rehabilitate historic vista to the west by thinning forest from Fort A to the adjacent agricultural fields.

Management strategies must balance resource preservation with interpretation needs and they must be developed with a clear understanding of the long-term maintenance implications. All management strategies should be described in writing and identified graphically on a basemap. For additional examples of management strategies, see Chapter 6.

5. DEVELOPING IMPLEMENTATION AND MAINTENANCE PLANS

An implementation plan provides clear directions for executing the management strategies. The implementation plan identifies the process, techniques, designs, details, and the work items that are needed to accomplish the strategy described for each management area and sub-area. This plan should also include a schedule and a budget, personnel to do the work, provisions for complying with NEPA and/or Section 106 as appropriate, and a list of items needed to get the project(s) underway (e.g., plans, specifications, details.)

A maintenance plan is developed to provide direction for ongoing preservation maintenance activities of an earthworks management area. A typical plan may include regular inspections, identification of work needed, methods for recording the results of regular earthworks inspections, and a seasonal calendar of earthworks preservation activities. This information should be compiled into a sortable database. The Guide to Developing a Preservation Maintenance Plan for a Historic Landscape by the Olmsted Center for Landscape Preservation is a good model to consider when developing such a plan for earthworks management.

6. DEVELOPING GOOD MAINTENANCE AND MANAGEMENT RECORDS

Keeping good maintenance and management records is critical to the process. This includes recording all information from earthworks inspections and collecting information about maintenance activities, labor, materials, equipment and costs. This information may be collected on simple field forms then entered into a maintenance database. The frequency of field inspections and maintenance activities should be identified in the maintenance plan. For earthworks under forest cover, activities and/or inspections may only occur once every two or three years. Earthworks and associated areas managed in open conditions will require more frequent activity.

7. MONITORING AND EVALUATING EARTHWORKS MANAGEMENT

Monitoring and evaluating the effectiveness of any management plan is a critical step to ensure successful earthworks preservation. The evaluation of the management plan should be based upon its success in meeting all stated objectives and in meeting other management requirements such as budget, labor, materials and equipment. If there is a significant difference, for example, in the cost of actually implementing the strategy versus what was budgeted,
there may be a need to modify your plan either by increasing funding, changing techniques, or reexamining the boundaries of a particular management area. Similarly, if maintaining your earthworks using a core team of student volunteers is not working well, then a new way of obtaining appropriate staff must be considered. A process that works for one manager may not work for another. The efficiency and cost effectiveness of a process largely depends on the resources and capabilities of an individual organization.

![Figure 5.3. A sample of the field forms for documenting maintenance data found in Chapter 7: Technical Support Topics.](image)

**SUMMARY**

Successful earthworks preservation depends on an integrated management approach that balances resource preservation with maintenance and interpretation goals. While a management plan must be tailored to meet the unique needs of each park or organization, there are several components that form the basis of the management process: a thorough identification and understanding of the resource, clear management objectives, a clear management strategy, an approach to implementing and maintaining treatments developed from the strategy, keeping good records, and a willingness to modify unsuccessful management strategies.

---

*Guide to Sustainable Earthworks Management - 90% Draft*
INTRODUCTION

In this chapter, several specific management strategies (Step 4 in the planning process) are laid out as illustrations of how field managers may apply information in this Guide to specific sites, or management units. Each of the sites included in this chapter might be considered a management area which would have been identified in the first step of the earthworks management planning process.

The specific “Management Program” listed with each strategy is a suggested sequence of management actions, often with recommended calendar dates for accomplishing them. The intensity of work involved, and the resources needed will influence the date for initiating the management program. In cases where the management program requires fewer resources than are presently required, of course, it might be possible to initiate the proposed management program almost immediately, with a reduction in expense.

The management programs outlined in these scenarios are acknowledged to be experimental to some degree. Hence, the degree to which any of these illustrative management scenarios is implemented may vary with different parks and at different sites or management units. Basically, three levels of adoption might occur: (1) adoption on the entire management unit with appropriate annual monitoring to determine the level of success, (2) adoption on part of the unit, to be compared with another part of the site where the existing management program is continued as a “control” for comparison, and (3) adoption of the technique(s) in test plots only, e.g. ten feet by ten feet, placed at representative locations within the management unit.

Yet another type of experiment would be to adopt the recommended management program on test plots at other locations within the subject park where conditions may be similar, but which may not be so visible.

Regardless of the degree to which one of the illustrative management scenarios is adopted, the various treatment could be interpreted to the public as research plots designed to provide additional management information.

In the scenario for Petersburg’s Battery Five, (P-B5) two alternative sets of management objectives are identified. One is to actively increase the native herbaceous cover by supressing invasive exotics through a combination of
chemical and mechanical means. The other is to use an area of the site as a management experiment, to determine whether current management practices will produce similar results over time. With these objectives, the establishment of permanent meter-square quadrats to monitor change in cover and species composition annually is an important component of the management program. In view of the relative lack of past experience in applying several of the recommended vegetation establishment and management practices specifically to earthworks, comparative experiments are encouraged.

Among the various strategies included in this Chapter, several different types of conditions are treated. With these as starting points, and drawing on the list of recommended species for earthworks vegetation establishment, land managers dealing with similar sites may adopt these illustrative scenarios. It is strongly recommended, however, in developing such strategies, (1) that plant species not generally be planted outside their natural range; and (2) that the practices be tested in small plots, in order to evaluate their effectiveness before broad application.
MANAGEMENT STRATEGY ONE: MAINTAINING EARTHWORKS UNDER FULL FOREST COVER

Park: Colonial National Historical Park, Virginia

Site: A remote wooded area of the Yorktown Unit that is seldom visited and has limited interpretive value.

Figure 6.1. Protected earthworks at the Yorktown Unit of Colonial National Historical Park. Eighty-eight year old Loblolly Pine trees dominate the site at this remote location.

Current Management: At present, this area does not receive active maintenance.

Description: The earthworks at this site are in good condition. The forest floor is intact with a two-inch-thick organic layer. The overstory is fully stocked with the canopy primarily composed of a stand of loblolly pine eighty-eight years old.

Site conditions data is as follows:

<table>
<thead>
<tr>
<th>Basal area/ac:</th>
<th>142 sf</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Trees/ac:</td>
<td>140</td>
</tr>
<tr>
<td>No. Understory Stems/ac:</td>
<td>40</td>
</tr>
<tr>
<td>% Ground Cover:</td>
<td>2</td>
</tr>
<tr>
<td>% Forest Floor Cover:</td>
<td>98</td>
</tr>
<tr>
<td>% Bare Soil:</td>
<td>2</td>
</tr>
<tr>
<td>Forest Floor Depth:</td>
<td>2 in</td>
</tr>
</tbody>
</table>
**Management Objectives**

1. To maintain the fully protected condition of the earthworks in this area, including a full canopy and an intact forest floor.

2. To create a condition over time where there are not large trees rooted on the earthworks, yet where trees rooted off the earthworks provide the overstory cover and litter to maintain the forest floor intact.

**Management Program**

1. Active management is not necessary for these earthworks, but conditions still need to be monitored.

2. This earthwork and all others like it in the park should be inventoried and mapped, and checked every other year for hazardous conditions.

3. Trees on the earthworks that are already leaning or have low forks or splits constitute an immediate hazard and should be removed.

4. Other trees over 12 inches dbh on the earthworks can be occasionally cut as the budget allows.

**Notes:** Girdling is not an option in this stand since 58% of the overstory basal area is occupied by loblolly pine.
MANAGEMENT STRATEGY TWO: CREATING VIEWING OPPORTUNITIES THROUGH SELECTIVE FOREST THINNING

Park: Kennesaw Mountain National Battlefield Park, Georgia

Site: Area of earthworks located adjacent to a trail on Little Kennesaw Mountain at the Kennesaw National Battlefield Park.

Figure 6.2. Earthworks on Little Kennesaw Mountain at the Kennesaw National Battlefield Park. Heavy shrub layer precludes viewing, but the earthwork is in a highly protected state.

Current Management: At present, this area does not receive active maintenance.

Description: The site is currently in a protected condition under an 80 year old oak/hickory forest with a dense shrub understory that precludes viewing.

Site conditions data is as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal Area/ac</td>
<td>93 sf</td>
</tr>
<tr>
<td>No. of Trees/ac</td>
<td>90</td>
</tr>
<tr>
<td>No. Understory stems/ac</td>
<td>850</td>
</tr>
<tr>
<td>% Ground Cover</td>
<td>79</td>
</tr>
<tr>
<td>% Forest Floor Cover</td>
<td>100</td>
</tr>
<tr>
<td>% Bare Soil</td>
<td>0</td>
</tr>
<tr>
<td>Forest Floor Depth</td>
<td>1.5 in</td>
</tr>
</tbody>
</table>
**Management Objectives**

1. To open up a 100 yard long stretch of the earthworks for viewing, by removing the understory layer, essentially creating an intermediately-managed condition.

2. To maintain the protected condition of the earthworks in this area, maintaining an intact forest floor while reducing the basal area per acre of the understory by up to 33 square feet.

**Management Program**

1. As with all earthworks, these should be inventoried and mapped, so that the location and condition is monitored.

2. A section of earthworks that is near the trail and in good viewing condition for a 100 yard length should be identified, and the understory removed along the earthwork and in the viewing area between the trail and earthwork.

3. To reduce future brush cutting needs, as many of the larger understory stumps as possible could be painted with a herbicide approved for cut stump treatment (CST). All of the brush should be preferably chipped and left on the site, or removed.

4. The thinning should first remove all trees hazardous to visitors, then hazard trees on the earthworks. Additional trees that interrupt the view could also be removed, while maintaining the desired residual basal area.

5. The trunks and large branches of cut trees should be removed from the site, and the small branches chipped.

**Notes:** To reduce sprouting the stumps could be treated with an approved CST herbicide. If herbicide use is not desirable, cutting should be done from May through July. During these months tree root reserves are lowest and subsequent sprouting is reduced, though not eliminated. Maximum sprouting occurs when cutting is done during the dormant season.
Management Strategy Three: Enhancing Earthworks Legibility Through Selective Forest Thinning

Park: Petersburg National Battlefield Park, Virginia

Site: Fort Conahey. Point feature, extensive berms up to 3-4 meters high enclosing Fort. Partially wooded on both berms and floor of fort. Moderately interpreted.

Current Management: Selective clearing has been done, creating an open woodland.

Description: Dry-mesic open forest, with partial canopy cover including White Oak, Southern Red Oak, and Sweetgum. Loblolly Pines in canopy immediately surrounding. The middlestory is predominantly 6'-8' tall species and Loblolly Pines also, Flowering Dogwood, Sassafras, Amelanchier and Hickory species. Groundlayer is comprised of abundant Lowbush Blueberries and substantial leaf litter, with some Greenbrier, Muscadine Grape, and Spotted Wintergreen. Almost no exotic species are present.
**Management Objectives**

1. To make earthwork more legible.
2. To retain some vegetation for visual screening and protection from adjacent newly-cleared commercial area.
3. To retain and enhance existing native shrub and vine cover less than 2' tall.
4. To eliminate major trees from slopes of the Fort in the long run in order to eliminate potential tip-ups.

**Management Program**

1. Remove canopy trees actually growing on berms. Leave mature canopy trees inside and outside Fort.
2. Remove all sapling-size trees from berm.
3. Remove 90% of the saplings inside the Fort, over a three-year period, with 30% being removed each year. The remaining 10% should be Oak and Hickory species, to provide canopy replacement over time.
4. Annually, cut shrubs and seedling trees to 18"-24".
5. If Japanese Honeysuckle invades, it should be pulled at the earliest practicable date. Alternatively, cut the honeysuckle, and paint stumps with a 20% glyphosate solution, preferably in September.

**Notes:** The expected outcome of these practices is a gradually-increasing light level inside the Fort, increasing the density and vigor of the blueberry shrubs, and stimulating growth of the groundcovering grape and greenbrier vines. The thinning of saplings on an incremental basis is proposed, so that a drastic change in light level does not occur at one time, which could lead to invasion by unwanted species, rather than a gradual increase of the desirable species already present.

The management strategy described above would generally be applicable to Fort Fisher, with the following variations:

Retain existing pine canopy between roadway and the Fort. Remove pines inside Fort and on earthwork (they presently constitute only about 10% of the canopy).

Carry out the sapling thinning, and annual 18"-24" cutting of groundlayer shrubs and seedlings, as in the Fort Conahay management strategy.
MANAGEMENT STRATEGY FOUR: MAINTAINING AN OPEN UNDERSTORY TO ALLOW VIEWING OF EARTHWORKS

_Park:_ Kennasaw Mountain National Battlefield Park, Georgia

_Site:_ Area of low earthwork structures at Cheatham Hill. The site is currently under forest cover, and receives moderate visitation from a nearby trail.

*Figure 6.4.* Intermediately managed earthworks at Cheatham Hill at Kennesaw National Battlefield Park, Georgia.

_Current Management:_ The area receives annual weed whacking, above the level of the low groundcover vegetation.

_Description:_ The site is covered by a canopy composed primarily of oak and hickory trees with an open understory. The stand is approximately 95 years old. The groundcover includes periwinkle, Japanese honeysuckle, Virginia creeper, and muscadine grape.
Site conditions data is as follows:

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal Area/acre</td>
<td>94</td>
</tr>
<tr>
<td>No. of trees/acre</td>
<td>80</td>
</tr>
<tr>
<td>No. Understory Stems/acre</td>
<td>0</td>
</tr>
<tr>
<td>0/Ground Cover</td>
<td>73</td>
</tr>
<tr>
<td>% Forest Floor Cover</td>
<td>100</td>
</tr>
<tr>
<td>% Bare Soil</td>
<td>0</td>
</tr>
<tr>
<td>Forest Floor Depth</td>
<td>3 in</td>
</tr>
</tbody>
</table>

Management Objectives

1. To retain the area as it is, with open conditions in the understory.
2. To retain canopy trees unless they pose a threat to visitors or earthworks.
3. To retain the forest floor and groundcover layers intact.

Management Program

1. The site should be monitored annually for hazardous trees, and such trees should be removed when necessary.
2. Understory cutting, using brush cutters or weed whackers should be conducted annually or biennially.
3. Understory cutting should not damage the forest floor or groundcover species.

Notes: This area is already in the management category for which it is suited. Since the area is carrying 94 square feet of basal area per acre, additional removal of overstory trees which pose a threat to visitors or resources would pose no problems. The same protocol for tree removal described earlier would suffice at this site. The current absence of a shrub understory is a result of annual or biennial cutting. Ground cover is prolific on this site. As long as the forest floor is intact, the ground cover plays no significant hydrologic role. However, it does dissuade visitors from walking on the earthworks. This is desirable on sites such as this that have direct trail access.
MANAGEMENT STRATEGY FIVE: ESTABLISHING NATIVE HERBACEOUS COVER IN A SEMI-SHADED ENVIRONMENT

Park: Kennesaw Mountain National Battlefield Park, Georgia

Site: Small circular earthwork at “Camouflaged Cannons” Interpretive Station, Cheatham Hill. Berms 1.5 meters high surrounding flat interior, 20 meters across. Partly shaded by adjacent forest.

![Herbaceous vegetation and leaf litter covering small earthwork along Cheatham Hill Trail at Kennesaw Mountain National Battlefield Park, Georgia.](image)

Current Management: Interior “floor” is kept in a short-mown turf condition; earthwork berms are mowed infrequently, probably annually, to 2”-4” height.

Description: While the earthwork itself was cleared of trees within the past six to eight years (estimate by Dennis Kelley, formerly on staff), the site and site vegetation are influenced by the presence of shade from oak-dogwood forests immediately surrounding two sides of the earthwork, and tall pines 50’ away. Vegetation on the earthwork is dominated by Tall Fescue, but there is a high occurrence of Poison Ivy (50% frequency); Blackberry (40%); Japanese Honeysuckle (40%); Virginia Creeper (40%); and Pine seedlings (50%).
These frequencies were based on ten representative one-square-meter quadrats in which vegetation was recorded. Other measures obtained in this sampling procedure were:

- Average number of species per plot: 6.8
- Average % herbaceous cover: 49.2%
- Average % woody plant cover: 11.5%
- Average % litter (leaves, clippings): 35.8%
- Average % bare soil: 3.5%

**Management Objectives**

1. To establish >80% vegetative cover by native species that are tolerant of the semi-shaded environment.

2. To diminish or eradicate exotic species, especially the Tall Fescue and Japanese Honeysuckle.

**Management Program**

1. Eradicate Tall Fescue and Honeysuckle with early spring application of glyphosate herbicide (e.g., in March-April).

2. Also in April, mow vegetation that has been treated with herbicide to 1"; rake surface, and seed with a mix to include:

   - *Carex pensylvanica* (Pennsylvania Sedge)
   - *Chamaecrista fasciculata* (Partridge Pea)
   - *Elymus virginicus* (Virginia Wildrye)
   - *Parthenocissus quinquefolia* (Virginia Creeper)
   - *Potentilla canadensis* (Five-finger Cinquefoil)
   - *Tridens flavus* (Purple Top)

   Plant Bracken Fern (*Pteridium aquilinum*) roots on 5' spacing over the earthwork.

3. Mow to a height of 6" each year in April-May. If Japanese Honeysuckle recurs, it should be treated locally with glyphosate application before mowing.

**Note:** This management strategy is experimental in nature, in that it is designed for an uncanopied but semi-shaded environment. There are grasses included, but these are species that are tolerant of more shade than the *Andropogons*. The other species proposed here are semi-shade tolerant to varying degrees.
MANAGEMENT STRATEGY SIX: DEVELOPING MIXED NATIVE GRASSES ON A SITE WITH INVADING WOODY SPECIES

Park: Richmond National Battlefield Park, Virginia

Site: Fort Harrison, Traverse #1

![Figure 6.6. Woody species invading a planting of little bluestem on Traverse #1 of Fort Harrison, Richmond National Battlefield Park, Virginia.](image)

**Current Management:** Major linear earthwork, 3-4 meters high, 10 meters wide. Full sun exposure. Surrounding area mown as turf. Heavily visited and interpreted.

This site utilized the recommendations of the 1989 Manual, with an initial planting of *Schizachyrium scoparium* (Little Bluestem) plugs in the Spring of 1990. For the next three years, woody invasive species on the earthwork were pulled or cut on an annual basis. This was followed, however, by a hands-off policy until the Spring of 1995, when a prescribed burn was conducted on approximately one-half this earthwork on April 20, with the other half left unburned for comparison. Several changes in park staff occurred between 1991 and 1995, and some lack of management continuity occurred.

**Description:** During the four years that elapsed between the 1992 and the August 1995 assessment, woody species gained prominence visually and ecologically on this earthwork. These include native species (Sweetgum, Post Oak, Shiny Sumac, Blackberry and Loblolly Pine) and the exotic, Japanese Honeysuckle. Both the burned and unburned portions of the earthwork
have an uneven, chaotic appearance. This is due in large part to the presence of woody species. The average amount of aerial cover provided by herbaceous plants (mainly Little Bluestem) in ten one-square-meter plots was approximately 20% in both the burned and unburned plots. Woody plant cover was substantial in both burned and unburned plots; in the burned plots, however, it was generally under 3' tall; in the unburned, it ranged up to 10-15' tall. There was almost no litter in burned plots, and up to 30% bare soil. (Note: the percentage of bare soil should diminish as successive burns eradicate woody plants and stimulate grass cover). Unburned plots had a general litter cover on the ground, and less than 2% bare soil. Average species diversity on burned plots was 5.7 per square meter; it was 4.2 on unburned plots. Japanese Honeysuckle occurred in 60% of burned plots; 90% of unburned.

Visually, the burned plots were less chaotic than the unburned, since the woody plants generally had been set back and were approximately the same height as the grasses present. Still the color and texture of woody plants contrast sharply with those of the grasses.

**Management Objectives**

1. To increase the cover provided by herbaceous plants to greater than 70%, with the majority provided by native grasses.

2. To reduce the presence of woody species to less than 10% cover.

3. To eradicate Japanese Honeysuckle.

**Management Program**

1. Cut woody vegetation (including Japanese Honeysuckle) to the ground in April or September, and paint the stumps with a 20% glyphosate solution. Remove the clipped material.

2. Scarify any open soil with a rake. Seed these areas with a seed mix containing as many of the following species as are obtainable:

   - *Elymus virginicus* (Virginia Wildrye)
   - *Bouteloua curtipendula* (Sideoats Grama)
   - *Andropogon ternarius* (Splitbeard Bluestem)
   - *Andropogon virginicus* (Broomsedge)
   - *Tridens flavus* (Purpletop)
   - *Eragrostis spectabilis* (Purple Lovegrass)
   - *Aristida purpurascens* (Arrowfeather Threeawn)
   - *Chamaecrista fasciculata* (Partridge Pea)

   Seeding rate of all species combined should be approximately 20 lbs/acre; or for estimating purposes, 1/2 lb. per 100 square feet. After seeding into scarified surface, rake again, and compact soil over seed.
As an alternative to the above seeding treatment, mulch site in October with native hay obtained from Fredericksburg (Prospect Hill field, or Widow Tapp’s field) or Petersburg (field adjacent to Battery 5 at Visitor Center). Most of the above species are present in those stands. Areas to be mulched should be scarified before mulching, to provide “niches” for seed.

3. Repeat woody plant suppression method second year if necessary, i.e., cut and paint stumps.

4. Monitor herbaceous vegetation; clip once in early summer at 6”; then permit it to flower and produce seed.

5. Burn in March-April of second growing season, or clip to 6” height.

Notes: Once a 70% + herbaceous cover of mixed grass species is established, and an annual spring burn or 6” mowing is done, woody species should diminish. Honeysuckle might persist, however. An alternate treatment for its eradication could be to spray locally a glyphosate herbicide on it in early spring before native grasses begin growth.

The above treatment would be appropriate for other Traverses in Fort Harrison open field.
MANAGEMENT STRATEGY SEVEN: ESTABLISHING IMMEDIATE, LONG-TERM HERBACEOUS COVER

Park: Stones River National Battlefield, Tennessee

Site: Redoubt Brannan. Major earthwork, with 5-meter high enclosure around flat interior; approximately 2 acres, cleared. Not interpreted to date.

![Image](image_url)

*Figure 6.7. View toward the southwest along the traverse of Redoubt Brannan, Stones River National Battlefield.*

Current Management: After being almost totally covered by invasive species for many years, including a dense stand of Kudzu (*Pueraria lobata*), the entire site was treated with herbicide in the fall of 1995 and cleared of vegetation. In late fall, site was seeded with a combination that included annual rye grasses, Virginia Wildrye, Partridge Pea, and Crimson Clover, to provide cover in 1996. It is expected that an additional herbicide treatment will be necessary in the summer of 1996, to kill any recurrent Kudzu. Groundhog activity has created major impacts in places.

Management Objectives

1. To establish a predominantly herbaceous cover on an essentially barren site with steep slopes and a high erosion potential.
2. To provide immediate cover, as well as a long-term cover.
3. To reduce or eliminate groundhogs’ impact on site.
Management Program

1. In late spring of 1996, spray any re-emerging Kudzu foliage with Garlon 3, or equivalent selective herbicide which kills only broad-leafed plants, leaving annual ryegrass and Virginia Wildrye to provide cover.

2. Either hydroseed the earthwork in late May, and apply a straw mulch, or seed in October, with a mix to include as many of the following species as are available:

   - *Andropogon ternarius* (Splitbeam Bluestem)
   - *Andropogon virginicus* (Broomseed)
   - *Aristida purpurascens* (Arrowfeather Threetawn)
   - *Bouteloua curtipendula* (Sideoats Grama)
   - *Elymus virginicus* (Virginia Wildrye)
   - *Eragrostis spectabilis* (Purple Lovegrass)
   - *Panicum virgatum* (Switchgrass)
   - *Schizachyrium scoparium* (Little Bluestem)
   - *Sorghastrum nutans* (Indiangrass)
   - *Tridens flavus* (Purpletop)
   - *Chamaecrista fasciculata* (Partridge Pea)

   Seed at a rate of 20 lbs/Acre, Pure Live Seed. Mulch with clean oat straw, or if available, baled native hay, harvested from a local Broomseed/Little Bluestem field.

3. Clip once during the first growing season, to a height of 6", if equipment is available.

4. In Fall of 1996 or Spring of 1997, apply a broadleaf-selective herbicide to any recurrent Kudzu or privet plants.

5. In March-April of 1998, conduct a prescribed burn on the Redoubt or clip grasses to 6".

6. Throughout this period, trap and relocate groundhogs and repair earthwork, filling holes with soil mounded up by groundhogs.

Notes: Grass mix could be supplemented with easily-grown forbs (e.g., *Coreopsis lanceolata* and *Rudbeckia hirta*), for some flowering. Their presence, however, will complicate removal of other broadleafed plants with a selective herbicide.
ManagemenL Strategy Eight: Enriching Native Species

Park: Petersburg National Battlefield Park, Virginia

Site: Battery 5, at Visitor Center. Berms 3-4 meters high, circular areas 35 meters across, full sun. Heavily visited and interpreted.

Current Management: Mowing, every three-four weeks during the growing season with Dew-Eze self-levelling mower, to a height of 4"-5".

Description: Variable cover is provided by a mix of native grasses, low-growing forbs, shrubs and vines, early-successional tree seedlings, and litter consisting mainly of clippings. Cover is generally greater on the outside slopes than on the inside slopes. Ten one-square-meter quadrats distributed evenly around the outside of berm, midslope, revealed the following conditions:

- Average number of species per plot: 7.5
- Average % herbaceous cover: 31.5%
- Average % woody plant cover: 17.7%
- Average % litter (leaves and stems): 42.8%
- Average % bare soil: 8.0%

Japanese Honeysuckle occurred in 70% of the plots, Blackberry in 40%, and Trumpet Creeper in 30%, along with several tree species in seedling sizes.
Management Objectives (Alternative #1)

1. To increase living herbaceous cover to >80% aerial cover, predominantly with native grasses.

2. To reduce woody plant cover to less than 10%, with special efforts to suppress Sweetgum, Japanese Honeysuckle, Blackberry and Trumpet Creeper.

3. To permit native grasses to produce flowers and seeds.

Management Program

1. During April or September, cut the "target" woody species (Sweetgum, Japanese Honeysuckle, Blackberry, and Trumpet Creeper), remove the clippings, and paint stumps with a 20% glyphosate solution in water.

2. Following completion of the above treatment, hand-scatter bare areas with a rake, and hand-broadcast them with a seed mix to include as many of the following species as are obtainable:

- *Elymus virginicus* (Virginia Wildrye)
- *Bouteloua curtipendula* (Sideoats Grama)
- *Andropogon ternarius* (Splitbeard Bluestem)
- *Aristida purpurascens* (Arrowfeather Threeawn)
- *Tridens flavus* (Purpletop)
- *Chamaecrista fasciculata* (Partridge Pea)

or in October, mow the adjacent field to a height of 6", and mulch the earthwork with the seed-bearing hay.

3. Reduce mowing frequency on earthwork to one monthly mowing (at maximum cutting height for Dew-Eze mower -5") in April, May, and June, permitting warm-season grasses to flower and produce seed after that date.

4. Repeat the woody plant suppression program (cutting, then herbiciding the stumps) the following September or April until woody cover is reduced to less than 10%.

Notes: More frequent mowing on the “floor” in the interior of the Battery, and in a 2- to 3-ft. wide zone along the sidewalk leading to Battery 5 from the Visitor Center, may be useful to provide a more cared-for appearance, and to make the earthwork more legible.
Management Objectives (Alternative #2)

1. To use this site as an experiment of the ability of native warm-season grasses to invade the berms of the earthwork under current management practices.

2. To monitor the results, i.e. change in cover, on an annual basis, to determine rate of species change under present management program.

Management Program

1. Continue the approximately monthly mowing schedule with Dew-Eze self-levelling mower.

2. Establish 20 permanent 1-meter square quadrats, equally spaced on midslope of berm. Record species composition, and percentages of cover in following categories: woody plants, herbaceous plants, litter, and bare soil. Do monitoring inventory annually in August-September.
MANAGEMENT STRATEGY NINE: CONVERTING EXOTIC TURF TO
NATIVE TALLGRASS COVER

Park: Fredericksburg and Spotsylvania County Battlefields Memorial
National Military Park, Virginia

Site: Prospect Hill, low, linear earthwork, parallel with Lee Drive. Low,
linear earthwork, only 1-1.5 meters high; 100-meters long. Heavily visited
and interpreted.

Figure 6.9. A mix of mown lawn and mixed tall grasses along Prospect Hill,
Fredericksburg-Spotsylvania NMP, Virginia.

Current Management: Bi-weekly mowing to 2"±, maintaining a lawn-like
character

Description: Well-drained to droughty condition, with a diversity of low
herbaceous plants, predominantly native grasses with some rosette-forming
plants (e.g., Antennaria and Plantago spp), and creeping forms (e.g., Potentilla
canadensis). No planting programs have been used.

In sampling ten representative one-meter-square plots along the earthwork,
the following data were obtained:

- Average number of species per plot 9.6
- Average % herbaceous cover 68%
- Average % lichen & moss cover 11%
- Average % litter/clippings 11%
- Average % bare soil or exposed rock 10%
Visually, the frequent mowing has created a well-manicured look, and the earthwork form is quite legible. The frequent mowing has also suppressed any woody species. During the August 1995 drought, however, there was a brown, parched appearance.

**Management Objectives**

1. To perpetuate a diverse cover of herbaceous plants, with little or no presence of woody species.

2. To reduce the energy and labor demanded by the bi-weekly short-mowing.

3. To increase the live, vegetational cover to at least 80% cover during the growing season for enhanced erosion control.

4. To discourage visitor trampling on the earthworks.

**Management Program**

1. Change mowing height to 6".

2. Reduce mowing frequency to once a month, in April, May, June and July. Permit plants to produce flowers and seeds after the July mowing. Do not mow again until seeds have ripened, e.g., November, or wait until February/March for next mowing. Leave shredded clippings on site.

3. Once every two or three years, substitute a controlled burn for the late fall or early-spring mowing.

4. After four or five years, consider eliminating the monthly summer mowings and conducting only an annual mowing or controlled burn in early spring (before April 1), as a management practice.

**Notes:** The hillside between Lee Drive and the railroad presently has a good cover of herbaceous species, but with encroachment by shrubs and trees, but a minimum of exotic species. Periodically, e.g., every two to five years, conduct a spring burn (e.g., March 1-April 1) on this hillside, with a 10'-12'-wide firebreak mowed around the area to be burned, and one or two 15'-20' mowed breaks running parallel with the contours to provide erosion control in the period before new growth begins.
The fire should stimulate flowering and seed production of many species. In October of burn years, the field may be mowed to a 6" height, with the hay baled when it is sufficiently dry. The hay would constitute an excellent native seed-bearing mulch to apply to other sites where an increased cover of native grasses is desirable. Alternatively, seed may be collected by hand, possibly by volunteers or student interns, for use on earthworks sites.

Virginia Fish and Game Department, and local fire departments are potential cooperators in this effort.
MANAGEMENT STRATEGY TEN: ENHANCING LEGIBILITY OF FORTIFICATIONS THROUGH PLANTING AND MOWING

Park: Ninety-six National Historic Site, South Carolina

Site: Star Fort. 2 to 3-meter high berms in the form of a star, with flat interior; approximately 35 meters wide in full sun.

![Image of Star Fort berms after reseeding](image)

Current Management: In spring of 1994, a warm-season grass mix was seeded into the mown turfgrass cover on the berms of the fort, which had been treated with glyphosate herbicide. Berms were left unmown during the summer of 1994. The floor of the interior of the Fort was maintained as mown turf. During 1995, berms were mowed three times to a height of 4"-6" with a sickle bar mower, in June, July, and August. The interior of the Fort continued to be mowed to a 2" height on a frequent basis.

Description: On September 9, 1996, the Star Fort berms had a consistent 6" cover of grasses which contrasted visibly with the turf-grass interior. With the benefit of late summer rains, the cover was a consistent green color.

Twenty one-square-meter quadrats were laid out to provide a representative sample of the berm vegetation, with ten plots placed on the inner slopes and ten on the outer slopes at even spacing around the perimeter. Grass species identification was complicated by the fact that the mowing had eliminated any flowering or seed stalks. Hence, not all grasses were positively identified.
Data from the sampling procedure, with that limitation, yielded the following:

- Average number of species per plot 4.1
- Average % herbaceous cover 82.3%
  (almost all of which was grasses)
- Average % woody plant cover 0.0%
- Average % litter (clippings mainly) 15.6%
- Average % bare soil 2.1%

The grass which occurred at the greatest frequency was the annual, Crabgrass (*Digitaria sanguinalis*), which had a 100% frequency. In contrast, *Andropogon* species occurred in only 35% of the twenty plots. A *Paspalum* grass occurred abundantly (80%). The legume, Partridge Pea (*Chamaecrista fasciculate*), which had been included in the 1994 seeding, appeared in 30% of the plots.

In summary, the cover was excellent; the aesthetic effect was pleasing; the earthwork form was highly legible. Yet, the naturally-invading grasses were more important than the species that had been planted seventeen months earlier. The invasion of Crabgrass is a common phenomenon in the Southeastern Piedmont. Being an annual, it typically performs an important soil stabilization role in the early years of oldfield succession; it typically is followed by warm-season native perennials, and especially Broomsedge (*Andropogon virginicus*).

**Management Objectives**

1. To maintain a herbaceous cover of greater than 80%
2. To increase the percentage of perennial warm-season grasses on the Fort berms.
3. To enhance legibility of Fort through vegetation contrast between the berm and the floor of the Fort.
4. To continue to suppress woody species on the berm.

**Management Program**

1. Mow berms at 6" or greater height in May, June, and July, permitting grasses to flower and produce seed after that date.
2. In March of 1997, burn the vegetation on the Fort. After the burn, scarify any bare areas, and seed with a mix of as many of the following species as are available:
   - *Andropogon ternarius* (Splitbeard Bluestem)
   - *Andropogon virginicus* (Broomsedge)
   - *Aristida purpurascens* (Arrowfeather Threeawn)
   - *Eragrostis spectabilis* (Purple Lovegrass)
   - *Tridens flavus* (Purletpop)
Rake seeds in (at a rate of 1/2 lb. seed per 100 square feet of planting area).

**Alternative:** If burning is not practicable in the Spring of 1997, mow at a 6" height in March; seed bare spots as above.

**Notes:** For the breastworks and adjacent fields, a similar mowing (and/or burning) schedule may be followed. If a good warm-season perennial grass cover is established by 1997, consider reducing mowing to one mowing per year between March and May, with a burn in March replacing the annual mowing every two or three years.
INTRODUCTION

This glossary is intended to provide a basic overview of the terms and parts of a field fortification. The definitions have been simplified to provide the user of this manual an idea of what they should be identifying in the field fortifications they are working on. Also, a short sentence or two have been included to show what might remain today and the significance or rarity of the feature. Terms that are typically used in relation to field fortification and describe features that are likely to be found today have been included. Definitions of several features that probably will not be found extant today have been added due to their widespread use and to provide a general knowledge of the entire entity of a fortification as a historic structure with historic features.

While using this glossary, remember that all terms are not always consistent. The people of the time used the same principles and doctrines for fortification that has been practiced for centuries in Europe. However, not everyone studied these principles in detail, and many added their own ideas to the design. Sometimes the remaining earthwork appears to be right out of Mahan and all the definitions fit perfectly. Other earthworks look like they were not based on any design, just constructed. Many times the soldiers of the time interchange the nomenclature of a structure mis-identifying features and entire structures. This practice has confused many and led to several mis-identifications. Such mis-identification is part of the historical record and should be recorded and maintained; even after correcting the mistake.

TERMS

Abatis - Felled trees, with small branches and leaves removed, placed as a defensive obstacle. Usually placed to the front of the fortification, often in an upright position against the counterscarp, or at the foot of the glacis. The remaining limbs would have been sharpened to produce knife-like edges. The abatis would have been placed so as not to obstruct rifle or artillery fire or line-of-sight. Little or no chance of finding historic examples of abatis in the field.

Advanced Covered Way - An advanced covered way allowed for movement into positions in advance of the main line. The covered way was an earthen terre plein with a back ditch and covered by some form of parapet. Advanced covered ways are not often found today due to their relative
smaller size and location. However, it is possible that some still exist. They appear as small level areas, between a ditch and parapet, well in advance of the main lines. Often the existing ditch and parapet have eroded tremendously due to their relative small size and weaker construct.

**Advanced Ditch** - An excavation beyond the glacis of the main fortification. Often associated with a covered way. The ditch is unique in the fact that the slope closest to the main fortification is cut down in order to prevent the enemy from using it as protection. Potential of finding it today is similar to the advanced covered way.

**Advanced Works** - Fortifications in advance of the main ditch, but still within firing range of the main works.

**Angle** - Point where two faces of a fortification meet.

**Angle of Defense** - The angle formed by one face and its opposite.

**Apex** - The foremost angle of a fortification.

**Approaches** - The trenches of a besieger used to move in toward the work under attack.

**Banquette** - An earthen step parapet which allows the defenders to fire over the crest of the parapet. The banquet is part of the parapet construction located at the base of the interior slope of the parapet. Today, the banquet is often found as a small mound of earth at the base of the interior slope of the parapet. It is also quite common for a banquet to be built as part of the glacis. It is not uncommon to find some element of the banquet today.

**Barbette** - A term meaning that the artillery in the fortification fired over the parapet wall, not through embrasures. When looking at a fortification today that apparently has no embrasures; the guns may have been en barbette. This was accomplished by raising the guns by means of a large carriage or building an earthen structure to raise the level of the guns. The earthen structure may be in the form of a gun platform or it may be an enhanced terre plein.

**Bastion** - Large fortifications with two faces and two flanks. A curtain (or curtain wall) connects two or more bastions. The two faces of the bastion provide fire covering the face of the curtain.

*Figure 7.1.1. Bastioned Fort*

abcde - Lunette Salient
gfhi - Lunette Salient
ef - Curtain
Fortification Terminology

- **abcde** Glacis
- **fghi** Ditch
- **klmnop** Parapet
- **jkqr** Rampart or Bulwark
- **ab** Glacis Slope
- **bc** Interior Slope
- **cd** Banquette
- **de** Glacis Banquette Slope
- **ef** Covered Way
- **fg** Counterscarp Wall
- **hi** Scarp Wall
- **ij** Berme
- **jl** Exterior Slope (if no Rampart, kl)
- **lm** Superior Slope
- **mn** Interior Slope
- **no** Tread of the Banquette or simply Banquette
- **op** Banquette Slope
- **pq** Terreplein
- **qr** Parade of Slope
- **rs** Embrasure
- **High Points or Crest:**
  - **b** Glacis Crest
  - **f** Counterscarp
  - **g** Counterscarp
  - **h** Foot of Scarp
  - **l** Exterior Crest
  - **m** Interior Crest
- **Low Points or Foot:**
  - **a** Foot of Glacis
  - **g** Foot of Counterscarp
  - **h** Foot of Scarp
  - **j** Foot of Exterior Slope (if no Rampart, k)
  - **p** Foot of Banquette Slope

**Figure 7.1.2. Terminology and Illustration for Fortifications Represented in West Tennessee (adapted from Scott, 1864)**

**Battery** - an artillery unit or the fortification constructed to defend such a unit

**Berme** - Narrow path around fortifications, between the parapet and the ditch, to prevent the earth from falling in. Today occasionally seen at the base of the exterior slope of the parapet. More times than not, earth has sloughed off the earthwork and obscured the berme. However, a cut through by an archeologist should reveal the different soil layers and identifies the berme.

**Block-house** - Building constructed of heavy logs in the shape of a square, rectangle, or cross. Used as a strong place in support of field works, or alone protecting a railroad or other transportation route. Mahan indicates the blockhouse was well suited as the keep in a fortification. Sometimes fieldworks were built nearby. Earth was often piled against the base. A ditch surrounded the blockhouse. Today very little is left of blockhouses. The ditch may still be present, or the earth that had been piled against the base may still be visible. Often the first floor of the blockhouse was
dug below ground and this excavation is visible. Archaeologists may find remains of the wooden logs, or where they were imbedded into the ground. Sometimes brick or stone floor or fireplaces were built and these are still evident. Blockhouses have been employed as a fortification since colonial days.

**Bombproof** - A bombproof is a structure built similar to a magazine but for protecting and housing troops not ammunition. Similar to magazines bombproof were set up more for habitation than storage. An archeologist would find evidence of occupation, such as fireplaces, extra ventilation, and debris of habitation. See magazine.

**Breastwork** - A hastily constructed fieldwork. The parapet is not high enough to require a banquet. Breastworks were constructed of earth, rock, and wood, basically any material quickly found that could be used for defense. They may, or may not, have ditches. Today remaining breastworks are much smaller than other field fortifications. Rarely seen as more than a line of earth a couple of feet high and a few feet wide at best.

**Bulwark** - Originally, the bulwark is a circular work found well in front of the fortification to prevent siege guns from being placed within range of the walls. It was usually constructed of earth and timber, even when associated with a masonry fort. By the middle of the Civil War the bulwark had become a structure erected in front of the work to protect the openings, such as a sally-port.

**Capital** - A line bisecting the salient angle of a work.

**Caponiere** - A redan that protrudes from the front of a curtain wall to enable infantry or artillery to provide enfilade fire into the ditch

**Cavalier** - A portion of the fortification built higher than the surrounding works. Sometimes the cavalier is surrounded by parapet walls, and sometimes only has one or two walls facing potential enemy positions. It is sometimes placed on the terre plein of the bastion, but not limited to this location. Today the cavalier is often seen as a more massive structure than the surrounding fortifications.

**Cheval-de-frise or Chevaux-de-frise** (plural) - A piece of timber or an iron barrel from which iron or wooded spikes project five to six feet, used to impede calvary or infantry. Also, sharply pointed nails or spikes set into the top of a barrier.

**Cheek** - The sides of an embrasure.

**Counterscarp** - The outer wall of the ditch. Cut slightly at an angle to help deter erosion and sloughing, the counterscarp is visible, in some form, in all ditches found today.
Covered Way - The space between the counterscarp of a backditch and the foot of the banquet which troops can move without being seen or fired upon. Most often used between the glacis and the main ditch or in advanced fortifications. Today a covered way is difficult to determine due to sloughing of earth from adjacent earthworks. Archeology may determine soil patterns that indicate the existence of one.

Cremaillere - An indented or zigzag line of fortifications.

Figure 7.1.3. Cremaillere or Indented Line
a - Salient
b - Re Enterings

Cunette - A small narrow ditch within and sometimes leading from a larger ditch intended to keep the larger ditch dry. The cunette provided another obstacle to attacking forces, especially when full of water. Rarely seen today, but possible.

Curtain (or curtain wall) - A line of fortifications connecting two bastions

Curtain Wall - Parapet connecting lunettes or redans, constructed by throwing earth from front to rear, thus creating a protective moat.

Demilune - A fortification constructed to protect the shoulders of the bastions and the curtain connecting the bastions. It normally has two faces, an open back, a ditch surrounding it, and two demi-gorges formed by the counterscarps. Sometimes referred to as a ravellin.

Detached Bastion - A bastion that is separated from the main line of fortifications by a ditch.

Detached Works - Fortifications constructed in front of the main line, generally out of the range of musketry. Intended to be self-sufficient during an attack.

Ditch - Ditches were in front of (front ditch), behind (back ditch), or both in front and behind the fortification. When the fortification was complete a ditch in front provided a defensive obstacle, and when in back additional protection for the defenders. In addition, the excavation of the ditch allowed for the builders to acquire the dirt needed to construct
the earthworks. Today ditches are usually, but not always, visible with surviving earthworks. Erosion of the earthworks may have caused the ditch to fill with dirt. Archaeologists can identify the existence of a ditch by observing soil patterns.

**Embrasure** - An embrasure is an opening cut in the parapet to allow artillery to fire upon the enemy. The embrasure was supported using either logs, wood planks, facines, or gabion. Today embrasures are often visible. They appear as slight indentations in the otherwise uniform line of earthworks. A good place for erosion to start an embrasure position may be the location of a major erosion blow out. Often a gun platform is evident just below and adjacent to the location of an embrasure. It is possible that several embrasures could be serviced by one platform. Or each embrasure was serviced by its own platform.

**En Barbette** - artillery positioned to fire over a parapet rather than through an embrasure in the parapet

**Entanglement** - Another name for abatis.

**Entrenchment** - A loose term for any form of earthen fortification

**Epaulement** - A semi-circular parapet protecting a single cannon, typically ditched in front

**Esplanade** - A large empty space for exercising, or reviewing, troops in the vicinity of a fortified place. In field fortifications this area would rarely be improved, and thus hard to see today. However, identification of the esplanade would be important to understanding the overall design of the fortification.

**Exterior Slope** - Outside face of the parapet. Sloped back 45 degrees from the berm. Today when earthen fortifications are found, the facing of the fortification can be determined by looking at the slope. The exterior slope, the one closest to the enemy, is sloped back 45 degrees. The interior slope, on the inside, is more perpendicular (straight up and down) to the ground. All extant earthworks will have some evidence of their exterior and interior slopes. Only heavily eroded works will not display this evidence.

**Facines** - A long cylindrical bunch of saplings tied together to form a log like structure used for revetment.
Fort - any enclosed fortification, see also redoubt

Figure 7.1.4.
Star Fort
(one of several forms)

Front - toward the enemy

Gabion - A basket formed by weaving saplings or sticks together and filled with dirt. Gabions were used in revetment, and to protect embrasures. Gabions are not found today.

Glacis - Earth placed in front of the ditch, sloped in such a way to cause artillery shot to ricochet over the main works. Although some manuals indicate that glacis was not used in field fortification, there are many instances during the Revolution and Civil War where it was used. Today there is a good possibility that remains of the glacis are still extant.

Gorge - The opening of a fortification on the side of a work facing friendly forces. The gorge was often covered by some temporary or easily moved obstruction. Often wooded palisades were used. If the fortification was to fall into enemy hands the temporary obstructions could be removed as the defenders fell back to secondary positions. The attacking force would then be exposed to the defenders fire without the benefit of the captured work providing cover. It has also been defined as; the inside space between the flanks of a bastion or an unbastioned polygonal fort.

Gun Pit - A parapet that protect a cannon, often enclosed by traverses

Gun Platform - Earthen floor behind the parapet in which an artillery piece would sit. Usually covered by a wooden floor. Often seen today in battery positions. On occasion the drainage for the platform can still be seen.

Keep - A redoubt behind a main line which can be used for a last-resort defense, sometimes called a citadel or cavalier
**Lunette** - A redan with flanks parallel to its capital and open at the back.

![Figure 7.1.5. Lunette](image)

- bc, cd - Faces
- ab, de - Flanks
- ae - Gorge
- (dotted line denotes angle of Pan Coupe)

**Magazine** - A structure built for storage of ammunition. Magazines were dug into the ground and covered by a series of heavy logs, facines, tarps, sandbags, and loose earth. Usually there would be two magazines per battery in field fortifications. Each magazine would be located at opposite ends of the work. In hasty entrenchments and other fieldworks only one magazine is usually evident. In more permanent fortifications one magazine serviced an entire battery, and sometimes the entire garrison. Today magazines are seen as mounds of earth near other fortifications. Determination of the existence of a magazine can be made by examining the location of the pile of earth in relation to the battery and archeological excavation. A magazine will possibly show evidence of the heavy timbers used as a ceiling. In addition, magazines rarely had fireplaces or evidence of human living quarters. The remains of magazines are usually found today as a pile of earth one to four feet high, in a circular pattern 12 - 25 feet in circumference or a rectangle 12 - 25 feet long and five to ten feet wide. Sometimes the pile of earth exhibits an indentation on one side or the other. This is the entrance to the magazine. Identification of this indentation helps to determine if the pile of earth is really a magazine and illustrate the facing of the magazine in relation to the battery.

**Military Crest** - The contour of slope from which the bottom of the valley or ravine can be seen.

**Palisades** - Logs placed in the ground as an obstacle to advancing infantry. The logs, usually 6" - 8" in width and as high as 7', were sharpened on one end. They were placed at the foot of slopes slanted toward the enemy and vertically in openings to block passage. Usually no remains of palisades exist above ground. Archaeologists may find remains of the wood or post holes below ground.

**Pan Coupe** - The short side on a fortification formed by cutting off the apex of a salient.
Parade - The area within a fortification for the assemblage of troops in a regular and prescribed manner. Usually this area was improved by leveling and draining. It is usually still evident in the larger works.

Parapet - Mound of earth, from three to fifteen feet tall, built upon the rampart of a fortification or directly upon the ground in more temporary fortifications. The thickness of the work was determined by the armament it was expected to withstand. Musketry required a parapet two to two and a half feet thick. To face field artillery, six to ten feet of earth was required. The interior slope of the parapet was usually reveted. The exterior slope was slanted at 45 degrees. A banquet step often was placed at the foot of the interior slope, except on parapets constructed four feet or less. Today, the most common remnant of field fortifications is the parapet wall.

Picket Trench, or hole - A rifle pit or fox hole.

Platform - A structure designed for artillery.

Postern (or Sally-Port) - A passage under the rampart to allow communication into the ditch. It is usually vaulted to support the parapet. Called a sally-port when the troops had free egress from the covered way into the country for a sortie. Rarely seen in surviving earthworks. When visible it is usually only a break or indentation in the parapet wall.

Priest Cap - Two adjacent redans, placed together to form a fortification shaped like the letter M.

Ramp - A road cut obliquely into the interior slope of the rampart. Visible today as a flat area cut into the side of ramparts.

Rampart - A broad embankment of earth which supports the functioning elements of a fortification. The parapet and banquet are located on the exterior edge, while ramps are placed on the interior slope for movement of troops and equipment. Ramparts are sometimes evident today. Usually, however, the parapet and rampart have eroded together and are impossible to differentiate. Many times, in the use of hasty entrenchments, ramparts were left out of the design of the fortification.
Redan - Small fortifications with two faces built to cover camps, advanced posts, villages, bridges, etc. The rear of the work is usually open. However, a traverse could have been constructed to protect the rear opening. Seen today as a V shaped structure, usually with no back.

![Figure 7.1.6. Redan](image)

- ab - Face
- bc - Face
- ac - Gorge

Redoubts - A fortification that is enclosed on all sides. Redoubts were constructed in the shape of a square, polygon, or circle. At times redoubts were constructed within other, larger, fortifications or along long lines of entrenchments as strong points. The important consideration for identifying a redoubt is not the shape, but the fact that it is entirely enclosed.

![Figure 7.1.7. Redoubt - Square](image)

- a - Traverse
- b - Outlet or Gorge

Reentrant Angle - Angle pointing to the rear of the line.

Revetments - Wall constructed to support the almost vertical interior slope of a parapet. Made of logs, wood planks, facine, or gabions the revetment provided additional protection from enemy fire, and, most importantly, kept the parapet wall from collapsing. Rarely seen today, there are several sites in the United States with a portion of a log revetment extant. Any existing remains of revetment would be greatly deteriorated and possibly found only by archeology. Revetment made of cypress logs in sandy soil have been found to last longer and be evident even on the surface of the work.

Rifle Pit - A hole or short trench providing cover for two men. Usually constructed as a hole four feet long and three feet deep with the dirt thrown out in front. Rifle pits were often constructed in advance of the main line or on flanks to provide cover for pickets. They are rare, and hard, to find. However, there are several locations with good examples extant.
Salient - A section of the line extending to the front, covering an important area. Sometimes found with the appearance of all other remnants in the area.

Salient Angle - The angle of the fortification projecting away from the main body (pointing to the front of the line), toward the enemy.

Sally-ports - Openings in the parapet, or rampart, to allow troops access to the covered way and the area in front of the fortification. See postern.

Scarp - The scarp wall is a wall, usually of the ditch or parapet, that has been cut down (scarped) to make it inaccessible. The walls of the ditch are usually referred to as scarp (interior) and counterscarp (exterior) walls.

Slit Trench - A short trench, similar to a rifle pit, constructed for 4-5 men.

Stockade - A fortification where the wall is made of logs arranged vertically and tied together. Small loopholes were cut in the logs to allow for rifle fire. More popularly seen as defense from Indians, stockades were used as protection for the flanks and other points of fortifications where full earthworks were not deemed necessary. Also, stockades were built as defensive positions along roads, railroads, and river crossings. On occasion, a stockade would be employed as a strongpoint in a larger fort. Remains of a stockade are rare. It is possible that an archaeologist may find evidence of the post hole or actual remains of the post in the ground. Often some use of an earthen structure was employed in addition to the stockade. A banquet or a parapet wall may be present or a ditch in front where the dirt was thrown against the logs.

Figure 7.1.8.
Stockade

af - preexisting grade
b - abatis
c - ditch
d - stockade wall
e - rampart

Terre-plein - A level space in the fortification. Usually identified as the area between the banquet and the interior slope of the rampart. Possibly visible in some fortifications.
Traverses - Mounds of earth similar to a parapet that is constructed to cover entry points and areas vulnerable to enfilade fire. Often they were constructed within the fortification to provide cover if another portion of the fortification was overrun by the enemy. Usually these structures were as massive as the main work and are as well preserve as the surrounding works.

Trench - The trench is usually three feet deep and from six to ten feet wide. A trench is the communication line, approach, zig-zag, or parallel used by besiegers against fortifications. Often the word trench is used as slang to refer to the ditch of a fortification, or refer to the fortification itself. Rarely seen, it is still possible to see some trenches in well preserved areas.

Work - Loose term to refer to any component of the fortification or to the fortification as a whole

Zigzag - Defiled trenches used as parallels of attack while besieging fortifications. See trench.
FIELD FORMS FOR THE
DOCUMENTATION OF EARTHWORKS

Technical Support Topic Two

(Instructions to be developed for inclusion in the completed document)
# Resource Identification: Earthworks in Context

<table>
<thead>
<tr>
<th>Name of Site:</th>
<th>Location:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recorder:</td>
<td>Date:</td>
</tr>
</tbody>
</table>

## Resource Description

**Size of Site in Acres**

**Boundary Description**

**Historical Context**

**Line features**

<table>
<thead>
<tr>
<th>quantity</th>
<th>total length</th>
</tr>
</thead>
</table>

**Point Features**

**Area Ground Cover**

<table>
<thead>
<tr>
<th>Acres/ Percent Cover</th>
<th>Current Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ forested</td>
<td>□ high □ med □ low</td>
</tr>
<tr>
<td>□ scrub/ regrowth</td>
<td>□ high □ med □ low</td>
</tr>
<tr>
<td>□ open field</td>
<td>□ high □ med □ low</td>
</tr>
<tr>
<td>□ developed</td>
<td>□ high □ med □ low</td>
</tr>
</tbody>
</table>

**Comments:**

---

*Guide to Sustainable Earthworks Management - 90% Draft*
### RESOURCE IDENTIFICATION: POINT FEATURES

<table>
<thead>
<tr>
<th>Name of Site:</th>
<th>Location:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recorder:</td>
<td>Date:</td>
</tr>
</tbody>
</table>

#### Point Feature

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Feature#</th>
</tr>
</thead>
</table>

#### Feature Type
- [ ] gun platform
- [ ] embrasure
- [ ] hole/dugout
- [ ] hump/traverse
- [ ] other

#### Break in Parapet
- [ ] engineered outlet
- [ ] stream/gully
- [ ] intrusion
- [ ] erosion

#### Measurements
- [ ] height
- [ ] width
- [ ] area

#### Area Ground Cover
- [ ] evergreen forest
- [ ] mixed forest
- [ ] deciduous forest
- [ ] meadow/pasture/grassland
- [ ] marsh/wetland
- [ ] scrub/regrowth
- [ ] maintained cover
- [ ] other

#### Acres/Percent Cover

#### Current Management
- [ ] high
- [ ] med
- [ ] low

#### Major Impacts
- [ ] visitor use (erosion, trails)
- [ ] animal burrowing
- [ ] erosion (natural, exposed)
- [ ] mechanical damage

#### Comments

---

*Guide to Sustainable Earthworks Management - 90% Draft*
**RESOURCE IDENTIFICATION: LINE FEATURES**

<table>
<thead>
<tr>
<th>Name of Site:</th>
<th>Location:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recorder:</td>
<td>Date:</td>
</tr>
</tbody>
</table>

**Line Feature**

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Feature#</th>
</tr>
</thead>
</table>

**Type of Construction**

- [ ] ditch in front
- [ ] ditch in rear
- [ ] ditch on both sides
- [ ] other

**Measurements**

- [ ] height
- [ ] width
- [ ] length
- [ ] area

**Line Feature Type**

- [ ] redan
- [ ] lunette
- [ ] redoubts
- [ ] parallels
- [ ] rifle trenches
- [ ] other

**Area Ground Cover**

<table>
<thead>
<tr>
<th>Acres/ Percent Cover</th>
<th>Current Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>evergreen forest</td>
<td>□ high □ med □ low</td>
</tr>
<tr>
<td>mixed forest</td>
<td>□ high □ med □ low</td>
</tr>
<tr>
<td>deciduous forest</td>
<td>□ high □ med □ low</td>
</tr>
<tr>
<td>meadow/pasture/grassland</td>
<td>□ high □ med □ low</td>
</tr>
<tr>
<td>marsh/wetland</td>
<td>□ high □ med □ low</td>
</tr>
<tr>
<td>scrub/regrowth</td>
<td>□ high □ med □ low</td>
</tr>
<tr>
<td>maintained cover</td>
<td>□ high □ med □ low</td>
</tr>
<tr>
<td>other</td>
<td>□ high □ med □ low</td>
</tr>
</tbody>
</table>

**Major Impacts**

- [ ] visitor use (erosion, trails)
- [ ] animal burrowing
- [ ] erosion (natural, exposed)
- [ ] mechanical damage

**Comments**
# Maintenance Data

<table>
<thead>
<tr>
<th>Name of Site:</th>
<th>Location:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recorder:</td>
<td>Date:</td>
</tr>
</tbody>
</table>

## Description

**Maintenance Activity/Project:**

**Desired Goals:**

**Compliance Required**

- **Section 106**
  - [ ] yes
  - [ ] no
  - [ ] Date Completed
- **NEPA**
  - [ ] yes
  - [ ] no
  - [ ] Date Completed
- **IPM Clearance**
  - [ ] yes
  - [ ] no
  - [ ] Date Completed

## Project/Activity Data

**Date Begun:**

**Date Completed:**

**Labor**

- [ ] day labor
- [ ] contract
- [ ] park staff
- [ ] other

**Materials used**

**Materials cost**

**Equipment used**

**Equipment Cost**

**Total project budget**

**Total project cost**

## Earthworks Condition Evaluation

**Earthworks Condition**

- [ ] good
- [ ] fair
- [ ] poor

**Goals Achievement**

- [ ] all
- [ ] some
- [ ] none

**Additional work needed for good condition:**

---

*Guide to Sustainable Earthworks Management - 90% Draft*
<table>
<thead>
<tr>
<th>Name of Site:</th>
<th>Park:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recorder:</td>
<td>Date:</td>
</tr>
</tbody>
</table>

**Current Management**


**Site Description**


**Management Objectives**


**Management Program**


*Note: Checklists to be developed for inclusion in the completed document.*
GPS MAPPING METHODOLOGY FOR
EARTHWORKS MANAGEMENT AND EVALUATION

Technical Support Topic Three

Note: This section is provided by David Lowe of the Washington Area Service Center and is currently undergoing revision.

INTRODUCTION

Earthworks management begins with reliable maps of the resources. Until the introduction of Global Positioning Systems, there was no cost effective method for producing accurate maps of surviving earthworks. GPS allows a survey crew not only to map the locations of earthworks but to record various attributes associated with these resources, such as relief, ground cover, and condition. This information collected in the field can then be fed into a PC-based GIS program like ArcView or Atlas GIS. Once mapped and in the GIS, the earthworks can be measured, buffered, and analyzed in association with other digital coverages like ground cover, soil type, vegetation type, tax parcels, and so forth. Earthworks segments can be linked to existing maintenance databases and assigned a priority according to available funding. Restoration or stabilization efforts can be recorded and tracked, so that the park retains a record even if important personnel leave or are transferred. Although many parks currently lack access to a GIS, it is a safe bet that GIS will be in all parks within ten years if not much sooner.

The first hurdle is to get the earthworks data into the computer. This can be done by conducting a GPS survey of surviving resources.

A GPS survey of earthworks for the purpose of management would be conducted in two phases: (1) Inventory and (2) Evaluation. A basic inventory of the surviving earthworks should be conducted before beginning any condition or vegetation assessments. This ensures that the park's GIS contains consistent baseline data for all surviving features before additional layers are added. A complete inventory of resources provides a foundation for all subsequent management decisions.

During the inventory phase, the earthworks are located and described. To accomplish this task, the GPS survey team needs a basic understanding of the methods and techniques of earthworks construction, a general idea of the historic context of the defenses, and the ability to identify predominant...
ground cover. In areas of heavy undergrowth, the inventory survey should be conducted (if possible) in fall-winter-early spring before vegetation has come out so that earthworks and related features are readily visible. The critical attribute collected is location, but the survey team should describe additional attributes that are important for interpreting and understanding the condition of the features. When designed for use with GPS, this list of descriptive attributes is called a data dictionary.

During the evaluation phase, vegetation is examined (sampled) at regular intervals along the linear earthwork and condition assessed. The survey team should have a more advanced understanding of vegetation and ecology or be accompanied by a biologist. The evaluation phase should be conducted in late spring-summer-early fall, when plants can be identified and counted.
FEATURES AND ATTRIBUTES COLLECTED DURING GPS INVENTORY SURVEY OF EARTHWORKS

Line Feature: Parapet

Earthworks (trenches, field fortifications) are linear features that reflect the deployment of military formations on the ground. Earthworks were sited according to principles of military science and therefore reveal much about the thinking and activities of the officers and soldiers who constructed them. Although many specific types of earthworks were built during the Revolution and the Civil War (redans, lunettes, redoubts, parallels, rifle trenches), all consisted of a parapet (a mound of earth) and a ditch (trench, moat) from which the dirt to form the parapet was excavated.

A GPS survey team approaches these features generically, mapping each as a parapet line that follows the course of the parapet. This generic approach allows the survey team to stick to observable features, thus minimizing interpretation in the field. The specific design of an earthworks feature can be determined later from the shape of the earthwork line on the map, its relationship to other earthworks, and from the various collected attributes, such as relief and type of construction.

1. Type of Construction

Military field fortifications consisted of a parapet, which is a mound of earth, and a ditch from which the earth was excavated. A field fortification typically faced in the direction of incoming enemy fire. A front line fortification “faced” in the direction that soldiers manning the trench pointed their rifles. Positions often received incoming fire from more than one direction, requiring other protective trenches with additional facings. “Feeder” or secondary trenches sometimes ran at odd angles to main, front lines. The parapets of such lines were piled on the side most likely to receive incoming “oblique” or “enfilading” fire. The facing of trenches might reverse from one side of a hill crest to the other as the source of incoming fire shifted from the right of the line to the left. The front of a line was toward the enemy; the rear was away from the enemy.

There were three techniques of earthworks construction: ditch in front, ditch in rear, and ditch on both sides. The simplest and most common method of construction was to line soldiers up along the intended course of a trench and set them to digging with shovels and picks. The soldiers threw the excavated earth to their front to provide a barrier of earth between themselves and the enemy. Often, the earth was thrown onto piles of logs or fence rails to increase the bulk of the parapet and its ability to absorb bullets. This
resulted in a ditch in the rear of the parapet or *ditch-in-rear* construction. The rifle or shelter trench shown here with four and a half feet relief could be constructed in about an hour and a half. If time permitted, the trench would be deepened, and the back side of the parapet could be revetted or reinforced with logs, braided branches, or sandbags. Often, soldiers added head logs — logs spaced lengthwise along the top of the parapet beneath which the soldiers could fire. This type of field fortification, commonly known as a rifle trench, or sometimes as a “rifle pit”, provided basic shelter for infantrymen and averaged four to five feet in relief.

The second technique used to construct field fortifications was to excavate a ditch in front of the parapet. The soldiers first constructed a retaining wall of logs or other materials, called a revetment. The soldiers then lined up in front, excavated earth, and threw it back against the revetment. The *ditch-in-front* method allowed the ditch to be deeper than a soldier could stand, often six to ten feet or more. The extra earth made the parapet correspondingly thicker and stronger. This type of construction placed the parapet and the ditch between the contending parties with the ditch serving as an additional barrier to attacking troops. Such works typically were used in semi-permanent fortifications, to shelter artillery batteries, or to provide extra protection for infantry from incoming enemy artillery fire. Detached works, such as redans, lunettes, and redoubts, were built this way, often under the direct supervision of a military engineer. Long, straight segments of ditch-in-front entrenchments for infantry connecting artillery strong points were called “parallels”.

*Figure 7.3.2. Profile of a rifle trench, showing ditch-in-rear construction.*

*Figure 7.3.3. Profile of a field fortification, showing ditch-in-front construction.*
The third type of entrenchment was built with a ditch on both sides of the parapet. *Ditch-on both-sides* construction often was employed as an ad hoc measure to strengthen a section of parapet, to adapt it to shallow topsoil, or to respond to uneven terrain. This technique was sometimes used to deepen a wagon road or protect a “covered way” that ran behind the parapet. It is also seen where trench segments were captured and refaced or “turned” to face the opposite direction.

2. **Relief**

The relief of an earthwork is the vertical distance between the top of the parapet and the bottom of the ditch.

3. **Width of Parapet**

The width of the parapet is measured from the angle of the parapet where it joins the original ground surface to the angle at the bottom of the ditch. Deep relief, narrower parapet, and sharper, “cleaner” angles imply good surviving integrity. For rifle trenches, a wider parapet, shallower relief, and blurred angles at ground level, show that the parapet has eroded, “melted” and spread out to fill the ditch. “Melted” parapets are often observed in areas that were clear-cut and exposed to the elements. In extreme cases, a parapet may have eroded almost flat, leaving only the shallow trough of the trench visible.

![Figure 7.3.4. Profile of a fieldwork, showing dimensions of relief and width of parapet.](image)

4. **Predominant Ground Cover**

It is important to collect the predominant ground cover associated with an earthwork in order to identify applicable management techniques. Collecting this information on the ground also provides a check for land cover information derived from other sources, such as aerial photographs. Past surveys have revealed that earthworks in mature forests, particularly deciduous forests, tend to retain the best integrity. In most areas, pine dominated forests indicate that the area has been recently timbered, typically
causing some erosional damage. It is rarer for earthworks to survive in open areas without the protection of tree cover, but it does occur, and parks have intentionally cleared and planted areas to exhibit earthworks.

The following vegetation categories are suggested as generic enough to be used by non-specialists in a range of climatic zones: evergreen forest, mixed forest (evergreen and deciduous); deciduous forest; meadow/pasture/grassland; marsh/wetland; scrub regrowth; maintained cover; and other (which can be used for unclassified cover). The park's biologist may wish to use already established vegetation categories in the data dictionary, so long as the surveyors are able to distinguish the differences among vegetation types.

**Point Feature: Earthworks Point**

Civil War field fortifications comprise more than the main front lines. A fieldwork complex can include secondary defensive lines, feeder trenches, covered ways, or military roads by which to move men and matériel to the front—all which can be mapped as line features. Associated with these linear features are a variety of point features that are important for understanding the layout of the defenses. The longer a military unit stayed in an area, the more elaborate the system of fortifications tended to become. Units established command posts and hospitals. Engineers laid out artillery strong points. Supply caches were established and dug in behind the main lines adjacent to military roads. Individual soldiers constructed dugouts, shelter holes, or fire pits behind the lines. Picket or skirmish holes (Civil War-era fox holes) were dug 50-200 yards in front of the main trench line to guard against a surprise assault. All of these earthworks points are important for understanding and interpreting the layout of a defensive line.

1. **Gun Emplacement (no embrasure)**

Some of the most important features associated with entrenched lines are the locations of the artillery. With some experience, a survey team can identify and map these gun emplacements. Field guns (mobile artillery) were sometimes entrenched individually behind crescent-shaped parapets, called demi-lunes, just large enough to cover the gun and its crew (12-15 feet across). Four to six guns were sometimes entrenched together as a “battery”. Field guns were also incorporated into the main defensive lines. The cannon could be sighted across the parapet (as shown in the illustration) or through a gap in the parapet, called an embrasure (discussed below). Platforms for the guns behind the parapet were smoothed out and lined with planks or split logs, if time permitted, to provide a level surface for aiming and servicing the gun.
Gun positions without embrasures can be recognized in the field by several indicators: the parapet will be thickened relative to connecting rifle trenches; the ditch is usually in front and may have switched abruptly from the rear to the front when approaching the position; a rectangular platform (12 x 15 ft.) may be seen behind the parapet; traverses might have been erected on either side of the platform to protect from enfilading fire; a ramp or cut might be visible behind the platform where the gun was brought in and taken out; and a rectangular hole (3 x 4 feet) might be present 12 to 15 yards behind the platform where the gun’s ammunition chest was entrenched. Typically, some but not all of these indicators are present.

2. Embrasure

An embrasure is an opening cut into the parapet through which an artillery crew could fire its weapon with less exposure to enemy fire. Embrasures are readily identified in the field by a narrow depression in the parapet behind which may be found some of the indicators discussed above—thickening of the parapet; ditch in front after ditch switching sides; visible platform; protective traverses; a ramp or cut leading into the platform. A single gun sometimes had more than one embrasure, particularly if sited in the angle of a work. Each embrasure should be mapped.

3. Hole/dugout

Many miscellaneous holes are associated with linear earthworks. All of these holes served a purpose for those who dug them, but understanding that purpose is now a matter of identification and interpretation. Although many of these “holes” can be described as magazines, officers’ holes, dugouts, ammunition holes, supply caches, or picket holes, often the purpose remains ambiguous. It is best for the survey team to map the holes as “holes” and leave interpretation to the archeologists and historians. The point feature contains a comment field to allow the surveyor to label the mapped features.

4. Hump/traverse

Traverses are shorter parapets erected at right angles to the main defensive lines to prevent an enemy enfilading fire from sweeping down the length of a trench and inflicting heavy casualties. Traverses often separated guns that were entrenched as a battery. Another “hump” feature might be a “baulk”, which was a narrow earthen divider left in a trench to separate two units in the line of battle. Often these baulks separated regiments. Mapping baulks might enable a historian to determine the positions and fronts of individual regiments in the line of battle. The point feature contains a COMMENT field to allow the surveyor to label the mapped features as traverses, baulks, or generic “humps”.

---

Guide to Sustainable Earthworks Management - 90% Draft
5. Other

Including an “other” category, allows the survey team to collect features of interest that might not be categorized. An example might be a sunken portion of a parapet that resulted from the collapse of a wooden drainage culvert that passed beneath it.

**Point Feature: Break in Parapet >3 meters**

If the gap between one trench segment and another is wide, the survey team will turn off the earthworks line feature and start another at the beginning of the next segment. Longer parapets are often penetrated by various types of breaks that are too narrow to justify turning the earthworks line feature off and back on. These include breaks that were left by the soldiers and breaks that resulted from later activities, such as farming, logging, and erosion. For convenience in the field and because of the accuracy of the GPS equipment, breaks less than about 3 meters in width are mapped as point features, nested on the earthworks line.

1. **Engineered outlet**

Breaks were often left in the parapets to allow skirmishers or artillery to go to the front or to allow egress for a road or path. An engineered outlet is an integral part of the fortification and should be noted when it can be identified.

2. **Stream /gully**

Narrow breaks were left in the parapet for drainage. Although many of these technically were “engineered”, it is good to note geographic features, such as streams and gullies, that later can be lined up with other geographic data layers in the GIS.

3. **Intrusion**

Post-construction intrusions, caused by farming or logging, account for many breaks in the parapet encountered in the field. An intrusion for a logging or farm road is typically made by pushing a portion of the parapet back into the trench with a bulldozer or front-end loader. This leaves tell-tale traces—disturbed ground surface, slumping along the original ditch, slumping in the ditch on both sides of the opening, and often vehicle ruts. An engineered break usually left the ground between the segments of parapet undug—the ground surface appears level and firm. When there is doubt about whether a break is engineered or not, it should be mapped as an intrusion. The width of the break can be collected as an attribute value.
4. Erosion

The action of water and wind can erode gaps into a parapet. Large trees sometimes gouge out gaps in the parapet when they throw. Foot paths, mountain bike or ATV paths, and animal traffic may erode gaps or depressions into the line. Mapping these gaps will indicate areas where the parapet is endangered by erosion.

Point Feature: Line Point

Parapets may be full of bends and angles that should be mapped during the GPS survey. Because many positions are averaged to compute a point feature during GPS data collection, point features are inherently more accurate than line or polygon features. To take advantage of this higher accuracy, it is important to collect point features in conjunction with a line to tie it down to the ground and assist in the editing process. These line points are used to mark the beginning, end, an angle, or an intersection on a line, thus improving confidence in the shape and accuracy of the line feature. Line points should be included in all data dictionaries.
**Suggested GPS Data Dictionary for Collecting Earthworks Inventory Features**

The inventory portion of the data dictionary contains one line feature with four required attributes and a comment field, and four point features.

**LINE FEATURE: Earthwork**

<table>
<thead>
<tr>
<th>Attribute:</th>
<th>Type of Construction (menu)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ditch in front</td>
</tr>
<tr>
<td></td>
<td>Ditch in rear</td>
</tr>
<tr>
<td></td>
<td>Ditch both sides</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attribute:</th>
<th>Relief in &lt;units&gt; (numeric)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attribute:</th>
<th>Width of Parapet in &lt;units&gt; (numeric)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attribute:</th>
<th>Predominant Ground Cover (menu)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Evergreen forest</td>
</tr>
<tr>
<td></td>
<td>Mixed forest (evergreen &amp; deciduous)</td>
</tr>
<tr>
<td></td>
<td>Deciduous forest</td>
</tr>
<tr>
<td></td>
<td>Meadow/pasture/grassland</td>
</tr>
<tr>
<td></td>
<td>Marsh/wetland</td>
</tr>
<tr>
<td></td>
<td>Scrub regrowth</td>
</tr>
<tr>
<td></td>
<td>Maintained cover</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attribute:</th>
<th>Comment (character)</th>
</tr>
</thead>
</table>

**POINT FEATURE: Earthworks Point**

<table>
<thead>
<tr>
<th>Attribute:</th>
<th>Feature Type (menu)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gun platform</td>
</tr>
<tr>
<td></td>
<td>Embrasure</td>
</tr>
<tr>
<td></td>
<td>Hole/dugout</td>
</tr>
<tr>
<td></td>
<td>Hump/traverse</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attribute:</th>
<th>Length in &lt;units&gt; (numeric)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attribute:</th>
<th>Width in &lt;units&gt; (numeric)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attribute:</th>
<th>Height in &lt;units&gt; (numeric)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attribute:</th>
<th>Comment (character)</th>
</tr>
</thead>
</table>

---

*Guide to Sustainable Earthworks Management - 90% Draft*
POINT FEATURE Break in Parapet <3 meters

Attribute: Type of Break (menu)
Engineered outlet (e.g. sally)
Stream /gully
Intrusion (e.g. vehicle cut)
Erosion

Attribute: Width of break in <units> (numeric)

Attribute: Comment (character)

POINT FEATURE Line Point

Attribute: Line Point Type
Begin
End
Angle
Intersection

POINT FEATURE Photo Point

Attribute: Photo ID (character)

Attribute: Direction of View (menu)
N
NE
E
SE
S
SW
W
NW

Attribute: Comment (character)

Note: Units of measure collected in the field should be consistent with the database that is used in the park. Collect data in meters if the database projection is in utms, in feet if the projection is in state plane.
Vegetation Evaluation and Condition Assessment

This data dictionary item would consist of a single Point Feature, called an assessment point, with the following attributes and menu choices:

Cover as indication of erosion control (x 10)

- 5 pts. > 80% living cover
- 4 pts. > 80% living cover & mulch/litter
- 3 pts. 60-80% cover
- 2 pts. 40-60% cover
- 1 pt. < 40% cover

Maintenance/management required (cutting, mowing, burning) (x 2)

- 5 pts. once annually or less
- 4 pts. 2-4 treatments /yr.
- 3 pts. 5-6 treatments /yr.
- 2 pts. 6-8 treatments /yr.
- 1 pt. > 8 treatments /yr.

Aggressive, persistent exotics (x 2)

- 5 pts. None observed
- 4 pts. < 25% frequency of exotics
- 3 pts. 25-50% frequency of exotics
- 2 pts. 50-75% frequency of exotics
- 1 pt. > 75% frequency of exotics

Species diversity (x 2)

- 5 pts. > 8 average species diversity per square meter quadrant
- 4 pts. 6-8 average species diversity per square meter quadrant
- 3 pts. 4-6 average species diversity per square meter quadrant
- 2 pts. 2-4 average species diversity per square meter quadrant
- 1 pt. 1-2 average species diversity per square meter quadrant

Visual quality rating (x 2)

- 5 pts. Legible earthwork, attractive
- 4 pts. Generally legible; discordant spots
- 3 pts. Partially legible; discordant spots
- 2 pts. Generally rough; inconsistent
- 1 pt. Chaotic, illegible

Negative human, animal impacts (x 2)

- 5 pts. Neither is evident
- 4 pts. Minor trampling or animal burrowing
- 3 pts. Major trampling or animal burrowing
- 2 pts. Both trampling and burrowing
- 1 pt. Extreme impact (e.g., ATV compaction)
SUSTAINABLE PLANT SPECIES FOR EARTHWORKS MANAGEMENT

Following is a list of plant species in different categories which appear to be well suited to the earthworks environment in the regions of this study. For the most part, these species were observed growing on or near earthworks in the subject parks. In some cases, they have been identified as primary candidates for consideration in meeting special needs, e.g. ability to grow in areas of moisture extremes or their tolerance to mowing or burning. The native ranges of these species are throughout the study area unless otherwise noted. The non-native species recommended here are known to provide good, reliable cover, but are not considered invasive, and generally require fewer additives than other more commonly used cool season turf grasses.

**GRASSES**
- *Andropogon ternarius* (Splitbeard Bluestem)
- *Andropogon virginicus* (Broomsedge)
- *Aristida purpurascens* (Arrowfeather Threeawn Grass)
- *Bouteloua curtipendula* (Sideoats Grama Grass)
- *Chasmanthium latifolium* (River Oats)
- *Elymus virginicus* (Virginia Wildrye Grass)
- *Eragrostis spectabilis* (Purple Lovegrass)
- *Festuca rubra* (Red Fescue)*
- *Panicum virgatum* (Switchgrass)
- *Schizachyrium scoparium* (Little Bluestem)
- *Sorghastrum nutans* (Indian Grass)
- *Stipa avenacea* (Needle Grass)
- *Tridens flavus* (Purple Top)

**GRASS-LIKE PLANTS**
- *Carex pensylvanica* (Pennsylvania Sedge)
- *Juncus tenuis* (Path Rush)

**FORBS**
- *Chamaecrista fasciculata* (Partridge Pea)
- *Potentilla canadensis* (Five-finger Cinquefoil)

**FERNS**
- *Pteridium aquilinum* (Bracken Fern)

**VINES**
- *Parthenocissus quinquefolia* (Virginia Creeper)
- *Vitis rotundifolia* (Muscadine)

**SHRUBS**
- *Satureja georgiana* (Georgia Basil)
- *Vaccinium vacillans* (Lowbush Blackberry)

* Non-native, but considered sustainable
GRASSES

Andropogon ternarius (Splitbeard Bluestem)

Warm-season, clump-forming perennial, 2'-4' tall with reddish fall and winter color, fine texture. Sun to light shade; well drained soil on ridges and knolls. Withstands periodic burning, but not annual burning followed by grazing/mowing. Seed ripens late August to September.

Andropogon virginicus (Broomsedge)

Warm-season, clump-forming perennial, 2'-4' tall, with copper fall and winter color. Full sun, with wide variety of soils, including eroded, low-fertility sites. Withstands annual mowing, either when dormant or early in growing season (e.g. not later than mid-June. Should be cut at 6" or higher).

Aristida purpurascens (Arrowfeather Threeawn Grass)

Cool-season perennial forming small clumps of fine, curly leaves, 4"-12" long. Starts growth early. Full sun to intermediate shade; sandy soils. Increases under grazing/mowing, and was present in most parks in study area on sandy sites.

Bouteloua curtipendula (Sideoats Grama)

Warm-season perennial rhizomatous sod-forming grass 12"-20" tall. Full-sun, tolerant of well-drained uplands, ridges and rocky slopes, preferably moderately alkaline. Increases under grazing/mowing, and should be tested in parks within its natural range (i.e. Tennessee and Virginia. Its natural range does not include the portions of Georgia and South Carolina with battlefields included in this study).

Chasmanthium latifolium (River Oats)

Cool-season, rhizomatous perennial that grows in colonies; medium texture, 3'-3 1/2' tall. Grows in moist, fertile bottomland soil, and mesic uplands when there is moisture (e.g. depressions or swales). Grows best in 40% or greater shade.

Elymus virginicus (Virginia Wildrye)

Cool-season perennial bunch grass, 3 1/2'- 4' tall, medium texture, with distinctive arching wheat-like seedheads, produced in May and June. Grows in both moist and well-drained soils, in 20%-30% shade. It survives grazing and mowing to 5"-6". As a cool-season grass that establishes well on open, disturbed sites, Virginia Wildrye is a likely candidate for revegetating open sites. Elymus canadensis may be more readily available commercially, and has similar growth habits.
*Eragrostis spectabilis* (Purple love grass)

Warm-season perennial bunch grass, 1'-3' tall, often occurring in colonies among other grasses. Seedhead is an open panicle with distinctive pinkish-purple color in late summer. Grown in medium to coarse-textured soils in full sun to light shade. Increases under annual burning.

*Schizachyrium scoparium* (Little Bluestem)

Warm-season, drought tolerant perennial bunch grass, with fine textured leaves, growing 2'-4' tall; reddish fall and winter color; seeds ripen in October and November. Grows on a wide variety of soils, but grows best in calcareous sites. Responds well to burning; should be cut no lower than 4" to avoid cutting growing tips; 5"-6" is preferable mowing height.

*Sorghastrum nutans* (Indian Grass)

Warm-season, rhizomatous perennial, with medium textured leaves up to 24" long; plume-like seedheads 5'-6' tall. Grows in full sun on soils ranging from moist, heavy clay to deep sands. Responds well to burning. Should not be mowed shorter than 5"-6".

*Stipa avenacea* (Needlegrass)

Cool-season clump-forming grass with open panicle of needle-like seeds; leaves form arching clumps 12" tall; often forming colonies. Grows in dry well-drained to occasionally-flooded soils under a wide range of light conditions, 30% shade to 70% shade.

*Tridens flavus* (Purple Top)

Warm-season perennial bunch grass, with medium-textured leaves 10"-28" long, and fine-textured open panicles of seeds, purple to almost black, 3'-5' tall. Grows on a wide variety of soils, bottomland to upland, in sun to semi-shade.

**GRASS-LIKE PLANTS**

*Carex pensylvanica* (Pennsylvania Sedge)

Perennial stoloniferous sedge, forming low clumps of fine-textured arching leaves, 6"-16" tall, often in colonies. Most often in dry, well-drained soils in wooded situations, it tolerates 30% to 70% shade. A good substitute for turf in shaded situations.

*Juncus tenuis* (Path Rush)

Perennial short clump-forming rush, with dark green round stems typically only 4"-12" tall. Named for its tolerance to trampling, this resilient plant grows in pastures, compacted soils of trails. Is tolerant of short mowing (e.g. 2"-3"), and of full sun to shade.
FORBS

*Chamaecrista (Cassia) fasciculata* (Partridge Pea)

Annual legume, 8"-16" tall, with yellow flower; grows on disturbed soils, roadides, pastures, and open woods. Has special value because of its ability to grow in disturbed soils; and as a companion to grasses in open sites. Reseeds as long as there is open soil.

*Potentilla canadensis* (Five-finger Cinquefoil)

Perennial prostrate evergreen vine, which stabilizes slopes by rooting at nodes along the elongated horizontal stem. Grows on poor soils under dry to intermediate moisture conditions, from full sun to open woods. Has yellow flowers, March to June.

FERNS

*Pteridium aquilinum* (Bracken Fern)

Perennial, upright fern, 18"-36" tall; spreads vegetatively to form colonies. Withstands dry conditions and full sun to semi-shade. Has a wide range of soil tolerance, but most often is found on sandy soils.

VINES

*Parthenocissus quinquefolia* (Virginia Creeper)

Deciduous woody vine with palmately-compound leaves which climbs trees but also creeps over the ground providing a semi-open groundcover. Grows in semi-shade to shaded situations in both upland and bottomland sites.

*Vitis rotundifolia* (Muscadine Grape)

Deciduous woody vine which may climb trees or creep over the ground, in wooded sites ranging from well-drained uplands to poorly-drained bottomlands, semi-shade to shade.

SHRUBS

*Satureja georgiana* (Georgia Basil)

Small deciduous shrub with branches and branchlets spreading laterally, 8"-18" tall. Has pinkish flowers in midsummer. Grows under dry to intermediate moisture conditions, from rocky or sandy slopes to levees along streams, almost full sun to semi-shaded sites. Native to Georgia and South Carolina Piedmont.

*Vaccinium vacillans* (Lowbush Blueberry)

Rhizomatous, deciduous shrub 8"-20" tall, often forming colonies in open dry woods; is present at a number of sites in study area, especially at Virginia sites.
The following list of nurseries/seed producers which specialize in the production of native seeds and plants is extracted from, *Nursery Sources of Native Plants of the Southeastern United States* by Jan Midgley, July 1993. Ms. Midgley may be contacted at 234 Live Oak Trail, Wilsonville, AL 35186, or by phone at (205) 669-4097. The list has been updated to July 1996, to insure that addresses, telephone, and fax numbers are accurate.

**KENTUCKY**

Shooting Star Nursery
444 Bates Road
Frankfort, KY 40601
Phone: (502) 223-1679

**MISSOURI**

Missouri Wildflower Nursery
9814 Pleasant Hill Rd.
Jefferson City, MO 65019
Phone: (314) 496-3492

**NORTH CAROLINA**

Boothe Hill Wildflowers
23B Boothe Hill Rd.
Chapel Hill, NC 27514
Phone: (919) 967-4091

Hoffman Nursery
5520 Bahama Rd.
Rougemont, NC 27572
Phone: (919) 479-6620
Fax: (919) 471-3100

Niche Gardens
1111 Dawson Road
Chapel Hill, NC 27516
Phone: (919) 967-0078
Fax: (919) 967-4026

We-Du Nurseries
Rt. 5, Box 724
Marion, NC 28752
Phone: (704) 738-8300
Fax:(704) 738-8131

**PENNSYLVANIA**

North Creek Nurseries, Inc.
Rt. 2, Box 33
Landenberg, PA 19350
Phone: (610) 255-0100
Fax: (610) 255-4762

**SOUTH CAROLINA**

Wavering Place Gardens & Nursery
Rt. 2, Adams Hayne Rd, Box 269
Eastover, SC 29044
Phone: (803) 783-1682
Fax: (803) 783-3177

**TENNESSEE**

Native Gardens
5737 Fisher Lane
Greenback, TN 37742
Phone: (615) 856-3350
Fax: (615) 856-0220
Guide to Sustainable Earthworks Management - 90% Draft
A diverse mix of native grasses can provide one of the best types of cover for earthworks that are presently in open, sunlit situations. The combination of erosion-controlling capability, relatively low management requirements, and aesthetic quality make this a logical cover for sites (1) which are currently mowed turf, (2) which have been planted to a single exotic species, or (3) which have recently been cleared for interpretive purposes.

In making recommendations for these three types of situations, the author is drawing on a comprehensive literature review, his own experience of the past two decades, and observations made in the field during the 1995 field reconnaissance of the seven subject parks. The amount of intervention necessary to establish a functional native grass cover on sites in the three categories above will of course vary. In all cases, however, the principle of minimum intervention for the specific set of conditions will be proposed.

As suggested in Chapter Six of this Handbook, the adoption of techniques that have not previously been applied to earthworks should be tried on an experimental basis initially. It must be recognized at the outset that specific climatic conditions are highly variable from year to year, so results are never 100% predictable.

Following are recommendations for establishing a predominantly native grass cover under three general sets of conditions that are likely to prevail.

**EARTHWORKS UNDER MIXED SPECIES, MOWN TURF**

This is the easiest situation to deal with, in terms of the amount of intervention required. It is targeted specifically at earthworks which currently have a variety of species as a cover, but which are mown to approximately two inches during the growing season. The management program for such earthworks centers around taking the following steps:

a. Raising the mowing height to 5"-6", permitting suppressed native grasses to develop.

b. Reducing the mowing frequency to once a month during spring and early summer for one or two growing seasons; and withholding any mowing after mid-July, in order to permit warm-season grasses to flower and produce seed.
c. In any bare areas, seeding with a mix of locally-collected grass seed (may be hand-collected by volunteers or student interns). Seeding may be done in hand-raked bare areas in fall (October-November) or spring (April-May). After seeding at a rate of 1/2 lb. per 100 square feet, rake seed in. Compact by tamping with a 4"x4" post, or simply by trampling the seeded areas by foot. Seed mix may contain three to five of the native grasses included in Section 3, matched with the conditions. It is strongly recommended that locally-harvested seed be used, to avoid introduction of varieties that are not adapted to local conditions.

d. As native grasses fill in bare areas, by the second or third growing season, mowing may be reduced to once a year, in late winter/early spring.

The best evidence that this technique will be effective is the fact that fields adjacent to mowed earthworks in several of the parks in this study have been converted to predominantly native grass cover simply by reducing the mowing frequency to once or twice a year at five inches or higher.

EARTHWORKS UNDER A SINGLE EXOTIC SPECIES

This technique is specifically targeted at earthworks which have been seeded to a monotypic cover of tall fescue. Conversion of this cover type to a native grass cover is more difficult because the existing cover is allelopathic (i.e., it inhibits the growth of other species through chemical interactions), and generally suppresses other species. Tall fescue has been identified by the Virginia Department of Conservation and Recreation as an “Invasive Alien Plant Species.” It is listed in that agency’s “most invasive” category, and as such, is a species which may “disrupt ecosystem processes, and cause major alterations in plant community composition and structure.”

Because of its invasiveness on the one hand, and its being subject to an endophyte fungus infection on the other, it would be desirable to revegetate earthworks under this cover to a mix of native grasses.

The steps leading to this conversion are as follows:

a. Mow the existing cover to a height of 4"-6" in late March to early April, or in mid-September.

b. After the tall fescue has shown new growth, spray with a glyphosate herbicide at a rate of two quarts per acre.

c. In May or October following the herbicide application, drill a mix of native seed mix into the soil. A Truax drill or equivalent is recommended, with two seed boxes: a fine seed box and a box for
large or fluffy seeds, and a maximum row spacing of 8". The drill should be equipped with trash rippers which will penetrate the vegetative mat and dig a furrow one inch wide and 1/2" deep. Seed is dispersed into the furrow, and a packer assembly compacts soil over it.

Seeding should be at a rate of 20 lbs. per acre PLS (Pure Live Seed). A mix ideally will include species in each of the following categories, in order to insure adaptability to the variable earthwork conditions:

- **Cool Season Grasses, e.g.,**
  - *Elymus virginicus* (Virginia Wildrye)

- **Warm Season Grasses, e.g.,**
  - *Andropogon ternarius* (Splitbeard Bluestem)
  - *Andropogon virginicus* (Broomsedge)
  - *Eragrostis spectabilis* (Purple Love grass)
  - *Tridens flavus* (Purpletop)

- **Warm Season rhizomatous grasses, e.g.,**
  - *Bouteloua curtipendula* (Sideoats Grama Grass)
  - *Panicum virgatum* (Switchgrass)
  - *Sorghastrum nutans* (Indiangrass)

Seed may be obtained commercially, but again, most of these species are present within many of the parks in this study in presently open fields. Field collecting from these fields by volunteers or student interns is preferable by buying the seed from distant sources.

d. During the first growing season, mow the newly-seeded area to a height of 5"-6" on approximately a monthly interval, to keep annual broad-leafed weeds from shading out the native seedlings, and to suppress any woody species which might appear.

e. During the second growing season, mow at 6" early in June and again in early July, permitting warm-season grasses to flower and produce seed during late summer and fall.

f. Thereafter, mow once each year, either in late fall or early spring. Early spring may be preferable because this treatment provides wildlife cover and the aesthetic benefits of the grasses in their winter colors of tan, copper and bronze.
RECENTLY CLEARED EARTHWORKS

This process is developed for earthworks that have been recently cleared and where bare soil now is exposed. An important consideration in such situations is the prevention of erosion. Therefore, the inclusion of one or more fast-growing annuals in the seed mix is highly advisable. Annuals provide early cover, but will not persist as perennial species develop. On many sites, there are seeds of annual grasses present in the soil (such as *Digitaria sanguinalis* and/or *Setaria* species) which serve a useful purpose as nurse crops, but which typically diminish in importance the second and third years after planting, just as they do in natural old field successional processes.

The establishment of a cover of predominantly native grasses in this situation includes the following steps:

a. Prepare site by cultivating to a depth of 3", in late April or early May for spring seeding, or in October for fall seeding.

b. Install seed immediately after cultivation, either drilling with a Truax drill, using the procedure outlined in “Earthworks Under a Single Exotic Species” above, or by broadcasting. Drilling with a Truax drill, as described above, has the advantage of planting the seed at a uniform depth. If the site is too steep for drilling, however, or if the appropriate equipment is not available, broadcasting the seed is a viable alternative. After broadcasting into the tilled seedbed, harrowing or hand-raking followed by compaction is recommended to insure good seed to soil contact.

Seed mixes for planting in this situation again should include at least three to five of the native grass species listed in Section 3. The combined weight of native grass seed, planted either by drilling or broadcast methods, should be 20 lbs./Acre. Additionally, annual species might be planted, at the following rates:

- *Lolium temulentum* (Annual Ryegrass): 10 lbs./Acre
- *Chamaecrista fasciculata* (Partridge Pea): 10 lbs./Acre

c. Mulch the seeded area either with hay from a local tallgrass-dominated field at a rate of one ton per acre or with clean oat straw at a rate of 1.5 ton per acre.

d. During the first growing season, mow to 5"-6" on approximately monthly intervals.

e. During the second growing season, mow at 6" in early June and in early July, permitting warm-season grasses to flower and produce seed.

f. Thereafter, mow once each year, either in late fall or early spring, to suppress woody species and to remove standing dead matter.

Guide to Sustainable Earthworks Management - 90% Draft
INVASIVE PLANT SPECIES AND
CONTROL MEASURES

Technical Support Topic Seven

A continuing problem in earthworks management is the invasion of plant species which tend to reduce plant diversity through their competitive ability or which diminish aesthetic quality and legibility due to their vigorous growth habits or coarse textures.

In this section, invasive plant species which were observed as problems in the seven subject parks are listed, along with possible control measures. Much of the information on control treatment is based on various authors' experiments or field observations which are compiled in *Compendium on Exotic Species*, published by the Natural Area Association. More complete documentation on the control measures summarized here may be found in that Compendium. For information on the results of on-going work on the control of invasive species, the reader is referred to current issues of *Natural Areas Journal* and to *Restoration and Management Notes*, both of which are cited in section eight.

**Elaeagnus umbellata** (Autumn Olive)

Native range: Japan, China, Korea

Introduced: 1830

Habitat: Disturbed upland areas, successional fields, open woods and forest edges.

Reproduction: Plants produce abundant seed crops which are spread by birds, raccoons, skunks, and opossums.

Control Treatments:

Mechanical: Pull plants when they are young and when soil is moist.

Mechanical / Chemical: Cut and paint stumps with a 10%-20% glyphosate solution in water, using sponge or sponge-type applicator, late in the growing season (i.e. July to September).

Note: Plants will resprout after burning, mowing, or cutting. Cutting at ground level without herbicide treatment of stumps is not effective.
**Festuca pratensis** (Tall Fescue)

Native range: Europe

Habitat: Pastures, abandoned fields, roadsides, grazed woods, along railroad tracks, levees and stream banks.

Reproduction: Seed. Forms dense solid stands, is allelopathic to many other species, and tends to reduce diversity where it develops.

Control treatments:

Mechanical: Mowing is ineffective

Burning: Late spring burning, repeated for several years, may gradually reduce Tall Fescue.

Chemical: A 1%-2% glyphosate solution, sprayed in early spring or late autumn when fescue is green but most other plants are not, is effective.

Biological: Infection by an endophyte fungus which suppresses Tall Fescue has been reported in Virginia and North Carolina by Stephen Capal of the Virginia Department of Game and Inland Fisheries. (This infection is occurring without being actively introduced as a management tool).

---

**Ligustrum sinense** (Chinese Privet)

Native range: China

Introduced: 1852

Habitat: Disturbed woods, fence rows, floodplains, old homesteads

Reproduction: Produces large numbers of black berries, which are ingested by birds, thus spreading seed.

Control treatments:

Mechanical / Chemical: Cutting and painting stumps with a 20% glyphosate solution has been found to be effective.
Chemical: Spraying with glyphosate solution during early spring or fall, when it is green but when most other species are dormant. May use fosamine herbicide if there is a desirable herbaceous vegetation present, since fosamine only affects woody species.

*Lonicera japonica* (Japanese Honeysuckle)

Native range: Japan

Introduced: 1806

Habitat: Thickets, fence rows, woodlands, meadows, prairies and roadsides.

Reproduction: Seeds transported by birds, root sprouting, rooting at nodes of runners.

Control treatments:

Mechanical 1: Pulling of young plants (less than 2 years old) can be effective.

Mechanical 2: Mowing twice in one growing season (about July 15 and September 15) prevented the spread of Japanese honeysuckle at an Ohio site.

Mechanical / Chemical: Cutting and painting stumps with a 20% glyphosate solution in water has been found effective.

Burning / Cutting: Burning in early spring, followed by cutting twice, in mid-to late summer has been found effective.

Note: A single cutting or single burn in one year has not proven effective in Japanese Honeysuckle control.
**Rosa multiflora** (Multiflora Rose)

Native range: Japan

Introduced: In 1866, as understock for ornamental roses. In 1930s, for erosion control and "living fences".

Habitat: Pastures, abandoned fields, hedgerows, open woods.

Reproduction: Abundant seeds eaten by birds and scarified in the digestion process; also rooting at ends of arching canes.

Control treatments:

Mechanical: Mowing annually in July has been found effective in keeping Rosa multiflora from spreading in a Pennsylvania study.

Chemical: Spraying of glyphosate solution in fall or spring has been found effective. However, it is non-selective, killing everything that is growing at the time. Fosamine herbicide is selective for woody species and may be suitable in situations where desirable herbaceous cover (e.g. grasses) exists.
Costs of vegetation establishment and management are subject to many variables, especially when non-traditional practices are used. The availability of volunteers, Americorps workers, or student interns can reduce the costs of such tasks as collecting seed, preparing seedbeds by hand-raking, hand-broadcasting seed, and compacting the soil after planting. Following are representative costs for plants or seeds of species recommended in this handbook.

**Grass Seedlings or Plugs**

Grass seedlings or plugs in flats, wholesale or contract-grown: $.50 to $.75 each. At 12" spacing, cost per acre, not including installation costs: $21,780 to $32,640 per acre.

**Grass Seed**

Commercially-grown grass seed, with a variety of species, ranges from $9.00 to $25.00 per lb., PLS (Pure Live Seed), depending on harvest method and abundance of seed. At an average estimated cost of $18.00 per lb. PLS, at a planting rate of 20 lbs./Acre, seed cost per acre, not including installation costs: $360.00 per acre.

**Seed Drill**

To drill seed of mixed species with seed ranging from fire, hard-coated seed to light, fluffy seed, along with cover crops, a special drill with multiple seed boxes is necessary. The drill should be capable of planting into an existing stubble (e.g. dead exotic grass stubble after herbicide), and compacting soil over seed in drill rows. Truax Seed Drill (available from Truax Company Inc., 3609 Vera Cruz Ave., N., Minneapolis, MN 55422; (612) 537-6639) is designed specifically for these purposes. Cost ranges from $12,500 for an 8-ft. wide drill to $19,000 for a 15-ft. drill.

**Site preparation costs**

(1994 data based on information obtained from Dave Shockley, Petersburg).

**Tree clearing**

Cutting trees at ground level, and grinding stumps to 4" below surface. Clearing a total of 78 trees, generally in trunk diameter range of 18"-30", under contract, total of $21,245 or $272 per tree.
Herbicide Treatments

Application of Garlon-3A on 1/2 acre at Fort Gregg: $719.
Application of Garlon-3A on 68,185 s.f. at Fort Wadsworth: $2156.
Application of Banvel CST, to 42 stumps, Fort Wadsworth (applied at rate of 1 ounce per inch of trunk diameter, 4.5 feet above ground): $958.
USEFUL REFERENCES FOR VEGETATION MANAGEMENT ON EARTHWORKS

Technical Support Topic Nine

Journals

Natural Areas Journal, published quarterly by the Natural Areas Association, P.O. Box 900, Chesterfield, Missouri 63006-0900.

Restoration and Management Notes, published twice yearly by the University of Wisconsin Press for the Society for Ecological Restoration. Journal Division, 114 N. Murray Street, Madison, WI 53711.

Restoration Ecology, the quarterly journal of the Society for Ecological Restoration, Blackwell Science, Inc. 238 Main Street, Cambridge, MA 02142.

Books and Reports


Minnesota Department of Transportation, Turf Establishment and Erosion Control Unit, Office of Environmental Services. 1993/94. Guidelines For Establishing Native Grasses and Forbs on Roadsides. Prepared by Robert L. Jacobson, Botanist, MN/DOT.


Archeological investigation can sometimes be the only way to determine the original form of an existing earthwork structure. Although few earthworks sites will actually be excavated, part of the preservation of all sites is the preservation of possible archeological resources. The following information will provide site managers with a basic understanding of where these resources are located and how, through prescribed maintenance, to best preserve them, thereby maintaining the potential for future archeological research.

Understanding the typical archeological profile of an earthwork structure is useful in understanding how archeological resources are distributed. Most all earthworks consist of two basic components, an excavated ditch and an earthen wall or parapet. At the time of construction, soil would have been excavated from the ditch and piled to create an adjacent parapet.

Typically, erosion occurred quickly in the years following the abandonment of a site. Over time, soil from parapets as well as from naturally higher ground would have been eroded through the forces of wind, water, and gravity to at least partially fill the ditch. As parapets eroded away and ditches were filled in, the overall relief of most earthworks features was greatly reduced. Factors such as the steepness of slopes, soil texture, vegetative cover, and land use effected how quickly this process progressed on different sites. In sites which returned to agricultural use, erosion rates would have been increased with repeated working of the land increased the amount of leveling which occurred. As vegetation colonized most abandoned earthworks, levels of erosion generally stabilized.

In-fill, deposited in ditches and downhill from earthworks forms in a series of geologic lenses or strata. These lenses appear as mottled remixed soils and tend to be dominated by silts. This is because the small silt particles tend to be moved most easily by erosive forces. Larger particles often settle out in place on the slopes as the smaller particles are moved down slope by water and wind. This in-fill can be made up of distinct soil lenses, each one representing an erosional episode, or it can be a much more homogenous blend. However, the point at which this disturbed soil meets the undisturbed soil below is generally more distinct. This boundary is where the most archeological evidence of the form and function of the earthwork is found.
Understanding where archeological resources are located can help in determining what types of maintenance activities may be harmful to them and jeopardize both their preservation and the future potential for study. Future archeological investigation of a site would depend on two primary types of information. First, analysis of soil layers helps to establish the original profile of an earthwork structure. Second, analysis of artifacts and where they are found within the soil helps to determine how the earthworks were used.

Maintenance activities that significantly displace soil, thereby destroying this information, or activities that leave soil vulnerable to erosion, would have a significant detrimental effect on archeological resources. Minor disturbance of the soil surface for the purpose of vegetation establishment would in most cases be preferable to leaving earthworks in a condition that would allow continued erosion.

Removal of hazard trees is an example of another maintenance activity which may disturb surface soils, but would be preferable to having major soil displacement occur in a windfall event. Special care should be taken in falling trees on or near earthworks to prevent gouging by equipment or falling branches.

The following considerations would apply to maintenance or repair activities conducted on any earthworks sites:

1. Test any experimental establishment or maintenance techniques on a small section of an earthworks site, or in another location with similar conditions if available.

2. If repairing holes in earthworks caused by fallen trees, burrowing animals, or other causes, use soil from a sterile source, i.e., soil which would not contain artifacts that could be taken out of context.

3. If doing any major stabilization work, have an archeologist or site curator on the project planning team to assist in proactively planning for resource protection.
BOARDWALKS AND VIEWING PLATFORMS FOR EARTHWORKS

Technical Support Topic Eleven

(To be developed for inclusion in the completed document)
BIBLIOGRAPHY


Mahan, Dennis Hart. *A Treatise on Field Fortification, Containing Instructions on the methods of laying out, constructing, defending, and attacking Entrenchments, with the General Outlines also of the Arrangement, the Attack, and the Defense of Permanent Fortifications.* New York: John Wiley, 1863.


INTRODUCTION

In this appendix, a review of the methods employed in the current study will be provided. This will be followed by a summary evaluation of current conditions of earthworks in the seven subject parks, based on late summer and fall observations made in 1995. Special attention will be given to those earthworks on which the 1989 *Manual's* recommendations were adopted to some degree.

METHODS

The initial activities associated with this project included familiarization with the 1989 *Manual* and an orientation to the project at an introductory meeting at Colonial National Historical Park in Yorktown, Virginia, with representation from the Park Service including staff from each of the seven subject parks:

- Richmond National Battlefield, Richmond, Virginia
- Colonial National Historical Park, Yorktown, Virginia
- Fredericksburg National Military Park, Fredericksburg, Virginia
- Petersburg National Battlefield, Petersburg, Virginia
- Ninety-Six National Historical Site, Ninety-Six, South Carolina
- Stone’s River National Battlefield, Murfreesboro, Tennessee
- Kennesaw Mountain National Battlefield, Marietta, Georgia

After this earliest orientation, the following sequence of activities was conducted: (1) field observation and data collection; (2) analysis and evaluation of field-collected data; (3) review of relevant literature of landscape management and restoration techniques; and (4) development of the *Handbook*, including information on methods and techniques for earthworks management planning and implementation.

Field Observation and Data Collection

A key step in developing an understanding of the range of earthworks and their conditions under different levels of interpretation and management was to visit each of the subject parks and, within each park, a representative cross-section of earthworks. These visits were carried out during the last ten days of August 1995 for the four Virginia battlefield parks included in the 1989 study and in September-October 1995 for the South Carolina,
Tennessee, and Georgia units, which are included additionally as Southeastern parks that are actively managing earthworks.

During this phase of the project, one or more staff members in each park provided an orientation, with a reconnaissance of representative sites within the respective parks. Staff members also provided information on the current earthwork management practices within a range of different site conditions, from highly-interpreted and managed sites to non-interpreted sites in secondary successional forests, requiring a minimum of management. This orientation was followed by field data collection, which ranged from quantitative quadrat sampling (see Figure A.1) to qualitative visual observations at other representative sites within each park.

Figure A.1. Example of quadrat for vegetation sampling. Star Fort slope, Ninety-Six National Historic Site, September 1995.

At sites where one-meter-square quadrat sampling was done, the plots were distributed in such a manner as to insure objective sampling; e.g., twenty plots were placed a uniform number of paces apart, to gain a representative look at the vegetative cover, as opposed to subjectively selecting sample plots. In such quadrat studies, the following measures were recorded:

a. % cover of living herbaceous plants (as viewed from 3' above, looking straight down)

b. % cover of living woody plants

c. % cover provided by non-living "litter" (standing dormant material and fallen leaves, stems or clippings)
d. % bare soil  
e. % tree canopy overhead, where applicable  
f. Number and identity of species present  

In addition, slope orientation, evidence of wildlife (e.g., groundhog) impacts and obvious human impacts (e.g., trampling and compaction of soil, and erosion) were noted.

Where qualitative visual observations were made, the following characteristics were noted:

a. Approximate tree canopy cover percentage  
b. Checklist of dominant (canopy) species present  
c. Checklist of prevalent understory and/or groundlayer species present  
d. Notable signs of erosion, and wildlife or human impacts

Throughout the field observation and data collection phase of the project, particular attention was given to noting plant species which appear to have potential as vegetative cover in a variety of microhabitats, e.g., those growing under different percentages of canopy cover; those which are capable of growing on dry, sandy exposed sites; those which tolerated mowing at various heights; and those which are capable of colonizing on recently-disturbed bare sites. These plants are incorporated and noted in Appendix A at the end of the Handbook. Some of these plant species are commercially available at present; others are not commercially available, but could be propagated experimentally from field-collected seed, by NPS, interested commercial growers, or possibly the Natural Resource Conservation Service (NRCS) of the U.S. Department of Agriculture.

Black-and-white photographs, as well as slides, were taken at all fieldwork sites. These provide: (1) a basis for analysis and evaluation, (2) illustrations for this and other publications emanating from the project, and (3) a semi-permanent record of the late summer/early fall 1995 conditions at the subject earthworks, with which future photographs may be compared.

Analysis and Evaluation

This phase of the project entailed, first, the compilation of field data at each site where quantitative data were recorded. From such data, the following specific analytic measures were obtained:

a. Frequency of occurrence of all species noted, expressed as a percentage, i.e., the number of plots within which a particular species occurred, divided by the total number of plots observed at the particular site.
b. Average percentage of aerial cover in all plots at a particular site, broken into the following categories:

- Herbaceous species
- Woody species
- Litter (dead plant material, fallen leaves and clippings).

c. Average percentage of bare soil.

d. Species diversity: the number of plant species in each square-meter quadrat, and average diversity in all quadrats at a particular site.

e. Average percentage of overhead tree canopy for wooded sites.

These data, along with descriptive notes recorded at each of the visited sites, were correlated with photographic documentation of earthwork characteristics in the field as a basis for evaluating the condition of the subject earthworks.

From the aggregated observations, a quantitative evaluation system for rating the condition of specific earthworks sites was devised. The first step in developing this system was to determine the criteria for evaluation and the relative weight assigned to each criterion, or category. The criteria, along with the relative value for each criterion, are shown in Table A.1.

<table>
<thead>
<tr>
<th>Weight</th>
<th>Criterion Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
<td>The degree of protection from soil erosion, based on the amount of cover provided by living vegetation and organic litter (dormant standing cover, fallen leaves, twigs, and clippings). The greater the cover percentage, the higher the rating.</td>
</tr>
<tr>
<td>10%</td>
<td>The average species diversity within sample plots. The greater the diversity, the higher the rating.</td>
</tr>
<tr>
<td>10%</td>
<td>The prevalence of persistent invasive species. The lower the presence of invasive species, the higher the rating.</td>
</tr>
<tr>
<td>10%</td>
<td>Visual quality and earthworks legibility. Consistency of vegetation texture and scale, in combination with the &quot;readability&quot; of the form of the earthwork, contribute to a higher rating.</td>
</tr>
<tr>
<td>10%</td>
<td>Human use and wildlife impacts. The less obvious and less damaging these impacts, the higher the rating.</td>
</tr>
<tr>
<td>10%</td>
<td>A &quot;sustainability&quot; rating, based on the number of treatments per year (e.g., number of mowings or burnings, and fertilizer or herbicide applications) required to maintain the earthwork. The fewer treatments per year, the higher the rating.</td>
</tr>
</tbody>
</table>

Table A.1. Criteria for Evaluating Earthworks and Relative Weights
Within each criterion category for evaluation, a rating scale of 1 to 5 was devised. This rating is, in spite of its numerical orientation, subject to some interpretation, especially in the “Visual Quality and Legibility” category. Nevertheless, when applied by one team across several sites, this method of evaluation provided a useful basis for comparison of earthwork conditions on a scale which ranges from 20 for the worst condition to 100 for the “perfect” score. See Table A.2 for a complete breakdown of the bases for rating within the six major criterion categories.

<table>
<thead>
<tr>
<th>Criterion Category</th>
<th>Rating Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover as indication of erosion control (x 10):</td>
<td>5 pts. - &gt;80% living cover</td>
</tr>
<tr>
<td></td>
<td>4 pts. - &gt;80% living cover &amp; mulch/litter</td>
</tr>
<tr>
<td></td>
<td>3 pts. - 60-80% cover</td>
</tr>
<tr>
<td></td>
<td>2 pts. - 40-60% cover</td>
</tr>
<tr>
<td></td>
<td>1 pt. - &lt;40% cover</td>
</tr>
<tr>
<td></td>
<td>Maximum points possible: 50</td>
</tr>
<tr>
<td>Average species diversity (x 2):</td>
<td>5 pts. - &gt;8 average species per square-meter quadrat</td>
</tr>
<tr>
<td></td>
<td>4 pts. - 6-8 average species</td>
</tr>
<tr>
<td></td>
<td>3 pts. - 4-6 average species</td>
</tr>
<tr>
<td></td>
<td>2 pts. - 2-4 average species</td>
</tr>
<tr>
<td></td>
<td>1 pt. - 1-2 average species</td>
</tr>
<tr>
<td></td>
<td>Maximum points possible: 10</td>
</tr>
<tr>
<td>Presence of aggressive, persistent exotics (x 2):</td>
<td>5 pts. - None observed</td>
</tr>
<tr>
<td></td>
<td>4 pts. - &lt;25% frequency of exotics</td>
</tr>
<tr>
<td></td>
<td>3 pts. - 25-50% frequency</td>
</tr>
<tr>
<td></td>
<td>2 pts. - 50-75% frequency</td>
</tr>
<tr>
<td></td>
<td>1 pt. - &gt;75% frequency</td>
</tr>
<tr>
<td></td>
<td>Maximum points possible: 10</td>
</tr>
<tr>
<td>Visual quality and legibility (x 2):</td>
<td>5 pts. - Legible earthwork form; attractive</td>
</tr>
<tr>
<td></td>
<td>4 pts. - Generally legible; discordant spots</td>
</tr>
<tr>
<td></td>
<td>3 pts. - Partially legible; discordant spots</td>
</tr>
<tr>
<td></td>
<td>2 pts. - Generally &quot;rough&quot;; inconsistent</td>
</tr>
<tr>
<td></td>
<td>1 pt. - Chaotic and illegible</td>
</tr>
<tr>
<td></td>
<td>Maximum points possible: 10</td>
</tr>
<tr>
<td>Presence of negative human/animal impacts (x 2):</td>
<td>5 pts. - Neither evident</td>
</tr>
<tr>
<td></td>
<td>4 pts. - Minor trampling or animal burrowing</td>
</tr>
<tr>
<td></td>
<td>3 pts. - Major trampling or burrowing</td>
</tr>
<tr>
<td></td>
<td>2 pts. - Both trampling and burrowing evident</td>
</tr>
<tr>
<td></td>
<td>1 pt. - Extreme impact (e.g., ATV compaction)</td>
</tr>
<tr>
<td></td>
<td>Maximum points possible: 10</td>
</tr>
<tr>
<td>Maintenance/management treatments required (cutting, mowing, burning) (x 2):</td>
<td>5 pts. - One treatment annually or less</td>
</tr>
<tr>
<td></td>
<td>4 pts. - 2-4 treatments per year</td>
</tr>
<tr>
<td></td>
<td>3 pts. - 5-6 treatments</td>
</tr>
<tr>
<td></td>
<td>2 pts. - 7-8 treatments</td>
</tr>
<tr>
<td></td>
<td>1 pt. - &gt;8 treatments</td>
</tr>
<tr>
<td></td>
<td>Maximum points possible: 10</td>
</tr>
<tr>
<td>Overall Rating</td>
<td>90-100 pts. - Highly Successful</td>
</tr>
<tr>
<td></td>
<td>80-89 pts. - Successful</td>
</tr>
<tr>
<td></td>
<td>70-79 pts. - Acceptable</td>
</tr>
<tr>
<td></td>
<td>60-69 pts. - Reevaluation needed</td>
</tr>
<tr>
<td></td>
<td>&lt; 60 pts. - Unacceptable</td>
</tr>
<tr>
<td></td>
<td>Total Maximum Points Possible: 100</td>
</tr>
</tbody>
</table>

Table A.2. An Evaluation System for Rating Earthworks
Literature Review

Concurrently with the analysis and evaluation phase of the project, a review of recent literature was conducted, with emphasis on: (1) landscape restoration and management techniques; (2) control of invasive species (especially persistent woody species); and (3) those plant species which show particular potential as protective cover for earthworks, based on their observed presence on or near existing earthworks in the subject parks. Especially relevant to this research were the following journals: *Restoration and Management Notes, Restoration Ecology,* and *Natural Areas Journal.* These journals, as well as publications from several public agencies, indicate that the experience and information base on land management practices for difficult sites is broadening.

Earthworks Management Field Handbook. This Handbook represents the culmination of the project to date, incorporating observations and information gained in the various phases outlined above, and providing recommendations regarding planning for and implementation of earthworks management practices.

OVERALL CONDITION OF EARTHWORKS AT SELECTED SITES

The earthworks in the seven parks that are the subject of this project fall along a broad range of the types outlined in Chapter Three. There is also a wide range of environmental contexts within which these earthworks occur in terms of soils, slopes, moisture, and vegetative cover. The intensity of use for interpretation and recreational purposes similarly spans a wide range, as does the degree of landscape maintenance or management activity. Categories of the intensity of interpretation and management include: (1) protected earthworks, with little interpretation or management, usually in secondary forest cover; (2) intermediately-managed earthworks where vegetation may be managed to increase the legibility of earth forms, usually within a secondary forest context; and (3) intensively-visited and interpreted sites that have been cleared or partially-cleared at some time in the past, with management activity devoted to keeping them cleared, and oftentimes to maintaining a manicured or semi-manicured appearance.

To the extent that widely varying situations permit, the following is a summary of the condition of representative earthworks in each of the three categories outlined above, based on observations and data collected in late summer and fall of 1995.

Protected Earthworks

In general, as noted in the 1989 Manual, those earthworks that have been permitted to develop a secondary forest cover during the period since the respective Revolutionary or Civil War battles occurred, are in excellent to good condition now (see Figure 4.2). The combination of a protective tree
canopy of 70%-90% when trees are in leaf, a variety of midlayer saplings and/or shrubs, and a groundlayer which often includes living herbs and vines, as well as a deep litter layer including slow-to-decompose oak leaves, provides excellent protection against erosion. The exceptions to the generally high level of protection on re-forested earthworks occur: (a) where heavy-impact recreational uses, e.g., use of “dirt bikes,” have resulted in vegetation removal, soil compaction and gully erosion; (b) where large trees growing on earthworks have blown down in windstorms, bringing up large tip-up mounds of roots and soil from the earthworks (See Figure 4.3) and (c) where groundhogs have burrowed in the earthworks, bringing soil from within to the surface, and compacted bare soil outside the entrances.

Intermediately-Managed Earthworks

The majority of these earthworks tend to be in good condition because they too usually have canopy cover overhead, and at least some shrub or vine cover, living groundcover, and leaf litter (See Figure 4.4). By virtue of greater visibility and accessibility associated with these earthworks, there is an increased likelihood of use by park visitors and recreationists. If activities such as hiking and jogging, occur directly on the earthworks, they lead to compaction and erosion.

The potential for uprooting of trees on these earthworks is again a problem. However, when the management involved in these intermediately-managed sites entails cutting of shrubs and saplings to a height of two to three feet, there are two positive effects: an increase in the density of shrub growth, and a long-term reduction in large trees, with their potential for blow-downs, growing directly on earthworks (See Figure 4.5).

Cleared or Partially-Cleared Earthworks with More Intensive Interpretation and Management Programs

On earthworks in this category, there is a whole spectrum of different conditions reflecting past and current management activities, as well as different interpretive goals. Based on the evaluation system explained earlier in this chapter (see Tables 1 and 2, pages 9-11), nine specific earthworks sites in this category rated from 66 to 92 points on the 100-point scale, with a median score of 76, or in subjective terms, an “acceptable” condition.

On frequently-mown earthworks that are treated very much like lawns, e.g., those at Fredericksburg’s Prospect Hill and Bloody Angle, the cover is almost totally comprised of herbaceous plants, including a variety of native and non-native grasses and low rosette-forming plants (See Figures 4.6 and 4.7). Woody plants are almost non-existent. During the dry period of late August 1995, the appearance of such sites was that of a spotty lawn, especially where sloping earth forms and sandy soil create very xeric conditions. Maintenance requirements for this earthworks treatment are high, with bi-weekly mowing during a normal season. The frequent, low mowing increases the chances
for physical damage from the mowing activity each time it occurs. Further, the very low cover does nothing to inhibit visitors' walking on the earthwork. Taller vegetation occurs on a number of non-forested earthworks in the subject parks, either as a result of changes in the mowing frequency and height, or of the active planting of warm-season native grasses as seedling "plugs" or as a seed mix. These various approaches to establishing a cover dominated by native warm-season grasses are to varying degrees in response to the recommendations made in the 1989 Manual (See Figure 4.8).

The most direct adoption of Manual recommendations is at Richmond National Battlefield Park, where the installation of Little Bluestem seedlings was initiated in 1989 and 1990 on several different earthworks at Fort Harrison, on sites with varying light conditions ranging from full sun to semi-shade. During the period from 1990 through 1992, woody species were mechanically removed from these plantings by cutting or pulling. Very little management activity occurred between 1992 and 1995, when a prescribed burn was initiated on April 20. During the interim, a dense growth of woody plants, both native and non-native, colonized on the unmowed earthworks. The fire had a suppressing effect on the woody plants, but herbaceous species (Little Bluestem in combination with approximately ten other species) provided only about 20% average cover in sample plots within the burned area in late August 1995. Bare soil occupied an average of 30%. (See Figures 4.9 through 4.12).

At Ninety-Six National Historic Site in South Carolina, seeding of a mix of native grasses and a legume was initiated in the spring of 1994 on the Revolutionary War Star Fort and restored siegeworks. No management activity occurred during the 1994 growing season, but monthly mowing at a six-inch height was initiated during the summer months of 1995. A high percentage of live herbaceous cover was noted in the seeded areas in September 1995, comprised predominantly of grasses. One of the major components was the annual, Crabgrass (Digitaria sanguinalis), a characteristic early successional species in Southeastern Piedmont fields once cultivation ceases. It is expected that a continuing program of monthly mowing at a six-inch height during the spring and early summer will permit increasing dominance of perennial grasses, both of species that were seeded in the spring of 1994, and other species whose seed is present in the soil (See Figures 4.13 and 4.14).

At Fortress Rosecrans at Stone's River National Battlefield Park in Tennessee, a native warm-season grass seeding was done in the fall of 1994 on a site that had previously been a forest with a dense understory growth of Privet (Ligustrum sinense). The tree canopy had been thinned and the Privet removed prior to seeding. Later during the fall of 1994, the warm-season native grass seeding was over-seeded with Tall Fescue (Festuca pratensis), a cool-season exotic grass. In September of 1995, the seeded area had only a
small percentage of bare soil, but a large presence of woody species’ seedlings (See Figure 4.15). The living herbaceous plant cover, which averaged 56.5% in twenty sample quadrats, was overwhelmingly dominated by Tall Fescue. This reflects the phenomenon of allelopathy, whereby one plant species releases chemicals which inhibit the growth of others. In recent research on grassland restoration, reported in Restoration and Management Notes, it has been observed that Tall Fescue inhibits the colonization of native warm-season grasses. In the future, a determination will need to be made regarding the potential of destroying the Fescue and re-establishing warm-season native grasses. Also, a mowing program will be necessary to suppress the growth of numerous woody seedlings on the Fortress, especially those of Privet.

In some of the battlefield parks included in this study, there have been no programs to actively introduce native warm-season grasses, but reducing the mowing frequency and/or raising the height of mowing has facilitated the development of a diverse cover of predominantly native, warm-season grasses.

At Colonial National Historical Park at Yorktown, Virginia, for example, the mowing of the major earthworks near the Visitor Center has been reduced to once per year, and is done with a boom-arm mowing unit. The mowing of these earthworks is typically done during late summer, at a height of two inches or less. The resultant cover is diverse, with an average of 7.1 species recorded in twenty quadrats, comprised of a mix of native and non-native grasses and forbs along with woody plants such as Japanese Honeysuckle and Blackberry. Average cover by herbaceous plants in the plots was 39% just prior to the summer 1995 mowing, with a 16.5% cover by woody species. Average bare soil per meter-square quadrat was 26% in the sampled area. Species distribution varied with the position on the slope, with a greater frequency of native warm-season grasses on the upper slopes, and a greater frequency of Japanese Honeysuckle and Blackberry on the middle and lower slopes (See Figures 4.16 through 4.18).

For the purpose of increasing the percentage of cover by warm-season grasses, it would be beneficial to change the annual mowing to May-June, and to raise the mowing height to six inches, since many of the warm-season native grasses are damaged by short mowing. If these options are not practicable because of interpretive needs, an alternative would be to supplement the existing cover with a sod-forming native grass which is tolerant of shorter mowing, Sideoats Grama Grass (Bouteloua curtipendula), whose seed could be introduced into bare patches.

At Petersburg National Battlefield Park in Virginia, a variety of approaches to clearing and revegetation have been followed, and have been well-documented in terms of procedures and costs. At Battery Five, near the Petersburg Visitor Center, the floor continues to be mowed weekly during the growing season at 2"-3". Contrasting with this, the earthwork berms are
now being mowed approximately on a monthly basis at a height of 5", using a Dew-Eze self-levelling mower. In August of 1995, in sample plots on Battery Five, herbaceous cover averaged 31.5%, woody cover averaged 17.7%; organic litter accounted for almost 43% of the cover. Species diversity averaged 7.5 species per quadrat. Warm season grasses are invading the berms, especially the upper slopes. There is a seed source of these in an annually-mown field adjacent to the Battery (See Figure 4.19).

At Fort Gregg (Petersburg) during 1992-93, a major clearing project was executed, cutting trees and shrubs and treating with glyphosate herbicide to kill sprouts. Topsoil was applied to 1"-2" in eroded areas, and bare spots were seeded with Tall Fescue, mulched, and a jute mesh was applied on steep slopes. Unlike Battery Five, Fort Gregg does not have a nearby source of native warm-season grass seed, and provides the opportunity to observe whether such species will invade without introducing them. At Fort Wadsworth (Petersburg), in 1994, a clearing project similar to that at Fort Gregg was carried out. After clearing, the entire earthwork was hydroseeded with Tall Fescue. This cover is presently being maintained with periodic mowing at 3", liming and fertilizing, and watering during dry periods.

In summary, there is a very wide range of conditions on earthworks. The greatest challenge, management-wise, are those earthworks that have been cleared at some time, where the overall condition is oftentimes rated only in the “fair” to “good” range. This reinforces the importance of recognizing that presently-wooded earthworks sites should be cleared only after careful consideration of the long-range management implications and continuing resource needs.
INTRODUCTION

As noted in the Introduction to this Handbook, the 1989 Earthworks Landscape Management Manual was conceived as the first step toward developing a comprehensive approach to planning and management of earthworks in battlefield parks within National Park Service jurisdiction. As a first step, it is subject to review and evaluation as more experience is gained and as new information is accumulated. In this section of the Handbook, a review of the 1989 Manual is provided, with the perspective gained from six more years of earthwork management experience in the parks, where projects were initiated based on the Manual and from the growing body of literature on landscape restoration and management. This critique is intended purely as a constructive one, identifying areas where additional experience and information either supports the 1989 recommendations or raises questions about them. Next, modifications or additions that can further advance the art and science of earthworks management are suggested. These observations are based on field data collected in late summer and fall of 1995 in the seven subject parks, and on (sometimes extensive) discussions with NPS staff involved in earthworks management, particularly on sites where 1989 recommendations were adopted to some degree.

The Manual is an important document, in that it provides useful information about the evolution and effects of different earthworks management practices up to the time of its 1989 publication. It also developed a typology of vegetative cover types with a generalized evaluation of the effectiveness of these different cover types. Furthermore, the Manual provides generalized management guidelines and more specific plans for two sites, Fort Fisher at Petersburg and Cold Harbor at Richmond. The final section of the 1989 Manual, “Management Guidelines for the Restabilization and Revegetation of Damaged Ground Surfaces,” provides a summary of bioengineering techniques (e.g., the use of live stakes, fascines, branch-packing, brush layering) for re-stabilizing eroded areas on earthworks.

The 1989 Manual recommendations have been adopted or adapted for earthworks vegetation management in an uneven manner at the study parks. Park personnel indicate that the bioengineering techniques identified in the Manual have been minimally utilized in their management practices. This may relate to the labor-intensive nature of such practices, but it also reflects a reluctance to utilize techniques which are invasive of the earthworks soil.
Furthermore, except in forested areas, the woody plant species recommended in bioengineering practices would diminish the legibility and textural consistency that is desirable on interpreted earthworks.

Recommendations in the Manual to establish warm-season grass cover on interpreted sites have been adopted to various degrees. In one park, active planting of Little Bluestem “plugs” was accomplished in 1990 and 1991. At others, a reduced mowing program has contributed to the development of a more diverse cover that includes “volunteer” warm season native grasses, with far fewer resources devoted to mowing.

The following review will summarize (1) strengths of the 1989 Manual and (2) portions of the Manual where revisions or modifications appear warranted and (3) areas requiring additional information.

**STRENGTHS OF THE 1989 MANUAL**

The 1989 work has served a very valuable role in raising awareness of the earthworks as irreplaceable resources, and of the complexities of balancing interpretive objectives with natural and cultural resource protection within a Federal agency in an era of changing management goals and diminishing or uncertain funding.

The Manual provides a set of “Guidelines for Earthworks Preservation” (pages B-6 and B-7) which includes particularly relevant perspectives on: (a) the need to monitor and evaluate management practices on a relatively small scale before they are applied on a larger scale (Guideline 3); (b) the fact that “no increase in the level of management required should be initiated unless it can be completed properly, adequately followed through, and maintained over time” (Guideline 5); (c) recognition of the need for annual monitoring (Guideline 6); and (d) noting that “the principle of ‘economy of intervention’ should be followed to minimize unnecessary effort and disturbance.”

Also, Section B of the Manual, the “Interpretive & Management History of the Earthworks” (pages B-8 through B-15), provides valuable discussions of such issues as: (a) the importance of keeping visitors off earthworks; (b) the threats to earthworks posed by the presence of large trees on the berms; (c) the conflicts inherent in historic scene restoration within rapidly urbanizing areas; and (d) the importance of experimentation with new techniques on demonstration projects which are monitored and evaluated in an on-going manner. These discussions are as relevant in 1996 as they were in 1989, as efforts to improve management practices continue.

Section C of the Manual is on “Evaluation of Existing Vegetative Cover Types,” divided into Forest Cover types, Field Cover types, and Special Conditions, based on observations in the four Virginia parks in this study. The observation that “the earthworks under forest cover are the most well

---

Guide to Sustainable Earthworks Management - 90% Draft
stabilized" is verified in 1995 observations. However, the Manual is correct in stating that earthworks under forest cover are subject to damage by trampling, erosion, and wind-thrown trees. Discussions of "Cleared Woodlands," "Rough Grass" and "Turf" accurately depict the problems associated with these increasingly manipulated cover types.

Section D of the Manual outlines "Recommended Vegetative Cover Types: Forest Cover, Light Forest Cover, Tall Grass Cover, and Turf Cover." In the Forest Cover Type, the Manual correctly points out the need to control access to earthworks in this condition or to provide slightly elevated boardwalks over earthworks to minimize impact. The discussion of Tall Grass Cover also correctly points out the fact that a tall grass cover will discourage trampling while still permitting visual access. It also recognizes the need for mowed paths that are located on level ground adjacent to earthworks with a minimum number of crossings, which again might be handled with slightly elevated boardwalks. This same section acknowledges that agricultural pasture or hayfields may be a logical cover in certain historic scene re-creations, but that these alternatives are not appropriate on actual earthworks. Section D closes with the point that turfgrass cover should be reduced, on earthworks and adjacent lands, due to the high costs and non-sustainability of this type of cover.

Sections F, G and H constitute the recommendation sections of the 1989 Manual. The importance of monitoring and evaluation is reiterated in Section F, but procedures for monitoring and recording observations are unclear (see 2., AREAS FOR MODIFICATION, below). Section G, "Management Guidelines for Recommended Forest Types," contains interesting commentary on such topics as forest configuration; natural processes and forest structure; and techniques such as prescribed burning, clearing, liming, and additional planting without specific information on how a park might apply these techniques.

Section H provides "Management Guidelines for Recommended Field Cover Types: Tall Grass and Turf." It is correctly observed that for the most part, the pre-Columbian Mid-Atlantic and Southeastern landscapes were naturally forested, and if permitted to, most presently open landscapes would become wooded ones today, albeit with a mixed composition of native and non-native species. Hence, to keep earthworks in an open, non-forested condition requires active management. This section again provides background information on configuration, natural processes and structure, but actual guidelines for field evaluation or application are difficult to winnow from the text (see 2., AREAS FOR MODIFICATION, below). Section H also includes information on establishing tall native grasses. Useful suggestions in this section include the use of a cool-season "nurse" crop in the seed mix for early protection against soil erosion, and the use of mowing during the first growing season to suppress competing species.
AREAS FOR MODIFICATION OF THE 1989 MANUAL

As suggested in the enumeration of the strengths of the 1989 Manual, it served a number of useful purposes in terms of its review and critique of then-current management practices in the four battlefield parks, its discussion of ecosystems and their dynamics, its development of a management planning approach, and its outlining of recommendations on the establishment or management of different cover types on earthworks.

At the same time, the recommendations in the Manual have not been widely adopted, because of a park’s inability to assess its earthworks condition or needs based on the Manual. When they have, the results have not been uniformly effective, as noted later in this chapter under “Overall Condition of Earthworks.” Hence, in the pages that immediately follow, we will identify areas in the 1989 Manual which might, with the experience and information gained since 1989, be reconsidered and revised, and other areas where additional information appears to be needed by managers in the field.

A recurrent question that arises in reviewing the Manual relates to the heavy reliance on one species of grass, Little Bluestem, in creating the Tall Grass Cover Type. The first reference to this occurs on page D-4 of the Manual, where it is correctly noted that its Latin nomenclature has changed from Andropogon scoparius to Schizachyrium scoparium. It is suggested that this grass is locally referred to as Broomsedge or Broomsage, a common name that is also used for Andropogon virginicus, probably the most abundantly-occurring and most visible native grass on impoverished soils of the Piedmont.
regions of the Southeast. During the August 1995 fieldwork phase of this project, it was noted that in fields where mowing has been reduced to once a year (e.g., adjacent to Battery Five at Petersburg; on Prospect Hill at Fredericksburg), a diverse mix of native grasses and forbs has developed. This was noted in a walk-through survey at the Prospect Hill and Petersburg sites. (see Figures B.1 and B.2). Following are native grasses noted at each site during those surveys:

Prospect Hill Field, Fredericksburg

*Andropogon ternarius* (Splitbeard Bluestem)
*Aristida purpurascens* (Arrowfeather Three-awn)
*Erianthus* spp. (Plumegrass)
*Paspalum* spp. (Paspalum)
*Schizachyrium scoparium* (Little Bluestem)
*Sorghastrum nutans* (Indiangrass)
*Tridens flavus* (Purple Top)

Visitor Center, Petersburg

*Andropogon ternarius* (Splitbeard Bluestem)
*Andropogon virginicus* (Broomsedge)
*Andropogon virginicus glauca* (Broomsedge)
*Panicum* spp. (Panic Grass)
*Paspalum* spp. (Paspalum)
*Schizachyrium scoparium* (Little Bluestem)
*Tridens flavus* (Purple Top)

Figure B.2. Native grass field, mowed annually in fall, near the Visitor Center, Petersburg National Battlefield Park, August 1995.
It would seem logical that for earthworks in the same parks, these diverse stands would serve as a model for planting the tall grass cover type, as opposed to planting only one or two species.

On page D-4, it is also noted that “almost any open site with 40% or less tree cover can be stabilized with native grasses. In fact, the *Andropogons* and *Schizachyrium* need almost full sun to thrive as noted in the USDA publication, *100 Native Forage Grasses in 11 Southern States*. Other species of grasses, however, can tolerate the partial shade represented by a 40% canopy, as noted in the same publication.


On page D-7, the comment is made that the “major obstacle in establishing this [tallgrass] cover type is the limited experience in creating and managing meadows.” In fact, research has been going on since the 1930s in prairie restoration at the University of Wisconsin Arboretum and since the 1960s at the Morton Arboretum. A number of state transportation departments have subsequently worked on stabilization of steep slopes, using native grasses. This experience is particularly applicable in earthworks management. While much of the early work was done in the Midwest, techniques for establishment are transferable to other regions, using species native to those regions (and a surprisingly large number of species occur in sunlit openings throughout a wide range, from the Midwest to the geographic area covered by this study).

Regarding costs, the claim is made on page E-6 that “almost without exception, the recommendations made herein are cheaper, more cost effective in the long run, and easier to implement than many current practices.” Indeed the recommendations that call for minimum intervention are less costly than many of the practices that had been in effect. However, such practices as plugging Little Bluestem are not economically practicable in most parks. Even the costs of doing prescribed burns for vegetation management purposes have escalated beyond the capability of most parks’ ability to fund.

In the “Monitoring and Evaluation” section, page F-2, the instructions state:

> The site monitoring and evaluation [sic] team should be equipped with pencils, a clipboard, adequate evaluation forms, and blank site maps (8-1/2” x 11”), a duplicate of last year’s evaluation forms and maps as well as a 100’ measuring tape. A camera is advisable for recording site information. Surveyor’s flagging tape may also be useful.

For purposes of the person(s) doing the monitoring, some guidance regarding what to look for is needed, as well as a sample evaluation form.
On page G-6, the practice of laying “shrub mats (collected locally or propagated commercially)” as a way of replacing shrub cover is recommended. This is questionable (a) on the basis of cost, in the case of commercially-propagated mats; and (b) out of concern for the potential damage to areas from which such mats might be collected locally and for resultant invasion by undesirable species. Tree planting details on pages G-8 and G-9 are of questionable value in that the cost of tree planting suggests that it would be far preferable to permit natural regeneration in areas where additional trees are desired (following the principle of “economy of intervention” generally promoted in the Manual).

There is a lack of clarity on page G-15 relative to the recommended treatment of Japanese Honeysuckle. On the one hand, it is noted that mowing the honeysuckle will “stimulate rooting and create a denser, more matlike cover, and improve effective stabilization.” Then, it is observed that “continued and repeated mowing will gradually diminish the plant and should proceed [sic] any herbicide control.”

On page G-16, except for Japanese Honeysuckle, the exotic species listed as needing control were not widely observed in the field during the 1995 fieldwork. Invasive exotics that were most frequently observed in addition to Japanese Honeysuckle (*Lonicera japonica*) were: Privet (*Ligustrum sinense*), Tall Fescue (*Festuca pratensis*), and Johnson Grass (*Sorghum halepense*).

Liming of forested areas is tentatively proposed on page G-17. This practice seems contrary to the “principle of economy of intervention;” it would appear far better to work with vegetation that is adapted to acidic conditions than to try to modify the pH even temporarily.

In Section H, “Management Guidelines for Recommended Field Cover Types: Tall Grass and Turf,” the conversion from “rough grass” to tall native grasses is implied to be a simple process that can occur within a two- to three-year period with decreasing levels of (unspecified) management. In fact, if the “rough grass” cover is dominated by a cool-season, allelopathic grass such as Tall Fescue, it may require an intensive effort involving spring burning and/or herbicide application timed to suppress the cool-season Fescue without damaging warm-season native species.

The use of fire in tall grass sites, while potentially effective at suppressing cool-season herbaceous plants and some woody species if timed appropriately, is not a practicable tool in many situations because of the complexities of burning in urbanizing areas, and the costs associated with it.

The practice of liming Tall Grass Cover zones (page H-6) is questionable. A more sustainable approach would be to simply utilize plant species capable of growing in acid soils, based on selecting species growing in such situations already.
The commentary on “Establishing Tall Grasses” is subject to revision for two major reasons: (a) the recommendations revolve around single-species plantings of either Little Bluestem or Switchgrass which would lack the benefits of species diversity; and (b) establishment of Little Bluestem as plugs is impractical in all but very small areas because of cost and also the vulnerability of seedlings to seasonal droughts immediately after planting.

Section I of the Manual is devoted to Revegetation of Damaged Ground Surfaces using bioengineering techniques, e.g., inserting live stakes or live fascines into earthworks or branch-packing or brush layering. As noted earlier, there has been minimal application of these techniques in the subject parks. Since the techniques have been used elsewhere over a long period of time, there is reason to believe that they could be successful on earthworks. However, two considerations override this. First, the insertion of stakes and branches, as well as 2" x 4" boards, deeply into earthworks, and the excavation for branch-packing, is potentially damaging. Secondly, if visibility or legibility of earthworks is a goal, the woody species recommended are contrary to the goal. Additionally, of the four recommended species listed on page I-8, two are wetland species (Willow and Red Stem Dogwood) which would only be suitable in swales or other low, poorly-drained areas; and two are invasive exotic shrubs, Privet and Russian Olive. In two small demonstration applications at Fort Darling and Fort Gilmer (Richmond) in 1989, the use of willow fascines was ineffective because the light level was too low for the willows. There was greater establishment of willow on a small demonstration of branch-packing with willow on a sunlit portion of Fort Hoke, also at Richmond.

AREAS REQUIRING ADDITIONAL INFORMATION

Additional information is needed in several areas, as follows:

a. List of plant species for a variety of different micro-environments, based on field observations.

b. Information on range, habitat, appearance, and management needs of this greatly-expanded list of plant species.

c. Information on specific observed invasive species and on their control methods (mechanical, chemical, fire).

d. Sources of seed of additional species.

e. Key publications providing current restoration and management research results.

f. Information on management and equipment costs.

g. Evaluation forms for assessing condition of earthworks, before initiating management, and during subsequent monitoring.

h. More specific information on seeding techniques (e.g., seed mixes, seeding times, and methods of seeding).

Chapter Five as well as the Appendices in this Handbook will include information in the above areas.