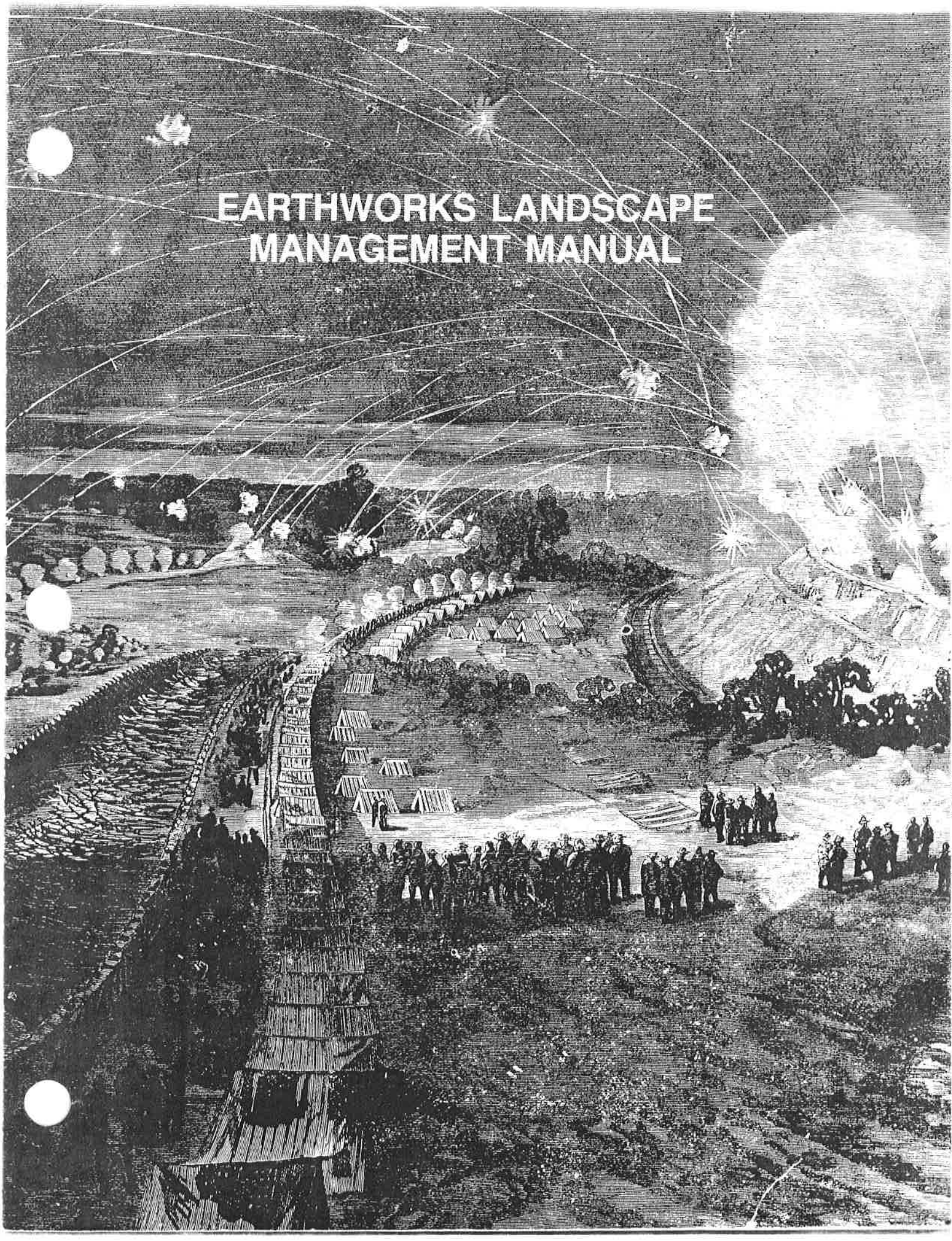
EARTHWORKS LANDSCAPE MANAGEMENT MANUAL



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Park Historic Architecture Division
Cultural Resources
National Park Service
U.S. Department of the Interior
Washington D.C.

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EARTHWORKS LANDSCAPE MANAGEMENT MANUAL

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A. EXECUTIVE SUMMARY

Today, the National Park Service is faced with increased usage of the parks, which is leading to increased deterioration of the parks' cultural and natural resources, including those associated with earthworks.

This Earthworks Landscape Management Manual's primary focus is to develop management strategies and interpretive guidelines which resolve current conflicts between the requirements for preservation and the impacts of interpretation and visitor use at the earthwork sites. The basic approach is intended to be adaptable for use at other earthwork sites under somewhat different environmental and cultural conditions, and with further limited study. Many of the recommendations will also be applicable to a variety of natural and cultural landscapes.

A major conclusion reached during the site reviews has also had a significant role in shaping the recommendations found in this manual: Earthwork sites stabilized by healthy, native plant communities are in the best condition, while some current management practices have contributed directly to the degradation of the resource. Past management has been directed toward increasing visitor access, but often is not supported by an increase in interpretive facilities, maintenance, or surveillance and monitoring. Similarly, past management has sometimes contributed to the degradation of the natural landscape, which, in turn, can diminish the historical and cultural setting. At the same time, the potential for well-managed native habitats to provide aesthetically satisfying, environmentally sound, low-cost alternatives to current maintenance practices has been underestimated and underutilized.

The recommendations in this manual, which have been developed jointly with the National Park Service, represent a significant departure from past management practices and also integrate recent interpretive trends into future park planning and management. The new practices recommended focus on managing native landscapes, which are both more ecologically sound and more cost effective than current practices. These new practices will lead to an increased variation in environments, which can provide new opportunities for interpretation.

This manual emphasizes the need to rely increasingly on management that favors native vegetation versus the maintenance of less suitable, although more familiar, horticultural standards, especially turf. This will also require revisions in interpretive expectations and the design of innovative, new facilities. For instance, at present there are few examples of interpretive programs for a forested site. However, the long-range need is clear to create more durable and effective facilities that can accommodate greater numbers of visitors as well as manage the resource.

The manual contains two major sections. The first is a review and evaluation of current management practices, which includes the criteria for evaluating current National Park Service management, derived from enabling legislation and policy. The driving force behind the evaluation of current management, attitudes, and procedures is also examined in this section, as well as an assessment of present vegetative cover types. This section concludes with recommendations for an overall management program aimed at integrating preservation and interpretation objectives.

The second major section is the management manual itself, which begins with procedures for evaluating and monitoring a site with respect to the proposed guidelines. Because effective adoption of the program will require a period of transition, initial management guidelines are distinguished from more routine maintenance issues. The major focus is directed toward dealing with the more serious problems, and will be augmented by a series of management training workshops for park personnel, which include more innovative and less familiar techniques.

Two specific sites, representing a diverse array of typical conditions and problems, are highlighted in this section to illustrate the recommendations: the Fort Fisher Area of the Petersburg National Battlefield, and the Cold Harbor Unit of the Richmond National Battlefield Park.

Manual Background & Acknowledgements

The Earthworks Management Manual project was organized into three distinct phases: preliminary assessment of existing natural and cultural resources; presentation and review of a conceptual framework for future management strategies; and development of management recommendations. As these recommendations are instituted and the NPS staff is trained in their use, it is likely that the site evaluation and monitoring of the work will lead to modifications of recommended practices and to new ideas that will refine these guidelines.

The preliminary assessment was done in the field during March and April 1986. This included taking infra-red and black and white aerial photographs to prepare topographic maps for two specific areas and to identify areas of critical archaeological importance; interviews with NPS staff from the regional office and the individual parks; and consultation with a range of other experts to help us develop the framework for our recommendations.

The preliminary interviews with NPS staff were done on-site and intended to determine their primary concerns and goals for this project. Those interviewed and sites reviewed included:

MID-ATLANTIC REGIONAL OFFICE
Interviews:

Brook Blades	Archeologist
John Bond	Associate Regional Director, Cultural Resource Management
Don Castleberry	Deputy Regional Director
James Coleman	Regional Director
John Costello	Management Analysis
Reed Engle	C.O.T.R. & Historical Architect
Fred Eubanks	Planner
Chet Harris	Regional Chief Interpreter
Ted Hillmer	Chief of Operations
John Karish	Regional Chief Scientist
Henry Magaziner	Regional Historical Architect
Jeff Marion	Regional Scientist
Stuart Maule	Regional Natural Resource Manager
Dave Orr	Regional Archeologist
William Supernaugh	Chief, Division of Resource Management & Visitor Protection

FREDERICKSBURG AND SPOTSYLVANIA COUNTY BATTLEFIELDS MEMORIAL NATIONAL MILITARY PARK

Interviews:

A. Wilson Greene	Staff Historian
Mike Johnson	Chief Ranger
Bob Krick	Chief Historian

Sites Reviewed:

Fredericksburg Battlefield: Lee Hill Exhibit Center; Lee Drive; Pickett Circle; Meade Pyramid; and Hamilton's Crossing

Chancellorsville Battlefield: Chancellorsville Tavern Site and Hooker Road

Wilderness Battlefield: Wilderness Tavern; Wilderness Exhibit Shelter; Hill-Ewell Drive; Chewning Farm; and Jackson Trail West

Spotsylvania Court House Battlefield: Spotsylvania Exhibit Shelter; Grant Drive; Anderson Drive; Bloody Angle Drive; East Angle; and Burnside Drive

Chatham: House & Garden

PETERSBURG NATIONAL BATTLEFIELD

Interviews:

Glenn Clark	Superintendent
John Davis	Chief of Interpretation
Bill Fluharty	Chief, Resource Management & Visitor Protection
Victor Martin	Chief of Maintenance

Sites Reviewed:

Petersburg Battlefield: Battery Five; Petersburg Visitor Center; Fort Friend; Battery Nine; Living History Exhibit; Harrison Creek; Colquitt's Salient; Fort Stedman; Fort Haskell; Fort Morton; and The Crater

Petersburg Auto Tour: Fort Sedgwick; Fort Wadsworth; Poplar Grove National Cemetery; Fort Urmston; Fort Conahey; and Fort Fisher.

RICHMOND NATIONAL BATTLEFIELD PARK

Interviews:

Keith Morgan	Chief of Interpretation & Visitor Services
Sylvester Putnam	Superintendent
Chuck Rafkind	Chief Ranger
Dan Roddy	Park Ranger
Junius Ross	Chief of Maintenance
Dave Shockley	Park Ranger

Sites Reviewed:
Chimborazo Visitor Center
Chickahominy Bluff: Overlook & Path
Cold Harbor Unit: Cold Harbor Exhibit Shelter and Interpretive Auto Road
Fort Harrison Area: Battlefield Park Road; Fort Gilmer; Fort Gregg; Fort Johnson; Fort Harrison Visitor Center; Fort Hoke; Hoke-Brady Road; and Fort Brady

GETTYSBURG NATIONAL MILITARY PARK
Interviews:

Cathy Georg Harrison	Park Historian
Robert Prosperi	Park Historian

When the earthworks were first constructed, much of the remaining fertile portions of the soil were buried or leached away. And given the droughty and acidic nature of the soils in this part of Virginia, the resulting poor growing conditions, combined with unrestricted access, tended to accelerate disturbance. Since restabilization is a complex issue, the following specialists were consulted:

SOILS

Jim Canterbury	Raleigh NC	Soil Conservation Service
Leo Cotnoir	Newark DE	Soils Consultant
John Dondero	Petersburg VA	Soil Conservation Service
Charles Lander	Richmond VA	Soil Conservation Service
Willis Miller	Richmond VA	Soil Conservation Service
Jim Orbannd	Yorktown VA	Agricultural Extension Service
Keith Salvo	Raleigh NC	Soil Conservation Service
Lester Seglin	Wiliiamsburg VA	Soil Conservation Service
Robbin Sotir	Marietta GA	Soil Bioengineering Corporation
Ron Wisniewski	Fredericksburg VA	Soil Conservation Service

GEOTEXTILES

W.C. Burrows	Midlothian VA	Erosion Control Systems
Steven Leonard	Norristown PA	Explo-Tech Inc.
Randy Thomas	Conshohocken PA	Atlantic Construction Fabrics

ARCHAEOLOGY AND INTERPRETATION

Steven Bressler	Shutesbury MA	Monadnock Media
John Cotter	Philadelphia PA	University Museum
Edward Rutch	Newtown NJ	Historic Conservation and Interpretation

ORDNANCE (Civil War shells and explosives)

Major Henry	Dover NJ	U.S. Army, E.O.D. Section

VEGETATION

John Karish	State College PA	Pennsylvania State University
Miles Johnson	Richmond VA	Virginia Commonwealth University
Gordon King	Amherst MA	Blueberry Grower
F. M. Moobury	Chadds Ford PA	Brandywine Conservancy
William Niering	New London CT	Connecticut State College
Dennis Ryan	Amherst MA	University of Massachusetts
Alfred Schuyler	Philadelphia PA	Academy of Science
John Williams	Tuftonboro NH	Horticultural Consultant
Don Young	Richmond VA	Virginia Commonwealth University

WILDLIFE

Robert Stovall	Philadelphia PA	Fish and Wildlife Service

The initial interviews, site visits, and reviews with consultants helped identify the areas of concern and the impact of current management practices. A framework of recommended strategies and a vocabulary of techniques was then developed to ameliorate the generic types of disturbance identified in the parks. A two-day workshop, for parks and regional staff, was held in Richmond, Virginia to present the preliminary assessment and the conceptual approach to management of the earthworks. The following is a list of workshop participants:

MID-ATLANTIC REGIONAL OFFICE:

John Bond	Associate Regional Director, Cultural Resources Management
Reed Engle	Historical Architect
Stuart Maule	Regional Natural Resource Manager
David Orr	Regional Archeologist
William Supernaugh	Chief, Division of Resource Management & Visitor Protection

COLONIAL NATIONAL HISTORICAL PARK:

James Haskett	Assistant Superintendent
R. H. Maeder	Superintendent
Wally Neprash	Assistant Superintendent
Dale Wilking	Facility Manager

FREDERICKSBURG AND SPOTSYLVANIA COUNTY BATTLEFIELDS MEMORIAL NATIONAL MILITARY PARK:

Jim Zinck	Superintendent
Skip Brooks	Crew Foreman
Pam Griffin	Resource Management Ranger
Mike Johnson	Chief Ranger
Bob Krick	Chief Historian

PETERSBURG NATIONAL BATTLEFIELD:

Glenn Clark	Superintendent
John Davis	Chief of interpretation
Bill Fluharty	Chief, Resource Management & Visitor Protection
Victor Martin	Chief of Maintenance

RICHMOND NATIONAL BATTLEFIELD PARK:

Keith Morgan	Chief of Interpretation & Visitor Services
Sylvester Putnam	Superintendent
Chuck Rafkind	Chief Ranger
Junius Ross	Chief of Maintenance
Fred Springer Jr.	Maintenance Mechanic

B. REVIEW & EVALUATION OF EXISTING MANAGEMENT PRACTICES

The Review's Rationale

Management, whether intensive or minimal, is motivated by a complex set of underlying assumptions and values. Most conflicts occur when critical values are overlooked, or when management for a single purpose overrides other values. With regard to the earthworks, there are varying interpretive goals and a clear mandate to preserve the natural and cultural resources, all of which must be resolved by management.

A critical function of the interviews and the workshop was to develop a working consensus on the objectives of management. Once established, these objectives became the basis for evaluating current practices and for generating the recommended management program.

A second major focus of this critique was to examine the relationship between objectives and implementation. Even when there is agreement on an objective, for example, the actual effects of implementation may be directly contradictory. Current management practices were reviewed and evaluated for their effectiveness over time, including the long-term consequences and costs of management.

This review is divided into two major sections. The first establishes the goals of management and the second evaluates current management practices from that perspective.

Legislative Mandate

The preservation and interpretation of cultural resources is basic to all federal historic preservation law. The Organic Act defined the National Park Service's mission as the preservation of the natural and cultural resources while providing for the enjoyment of the resources so as to leave them unimpaired for future generations.

All park managers are directed to locate, identify, evaluate, preserve, manage, and interpret qualified cultural resources in every park in such a way that they may be handed on to future generations unimpaired . . . consistent with the requirements of law, resources managers and professionals at all levels shall take positive action to

perpetuate unimpaired the cultural resources of the National Park System; to prevent adverse effects on these resources by development, visitor use, or resource management activities; and to prohibit vandalism or unauthorized excavation, collection, or appropriation of cultural resources.

The legislative mandate for earthworks is fundamentally about both the preservation and the interpretation of the resource. The original act establishing the Petersburg National Battlefield, signed in 1926 by President Calvin Coolidge, states the Park's purpose: "to commemorate the campaign and siege and defense of Petersburg VA in 1864 and 1865 and to preserve for historical purposes the breastworks, earthworks, walls, or other defenses or shelters . . ." and to provide roads, historic markers, and monuments for the visitor. The Historic Sites Act of 1935 provides for the preservation of historic American sites, and called for an "educational program and services" for the public. This growing awareness that public understanding is integral to the purposes of preservation is especially evident in the National Historic Preservation Act of 1966, which states "(a) that the spirit and direction of the Nation are founded upon and reflected in its historic past; (b) that the historical and cultural foundations of the Nation should be preserved as a living part of our community life and development in order to give a sense of orientation to the American people; (c) that, in the face of ever-increasing extensions of urban centers, highways, and residential, commercial, and industrial development, the present governmental and non-governmental historic preservation programs and activities are inadequate to ensure future generations a genuine opportunity to appreciate and enjoy the rich heritage of our Nation."

Despite the mandate to integrate preservation and interpretation, the situation in the parks today is one of continued conflict between these values. Use too often results in abuse, and the interpretive facilities themselves in some cases may directly contribute to the deterioration of the resource. These problems are aggravated by the serious impacts of suburban development surrounding battlefield parks, which alter views and may be environmentally damaging. Usage has grown and the need for maintenance has grown. From this dilemma came the impetus for this critique and the development of a Management Manual.

Consensus on Management Objectives

The following describes the overall objectives identified in this process, with regard to the preservation of cultural resources, including both archeological and historic resources and their integration, and the preservation of natural resources, including stabilization of the earthworks.

Guidelines for Archeological Preservation

Archeological concerns regarding management of the earthworks fall into three categories: identification and evaluation of the resource within its context; survey and

inventory of individual structures to identify the location and condition of all existing resources; and the coordination of the level of interpretation of a resource appropriate with its value and condition.

Archeological data is only found in the original fabric of the earthworks. Filled or covered features, like forts or trenches, probably comprise the major portion of the remaining resources of cultural and historical significance. However, earthworks which have been exposed or weathered should also be treated with care, because they may contain evidence of the original archeological fabric as well. In fact, some of the most significant earthworks, like Fort Morton in Petersburg, are now obscured, and unless careful attention is paid to all of the resources, they could easily be destroyed.

The earthworks are a valuable cultural resource and provide an opportunity to learn about military tactics of an earlier time in our history. However, from an archaeological point of view, the berm portions are the least valuable areas. The real richness lies in the trenches, hut sites, and interiors of the forts, where cultural artifacts are covered by layers of soil. From this perspective, the critical factor for the preservation of the resource lies in the completeness and intactness of the soil layers, or vertical stratigraphy. As the stratigraphy becomes increasingly mixed, the validity of any archeological findings, resulting from sanctioned digs, becomes more questionable.

Some of the archeological value of an earthwork is dependent on its above-ground condition and the integrity of the subsurface archeological fabric. The more complete and untouched it is, the more important and valuable is the earthwork as historical record. The following categories are useful in evaluating the importance of a structure:

Above-Ground Condition	Archeological Integrity
1. well preserved	excellent condition
2. major restoration	good condition
3. poorly preserved	good condition
4. poorly preserved	poor condition
5. total reconstruction	non-existent

For the most part, an earthwork will fall into one category; however, because records are not always complete or available, categories 2 and 3 may be difficult to define.

If the earthworks can be clearly identified and categorized, an appropriate interpretive scenario can be developed. No interpretive program should endanger an earthwork. Active interpretation, with large groups or hands-on activities, should only occur on earthworks in categories 4 and 5. These have been disturbed so radically that this intense use will not alter their condition. Earthworks in the first three categories cannot

withstand intense use and require significant protection if their archeological value is not to be lost.

Since the turn of the century, many earthworks have undergone intensive restoration, including Civilian Conservation Corps projects of the 1930s. Much of this work focused on removing eroded material from the back of the slopes and placing this material on top of the earthworks, with the goal of reestablishing the historic form. In some cases, these reconstructed versions are indistinguishable from the original ones.

Since accurate records were not always kept, pinpointing which earthworks are real and which are reconstructions is sometimes difficult. In addition, in the process of moving the eroded material, cultural information in the trenches and building sites may have been shifted. Therefore, earthworks where the stratigraphy has been undisturbed by restoration efforts, tree roots, or relic hunters are of major archeological value.

Until a survey of the authenticity of earthworks is completed, all earthworks, except documented reconstructions, are assumed to be original and of historic value. Protection of the archeological resources will require the completion of this comprehensive site-by-site inventory. The inventory will identify and locate critical resources and evaluate authenticity, level of disturbance, and archaeological value of each designated area. Until this inventory is completed, all trenches, in addition to documented sites, such as huts and bomb proofs, are assumed to be important. As more and more of the sites outside National Parks Service jurisdiction are disturbed, all protected sites will increase in value. Soon, the only ones considered archeologically significant for future exploration are likely to be within park boundaries.

Upon completion of this inventory, specific interpretive strategies and the appropriate level of management and protection for each site can be determined and prioritized. At present, there is no identified need for archeological investigation of any sites, so the most critical objective is to preserve the resource with as little disturbance as possible for further research and investigation. All authenticated sites should be protected from any further deterioration, with protective vegetative cover restored as needed.

Some of the sites may be considered appropriate for inclusion in the interpretive programming. As long as more destructive activites, such as relic digging and indiscriminate erosive trampling, can be controlled, there are no major problems associated with foot traffic in terms of the archeological resource as long as adequate cover is maintained and the integrity of the earthen form is preserved.

The following guidelines are recommended for the protection of significant archeological resources:

1. Adequate protective cover should be maintained on all archeological sites.

2. Presently undisturbed and unforested sites should be maintained in herbaceous or shrub cover to limit potential disturbance of the stratigraphy from the root systems of mature trees.

3. Vigorous enforcement of the law regarding vandalism and active prosecution of offenders should be pursued.

4. No site should be opened to use unless adequate surveillance can be provided.

5. Access should be restricted to repeatedly vandalized sites, which may also require alterations of the interpretive program.

6. Any disturbance to the vertical stratigraphy should be appropriately marked and recorded for future investigators.

Guidelines for Interpretive Programs

The interpretive program frames the visitor's experience, providing access and educational opportunities. In the past, access was sometimes uncontrolled, which led to deterioration of the resource. More recently, interpretive facilities have been designed to provide a more directed visitor journey. The educational focus of interpretation has also evolved over time, expanding beyond the original emphasis on memorialization and battle strategy analysis to embrace a broader understanding of the heritage and history of each era and its lessons for us today.

The management of an historic site is inseparable from its interpretive program. It determines the look of the landscape and should reveal the story of the place to the visitor. While the management program does not aim to address all aspects of interpretation, the landscape character and the nature of access are critical components.

The following guidelines focus on the development of appropriate settings and access which minimize the opportunities for disturbance and degradation often caused by interpretation. It is clear that in order to achieve these goals, some reevaluation of the layout and design of current facilities will be required to achieve an effective management program:

1. An authentic landscape setting should represent what might have existed during the historic era of the park.

2. A complete restoration of the historic setting at any one site should be undertaken only when funding is available to ensure adequate site stabilization and long-term management.

3. Agricultural management should maintain the landscape character.

4. All habitats, whether natural or agricultural, should be maintained in a healthy condition and protected from adverse environmental impacts.

5. The development of disturbance communities, which are typical of degraded environments, should be minimized and controlled.

6. Visitor access to cultural and historic resources should be clearly defined and directed in order to restrict casual use and potential damage to the resource.

7. Access should not be increased or provided at any site without a comprehensive interpretive approach which addresses the needs of resource preservation and long-term management requirements.

8. Access which entails or invites walking upon the earthworks should not be permitted on any authenticated sites and should be reevaluated for reconstructed earthworks and degraded sites.

9. The interpretive program should develop a 'storyline' which integrates the specific historic sites, incidents, and environments of each park.

10. The interpretive program should reveal the uniqueness and special qualities of each site.

Not all interpretive needs can be met within park boundaries. Like preservation goals, interpretive goals will also require cooperative negotiations with other agencies and land owners adjacent to the park. It will be important to develop visual standards for areas which impact the viewsheds of the parks, especially those closest to scene restoration areas.

Guidelines for Earthworks Preservation

What is preservation in the context of an earthwork? Most of the earthworks were constructed, at best, to last the duration of the Civil War and required continuous repair to remain useful. The bare soil surface was continuously vulnerable to erosion by wind and water, not to mention bombardment. The earthworks were also subjected to compaction as the piled sediments settled over time. After the Civil War, vegetation gradually developed to stabilize the soil, but additional settling occurred as the heavy timbers and brush, used for structural reinforcing, decomposed. Clearly, preservation can at best reduce the rate at which the form of the earthwork deteriorates, unless reconstructive work is undertaken.

In many areas, the earthworks have been reconstructed. This began almost immediately after the war. In some cases, the reconstructed earthwork was not sited with historical accuracy. While archeological and historical values may have been compromised, many of these reconstructions provide very effective interpretive experiences.

The maintenance of appropriate vegetative cover and the control of disturbance are the two most important aspects of earthworks preservation. The first depends on the vegetative cover type, and the second is related to access and interpretive programs.

The following guidelines are recommended to ensure earthworks preservation:

1. All earthworks should be managed for a recommended vegetative cover type which provides effective stabilization.

2. Management should be keyed to cover type and reflect a real understanding of the specificity of each vegetation type and the long-term consequences of management.

3. All management techniques and practices should be monitored and evaluated before they are applied on a large scale.

4. Any management practice which contributes to soil destablization should be stopped and new strategies devised.

5. No increase in the level of management required should be initiated unless it can be completed properly, adequately followed through, and maintained over time.

6. All sites should require at least an annual monitoring, and most sites will require at least a minimal level of management.

7. Adequate sediment and erosion controls should be incorporated into all management.

8. The principle of 'economy of intervention' should be followed to minimize unnecessary effort and disturbance.

9. Access should be restricted during restoration work and during the establishment period of vegetative cover types.

Interpretive & Management History of the Earthworks

Attitudes toward interpretation and preservation have evolved gradually over time. However, two major interpretive concerns have been consistently important: the form of the earthworks and the setting in which they are viewed.

In the early years, the landscape was managed similarly to the farmlands surrounding the park sites. Once land was acquired, the earthworks were protected from gross disturbance, such as being plowed away by farmers. Areas where commemorative memorials had been created, and where visitorship was high, were kept in turf. Elsewhere, portions of parkland were released to return to forest.

The landscape setting of the earthworks has been another major interpretive concern of the National Park Service. For a number of years, the primary interpretive focus was on battlefield tactics and the individuals or groups who played a significant role at each site.

The need to protect the form of the earthworks from trampling by visitors slowly became evident as paths were worn at favorite crossings. Initially, these heavily used areas were simply reinforced, for example, with steps set into the earthwork. Later, construction became more elaborate, as continued degradation of the earthwork became apparent, and stiles, bridges, decks, and paved paths were added. The visitor perspective remained unchanged: the journey was still up and over the earthwork, where the view was good and the positions of the troops in battle could be clearly seen. Sites which were very popular, such as the Crater at Petersburg National Battlefield, were literally trampled away and eventually required complete renovation and the installation of a pathway and viewing sites to better control access and use.

Recently, the inherent conflict between visitor access to the earthworks and protection of the form of the earthwork has been increasingly recognized. Older crossing sites are now being decommissioned and new pathways follow a journey which respects the earthworks. Even at recently reconstructed sites with intensive interpretation, such as the Living History site at Petersburg, the visitor, like the soldier during the war, is kept off the earthworks. As sites are restored, this new practice is gradually being implemented. The bridge at Cold Harbor, which is in need of repair, will probably not be replaced. Issues about alternate parking sites and viewer orientation are being raised, and new solutions sought which should reduce visitor damage to the earthworks. These new directions underscore the need for review of the interpretive storylines. Some sites will require a complete redesign of the visitor experience before the earthworks can be adequately protected. At Chickahominy Bluffs, for example, the visitor parks almost adjacent to the bluff and is at the major overlook within seconds. Unfortunately, from this vantage, the major access path is not visible so many people end up on the maze of trails running along the tops of the earthworks which can be seen from the overlook. When interpretive facilities fail to provide adequate access or

control, the resource is prone to damage, which in turn compromises future interpretive opportunities.

One of the driving forces behind current management practices is the consistent perception that trees are inherently damaging to earthworks. The summary recommendations of the "Petersburg Conference on the Conservation of Earthworks", held on July 30-31, 1974, concluded that "Trees are the major destructive element" [A, App. I, p. 67]. "Cotter noted that a pure approach to earthwork conservation initially would be to isolate the tender original remains and keep people and trees alike off of them since the first constitute a mechanical erosion agency and the second a chemical and physical disruption due to the acidification of the soil by leaf fall and the disruption of roots and tree trunks" [A, App. I, p. 4].

Ambrose acknowledges that "in some areas, it will be preferable to allow the natural regenerative processes to develop a wooded cover, thus keeping the works hidden from adverse visitor use" [A, p. 75], but generally concurred that trees threatened earthworks and recommended that "a long-range thinning process should be used to prevent uncontrolled growth resulting in domination of large diameter trees"[A, p. 76].

It is clear that large dying trees do pose a threat, when sited directly on an earthwork or on a critical archeological site. As Ambrose notes: "When trees in and around the earthworks are allowed to die in place, their falling limbs can damage the works below. If a tree is blown down by heavy winds, there is the possibility that its uprooting will leave large holes in the fortifications" [A, p. 57].

This perception that all trees have been damaging to the earthworks has led to a current management practice of clearing almost all understory vegetation on forested sites and the removal of most smaller trees (under13" dbh caliper) leaving only a few solitary mature individuals standing in isolation on the earthworks.

The consequences of this practice have been problematic. Thinning and removal of the understory layer can contribute to the immediate destabilization of the earthwork by increasing the rate of erosion from stormwater. In addition, the earthwork is more visible and consequently more vulnerable to human disturbance if surveillance and security are not increased. Lastly, with the elimination of trees from the area of the earthworks, the ground surface will almost certainly be overwhelmed by vines, Japanese honeysuckle, in particular, unless turf or other groundcover is established and properly maintained.

The perception that the large tree is a threat has been translated into the implied perception that all native landscapes are a threat to the earthworks, and has led to a search for special cover types suitable for earthworks. Grass was generally perceived as preferable to forest, although rates of runoff and erosion from turf on slopes are widely acknowledged to exceed those from a natural forest. Similarly, erosion can increase as much as 30% to 40% when a forest is cleared or partially cleared. "The

point was made by Cotter that usually trees were deleterious to earthworks inasmuch as they may retard the growth of a grass or other cover which will hold the earth. This is especially noticeable in the case of conifers and oaks which leave a highly acid residue which may prevent growth of grass, especially in sandy soils" [A, App. I, p. 2].

If one examines the earthworks themselves, it is clear that Cotter and others were not accurate about the negative impacts of trees. Forested earthworks are in all cases the most well preserved of their kind. An attitude of strict preservation would leave the earthworks completely undisturbed under the blanket of forest and vigorously protected from trespass. Archeologically, the stratigraphy has already been disturbed and clearing the vegetation would lead to further deterioration as root systems decomposed. Damage due to windthrows or poor sod under canopy trees are due more to the effects of partial clearing and improper grass species than to the deleterious effects of trees.

It is almost axiomatic that, for all practical terms, access is equivalent to erosion, as the most open and accessible sites are the least well preserved. In recognition of this, for example, after Fort Stedman and the Crater required complete restoration, the National Park Service reduced and focused access to limit future impacts.

In his review of conditions at Fort Fisher, in the Clemson Study, Ambrose also observed that keeping earthworks in forest will promote preservation: "Fort Fisher. . . . is in an almost perfect condition with distinct parapet walls and moat. The entire Fort and the area on its north and east sides are covered by young forest growth" [A, p. 59]. The key word here is 'young'. Because of past agricultural use, virtually all the forests of this region are relatively young. Even in a mature forest, only a few of the sapling trees ever become forest giants.

The effectiveness of forest cover in preserving the earthworks was also recognized in the Clemson Study, which recommended: "Tree removal at Fort Fisher should be selective. Natural revegetation should be guided so that a wooded cover will be maintained thus helping to keep the work in obscurity. A long-range thinning and cutting program should be used so that tree growth will not be allowed to continue uncontrolled until only large diameter trees dominate the fort. A mixed-age cover will provide a better screen than will a climax forest" [A, p. 112].

Recognition of the role of forests in preserving earthworks is also noted in a 1980 memorandum from Robert Melnick, historical landscape architect. Concerning management at Fort Foote directed to providing better visual access, Melnick recommended that "vegetation on the earthworks and within the fort should not be cleared. Such clearing will lead to eventual destabilization and erosion of the earthworks. Maintenance of the fort and immediate surroundings should be allowed. Vegetation on the earthworks, especially trees and shrubs, should be carefully pruned in a limited manner." Despite these observations, earthworks are still being cleared in the name of preservation. At Kennesaw Mountain National Battlefield Park, for

example, earthworks have not only been cleared recently, but the pine needles and litter layer have been raked away to expose the bare mineral soil to even more rapid erosion. Unsightly piles of brush and rakings have been left on top of the earthworks.

The fact that forest cover better preserves the landform of the earthworks does not necessarily mean that forest cover should blanket all earthworks. The 1974 Petersburg conference recognized that the 'pure' approach was not necessarily the best approach to a complex mandate. Even the highly trampled and severely disturbed earthwork is more valued by the uneducated visitor than a lost relic which is unseen in the forest [A, App. I, p.7].

It does mean, however, that a variety of native plant communities, which are inherently suited to the local conditions and which were largely ignored by earlier efforts, might be managed more effectively to provide greater protection than current practices, while fostering interpretive goals as well. It also means that some long-held assumptions must be relinquished before new management strategies can be adequately explored. And, lastly, it means that the large tree on the earthwork must be confronted and dealt with. This situation only becomes more urgent, as thousands of pines throughout the area are stressed by disease and infestation.

In summary, what we are seeing is that forest, which is the single most effective cover for preservation of the earthworks, is sometimes mismanaged to achieve the interpretive goal of greater visibility. Forest quality, including health and diversity, often deteriorates with intensive management, and declines as long as misguided management is continued. The physical form of the earthwork is also impacted by accelerated erosion and subsequent trampling and visitor abuse, while native cover types are overlooked.

Similar management problems occur in the non-forested portions of the park. In these open landscapes, the earthworks are almost always turf covered, as if turf and interpretation were synonymous. A large majority of these have been severely trampled and restored or rebuilt over time. Turf is an extremely high-cost groundcover. As maintenance has been reduced in many areas, turf cover has deteriorated to a poorly stabilizing rough grass. In some places, damages from the mowers exceeds that from trampling. In nearly all cases, turf cover has required frequent rehabilitation and a continuous upgrading of facilities to provide greater control of visitor access. Very few original earthworks in good condition exist in turf, yet a disproportionately large percentage of every year's budget goes to mowing and turf maintenance. This is not a new concern and repeated efforts have been made to reduce the costs of turf maintenance; however, these measures have amounted to corner cutting, such as reducing required fertilization and liming which are necessary to maintain healthy turf in this part of Virginia. The more fundamentals issue of where turf is appropriate and where an alternative cover type might be more appropriate than turf has not been adequately addressed.

There is, at present, a strong interest at the National Park Service in an approach to interpretation in which the larger setting of an historical event is restored and presented to the visitor. 'Scene restoration' is opening up new possiblities for interpretation, including the development of new storylines and access patterns which integrate the visitor's experience with the message being conveyed.

With the recreation of entire scenes, much thought will have to be given to the management of adjacent landscapes to evoke an aura of authenticity. For example, some of the land currently in forest was once part of the scene of a significant battle and was probably worked as farmland, either crop or pasture. Like the once pastoral countryside of the region, the landscapes of the parks have changed dramatically. As development replaced the croplands and pastures outside park boundaries, the once open fields within the parks gave way to forest regrowth, ultimately obscuring strategic vistas. The initial emphasis of scene restoration focused on military tactics and sought to reestablish the terrain of the battlefield. This has led to fairly extensive clearance of forest, with many more areas scheduled for eventual clearance.

However, despite the desirability of a return to some form of agricultural use on certain sites, there are still a number of issues to be resolved. The prospect of future use by local farmers contains inherent conflicts with the goals of both interpretation and preservation. For example, the patterns of modern agriculture are increasingly at variance with the patterns of historic agriculture and accurate scene restoration. Use of modern agricultural equipment creates a configuration of fields that is both larger in scale and different in form than historic practices. Dramatic regrading of the land or extensive drainage systems are also often required. Herbicides and insecticides may be frequently used, especially with no-till agriculture.

Pasturage and hay cropping conflict with preservation goals. Healthy pasture requires periodic mowing and reseeding, and it is unlikely that fields created from recently cleared forests, with their slowly rotting stumps, would be suitable for adequate pasturage within ten to fifteen year's time. Healthy pasture requires continuous liming and fertilizing to foster the growth of the typical European pasture grasses and are often inadequately maintained to provide adequate cover.

Due to inadequate site preparation and poor maintenance of other newly seeded areas in the park, sites that might be returned to pasture have lost the installed seed. Ultimately, these sites will be taken over by native grasses, but in the interim there will be a considerable amount of bare soil exposed to erosion and large volumes of topsoil would be lost even if gullying is not readily apparent. Earthworks would also be impacted, as this erosion contributes to a long-term loss of soil fertility, which increases the problems of stabilization.

Scene restoration can best be undertaken where the land holdings are large enough to include not only the site but an adequate buffer as well to ensure that no visual intrusions from modern landscapes destroy the illusion of an appropriate historical

context. Within the fragmented and more linear parts of some parks, the problems of these limitations are becoming apparent. Many of the most severe threats to the form and setting of the earthworks come from development around the parks, and can only be minimally improved by altering management practices within the parks. These external threats may be direct, such as the legally authorized driveways through the earthworks in some areas along roads built by the National Park Service for the purpose of interpretation. These same roads are already deteriorating under a traffic load greatly exceeding their capacity and have brought the added disturbance of phone lines and other services as well. For example, as more residences are built along Flank and Defense roads at Petersburg National Battlefield, the same management strategy that exposed the earthworks to the visitor's view also reveals the conflicting and very busy world of the home landscape -- it is not unlike the warrior's memorial statue now captured in the strip development along Crater Road. The legal precedents allowing access may be expanded in the future.

The expansion of airport facilities and the completion of Interstate 295 near Richmond National Battlefield Park, with a major interchange only three-and-a-half miles from a park entrance, will determine much of the remaining future of the fields and forests that surround the Richmond National Battlefield Park. The visual context will change dramatically as strip development coalesces along the major roadways, and the number of people looking for recreation sites will increase as undeveloped land disappears. Evidence is growing to suggest that use of the parks for recreational purposes represents a far greater threat to the earthworks than visitor interpretation.

Urbanization of the land around park boundaries inevitably means environmental degradation in a number of ways. Extreme environmental impacts from increased rates of sedimentation are inevitable unless stormwater management is dramatically improved throughout the region. The stresses to the forest and other native plant communities will be profound and grossly diminish the health and diversity of remaining habitats. Disturbance species will be continuously favored in this competition for land.

The more one examines the issue of preservation, the more one realizes that there has been very little experimentation in the management of earthworks, although the need for real research and development has been frequently stated. The 1974 Petersburg conference concluded: "It was evident that a certain amount of experimentation involving different types of vegetative management are needed" [A, App. I, p. 7]. In actuality, there is very little experimentation, and management decisions effecting very large areas are often made on the basis of 'policy' without any clear understanding of long-term consequences. Hundreds of acres may be cleared for 'scene restoration' without adequate funds to properly stabilize the cut-over land. Miles of earthworks may be cleared and opened to access. After clearing, these earthworks need continued management, but there is rarely any clear program or assured funding for future maintenance. One person interviewed described the approach as "ready-fire-aim." This strategy is a familiar one in government agencies and is as frustrating to those within

the system as it is to others looking in from the outside. In this light, it is remarkable how caring and committed the staffs at Fredericksburg, Petersburg, Richmond, and Colonial are, and attests to the power of the earthworks to move the human heart. There is an evident respect and reverence for the earthworks -- the same kind of feelings one hopes to spark in the visitor. There is also pride in the National Park Service and a real desire to do the job well, though these feelings often get suppressed by day-to-day operations. There is a great potential within the individual park staffs and, at present, very little opportunity to tap this resource. It is critical at this time to find ways to fuel creative efforts and focus the experience and expertise of those working in the parks. Otherwise, there is a tendency to cling to the tried and true and to resist any modification. Only when people have a personal stake in improving the management and developing innovative approaches can the old conventional modes be broken. This is the time to develop the Art of Earthworks Management.

The other critical half of experimentation is continuity. There must be real monitoring and useful assessment of all demonstration projects, and a willingness to adapt and repair as expertise is gained. One of the products of this project will be to develop a sequence of demonstration projects for applied research on some of the more complex problems of management. There is also an evaluation phase which concludes this project, and which will hopefully be the first of a series of reevaluations framed by the Management Program. As experience is gained and information documented, it will be the time to develop the Science of Earthworks Management. While outside consultation will continue to be effective, the really important work should be happening within the parks themselves. This will require close cooperation and improved communication with the regional representatives. The Manual is intended to provide both a structure and a common language to facilitate this effort.

References cited in the text:

A: William S. Ambrose, "An Interpretive Earthworks Preservation Guide for Petersburg National Battlefield". Report prepared for the National Park Service by the Department of Recreation and Park Administration, College of Forest and Recreation Resources, Clemson University (March 1976).

A, App. I: Appendix I: "Petersburg Conference on the Conservation of Earthworks", July 30-31, 1974, Recorder: John L. Cotter.

C. EVALUATION OF EXISTING VEGETATIVE COVER TYPES

Vegetation is the key to earthwork preservation and interpretation. With only minor exceptions, all the earthworks are vegetated and support a diversity of cover types, which vary in effectiveness with regard to the archeological, interpretive, and preservation values previously described. For the purposes of this review, the existing cover types are divided into three major groups: Forest Cover Types, Field Cover Types, and Special Conditions. The following evaluations are based upon field observations at Petersburg National Battlefield, Richmond National Battlefield, Fredericksburg and Spotsylvania County Battlefields Memorial National Military Park, and Colonial National Historical Park.

FOREST COVER TYPES

The forest cover types include Forest [see Figure 1] and Cleared Woodland [see Figure 2]. Trees provide the primary stabilization, which may be augmented by shrubs, understory trees, vines, and herbaceous plants.

Forest Cover Type

Most of the earthworks in forest [see Figure 1] occur in the oak-pine forest region of the Mid-Atlantic states, bordered to the north by the oak-hickory forest and to the south by the southeastern evergreen forest. The Petersburg, Richmond, Fredericksburg, and Colonial parks are all located in the oak/pine forest region which extends from New Jersey south to Georgia, and west to the Mississippi River Basin. The landscape is gently rolling topography which in Virginia occurs on the coastal plain north of the James River and over much of the Piedmont. The forests are typically mixed oak and pine with more pine occurring in younger landscapes and a gradual replacement by deciduous species. Pines, however, will persist on poorer and drier soils and were prominent in the pre-settlement forest cover. When mature, the forest type is very similar to the oak/hickory forest found further north and west except for the presence of abundant sweetgum and sourwood in the oak/pine forest.

The more northern earthworks sites such as Valley Forge occur in the oak/hickory forest. Further to the south the transition is made to the southeastern evergreen forest, where longleaf pine, which is absent from the oak/pine forest, becomes abundant. Land that is cleared for agriculture and later abandoned is usually initially invaded by pine. The pine forest which then develops is invaded by hardwoods which first appear as a dense understory layer. The forest gradually becomes mixed pine and oak and may in places succeed to mixed oak or oak and hickory.

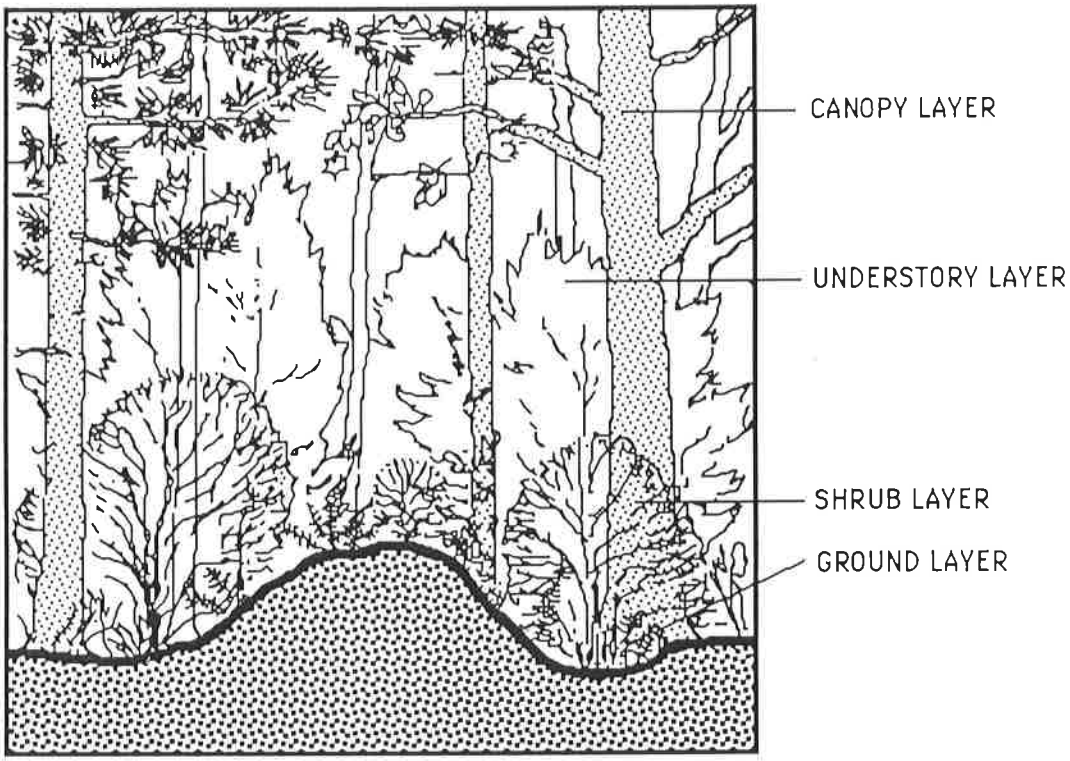


Figure 1:
Existing Forest Cover Types: Forest

Dense native forest. Earthworks well stabilized.

Lowland vegetation types generally occur in valley bottomlands in the Piedmont sections, while in the coastal plain, broad upland swamps may occur in the shallow interstream topography. Sweetgum, elms, red maple, ash, willow, and water oak are found in the lowlands, as well as river birch, black willow, sycamore, and cottonwood, especially along the stream channels. Common shrubs include blueberries, viburnums, huckleberries, and laurels.

Although there is more forest today than in the earlier eras, when agricultural areas were more extensive, many of the remaining forests today are threatened by disturbance. Despite local disturbance, these forested areas represent a very significant regional resource in the preservation of the heritage of historic native landscapes. At present, however, the opportunity to interpret this aspect of the historic context is largely unrecognized.

It is from an interpretive perspective that the most serious difficulties arise. There are, at present, few satisfactory models for interpreting a forested earthworks. Fort Darling or Drewry's Bluff, part of Richmond National Battlefield Park, is one of those few successfully interpreted forested earthworks. As this cover type is already the least accessible, the problem of trampling and other undesirable uses can only be solved by providing a more satisfactory alternate visitor experience and by resolving the conflicts of non-park related uses.

From an archeological perspective, with earthworks already under forest, potential damage to the stratigraphy by large tree roots has already occurred. If large numbers of trees are then cut in an effort to protect the resource, greater damage may be done by the rotting root systems left in the earthworks. One solution to the problem of large old trees collapsing and tearing apart the earthworks may be to target a few critical sites where the maturation of existing large trees can be inhibited by selective cutting.

The earthworks under forest cover are the most well stabilized. The naturally acid condition of the soils inhibits some decomposition and actually reduces the rate at which organic matter, such as heavy timbers and old root systems, deteriorates. This is counteracted when the soils are limed to support turf grasses and other non-native vegetation. The forest structure, which is visibly layered above ground, with canopy, understory, shrub, and ground layers, is also layered below ground, with a complex of layered roots which in mass are equal to the trunks and branches above. This does not mean, however, that they are without problems. Erosion and trampling may be locally severe, especially when these areas are adjacent to interpreted sites or other facilities. Damage from animal burrowing and dead or windthrown trees also occurs. Often these problems are used to justify 'management for preservation', and hence clearing. Clearing operations, however, do not control or eliminate any of the undesirable uses. Most presently forested sites are too remote to be adequately monitored, regardless of cover type, and casual recreational use on the earthworks is the greatest cause of immediate degradation.

In summary, the forest cover type is by far the most effective in preserving earthworks. There are presently no forested earthworks which would be better preserved by changing cover type and many cleared earthworks should be restored to forest.

Cleared Woodland Cover Type

Cleared woodland is a cover type which results from management of previously forested sites. All understory and shrub layers are removed and most canopy trees leaving only a few widely spaced large trees [see Figure 2]. The ground layer is frequently bare, with some leaf litter, vine cover, or occasional herbaceous plants. This management is designed to increase visibility for interpretive and surveillance purposes, and to limit future tree growth, which is currently perceived to pose a threat to earthwork stability, because of root damage and the possibility of windthrow. With the exception of an occasional temporary seeding of annual rye, no effort is made to establish turf or any other ground-layer vegetation. The only plants which appear to be favored by this clearing are vines, especially Japanese honeysuckle, an invasive disturbance species. The rate of the spread of honeysuckle varies with the degree of local infestation and the density of existing canopy cover. Since there has been no provision for eventual canopy replacement, tree cover will continue to diminish over time and vine growth to accelerate, ultimately eliminating the woodland character. In addition, there is the danger that forested areas can be impacted by invasion of disturbance species moving in from areas of cleared woodland.

Clearing to create open woodlands is widespread throughout the parks in forested areas. Unfortunately, it is easy to accomplish with unskilled and changing labor crews, such as students. Although this cover type gives the immediate appearance of a tidy, open woodland, the impact on earthworks stability is always negative. Clearing initiates a major cycle of erosion and encourages continued soil loss over time. The stress of trampling often accompanies increased visibility and access. Along Lee Drive at Fredericksburg, where brush has been removed at irregular intervals over the last fifty years, the dense shrub and sapling layers, which in the surrounding unmanaged forest sharply limit visibility, are noticeably absent, permitting the desired distant views. However, at this site bare soil is exposed over a large proportion of the ground area, with evidence of rain-spash erosion and occasional rills.

The severity of the impacts of this cover type are especially evident the first time an area is cleared. Portions of Fort Conahey at Petersburg show several inches of soil loss within less than one year after clearing. When similar problems were observed on newly cleared sites in the National Capital Region, the clearing process was modified to leave behind at least six inches of stubble, which reduced but did not eliminate erosion. In many areas, the added access in cleared woodlands has aggravated existing problems. In an effort to control relic hunting by increasing visibility, several tiers of earthworks were cleared at Cold Harbor in Richmond. These earthworks are now entirely crisscrossed with trails. Relic hunters have not been controlled by this effort, though they may have retreated deeper into the woods.

Cleared woodlands as a cover type seriously jeopardize the stability of the resource. Despite its widespread acceptance throughout the parks, this cover type should be eliminated. The goal of increasing visitor interpretation by increasing visibility of the earthworks must be reevaluated in light of its destabilizing effects, and alternate solutions to interpretation developed.

FIELD COVER TYPES

There are currently two field cover types: Rough Grass [see Figure 3] and Turf [see Figure 4]. In both cases, grass provides the primary stabilization, although occasional individual trees may occur.

Rough Grass Cover Type

Rough grass usually looks like a poorly maintained lawn. The cover is often discontinuous, and in places may be very sparse, with exposed patches of bare soil [see Figure 3]. The species present are typically a mixture of turf varieties, familiar lawnweeds, desirable and undesirable native grasses, and native wildflowers. Rough grass is typically mowed a little less frequently than turf, but still often enough to inhibit the development of a dense stand of native grasses. However, these infrequent mowings are also inadequate to stimulate good turf cover in the absence of other appropriate maintenance procedures. Much existing rough grass is in park areas where casual recreational use is high and has encouraged problems of littering, trampling, and occasional vandalism.

The rough grass cover type generally occurs in areas which were formerly turf, but which have deteriorated due to poor maintenance and/or poor soil conditions. Examples include portions of Bloody Angle and East Angle at Fredericksburg and portions of Fort Gilmer and Fort Harrison at Richmond. In some areas, such as Fort Wadsworth at Petersburg, turf grasses were seeded, but failed after the first season because of inadequate site preparation and poor maintenance. Occasionally, rough grass cover has resulted from repeated mowing of native grasslands, such as at Colquitt's Salient at Petersburg and Cold Harbor at Richmond.

Rough grass is also found on many sites which have been cleared for scene restoration. In most cases, the intent was to establish pasture grasses for future agricultural use. However, inadequate site preparation and poor maintenance of newly seeded areas is typical. During the period from the demise of the original seed until takeover by native grasses, there is considerable bare soil exposed to erosion, and large volumes of topsoil are lost even if gullying is not readily apparent. This not only leads to excessive soil loss, but diminishes long-term soil fertility. Unless there is justification for an appropriate level of investment to maintain dense pasture cover, all

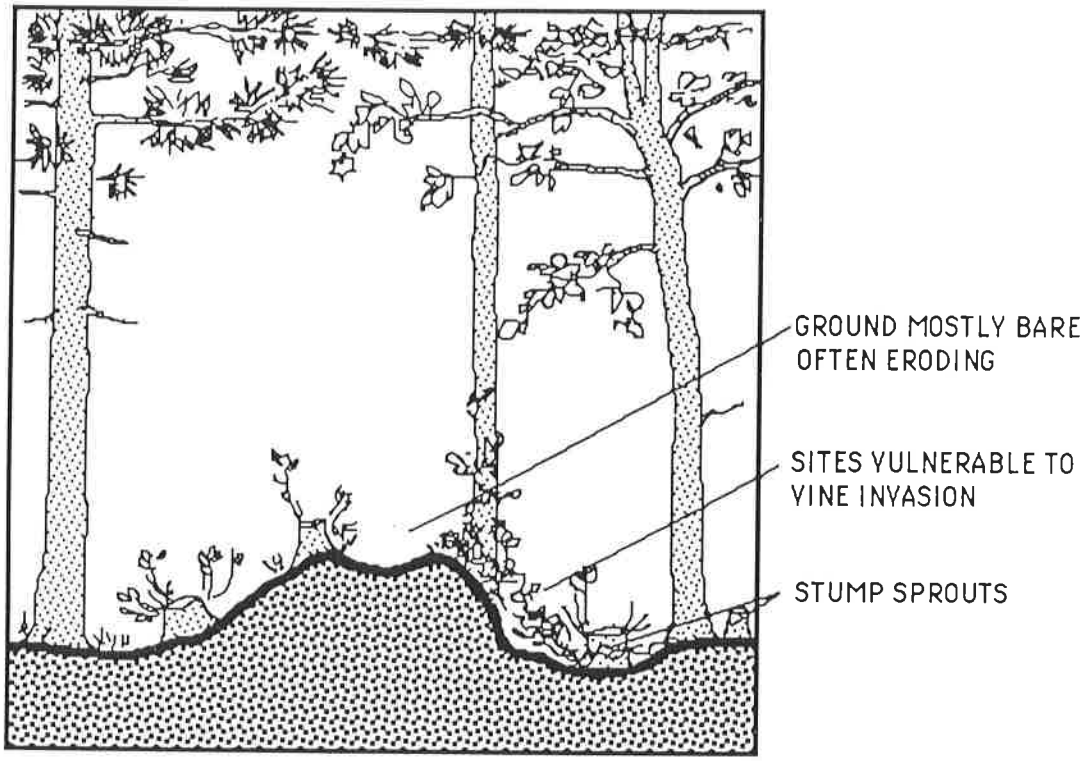


Figure 2:
Existing Forest Cover Types:
Cleared Woodland

All shrub and understory layers removed, with only a few larger canopy trees left standing. Ground mostly bare, with occasional stump sprouts. Erosion often severe.

these sites should be converted to native tall grass meadows, which are less costly to maintain and provide more effective stabilization.

From an archeological perspective, rough grass poses no direct threat to the resource, but its limited stabilizing effect could lead to excessive erosion in some areas.

In summary, rough grass cannot be maintained in good condition, because it is suspended between two vegetation types -- turf, which requires mowing and alteration of native soils, and native grasses, which are intolerant of frequent mowing and favor existing soil conditions. In virtually all cases, rough grass should be converted to another cover type. Although much of the extent of rough grass is presently perceived of as turf, it should not be rehabilitated to support turf in the future. Failure to establish turf often indicates the site is unsuitable for turf for a variety of reasons. Sites, such as Fort Wadsworth which was inadequately prepared for turf, would require too high an initial investment to maintain in healthy turf. This site, also too remote for adequate surveillance, is better stabilized by forest.

Turf Cover Type

The term 'turf' refers to what is commonly known as mown lawn [see Figure 4]. Today lawns are comprised primarily of hybrid varieties of non-native grasses which retain a green color during the spring and fall growing seasons and brown out during the summer and winter dormant seasons. These grasses are tolerant of frequent mowing which stimulates the development of new shoots. This maintained juvenile growth pattern is uniform and carpetlike in appearance.

From an interpretive perspective, turf cover is very satisfactory, since the form and scale of the earthwork is completely visible to the viewer. Turf in combination with shade trees also contributes to a park-like character, and grass is often considered a high priority by most park managers and visitors.

The root system of turf is similar to the shoot system. When intact, the dense, fine, and relatively shallow root network provides good stabilization of the surface, but does not anchor a slope with the graduated system of larger woody roots, typical of trees and shrubs. Turf, when well maintained, protects the earthworks from erosion. The shallow rooted grasses do not disrupt the stratigraphy of soil and artifacts below grade.

Turf does not occur naturally and is usually established by seed. During the growing season, turf requires almost continuous mowing. Turf grasses require a higher pH than the soils native to most of the eastern United States and must be limed regularly. Turf also requires supplementary fertilization, in part to support the continuous new growth. These maintenance requirements are exaggerated on earthworks where the less fertile and more acid subsoils occur at the surface. The construction of the earthworks did not entail reserving the topsoil for use to provide a good turf growth medium.

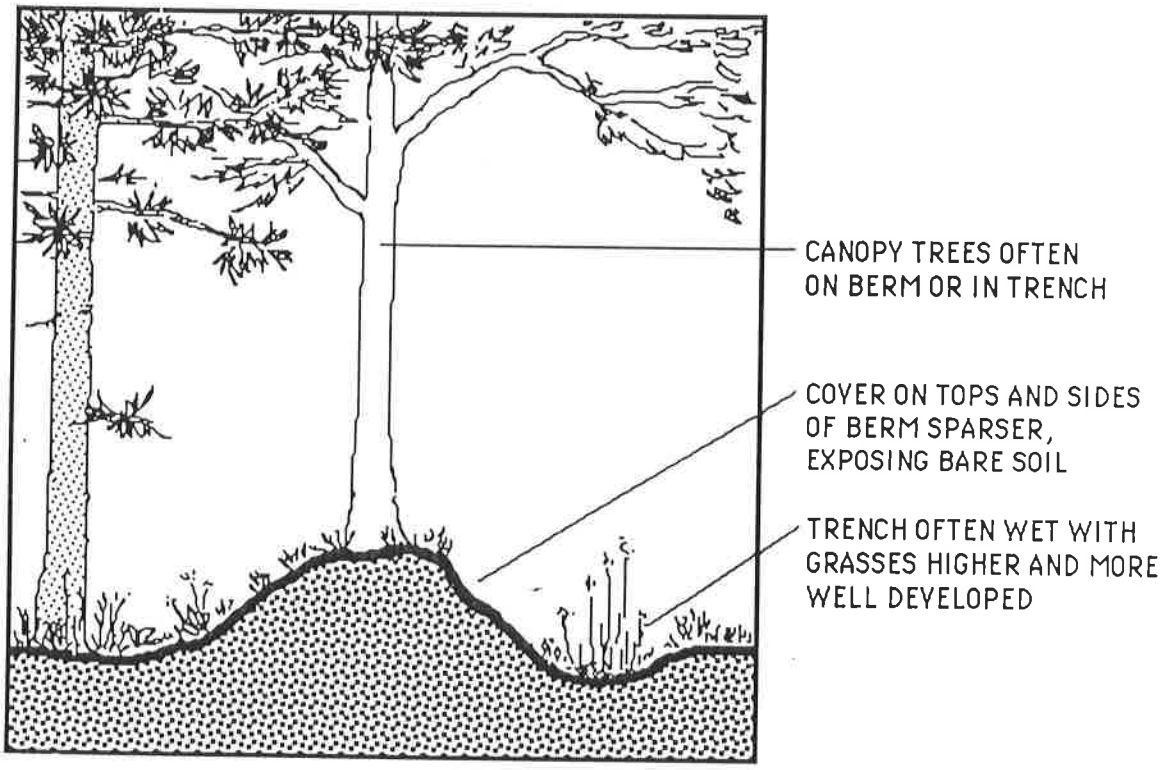


Figure 3:
Existing Field Cover Types:
Rough Grass

Patchily established mixture of lawn grasses, native grasses, and wildflowers.

As a cover type, turf is labor intensive and costly to maintain. Currently, a significant proportion of park management budget goes to turf maintenance, draining funds which might be directed to more critical projects.

Turf is found throughout the parks and is the cover type most characteristic of interpreted areas and areas with a high visitorship. It is most frequently found on intensively interpreted earthworks, generally near major visitor centers which are centrally located within each battlefield park. At Fredericksburg, examples of turf cover include the fields and earthworks at the Lee Hill Exhibit Center and portions of East Angle and Bloody Angle. At Petersburg, the Visitor's Center area, including Battery Five, the Crater, and Fort Stedman, are turf covered. In contrast, at Richmond, there is almost no turf cover intact on earthworks, though some lawns are maintained adjacent to some facilities, such as the Chickahominy Bluffs Overlook. At Colonial, virtually all the interpreted earthworks are turf covered. The condition of the turf on these sites varies considerably with the intensity of use and level of maintenance.

The most effective turf cover is generally found on restored or reconstructed earthworks which have had a surface application of topsoil and appropriate liming and fertilization, at least during the establishment period. While the grass at some of these sites is still in relatively good condition, elsewhere it has deteriorated over time, because routine maintenance, such as fertilization and liming, has not been adequate to maintain turf in good condition.

At Colonial, where some earthworks were reconstructed in the 1930s and 1950s, and again in 1976, the grass is still in excellent condition. Native soil conditions at Colonial are less acid and less sandy than those found at Fredericksburg, Richmond, and Petersburg and therefore are considerably more favorable for the establishment and support of a turf cover, and eroded places are consistently repaired as needed. Erosion problems still occur, however, where foot traffic is concentrated and uncontrolled, and on some steeper slopes where establishment of turf is poor.

The most serious problems with turf cover type are related to stabilization issues. Many of the earthworks are more steeply sloped than is generally recommended for grass stabilization, and would be better reinforced by the more complex root network provided by forest cover.

The steep slopes are difficult to mow. Where the surface is uneven, the grass cover may be skinned off by the mower, exposing bare ground. Eroded patches are ubiquitous and require continuous repair, which in places exceeds the present maintenance capacity of the park units.

Most critically, turf provides virtually unrestricted visitor access. Wherever there is trampling, compaction occurs, and where it is excessive, the cover fails and the surface erodes. Where foot traffic is largely uncontrolled, alterations of the earthwork form due to compaction are inevitable. While the open character of a grass landscape allows good visibility, this is only effective where nearly continuous surveillance is possible.

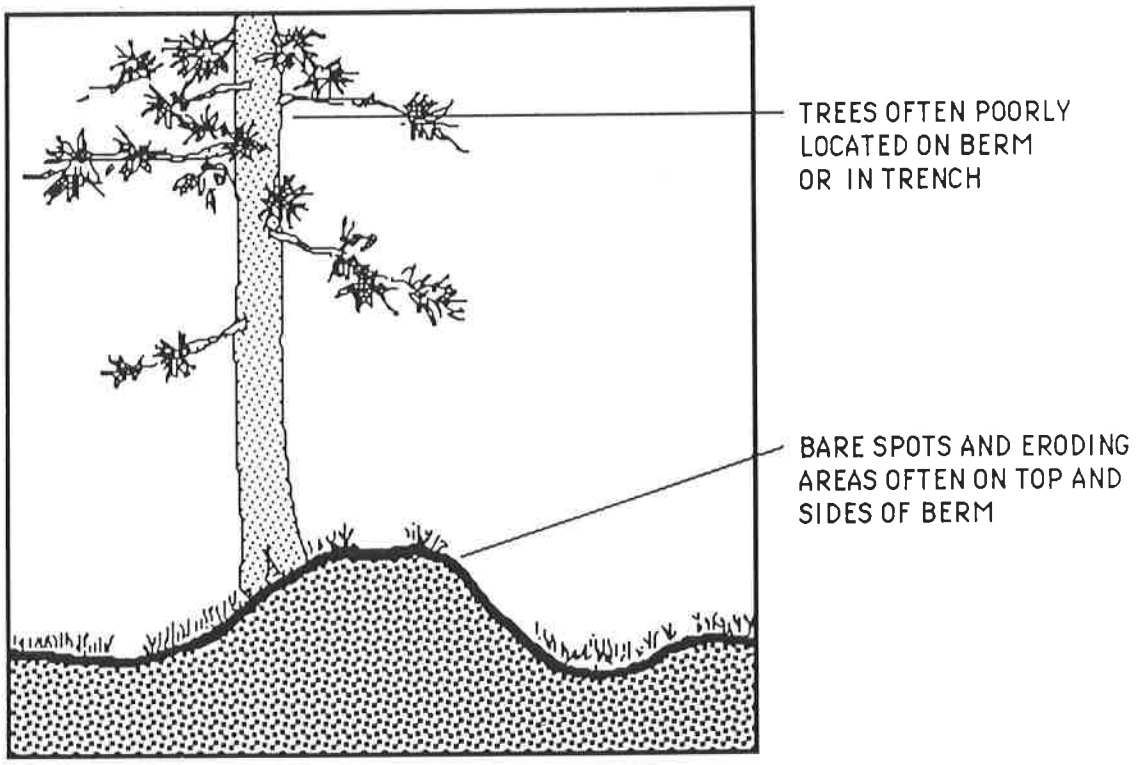


Figure 4:
Existing Field Cover Types: Turf

Lawn grasses often poorly established, under occasional tree canopy.

There is, at present, insufficient evidence to determine the level of stabilization that can be achieved using turf cover versus forest cover. Most of the sites which now support turf have been so significantly altered by trampling and subsequent erosion that evaluation of the effectiveness of the cover type is difficult. At Colonial, where good cover has been maintained for a period of time, the geometry of the earthworks appears to be largely intact. The reconstructions at Colonial have held up well despite high visitorship. Since walking on the earthworks is integral to the current interpretive program, conditions are likely to deteriorate over time. While it is clear that earthwork walking is a very enjoyable visitor experience and provides an excellent battlefield view, it clearly conflicts with preservation goals and with objectives at other battlefield parks.

In summation, turf provides appropriate stabilization only when maintained in good condition. Given the high cost of existing turf maintenance, turf should be restricted to those areas where visitor access can be adequately controlled. Where visitor access cannot completely controlled, no original earthworks should be stabilized by turf, nor should turf be used at remote sites which cannot be monitored. Rehabilitation of existing turf in poor quality should be given high priority, and those areas which cannot be properly maintained should be converted to a cover type which better restricts access and provides a higher degree of preservation.

SPECIAL CONDITIONS

Vine Cover Type

While honeysuckle, an alien species, is the predominant vine in this cover type, many native vines, such as poison ivy, catbrier, and raspberries, are also vigorous, though less abundant. Kudzu, found frequently outside the park, was not observed within park boundaries, although it may occur occasionally. Native vines are not invasive enough or found extensively enough to cause significant problems. Japanese honeysuckle mounds occur largely in monospecific patches of greater or lesser extent, depending on the age of the patch and the amount of disturbance at the site. Because of the dense growth characteristic of honeysuckle, tree and shrub germination are inhibited and existing woody vegetation, other than the vines themselves, are smothered and eventually killed.

The vine cover type [see Figure 5], which is predominantly honeysuckle, is at present relatively limited in extent, the most extensive areas are found in Richmond along Battlefield Park Road. Smaller localized patches of this cover type occur throughout the parks, especially in areas where forest has been cleared of brush and cleared woodland created, or in those areas where the ground is bare. Patches of vine cover can also occur even in forested conditions as the result of invasion from adjacent cleared areas. For example, at Fort Harrison, honeysuckle was well established in the forest even before the site was cleared nearly fifty years ago.

As more land is cleared for agriculture and urbanization, many of the remaining fragments of forest are threatened by disturbance from invasive alien species. Many of these species, such as honeysuckle and kudzu, were introduced to control erosion resulting from excess grazing, tilling, or grading and have become serious pests. This cover type, ubiquitous throughout the region, was probably well established in the area even before the Civil War and was planted to stabilize railroad embankments throughout the region. Honeysuckle also spread rapidly as a consequence of forest clearance by the National Park Service and the continued disturbance of forested areas throughout the region.

Honeysuckle, like kudzu, was once widely perceived as an excellent ground stabilizer. Growth is rapid, cover seems complete, and applicable to almost any site. But the long-term results did not warrant the early optimism. The vine's shallow, opportunistic root systems do not provide anything close to the level of stabilization of native forest systems. Slumping and soil slippage continue to occur, and surface soils are still exposed to erosion beneath the heaping cover. In Virginia, where honeysuckle is virtually evergreen, it holds the soil far better than kudzu when young. As it matures, however, it heaps higher and higher over old stems and the number of rooting sites diminishes, with a probable decrease in its capacity to check erosion. Not only do these species fail to stabilize as hoped, they have proved to be highly invasive and largely free from the natural controls of their own native habitats. An equally serious problem related to this cover type is its potential impacts on native habitats within and near the park lands. As forests throughout the region are increasingly disturbed and fragmented, they are ever more vulnerable to honeysuckle.

From an interpretive perspective, the overall layout of a fort is adequately called out by the vine cover type, where the floor of the fort is mown grass and contrasts well with the darker leafy vines. The specific form of each earthwork, however, is somewhat obscured as the vines mature and form heaping masses. Along linear earthworks, the visual distinctions between trench and berm are gradually obliterated as the vine mound enlarges. The vine cover type also does not satisfy the goal of recreating an authentic historic setting, either cultural or natural, although vines present no significant threat to buried archeological artifacts.

In summary, management for preservation of earthworks should not foster the widespread distribution of a disturbance species which threatens the health and diversity of native plant communities both in and adjacent to the parks. We recommend elimination of this cover type, especially since there are other cover types which can provide more effective site stabilization.

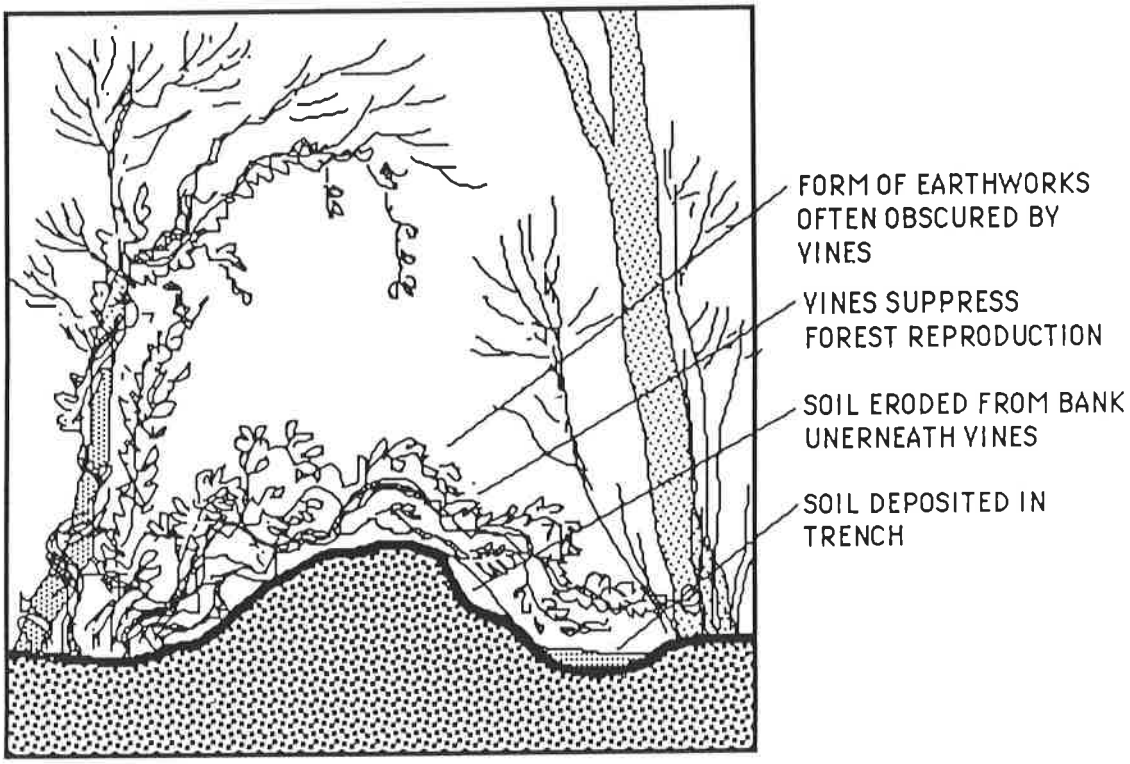


Figure 5:
Existing Special Conditions: Vine Cover

Nearly monospecific mounds of vines, predominantly Japanese honeysuckle. Typically found in patches, and occasionally forms nearly solid undergrowth.

Horticultural Groundcovers

Despite the fact that most previous management reviews have recommended a variety of low growing woody and herbaceous groundcovers, there is very little of these cover types established in the parks. Some periwinkle (Vinca minor) was planted at Fort Harrison, and is being overtaken by honeysuckle. Some sand lovegrass was also planted at Fort Harrison in the repair of eroded areas, but it has taken only in patches. Periwinkle was planted by the CCC in the 1930's on miles of earthworks along Lee Drive at Fredericksburg. Where forest edge conditions of partial shade exist, this groundcover provides effective stabilization. However, in full shade cover is insufficient and severe erosion is evident. In full sun periwinkle is at a competitive disadvantage with more vigorous vines and woody plants. Current National Park Service policy discourages the introduction of exotic plants such as periwinkle.

Other groundcovers recommended in past reviews fall into three groups: (1) invasive alien species, such as memorial rose, which is contrary to current objectives and should be viewed as a disturbance species; (2) native vines, such as trumpet honeysuckle and Virginia creeper, which do not provide adequate cover for stabilization; and (3) conventional stabilization species, such as crownvetch, sand lovegrass, and 'wildlife grains', all of which do poorly under the light tree cover found on most of the earthworks and are also not native, conflicting with existing objectives. All of these species are extremely vulnerable to honeysuckle invasion.

From an interpretive perspective, groundcovers might serve to clearly call out the form of the earthworks, but the idea of maintained beds of horticultural plantings on earthworks conflicts with the objectives of evoking a genuine historical setting.

There appears to be no reason to further pursue the establishment of groundcovers for earthworks preservation. This cover type is costly to install and maintain, is poorly suited to solving large-scale, long-term management problems, and represents a hazard to the native plant communities. Several of the flowering groundcovers, such as thrift or creeping phlox, provide no cover whatsoever during the winter months. A gardenesque approach cannot be implemented on the scale of the earthworks, and it is questionable if, from an interpretive perspective, such groundcover beds are appropriate. Despite the suggestion that species selected be suitable for existing environmental conditions, most are not well suited to the acid, sandy, clay loams of this region and require substantial fertilizing, liming, weeding, and mowing.

Bare Soil

A bare soil condition is maintained at the demonstration earthworks built as a Living History exhibit at Petersburg. The site requires regular maintenance similar to that which was required during actual military use, and this is incorporated into the interpretive program. As these are not original earthworks, the soil loss and subsequent rebuilding does not impact any cultural or archeological resources. The exhibit is a very effective interpretive tool and helps provide a sense of immediacy that is not possible

with vegetatively stabilized sites. The current management and maintenance appears appropriate and adequate. It is, however, important to ensure that no sedimentation occurs in nearby small tributary streams.

Gravel Stabilization

A replica earthwork built by Civilian Conservation Corps crews at Lee's Lookout, Fredericksburg, was stabilized at the surface with a graded gravel, designed to accommodate foot traffic. But because this cover type occurs where the earthworks have been recreated and are not authentic, like the Living History sites, no critical cultural or archaeological resources are impacted. As the earthwork is bare, it allows the visitor to see and experience it as it was during the Civil War. Gravel also appears to work well in stabilizing the earthworks. At the earthwork at Lee's Lookout, there is some erosion on the side slopes but, considering that the site has been virtually unmaintained for fifty years, it has held up remarkably well. However, since this cover type encourages pedestrian use, it conflicts with objectives, as interpreted herein, to avoid all traffic on the earthworks, and if used on original earthworks would lead to excessive trampling.

Other Proposed Non-Plant Cover Types

Some interest has been expressed in non-plant stabilizing materials, such as plastic fibers and netting as well as soil cement and epoxy treatments. While limited use of some of these products may be useful for reclamation of severely disturbed areas, none is applicable for broad application in earthworks stabilization. The cost would be prohibitive and in many cases such treatment would actually inhibit the establishment of stable vegetative cover and long-term preservation.

D. RECOMMENDED VEGETATIVE COVER TYPES

In order to provide vegetative cover that will be lower in cost, easier to maintain and that will also protect the resource, four cover types are recommended. Forest and Light Forest cover types are suited to closed forest landscapes, where canopy cover is virtually continuous and woody plants provide primary stabilization. Tall Grass and Turf cover types are suited to open field landscapes where herbaceous plants provide primary stabilization. For both forest and field landscapes, there is a high- maintenance and low-maintenance alternative, each with appropriate interpretive strategies to permit visitorship to the earthworks without degradation.

Forest and Tall Grass, which provide the greatest level of stabilization and require the least maintenance, should become the most prevalent cover types over time. Light Forest should be restricted to areas where visibility is important and is related to appropriate interpretive facilities. Turf, which is already too extensive, should be substantially reduced. The existing Rough Grass, Cleared Woodland, and Vine cover types should be completely phased out, and current management of these cover types immediately revised.

FOREST COVER TYPES

Forest Cover Type

The forest cover type [see Figure 6] is comprised of naturally established native forest communities. The forest landscape is enclosed and intimate. Visitor attention is focused on specific site details, rather than on the larger panorama. As development increases everywhere, the experience of real forest becomes more special and immediately conveys the sense of stepping back in time. The fact that these earthworks were not forested at the time of the battle is not likely to confuse the visitor. They were not in turf either. Rather, the visitor will experience the excitement of discovering the artifact preserved beneath the forest blanket. In addition, many of the forested sites are located where land parcels are quite small and only the forest cover provides an adequate buffer from the intrusions of surrounding land uses.

Because of the limited tolerance to trampling of the forest cover type, all interpretive facilities require a high degree of control of access. No undirected interpretation should be permitted. For example, a parking area and signage without a related path system only invites misuse of the resource by the visitor. It is also important that the path system clearly convey the message of the fragility of the earthworks and forests.

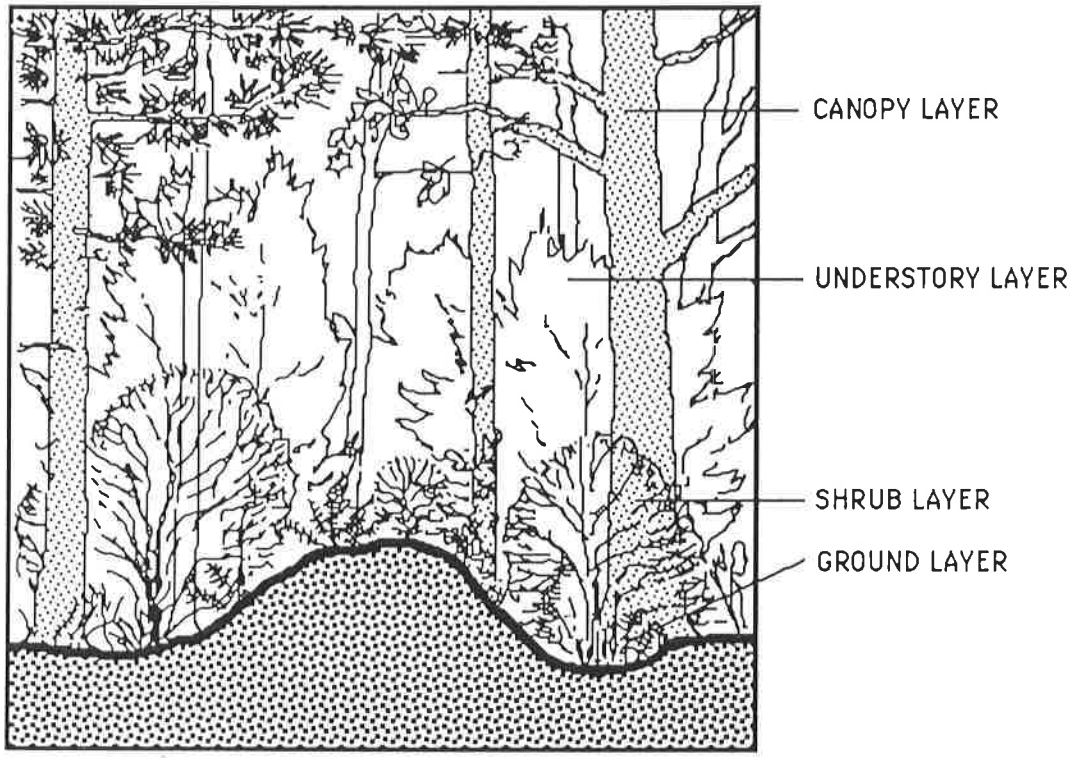


Figure 6:
Recommended Forest Cover Types: Forest

Dense native forest managed to maintain multi-aged, multi-layered structure. Monitor for hazards, such as windthrows, animal burrows, and relic hunter's holes.

Therefore, a boardwalk, slightly elevated and preferably with railings, is recommended rather than a simple paved trail. Design details which minimize construction damage to the earthworks can be developed. A boardwalk allows the visitor to see the earthworks from different elevations and can compensate for the limited visibility within the forest. Views can be directed to site details, which might otherwise be overlooked from a paved path. Signage should occur along the entire journey at selected viewpoints, rather than occurring only at the point of entry. Boardwalks are more costly than paved trails and will require careful planning and a well thought-out design. In places, a combination of boardwalk and path trail may also be effective. Sustaining the remarkable level of preservation of many forested sites is worth the investment and would allow these areas to be interpreted. Vandalism, when it does occur, is most likely to be directed toward the facilities, which are replaceable, rather than toward the resource.

Virtually all currently forested or recently cleared sites are suitable for the Forest cover type, although it is largely restricted at present to uninterpreted sites. When established and protected from disturbance, these sites are virtually self maintaining. Under forest, the ground is protected from erosion and monitoring will control damage from windthrows, rotting stumps, burrowing animals, and relic hunters. Because forest cover restricts access more effectively than any other cover type, all remote uninterpreted sites should be left forested or allowed to return to forest. In some cases, where unauthorized access is a severe problem, the forest canopy might be thinned to encourage a denser shrub and understory layer to develop. This could also be augmented with planting.

The ultimate managment objective of the forest cover type is to have a stable, healthy, and self-sustaining native landscape community requiring almost no maintenance. Where the budget allocation is directed primarily toward upgrading the interpretive program, education about historic native habitats should also be incorporated into the program, and might address such issues as timber harvesting, medicinals, livestock browsing, hunting and trapping, and other historic uses of forest resources, as well as the natural and ecological history of native habitats.

Light Forest Cover Type

Light Forest cover [see Figure 7] is simply naturally established native forest communities which have been selectively thinned or prescribed burned to provide greater visibility, while retaining the natural stratification of canopy, understory, shrub, and ground layers. As a management type, it is recommended to replace the present Cleared Woodland cover type, which removed all trees less than 13" dbl caliper and all shrubs, thus eliminating long-term forest vegetation.

The character of a light forest should be similar to the surrounding native forest. Visitor attention should be focused on the earthwork, without a specific awareness of the thinner cover.

Selective thinning and prescribed burning are intended to maintain the natural layered structure of the forest, removing only a portion of the shrub and understory plants, or reducing their height, rather than removing these layers completely. In this manner, greater species diversity can be maintained as well as reproductive continuity of the forest community.

FIELD COVER TYPES

Tall Grass Cover Type

Tall grass cover is composed primarily of native grasses with occasional naturalized alien grasses and wildflowers [see Figure 8]. Tall grass cover that is not mowed or burned yearly or bi-annually will return to forest. The root systems of tall native grasses are relatively dense and deep and this cover type provides excellent stabilization. which is persistent and requires low maintenance. Pasture is a more intensely managed alternate to native grasses, which today is comprised primarily of Kentucky tall fescue (K 31), chewings fescue, and clover.

At present, examples of tall grass cover are found on virtually all abandoned crop and pasture fields in the region. These areas typically revert to native grasses before gradually returning to forest or being taken over by vine mounds. The most predominant grass is little bluestem which is also called locally broomsage or broomsedge, and is botanically familiar as Andropogon scoparius, recently reclassified Schyzachrium scoparium. Most of the recently cleared woodlands in the park are developing native grass cover naturally. It usually takes at least three to five years for dense cover to establish, as most of the grasses in the parks are long lived and relatively slow to develop. Portions of tall grass meadows occur at East and Bloody Angles, in Spotsylvania, and between Fort Stedman and Colquitt Salient, and in virtually every park, although most are being managed as rough grass.

Tall grass cover is especially suitable for sites where a dense stable cover can be established fairly quickly, with some alterations to current management practices. Some examples include portions of East and Bloody Angles of the Chancellorsville Battlefield and Colquitt Salient at Petersburg. Almost any open site with 40% or less tree cover can be stabilized with native grasses. The acid, infertile subsoil which occurs at the surface of most earthworks is a poor growing medium for turf but will support dense growth of native grasses with only minimal maintenance required.

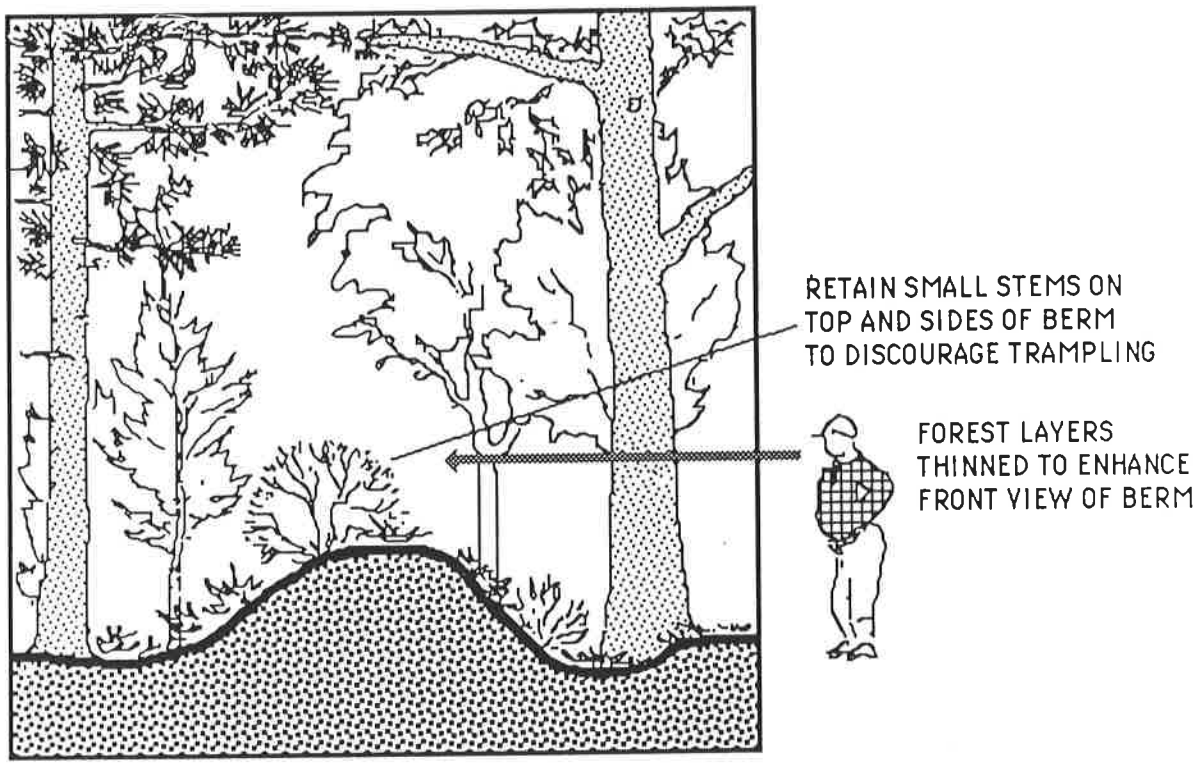


Figure 7:
Recommended Forest Cover Types:
Light Forest

Native forest selectively thinned in the shrub and understory layers to allow adequate visibility while retaining overall layered structure. Only a small amount of thinning should be done each year.

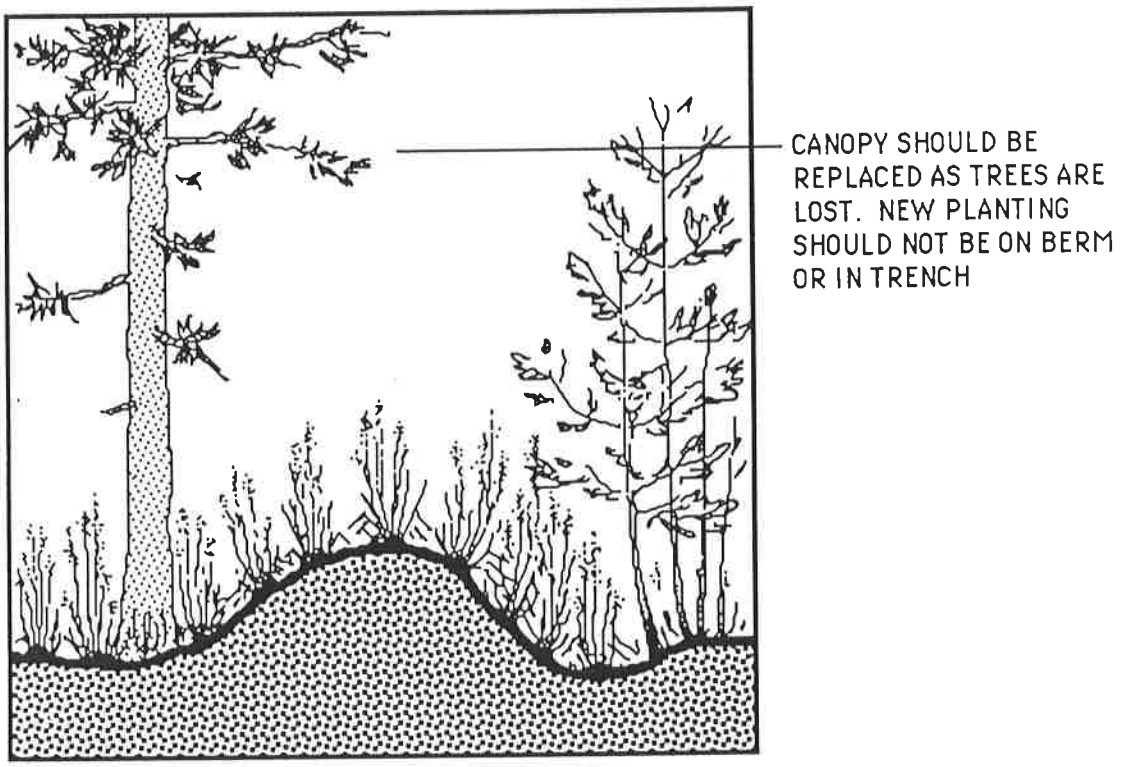


Figure 8:
Recommended Field Cover Types:
Tall Grass

Dense stands of native grasses, primarily little bluestem, under a light tree canopy.

There are extensive areas in the park units which now support poorly established native, pasture, and rough grasses. Many sites currently maintained as rough grass provide less effective stabilization than they might. If they were managed to favor tall grasses instead, a considerable cost saving over time could result.

From an interpretive perspective, tall grass discourages trampling and access more effectively than turf and still provides excellent visibility of the earthwork. The path system for interpreted earthworks in tall grass cover can be either hard surfaced or turf. It is recommended that turf trails set in larger tall grass areas should be eight to twelve feet wide to limit concentrated foot traffic and to minimize visitor exposure to ticks and other pests. The general guidelines for paths would be similar to those for other cover types, such as keeping to level ground adjacent to the earthwork and minimizing crossings. No trail should be located on the top of an earthwork and all crossings should occur slightly above grade. Wooden boardwalks and paved surfaces with handrails can be used where more intense foot traffic is anticipated.

The most significant opportunities for tall grass cover occurs at sites designated for scene restoration, where large expanses of herbaceous cover must be maintained economically. Like turf, tall grass can be used to create broad sweeping vistas and reveal the natural contours of the land, as well as the dramatic forms of the earthworks. Where it is desirable to give the impression of an historically accurate setting, tall grass is preferable to turf because of its natural character which creates a pastoral rather than a park-like setting. The relatively uniform character of a tall grass meadow can create the image of 19th-century agricultural use. A rich interplay of native field and forest habitats could provide a landscape very similar to that which must have existed during the Civil War and this evocation of an historical setting is increasingly important to a coherent visitor experience as the surrounding rural environment, which once was the context for all the parks, disappears.

Agricultural pasture grass should be considered a suitable alternative to native grasses only where the area can be adequately maintained with properly supervised agricultural lease programs, including mowing, fertilizing, and periodic reseeding. It is recommended only for open fields with no cultural resources. It is not suitable for earthworks, or where actual cropping or pasturage would result in environmental damage, or threaten critical cultural resources through the grading, tile drainage and access roads associated with modern agriculture.

In summary, existing turf and rough grass areas which cannot be adequately maintained could be effectively converted to native tall grasses. The major obstacle in establishing this cover type is the limited experience in creating and managing meadows. The manual guidelines are only a beginning and should be continuously revised and updated as expertise is gained.

Turf Cover Type

The Turf cover type [see Figure 9] consists of mown lawn grasses with occasional groves and specimen trees. It is described fully in the Existing Cover Type section. Turf is an effective stabilizer only when properly maintained and is not suitable for steep slopes. The use of turf as a cover type must be accompanied by a real commitment to regular care and immediate patching of washed out or thin areas.

Because turf is an effective stabilizer of earthworks only when well maintained and is far and away the most costly cover type, it should be restricted to those areas where it meets special interpretive needs, and to those areas where visitor use warrants such a high investment.

Turf alone does not create a landscape setting. The overall character of a predominantly grassy landscape is actually determined by the topography of the site and by the landscape elements such as hedgerows, groves and woodlands, which define the spaces and the views. Whether a literal scene restoration is undertaken or not, it is important to address the aesthetic considerations which establish the park character. Many of the open spaces in the park are relatively small when compared with the historic landscape, due to forest regrowth and the limitations imposed by the park boundaries.

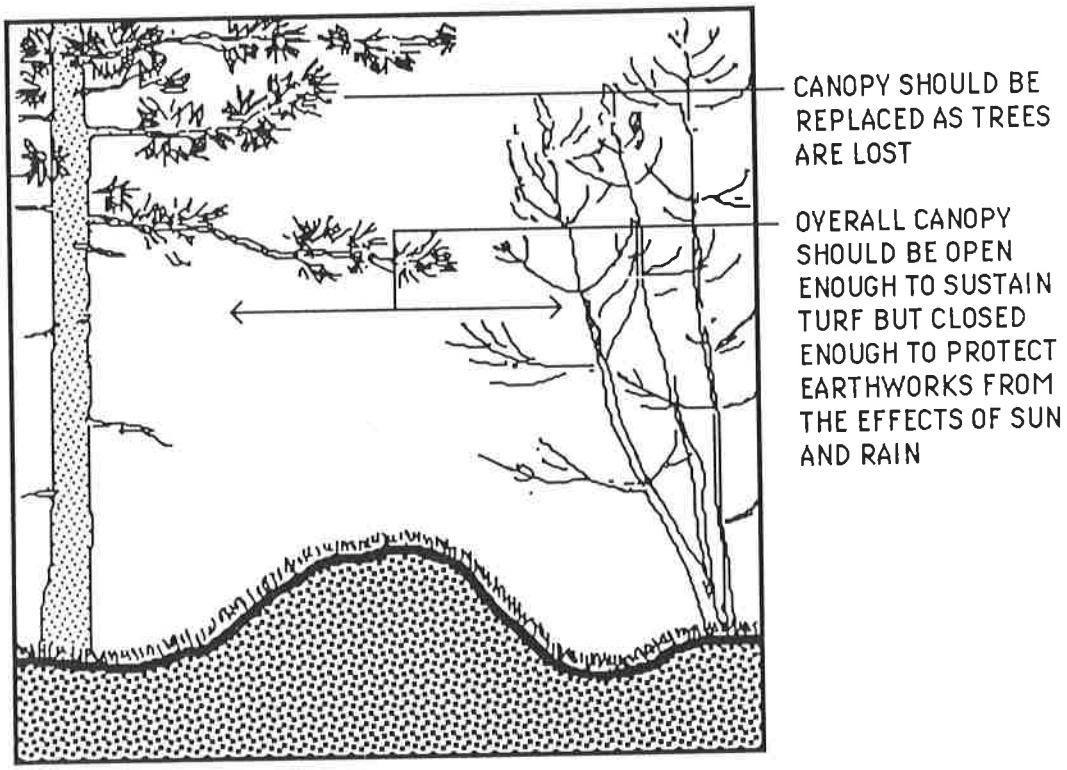


Figure 9:
Recommended Field Cover Types:
Turf

Mown lawn grasses, with occasional groves and specimen trees. Turf should be managed to be dense and with a continuous cover to prevent erosion.

In order to enlarge the sense of perceptual spaces broad changes in the scale and texture of the landscape should be used to create a landscape setting which includes foreground, middle ground and background. These recommendations are to be utilized in the context of interpreting the historical significant of the site.

For example, a specimen shade tree near a visitor center might frame a view across a lawn to a tall grass meadow embraced by groves of trees in the middle ground, with the forest beyond in the distant view. In this way, the lawn occurs in a larger landscape context evocative of the era, but restricted to those areas intensely used by visitors and to selected memorial settings.

All cultural sites with turf cover should have a hard surfaced path system. Even turf will not tolerate excessive trampling and grass paths cannot be appropriately delineated. Asphalt paving is currently most frequently used; however, gravel paths and other historic paving materials, such as brick dust and crushed shells should also be considered for use, as well as porous asphalt. Appropriate stormwater management of path drainage is crucial to prevent erosion at the edges and bases of paths. Existing eroded edges should be patched during the Interim Stabilization Program, such as at Battery 5, at Petersburg National Battlefield.

A path should never run along the top of, or cross over or run through an earthwork. Where a crossing is mandatory, a wooden stile which does not touch the earth surface should be used. The unvegetated portion beneath the decking can be stabilized with gravel. Specific viewing sites and associated interpretive signage should be incorporated along the path journey. When existing path systems require restoration, a complete review of their suitability relative to these guidelines should be undertaken. Redesign of the system should be completed before any rehabilitation work is undertaken.

The most significant deviation from these recommendations occurs at Colonial, where uniform turf cover is maintained in the central interpreted area adjacent to the Visitor's Center. At Colonial, current maintenance is generally adequate to maintain cover despite heavy use, but there are some localized problem areas which should be evaluated in light of these recommendations. In places, the turf simply needs rehabilitation, but where eroded pathways are developing, a more stable path surface or more effective control of pedestrian movement may be required. Similar situations occur elsewhere, for example, at Gettysburg where reconstructed lunettes are turf covered and well-trampled. A long-range plan should also be undertaken to determine if a suitable path system can be reasonably developed to eliminate the conflicts between Colonial and the other earthworks parks units where no walking on earthworks is permitted.

In summary, at present, the extent of turf in the parks is greater than can be adequately cared for or protected from inappropriate use, and maintenance costs monopolize

budgets despite the needs or other areas with serious environmental problems. Many areas currently in rough grass would be better maintained as tall grass rather than turf. There were no sites observed in the field which warrant conversion to turf. Where an authentic restoration of the historic scene is desirable, turf should only be used where turf occurred historically. It is not a suitable substitute for pasture, meadow, or cropland. Most importantly, a careful reevaluation of the need for turf for interpretive purposes must be undertaken, and a program for the selective reduction of the extent of turf initiated. The Management Manual is directed toward maintaining a limited area of well-cared-for turf only where visitorship and facilities are concentrated.

E. RECOMMENDED INTERIM AND PERMANENT STABILIZATION PROGRAMS

Introduction

The National Park Service is committed to both preserving and interpreting the historic battlefields in their care. Clearly, however, there can be no interpretation if there is no site, and current conflicts in objectives are resulting in an unacceptable rate of deterioration of this irreplaceable resource. The recommendations contained in this section, therefore, emphasize the fact that preservation must be effective, if there is to be a resource worth interpreting. Once a successful preservation program is in place, the interpretive programs can be evaluated and fully integrated with the management of the sites.

The recommendations address both the specific methods of preservation and the strategies by which the current management issues can be handled in the interim, as the new program is phased in. The recommendations are as follows:

1. Interim Stabilization Program

The evaluation of current management practices identified severe conflicts between preservation and interpretation. Many current practices directly damage the earthworks, as well as being detrimental to other cultural and natural resources within the parks. Access and security needs, for example, are often met at the expense of preservation, and the long-term quality and survival of the resource is compromised. It is recommended, therefore, that there be an immediate reevaluation of any proposed new program, practice, or facility. Simultaneously the most pressing problems of preservation should be identified and critical situations stabilized. The goal of this program is to achieve adequate stabilization of all the sites and should include the following components:

1a. Reconnaissance Survey

A reconnaissance survey of all the sites should be undertaken to determine the level of stability of the resource, with an inventory of all severely damaged or threatened areas. Because of the importance of achieving a proper balance of values in all the issues involved, the survey team should be comprised of the superintendent, senior staff responsible for both cultural and natural resources, and the chief of maintenance in each park.

The extent and severity of all damaged or threatened areas should be identified and mapped by the inventory team. This should include, but not necessarily be limited to, the following: inadequately stable cover types, such as cleared woodland; poorly established cover types, such as failing turf; disturbance vegetation; dead or dying trees which threaten earthworks or other resources; damage from stormwater, including erosion, sedimentation, and earthworks collecting roadside drainage; damage from relic hunting, trampling, windthrows, animal burrows, or trails; and damage resulting from inappropriate facilities.

1b. Determination of Cause

In each case, where damage has been identified, the cause of the damage should also be determined. In particular, it is important to identify whether the cause is external, such as increased stormwater runoff generated by adjacent development, or related to Park Service practices, such as a poorly designed path.

1c. Establishing Priorities

Not all problems will have the same level of urgency, so it is essential that a clear list of priorities be established. This should be closely tied to an action plan that ensures that the most critical areas get immediate attention and that damaging or destabilizing practices are discontinued.

1d. Action Plan

An Action Plan for stabilizing every site should be implemented. At this stage, the focus should be on early and effective action, guided by the priorities established above, to halt the most serious deterioration. In the long term, it is recommended that the principal method of stabilizing the sites should be the establishment of appropriate vegetative cover. To do this for all the sites will require a careful program that will take time to achieve and this is addressed more fully under the heading 'Permanent Program' at the end of this section and in the Management Manual. The Action Plan is designed to enable stabilization to begin immediately. Many of its recommendations are very simple, such as the cessation of mowing. Specifically, the main areas of concentration should be:

i.) All management practices that destabilize the vegetative cover, such as brush clearance on earthworks, or more than twice a year mowing of any grassland area (except turf) should be stopped.

ii.) All conditions where bare soil exists should be repaired and revegetated (except living history and demonstration reconstructions).

iii.) Facilities that tend to destabilize the resource should be removed or repaired. This may entail a temporary reduction in

the level of interpretation and/or access until stabilization is achieved.

iv.) Management practices which increase maintenance demands, such as forest clearance for scene restoration and turf establishment, should be halted until all existing sites are adequately stabilized.

The Interim Stabilization Program is intended to address the most serious degradation of the resource at the earliest possible time. It can, therefore, only deal with the most obvious problems in ways which do not require lengthy research, major changes in long-term policy, or reeducation of staff. However, there is no hard and fast line between the recommendations for immediate action and those for the long term, and it is expected that the Interim Stabilization Plan will, in fact, be the first steps to the implementation of a permanent program.

2. Establishing a Permanent Management Program

A permanent program for the management of all the National Park Service sites should be established, which ensures the survival of the resource for the conceivable future, is fully integrated with all interpretive programs, and is compatible with the needs of daily operation, security, and maintenance of each site. Since current practices have been the cause of many of the problems in stabilization, there will be a need for a period of transition, during which workshops and demonstation projects should take place in order that the new policies can take root and become firmly established in the institutional fabric. It is suggested that the following steps be taken to implement the permanent program:

2a. Establish Standards for New Cover Types

One of the principal management recommendations is the establishment of appropriate vegetative cover at all the sites. Forest is the natural condition for this area and as such gives the maximum protection from both man-made and natural erosion. It is also the least costly to maintain once properly established. In all cases, therefore, compatible with the function of the area, the object is to move the cover type closer to the natural forested condition. On most sites, this will mean that there has to be a transfer of cover type from what is currently there to the recommended type. This can be briefly summarized as follows:

i.) Where the current cover is healthy forest this should be kept.

ii.) Where the current cover is cleared woodland, this should be allowed to revert to forest.

iii.) Where the current cover is rough grass, this should be converted to tall grass meadow.

iv.) Where the current cover is turf, this should be evaluated for condition and need, and where possible, be converted to tall grass meadow, or otherwise remain in turf.

Specific methods for the establishment and management of the recommended cover types are described in the Earthworks Management Manual.

2b. Establish Design Standards Compatible with Preservation Goals

Not all of the problems in the parks are caused by inappropriate vegetative cover. There are many examples of design flaws that cause unnecessary damage, such as paths that lead people into sensitive areas, poorly placed signage, poorly located parking and entrance areas, poorly placed drainage, etc. These are all matters of design and can be changed provided there are clear guidleines that relate to preservation and management. Such guidelines should be developed and should address, but not necessarily be limited to, the following issues:

i.) All facilities for access and interpretation and maintenance should be designed for the least possible intrusion on the resource. In particular, penetration or other disturbance of the soil that would damage the archeological strata should not occur unless there is absolutely no alternative and, if so, be properly recorded.

ii.) Construction techniques for any new facilities should be compatible with preservation goals; structures, for example, should avoid extensive foundations, services that need extensive trenching, or methods that require heavy machinery and equipment, should also be avoided near the resource.

iii.) Address stormwater management and erosion and sedimentation control design standards for application within the parks.

iv.) Existing facilities that do not meet these requirements should be redesigned.

2c. Establish Preferred Standards for Community Context

Some problems originate outside the parks. Originally, most of the battlefields were in rural areas,but as time has passed, development has begun to encroach on park perimeters, causing a number of problems.

A review of the immediate context of each park should be undertaken that addresses, in particular, the following issues:

i.) Stormwater management standards, erosion and sedimentation control standards, and enforcement strategies should be developed for all park watersheds. Ideally, this should be done in coordination with local regulatory agencies.

ii.) Policies to address the casual recreational use of the parks by people from adjacent communities should be developed. These may range from denying or restricting access to severely impacted sites, to promoting alternative recreational developments in cooperation with appropriate county and municipal agencies.

iii.) Develop a protection plan for each site, in cooperation with local agencies, civic and other private groups that will act as an early warning system against possible threats and help develop an informed support constituency for the parks.

2d. Workshops and Demonstration Projects

To explain and establish the new management policies, there should be a program of workshops and demonstration projects. These will be given, in cooperation with the Park Service, by Andropogon Associates Ltd., Soil Bioengineering Corporation, Inc., and other consultants. The focus will be on the three major issues addressed in the Earthworks Management Manual:

i.) Learning to evaluate the sites to determine appropriate management solutions.

ii.) Learning methods of reestablishing ground stability and establishing recommended new cover types.

iii.) Learning methods of managing the new cover types over time.

It is important to reaffirm, at all stages, the necessity for the integration of all aspects of the operation of the Parks; therefore, as with the reconnaissance survey, the workshops should be attended by superintendents and staff responsible for both natural and cultural resources, as well as maintenance and other personnel. The workshops are primarily designed to introduce a policy and kick-off the permanent program; however, as the program becomes established, it is also recommended that workshops become a regular part of the National Park Service routine, both to train new personnel as they come into the Service, and to ensure that the program is updated as experience grows and that the basic principles are adhered to over time.

The demonstration projects will be useful on several counts. Initially, test and control plots should be established to monitor the effectiveness of different management practices. These will be useful in both the current and future training of personnel. They will also be useful for obtaining preliminary data on the actual costs, in real time, manpower and expenses of different techniques, which could ultimately be convertible into realistic budget allocations and scheduling for future preservation and management.

3. Integrating Interpretation with Management and Preservation

The emphasis of the recommendations has been on stabilizing and preserving the resource, and on the continuing managment of that resource into the future. Although it is not in the scope of this report to specifically address the subject of interpreting the sites, it is nonetheless critical that all standards and activities relating to stabilization, preservation, and continuing management, be developed in the context of interpretation.

As preservation and management needs of each site are identified and developed, it will become imperative to develop a parallel program for interpretation that dovetails with the preservation effort. Clearly, many on-going interpretive programs will continue, though perhaps with an altered context in the light of new preservation and management imperatives. However, there is considerable scope for the development of new interpretive ideas that do not conflict with preservation objectives. Many current sites are visually similar, and the frequently used 'Park Drive' concept is increasingly compromised by surrounding development.

Furthermore, forested sites are virtually uninterpreted, despite the fact that they contain some of the most dramatic earthworks. New interpretive programs should therefore be developed that highlight the special character of each park. On forested sites, programs could be designed to preserve the resource by controlling the access appropriately while providing the visitor with a rich and dramatic story. In contrast, broad fields spanning the battle scene offer equally dramatic interpretive opportunities.

4. Conclusion

Preservation is the cornerstone of the National Park Service policy. This is intelligent and right. However, a false dichotomy has somehow permeated the institution that there is an inherent conflict between preservation and interpretation. It is the contention of this report that this is not the case. While it is true that any use of a site will require some environmental modification, far lower levels of disturbance can be achieved. In fact, solutions to many of the perceived conflicts are very simple: just stop doing something that is both detrimental and not needed. Almost without exception, the recommendations made herein are cheaper, more cost effective in the long run, and easier to implement than many current practices. They do require that the parks be

seen from a new perspective. For not only are the solutions there for those that wish to see, but with imagination and dedication, a much richer and fuller future is possible for these legacies of the most traumatic period in America's history.

F. MANAGEMENT MANUAL INTRODUCTION

Management generally consists of a set of typical practices which are repeated over and over again. In the case of the earthworks parks, these practices include lawn and meadow mowing, brush and understory clearance, installation of paths and features, etc. Despite the diverse characters of the parks examined, current management practices are remarkably similar, sometimes leading to consistently negative impacts. The goal of this Management Manual is to replace this widespread set of current practices with an alternate set of practices that are more effective in preserving the cultural and natural resources, both in the short run and over time, while meeting interpretive needs.

The Manual is comprised of two major sections. The first addresses vegetation management of the recommended cover types, from on-going maintenance to restoration practices. The second section addresses the repair and restoration of sites where disturbance of the ground stability has occurred.

The maintenance of healthy native plant communities lies at the foundation of this Manual. However, native vegetation is the one aspect of the park sites that park personnel are generally the least familiar with. The contribution of native landscapes to the site character is frequently misunderstood and undervalued. It is recommended that each park seek additional training in recognizing native plant communities and the patterns of natural succession as well as disturbance.

Monitoring and Evaluation

The continuous monitoring and evaluation of a site over time is a critical component of an effective management program, and is limited by the accuracy and the continuity of observations of site conditions. Because a landscape is a complex living system impacted by a great variety of factors, many of which are beyond the control of the National Park Service, the best management is that which is highly responsive and adaptable to changing circumstances.

The objective of site monitoring and evaluation is to identify and record an accurate description of what is happening at each site over time -- to see change, so that management can be effectively adjusted. The goal is to look at both the whole site and to see it as a complex system, as well as the specific symptoms of change or disturbance which may require action or closer scrutiny. Particular problems, such as a windthrow on an earthwork, are often straightforward. However, larger decisions, such

as the need to significantly alter an interpretive scenario, require a clear perspective of the whole site.

Because no one factor necessarily overrides any other, it is important that the evaluation be undertaken by managers of both natural and cultural resources as well as park administration, security, and maintenance personnel. Field review and evaluation of all earthworks sites should be made on an annual basis and form a significant portion of the data base for developing the next year's management program and clarifying long-term goals.

The site monitoring and evalutation 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.

The original site evaluation forms and maps should become part of a site notebook which is kept, independent of office files. Its purpose is to monitor and document each site's condition as well as the nature and effectiveness of management to date and over time.

G. MANAGEMENT GUIDELINES FOR RECOMMENDED FOREST COVER TYPES: FOREST AND LIGHT FOREST

FOREST COVER TYPE

Criteria for Forest Review & Evaluation

Each forested site should be examined as part of a larger regional forest system as well as an earthworks cover type. The conditions which are necessary for long-term growth and health of the forest plant community should be carefully considered when formulating management plans.

Forest is the highest value cover type for earthworks preservation and every effort should be made to retain it intact and in a healthy condition wherever it currently exists. Forest should not be converted to another cover type without an effective interim strategy. Most Cleared Woodlands should gradually be returned to forest. Limited areas of Light Forest could be substituted for Cleared Woodlands, but only where there is an overriding interpretive demand.

Configuration

One of the most critical aspects of a forest is its configuration. The continuous forest cover which greeted the European settlers has been reduced to fragments and strips in an increasingly developed context. Species composition has been affected, invasive alien species and pests have been widely disseminated, and natural processes, such as fire or rainfall and recharge have been substantially altered. Most endangered is the forest interior and the species limited to that environment. While a popular axiom holds that forest edge conditions are favored by wildlife (often 'game species') and urges the creation of more edge, a more realistic view in this region is that forest edge abounds, while the amount of forest interior is diminishing steadily.

This issue is an important one for management. In the past, decisions to clear forested land for scene restoration have often been made on the basis of interpretive needs alone, without consideration of the impact on long-term management of the parks' natural resources.

Measurements of the distance into the forest over which edge effects occur are variable, and may range over 300 feet. Therefore, a block of forest 1,000 feet square or almost 23 acres in size can support little more than 3-1/2 acres of interior habitat. A minimum of ten acres of forest is required, roughly circular in shape, to reliably support any interior habitat at all. Clearly then, every effort should be made to minimize disturbance to any forested blocks over ten acres in size. This includes road building and facilities development as well as the clearance of vegetation. Where disturbance does occur, it should be confined to the edges, which are already subject to more disturbance and more accessible to management. Since most disturbance in a forest occurs on the edges, large unbroken forest tracks require the least management of all landscape types and permit management budgets to be spent primarily on serving visitor and interpretive needs.

The long-term management of smaller and narrower forested areas, which might not necessarily support interior habitat, is also facilitated by limiting the amount of edge condition created and sustaining a less fragmented pattern. Long-term management costs will be reduced and long-term maintenance of native communities will be fostered.

Continuity

Continuity is as important to natural systems as configuration. Islands of habitat isolated from surrounding natural areas experience a decline in native species diversity and are less adaptable to stress over time. Management and proposed alterations in current forest patterns should always encourage, rather than reduce, the continuity of natural habitats. Critical forest linkages should be protected and missing links should be reestablished through management. This is equally important at all scales of the landscape.

Natural Processes

A major goal of management is to undertake the least intervention necessary to achieve the desired condition. In all cases, where natural processes regulate and sustain the habitat, the need for outside management diminishes while the health of the whole landscape system is improved.

Environmental conditions have been substantially altered by man's activities over time and severely compromise the long-term prospects for the sustenance of complex natural systems. Some impacts are virtually global, such as the greenhouse effect, and can only be minimally offset by actions within the park. The maintenance of expansive forest cover is somewhat helpful, for example. Others, such as acid rain are expressed more regionally and can be substantially impacted by activities and regulations at the federal and state levels. Still others are operative almost entirely at the local level and

the gradual accumulation of negative impacts can be substantially turned around by actions taken within the parks and surrounding communities. It is these issues that are primarily addressed in the Management Manual.

Hydrology

Throughout the developed landscape, a major shift in natural hydrology is occurring. Water which previously was recharged into the ground to support the water table and the base flow of streams is being collected from impervious surfaces and pipes and discharged as stormwater runoff. Streams become flashier; that is, peak and flood flows increase dramatically, increasing both erosion and sedimentation, while streams dry up during droughtier periods because of the lowered groundwater table. Newly implemented regulations focus primarly on the retention of stormwater to reduce flooding conditions downstream in severe storms, but rarely result in more effective recharge, and often ignore the negative impacts of the high-frequency rain storm which may be a real gullywasher after development has occurred. These impacts occur at every scale, from road drainage which is inappropriately discharged into an earthworks trench along a park road to the wholesale development of a creek's watershed beyond park boundaries, such as Poor Creek in Petersburg. The impacts are varied and often severe. Earthworks and other park features, including roads and bridges, are structurally undermined, native plant communities are subjected to severe stress, and the long-term protection of surface and groundwater resources jeopardized. The problem must be addressed at all levels and should be pursued by the National Park Service to foster better regional stormwater management as well as to eliminate damage to park resources.

Fire

The control of fire has been a focus of forest management for so long that many people forget that fire was once integral to the natural processes of the forest. Some areas, such as sandy, barren sites with mixed oak and pine often burn more frequently and visibly, but there is no forest without a fire history. Recently there has been a rediscovery of the importance of fire to the management of natural areas, as well as to the beneficial effects and relatively low cost of fire as a management tool. Management approaches range from virtually wildfire cycles which are being reinstituted on large tracts where a major conflagration would not pose undue hazard to settled areas to annual winter burns over smaller areas to favor certain game species and reduce the likelihood and severity of wildfire. Ultimately, the goal of all fire management should be to restore as near a natural fire cycle as possible. In most areas of the earthworks parks, light controlled burns limited to restricted sites are probably the most feasible.

Since most of the earthworks were once battlefields, there is the possibility that unexploded shells could be buried in the earthworks. Both the U.S. Army Ordinance

Section and the National Park Service have expressed concern that burning might ignite some of these shells. Because each site history is unique and subsequent use different, this issue will have to be addressed on an individual site basis by a team of fire management people, explosive experts, local park historians, and regional staff.

The National Park Service recognizes the importance of fire as a management tool. Consequently, guidelines for the control of wildfires and the management of prescribed and research burns have been developed and are described in Wildland Fire Management: NPS-18. Major topics included in this Manual are the identification of roles and responsibilities of governmental agencies, procedures for site analysis, documentation, and staff training, as well as guidelines for wildfire control and management objectives for prescribed burning.

Highest priority should be given to reestablishing fire in larger forested tracts, especially those which support interior. A pulsed cycle, with varying intervals of burn, rather than regular intervals, is preferable. For example, annual burning for the first few years in a forest to reduce fuel accumulation and renew herbaceous cover may also stimulate germination of oaks and other woody species. At this point, fire could be withheld to allow the new saplings to develop to sufficient size so that they would not be killed by a subsequent light ground fire.

High priority for fire management should also be given to those areas where fire management could serve interpretive needs, while maintaining stable cover and reducing long-term management costs. For example, flanks of earthworks along park roads currently managed by clearing, which often causes erosion, could be managed by fire to form more stable herbaceous and low shrub growth while increasing visibility.

There are several caveats to fire management. Adequate control of a prescribed burn is dependent on a system of fire breaks, which may include natural features, such as streams and wetlands, or built features, such as roadways and lawn areas. Where new fire breaks are required, careful review is mandatory to ensure that the firebreak does not serve as a route for disturbance, disrupt natural drainage, or otherwise adversely impact the forest.

Natural Checks and Balances

The components of natural habitats found in a region have coevolved over millennia to produce a natural system of checks and balances. While this does not insure that dramatic change will never occur, the overall vulnerability of a complex community to natural stresses is reduced. The introduction and often widespread dissemination of alien species by man into an environment where there are no natural controls or defenses can be devastating. When kudzu was in vogue, for example, and falsely perceived of as a cure-all for erosion, over 34 million seedlings were distributed from a government nursery in Georgia. While it is true that over time natural systems will

change in the presence of a new entity or disturbance, it is also true that this change can decimate extensive areas of native habitat and limit the capacity for recovery in a system already severely hampered by a wide range of environmental stresses. Indeed, some native pests are exerting a greater influence now than in the past due to accumulated stresses on the landscape and the diversity and quality of protected natural areas are deteriorating everywhere in the developed corridor along the East Coast.

Even when the need to control diseases, such as Dutch elm disease, or invasive vegetation, such as honeysuckle, is accepted, how to achieve effective results is often unclear or hotly debated. Despite the lack of widespread agreement on approach, several guidelines are appropriately followed.

Evidence is mounting that restoration practices which foster more natural fire and hydrologic cycles make the natural habitats more resistent to invasion by exotic plants and animals as well as to debilitating diseases and pests, both introduced and naturally occurring. Therefore, management which sustains natural processes and patterns in order to foster a healthy diverse community is the most resistent to a wide range of environmental stresses. The restoration of native shrub and understory layers and the reestablishment of a natural fire regimen appears to be more effective in controlling pine bark beetle, for example, than vigorous eradication and clearance efforts. Unfortunately, past management often has fostered the spread of exotic disturbance species and has tipped the scales heavily against native communities, warranting a concerted effort to mitigate the consequences. Japanese honeysuckle, an invasive species that was already widely distributed at the time of the Civil War, presents the greatest threat to forest resources in the earthworks parks, although other alien species may be a problem locally.

Current National Park Service policy favors the Integrated Pest Management (IPM) approach which seeks to achieve effective control rather than total eradication and to minimize the use of chemicals by employing a combination of methods, including mechanical and environmental controls such as prescribed burning.

Occasional concern is expressed over the natural aging process of a forest's development. As a landscape matures, for example, concern may be voiced that the older canopy is now vulnerable to disease or that the canopy should be 'therapeutically' thinned. There is no evidence that these fears are real or that treatment is necessary or productive. More often than not it is destructive, so the temptation to "thin" the canopy of mature forests should be resisted.

Occasionally, the removal of a dead or dying tree may be required if an earthwork or other resource is jeopardized by the likelihood of windthrow or drop of major limbs. Often, the root system may still be alive and may resprout, providing canopy replacement and limiting decomposition of the old root structure. In order to maximize

the likelihood of sprouting, hardwoods should be cut before they are entirely dead and the trunk cut six inches above the ground; the cut should be made at a slight angle to shed rainwater and minimize rotting. Evergreen species, which will not resprout, should be cut flush with the ground. Stump removal is not necessary. Standing dead trees which do not pose a liability hazard to the visitor or threaten a resource should be left standing and nature allowed to take its course. Such trees often provide critical den space and are an important food source for such species as woodpeckers. Felled trees, which cannot be conveniently removed, should be stacked with logs and brush in piles out of public view. A hazardous limb which threatens the earthworks or visitors should be cut appropriately [see Figure 10].

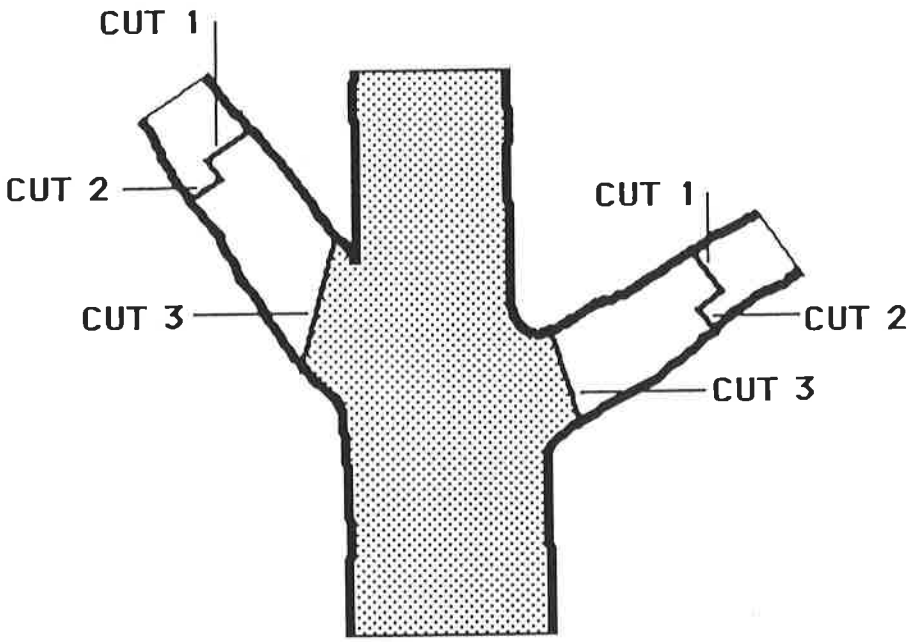
If larger scale decisions are appropriately made along these guidelines, routine maintenance of forested areas should be remarkably minimal. Once a healthy community is established, monitoring change over time is perhaps the most critical activity and insures that potential problems will be detected and acted upon early.

Natural Structure

A forest is naturally layered, and in this region typically includes a diversity of species in the ground, shrub, understory, and canopy layers. While some very young or very old landscapes might be notably less layered than others, the general tendency of a landscape to layer or stratify can be seen even in the herbaceous oldfield where 'understory' and 'canopy' grasses can be distinguished. Management which eliminates one or more layers completely is essentially disruptive, and the impact accelerates with an increase in the extent of clearance. Not only is the existing structure destabilized, but a whole raft of "empty niches" are created which often are then colonized by rapidly spreading disturbance species.

Where layers of the forest are missing, especially on earthworks, some replanting is desirable. Vegetative cover on earthworks provides an essential reduction of the impact of raindrops, a major component of erosion. Where large stretches of an earthwork have inadequate cover, or where bare soil is exposed, woody cover should be replaced. Both bareroot or balled-and-burlapped planting methods require excavation of a planting pit [see Figures 11 & 12]. Therefore, canopy replacement species should be not planted directly on earthworks trenches or over historic artifacts, but can be planted adjacent to them in order to achieve long-term canopy cover. Where bare soil is exposed on an earthwork, shrub mats (collected locally or propagated commercially) can be planted [see Figure 13].

The need to respect the forest's layered structure is most evident in the interpretation of forested sites, which previously were cleared to achieve greater visibility. While this practice should be eliminated, the need to view the earthworks and other features remains and can be met by selective clearing or prescribed burning.



CORRECT CUTS TO PREVENT TEARING (1&2) AND TO ALLOW HEALING OF WOUNDS (3)

Figure 10:
Typical Pruning Detail for Large Branches

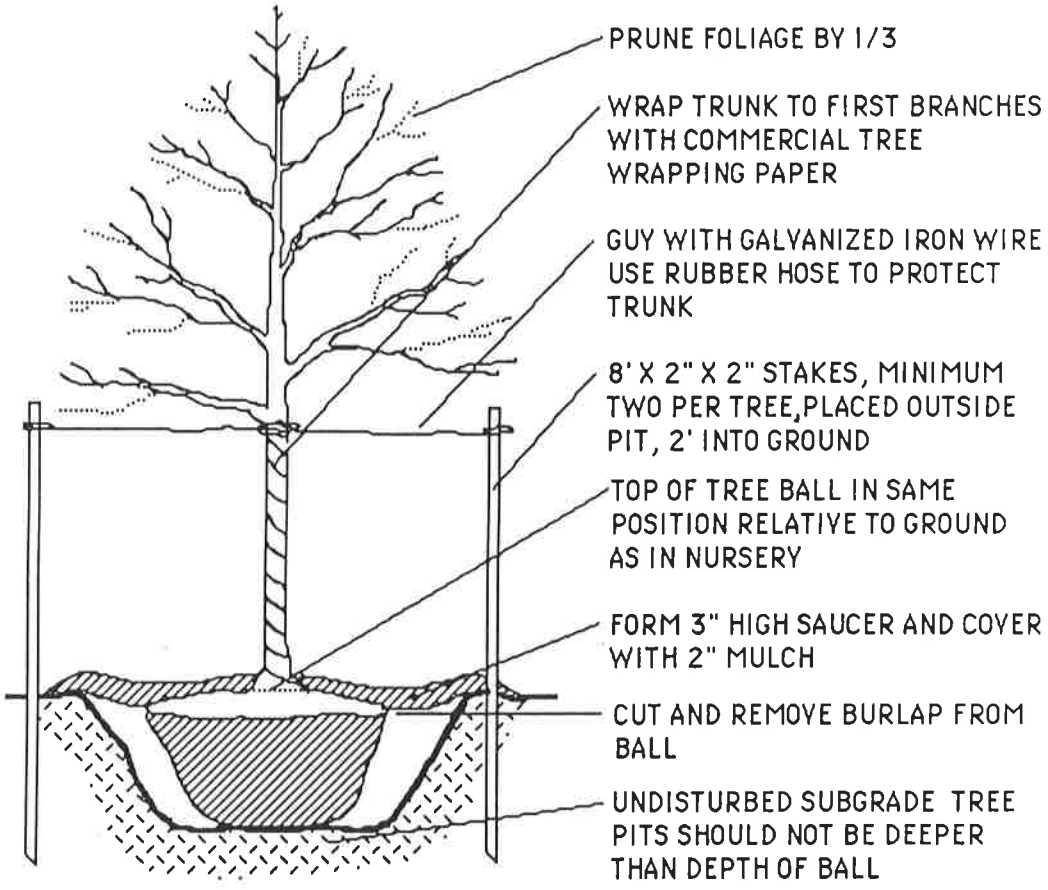


Figure 11:
Typical Balled-and-Burlapped (B&B)
Tree Planting Detail

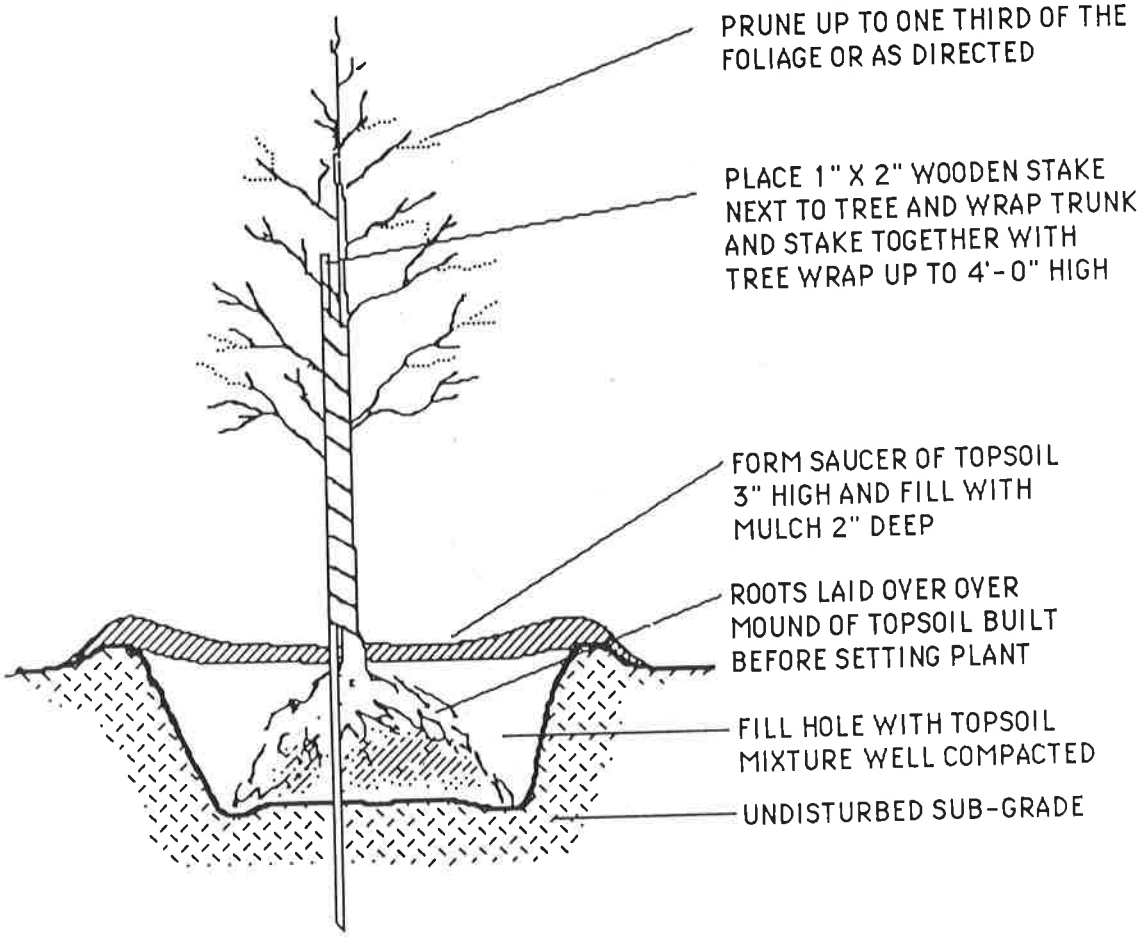


Figure 12:
Typical Bareroot Tree Planting Detail

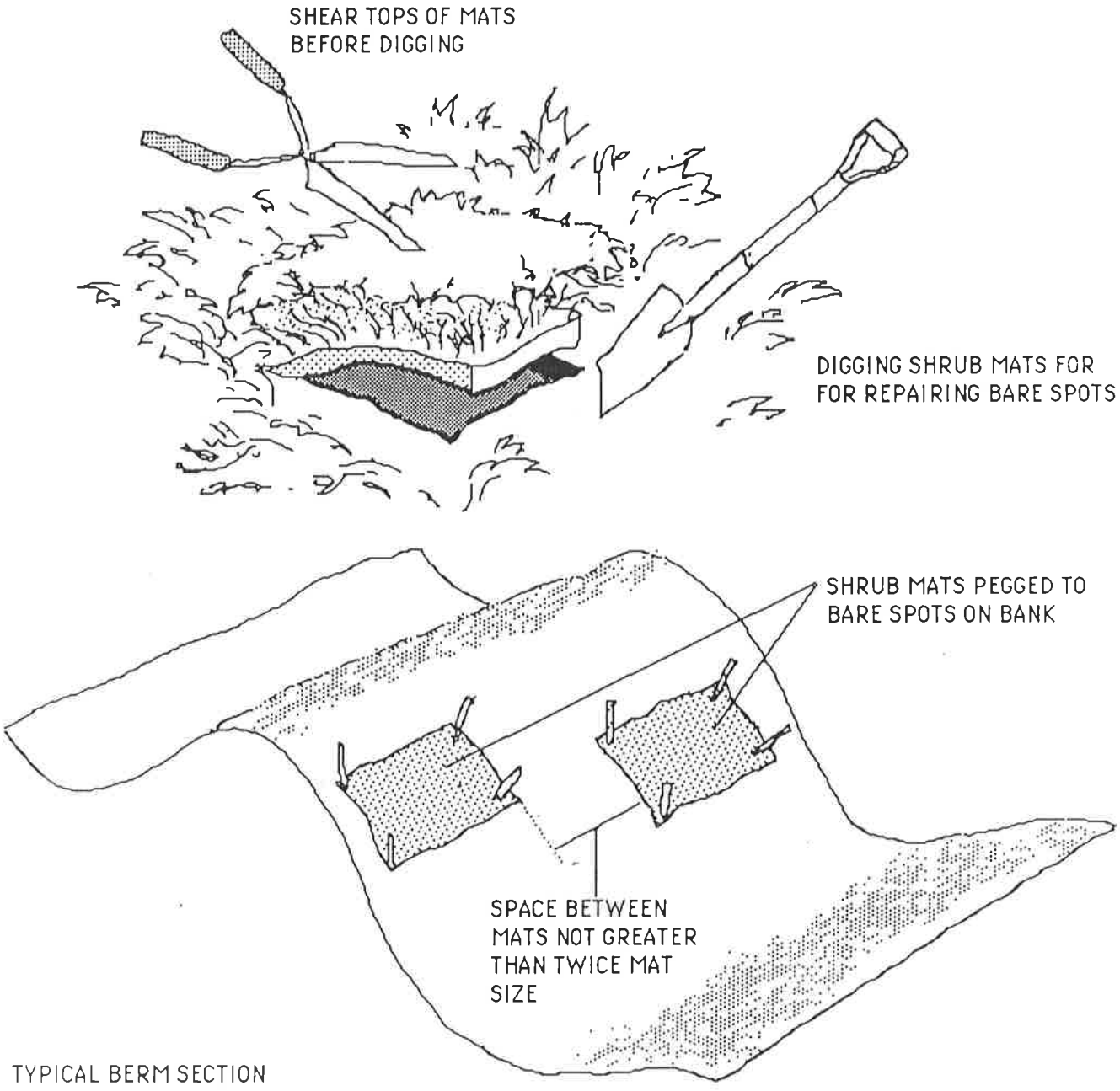


Figure 13:
Shrub Mat Establishment Detail

LIGHT FOREST COVER TYPE

Where selective views are desired, the Light Forest cover type is recommended. This cover type can be managed by prescribed burning or selective clearing. The primary goal of management of the Light Forest Cover Type is to maintain stability while increasing visibility. As Forest cover should be as continuous and unfragmented as possible, Light Forest as a cover type should be patchy, isolated, and limited in extent.

Prescribed Burning

Prescribed burning can be undertaken in limited areas to create selective views. Relatively frequent burns initially -- such as once a year for two years, decreasing to once every ten to fifteen years -- will stimulate lower, denser shrub growth and denser more diverse herbaceous cover, while somewhat limiting the development of new canopy. Because this promotes site stabilization and reestablishes a natural process, it is recommended as the preferred method for establishing Light Forest. It is especially appropriate for displaying running lengths of earthworks or tiers of earthworks where relatively large areas should be visible to the public; this practice also does not have the destabilizing effects of brush clearance.

Prescribed burning is being used on a broader scale today than in the recent past. In many areas where fire had been completely suppressed, excessive fuel had accumulated over time, greatly increasing the hazard of wildfire, which sparked renewed interest in fire management. Fire plays a role in landscape succession and impacts species composition, reproductive patterns, as well as the appearance of the landscape. After a burn, the soil pH is temporarily slightly raised and the immediate availability of nutrients is increased which may counteract some impacts of acid rain and excessive litter accumulation. This also favors grasses and some legumes. Most prescribed burns are undertaken in the winter dormant season to reduce impacts to wildlife and the likelihood of an uncontrolled burn. The fire is typically very light and the larger woody vegetation is usually not affected. Top growth of vines, shrubs, and saplings may be killed but resprouting often occurs.

The specific timing and cycle of burning can be periodically altered to affect reproductive patterns as shown in recent field experiments at Connecticut College Arboretum under the direction of Dr. William Niering. In a section of oak woodland which had been burned annually for several years, excellent seed reproduction of oaks was observed. This was significant because many foresters are concerned with the failure of seed reporduction of oaks in most eastern forests when oak growth is often confined to sprouts on old rootsocks and maples may be more abudant in the sapling layer. Niering suspended burning for several years until the oak seedlings were tall enough to survive a light burn. Such methods could be used experimentally in Virginia, for example, to stimulate oak reproduction where loblolly pine is collapsing. The

temperate forest of the east has been altered and disturbed over time and fire management offers great potential for restoration and management.

Prescribed burning is not a panacea, however. It results in temporary and localized air pollution which may be unacceptable in some areas. Smoke also can reduce visibility and cannot be tolerated where a driving hazard is likely. Where adjacent development could be threatened, prescribed burning may simply be too great a risk. Scheduling a burn may also be difficult due to exacting climatic requirements and narrow time frame. In some areas the contruction of fire breaks would be more damaging to a site than the benefits of fire managment would warrant.

All prescribed burning should follow the guidelines in Wildland Fire Manual: NPS-18 for staffing, site analysis, control methods, and documentation and be coordinated through the Regional Chief of Natural Resources.

Selective Clearing

Where fire management cannot be undertaken to achieve Light Forest, selective clearing is recommended. The object is to eliminate as little as possible from each of the shrub, sapling, and understory layers, while increasing visibility [see Figure 14]. Except for coniferous species (which should be cut flush with the ground), trees should be cut leaving 4-6" of trunk or stalk remaining; this will help reduce potential erosion and provides a discouragement to walkers. The appearance of the forest after selective clearing results in an overall thinning of the middle layers of the forest, in contrast to prescribed burning which tends to reduce the height of the middle zone of the forest.

The most fundamental difference between the kind of selective clearing which is recommended here and the blanket clearing undertaken in the past is that selective clearing is determined by the existing site conditions and responsive to them. The presence or absence of specific vegetation determines the site's opportunities and limitations. Where there is invasion of disturbance vegetation, the removal of these species will take precedence and the remaining vegetation will be important for stabilization. Elsewhere, healthy native habitats can be managed to establish selected views.

It is also important to recognize that selective clearing is incremental, and proceeds in steps rather than all at once. The goal is to effect a gradual change in the patterns of the vegetation rather than disturbing large areas of the landscape. Ideally, selective clearing will require progressively less management over time as more desirable vegetation becomes established. Selective clearing is more labor intensive initially but can effect important savings in labor over time, in contrast to more blanket clearing which stimulates continuous sprouting.

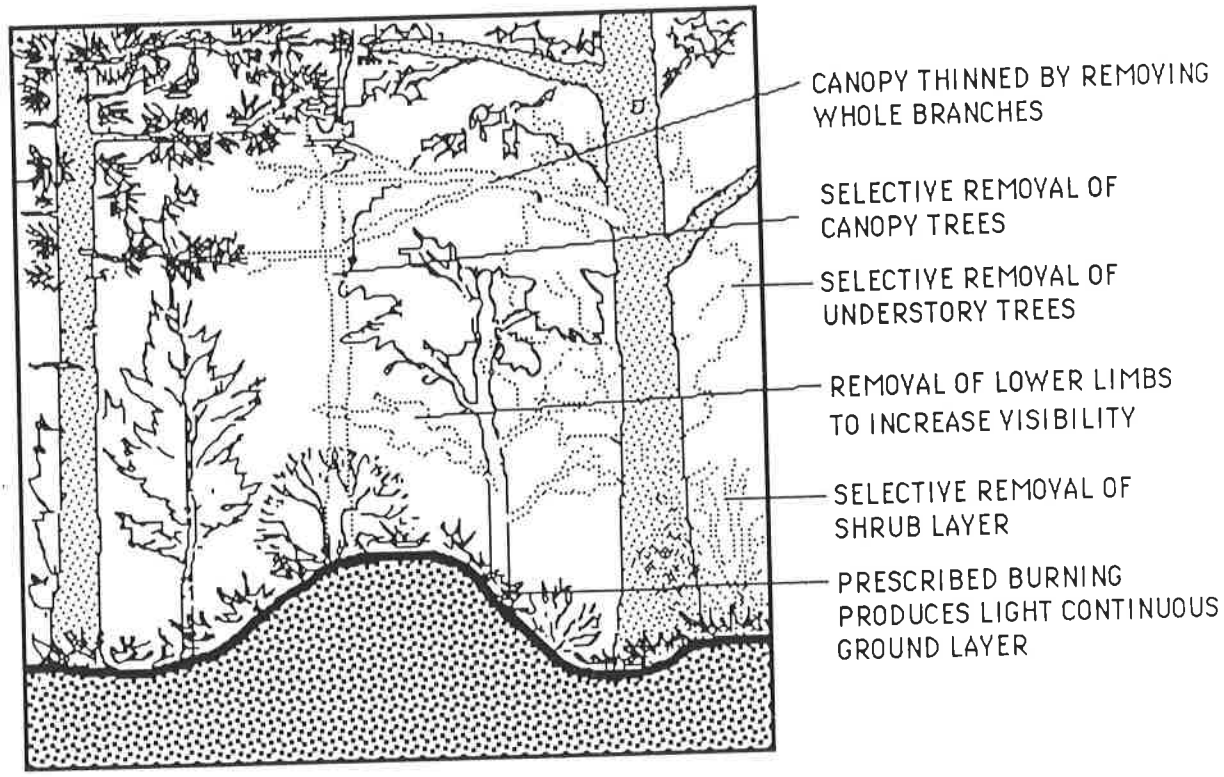


Figure 14:
Light Forest Management --
Prescribed Burning and Selective Clearing

The first step typically would be to remove any hazardous trees or major limbs as well as invading disturbance vegetation (except where exotics provide the only effective soil stabilization). At this point and at the completion of each successive step it is advisable to step back and reevaluate the site and the management and interpretive needs. The second step would be to observe what desirable shrub and groundcover species are sprouting and growing in the immediate area. In the Virginia parks, for example, lowbush blueberry, huckleberries, maple-leaf viburnum, and many ferns are relatively common. The spread of these species should be encouraged by clearing the competing woody species just adjacent to them. Lastly, additional trees and shrubs can be removed individually as necessary, as long as no area is completely cleared. Where sight-line clearing is undertaken it is often very useful to have one person stationed at the viewing point directing the clearing operations. Someone in the field, for example, can shake a plant and only remove it if confirmed by the person at the viewing area. A walkie-talkie can also be helpful. It is better to clear too little rather than too much and trigger erosion. Anywhere there is bare soil exposed, there is inadequate cover.

In areas which have been in the past treated as cleared woodland, selective clearing can be used to permit gradual restabilization of bare soil while maintaining designated views and controlling long-term tree growth on the earthworks. Regrowth of low shrubs should be encouraged. In areas where there are no shrubs, some regrowth of tree species should be permitted in order to achieve some revegetation, unless replanting of shrubs is undertaken. These sapling trees can be cut every few years before a large trunk develops. In larger bare areas it is important to reestablish shrub cover which can be harvested on site or propagated in a nursery. Similarly, the replacement of canopy cover is crucial, both on recently cleared sites and where there are no younger canopy trees. For example, in some places where trees have been cleared from the earthworks themselves, there are inadequate trees immediately adjacent to protect the earthworks from rainsplash. Elsewhere, such as at most forts, there are large specimens but no developing replacement trees. Elsewhere, canopy trees will develop naturally and should be protected until they attain adequate size. In some areas, especially where there is a lot of trampling or mowing, canopy replacement trees will have to be planted.

Resprouting of cut hardwoods, saplings, and other woody vegetation can be controlled by the spot application of concentrated herbicide to the cut stump and remaining stem. Herbicides (particularly those with trichlorpyr as the active ingredient) concentrated in basal oil seem to be particularly effective as the oil penetrates the woody stump to distribute the active chemical. All herbicide use must be approved through the proper NPS procedures and will be part of each park's IPM Plan. Only trained and/or licensed applicators should handle the herbicide and all work must follow NPS and state safety guidelines.

The National Park Service is to be applauded for its conservative policies regarding the use of herbicides. In recommending herbicides for vegetation management this report

stresses the minimal, most effective, and responsible use of these potent and potentially harmful chemicals.

Herbicide Management

The use of herbicides for vegetation management is still a very controversial subject. While the IPM (Integrated Pest Management) approach has been endorsed within the park system, there has been insufficient time for implementation and monitoring to develop a consistent set of procedures.

General objectives and guidelines for vegetation management techniques as well as specific targets are described in the National Park Service's Integrated Pest Management Information Manual. Split into two sections, the first part is a National Park Service policy statement on chemical control and the second is a series of updated information package on specific pest, disease, or problem vegetation species. One of the most appropriate is Exotic Weeds II which focuses on Japanese honeysuckle (Lonicera japonica); this section describes the plant's biology and ecology as well as techniques for chemical, mechanical, and environmental control. Essentially, the package recommends close monitoring and immediate suppression. If large areas are infested, immediate stabilization with native woody or herbaceous vegetation is recommended to prevent erosion. Where honeysuckle infestations are minimal, only minimal efforts should be necessary to prevent its spread, if adequately monitored. Control at the edges of larger forested tracks is particularly important in sustaining more extensive undisturbed habitats, while many narrow forested strips may present almost insurmountable control problems. In all cases, however, early efforts at control before infestation becomes widespread, are most effective.

There are several typical conditions which recur throughout the forested sections of the earthworks parks. Where there is only a light infestation of honeysuckle, control is important in areas where the spread of the vine is increasing. Areas where an infestation is static or decreasing are less important. This underscores the need for monitoring so that change over time can be evaluated. In some places honeysuckle is completely established in the ground layer, such as Ft. Harrison. In such a case, the first priority would be to manage the honeysuckle by mowing to stimulate rooting and to create a denser, more matlike cover, and improve effective stabilization. Continued and repeated mowing will gradually diminish the plant and should proceed any herbicide control. Lastly, an herbicide treatment on the areas where new growth is sprouting is likely to be required before the species is eliminated, at which time revegetation of the site is necessary immediately. The size of an area treated should be in part determined by the amount of time and money available for adequate follow through for restabilization.

In many other areas, honeysuckle is abundant but has not overwhelmed the site. Here, honeysuckle should be removed where it competes directly with native vegetation. As native communities rebound, a progressively larger area of honeysuckle can be controlled. It is a gradual process where the speed is determined by the rate of recovery of native vegetation.

Some of the most critical areas for herbicide management are those which have been recently cleared. Many of these sites are experiencing very rapid invasion of exotic species and in a few years, if unmanaged, are likely to be completely overwhelmed. These should be given the highest priority.

Prescribed burning, selective clearance, and liming also may have unpredictable impacts relating to the spread of invasive species, especially honeysuckle. Prescribed burning sometimes may temporarily encourage sprouting or may help exhaust rootstocks in a management program. In all cases, a plan for monitoring and limiting the spread of disturbance species should be included in the management program.

The specific chemicals, rates, and timing of applications should be verified with locally licensed park personnel as the recommendations are variable over time and in different areas.

While this review has focused on honeysuckle, there are other disturbance species which should also be controlled and might include Norway maple (Acer platanoides), sycamore maple (Acer pseudoplatanus), kudzu (Pueraria lobata), bush honeysuckles (Lonicera morrowi, L. tatarica), Oriental bittersweet (Celastrus orbiculata), Japanese knotweed (Polygonum cuspidatum), and multiflora rose (Rosa multiflora). It is also advisable for park personnel to be aware of what exotic species are locally invasive and to watch for their occurrence on park land.

Liming

Areas where herbaceous cover is sparse, or where shrub growth and woody reproduction are limited, may benefit from a very occasional (no more than once every ten years) light application of lime. These applications should be considered experimental and evaluated and revised as results indicate. The native soils, for the most part, are naturally acid and the earthworks, which usually have a high proportion of subsoil at the surface, may be excessively acid. Where some selective clearing is desirable for visibility, additional liming may foster the development of denser herbaceous cover, which may encourage a display of native wildflowers. The most suitable sites for wildflowers are on the damper slopes around the trenches. On the drier berm portions, liming may permit more dense grass growth. No liming should be undertaken without a soil test.

Soil testing is done at the Soil Testing Lab, Smyth Hall, VPI & SU, Blacksburg VA, 24061. It is important to remember that recommendations from the lab, Soil Conservation Service, or the Extension Service are aimed at agricultural or horticultural crops and not for the maintenance of native landscapes. Consequently, ask how to raise the pH to a specific level -- 5.5. for Light Forest -- rather than for a specific type designated on the form. Send one pint of soil in a carton clearly marked with the name of the location. Since only the first word will be registered by the lab, make sure it is adequately descriptive -- for example, use 'Stedman', rather than 'Petersburg-Stedman'.

Liming is likely to be required only once in any forested situation, and the goal is to raise the pH to around 5.5 for a short period of time. Use agricultural limestone with 100% passing a 35-mesh sieve and 80% passing a 100-mesh sieve. If the soil tests reveal that the magnesium level (Mg) is higher than the calcium level (Ca), use calcite limestone instead of agricultural limestone, ground to the same sieve fineness. The limestone should be hand broadcast and left on the surface. Try to scratch it into the top one inch in areas adjacent to streams, on steep slopes, and in swales. Spread the limestone three to four days before rain is anticipated if possible.

At present, there has not been enough testing in the field to assess the effectiveness and suitability of occasional liming for the forest cover type. The procedures recommended here should be viewed as experimental. Further monitoring and field evaluation is required, and this is an example of where the monitoring and evaluation procedure recommended will lead directly to making a real contribution to the amount of information available on natural areas management versus horticulture maintenance.

A major exception to this recommendation is where there is good development of acid-requiring shrubs, such as azaleas, laurels, hollies, blueberries, and huckleberries. Additional lime adjacent to these shrubs could reduce their vigor and should be avoided. Similarly, disturbance species should not be limed or fertilized.

Additional Planting

It is strongly recommended that, with the exception of specific historic site restorations, all additional site plantings should consist of locally native species, including landscaping at a visitor center or parking facility.

Transitions

The most difficult transitions are from closed to open landscapes, i.e., forest to field, and require an extra measure of concern and management. It is during and immediately

subsequent to clearing that the most serious damage to earthworks occurs, with the exception of vandalism and outright destruction.

Clearing a forested area for interpretive purposes may result in unforeseen ecological consequences. Runoff from the site is likely to increase dramatically and may exacerbate existing drainage problems. Protected wetland areas may be affected adversely and adjacent habitats degraded. These impacts should be examined carefully and reduced wherever possible. Approximate solutions may require alteration of the proposed configuration of the cleared land or reevaluation of the interpretive goals in the larger context. Where only a sightline is required, for example, selective clearing to create a view might be both less destructive and easier to maintain in the long run than a cleared swath of land.

Wherever clearing is undertaken, special measures should be taken to eliminate unnecessary disturbance. The grading plan for the site should minimize unnecessary disturbance to the site while providing both temporary and permanent retention areas. Both berms and swales along the contours may be useful as well as furrow-making equipment such as a land imprinter. Wetland areas might also be left in swamp cover. A complete equipment and procedure review is necessary and other recently cleared sites in the region should be evaluated by those who will be responsible for a clearance project. A stormwater management plan should be prepared, including temporary drainage, erosion and sediment control measures.

The timely establishment of effective herbaceous cover is directly related to the amount of competition from sprouting woody species and adequate control of regrowth is essential to restabilizing the site. The new seed bed must be adequately prepared and a comprehensive program of site management which includes long-term maintenance and regular evaluation should be established. Site management should continue until effective cover is established and an appropriate maintenance schedule demonstrated. Budgets allocated should be adequate to cover some contingencies such as a reseeding required due to drought conditions.

It is also important to remember that these sites are especially vulnerable to invasion by exotics, especially vines such as honeysuckle. High priority should be given to providing effective control during the regrowing period to ensure that disturbance species do not out-compete the regenerating native community. The more severely disturbed sites will require a higher level of monitoring and management than less radically altered sites, and recovery will take longer.

Virtually all areas of Cleared Woodlands should be managed to return to a layered forest cover. Lightly cleared sites with low disturbance and good sprouting could be relatively well-layered within as little as two years, while severely disturbed sites with serious access problems, such as Fort Gilmer, may require some level of intervention for decades. On some sites, resprouting may be minimal and additional cover may be

required. In these situations, canopy and understory replacement species should be planted adjacent to, but not on, the earthworks; shrub mats could be established on the earthworks, especially where bare soil is exposed [see Figures 11, 12, and 13].

Fort Fisher

For sites which are well preserved under forest cover, the development of new interpretive models which provide focused visitor access and selective views is required. Fort Fisher in Petersburg has been redesigned as an illustrative example of the recommended approach.

Fort Fisher is one of the best preserved earthworks of the National Park Service. Because it was never the site of a battle, acting only as a storage depot, and has been heavily wooded since the end of the nineteenth century, the details of the structures, from cannon carriage ruts to firing steps, are still very clear.

Recently, however, the front half of the fort was cleared, except for canopy trees, and a parking lot was built. In addition, it was identified as a destination on park literature and shown on guide maps. In one corner, the outer trench was filled in where a ramp was built to provide access into the interior of the fort. No trails were built, so people tend to walk around on the top of the earth walls. Increased traffic has also led to the paving of roads on two sides, diverting runoff into the outer trenches. This increased use and clearing has sharply increased the rate of erosion, blurred the clarity of detail, and threatens the stability of the outer walls [see Figure 15]. To preserve the valuable resource, the forest should be reestablished, access controlled, and runoff redirected from the road [see Figure 16].

Through burning, limited pruning, soil modification, and planting, a multi-layered forest can be encouraged to grow over time. In addition, the filled-in portion of the outer trench and existing entrance and parking area should be removed. Finally, the stormwater runoff from local roads should be redirected. This is a very complex management issue and should be addressed in a consistent manner throughout the parks. Currently, there is no established park strategy or design standards. During the interim stabilization period, therefore, critical stormwater problems should be addressed on a site-by-site basis.

Once stabilization is achieved, and interpretive guidelines revised, a new visitior path loop and services might be appropriately installed [see Figure 17]. Elevated walkways and an entrance bridge could be constructed inside the fort to provide access and reveal specific historical, structural, or contextural information. In the areas immediately surrounding these destination points, the forest could be selectively thinned to enhance the view.

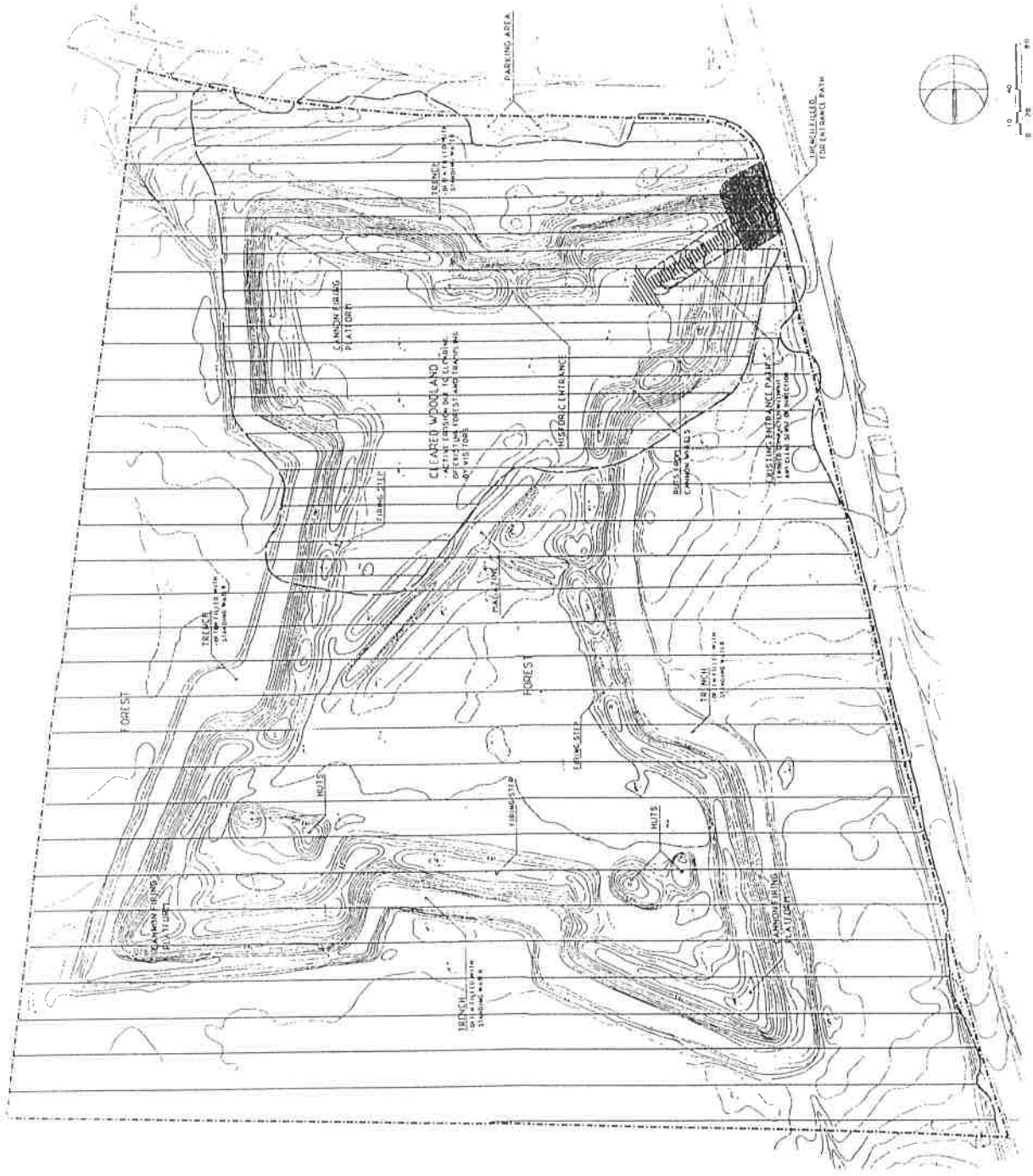


Figure 15: Fort Fisher, Existing Conditions

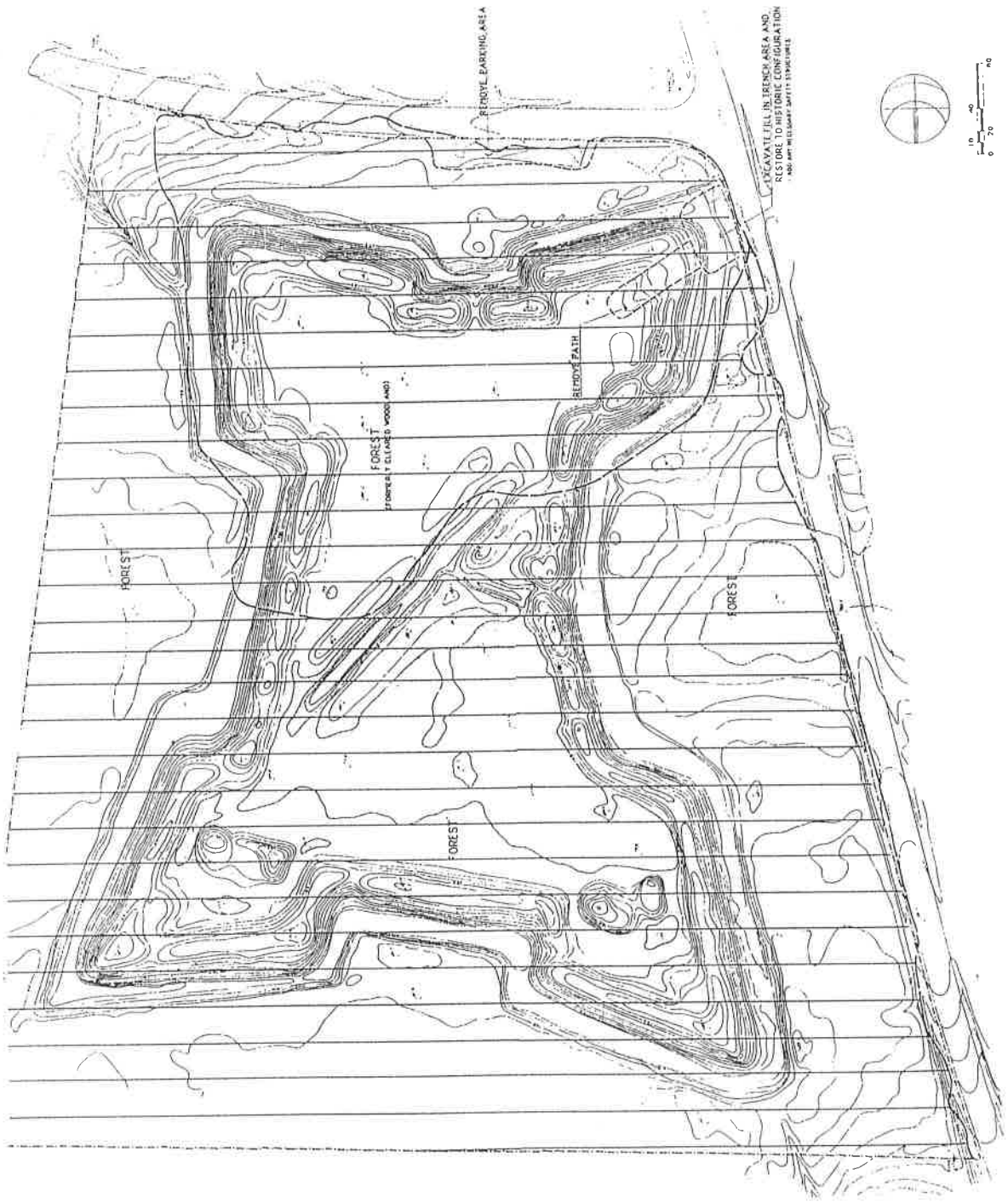


Figure 16: Fort Fisher, Interim Stabilization Program

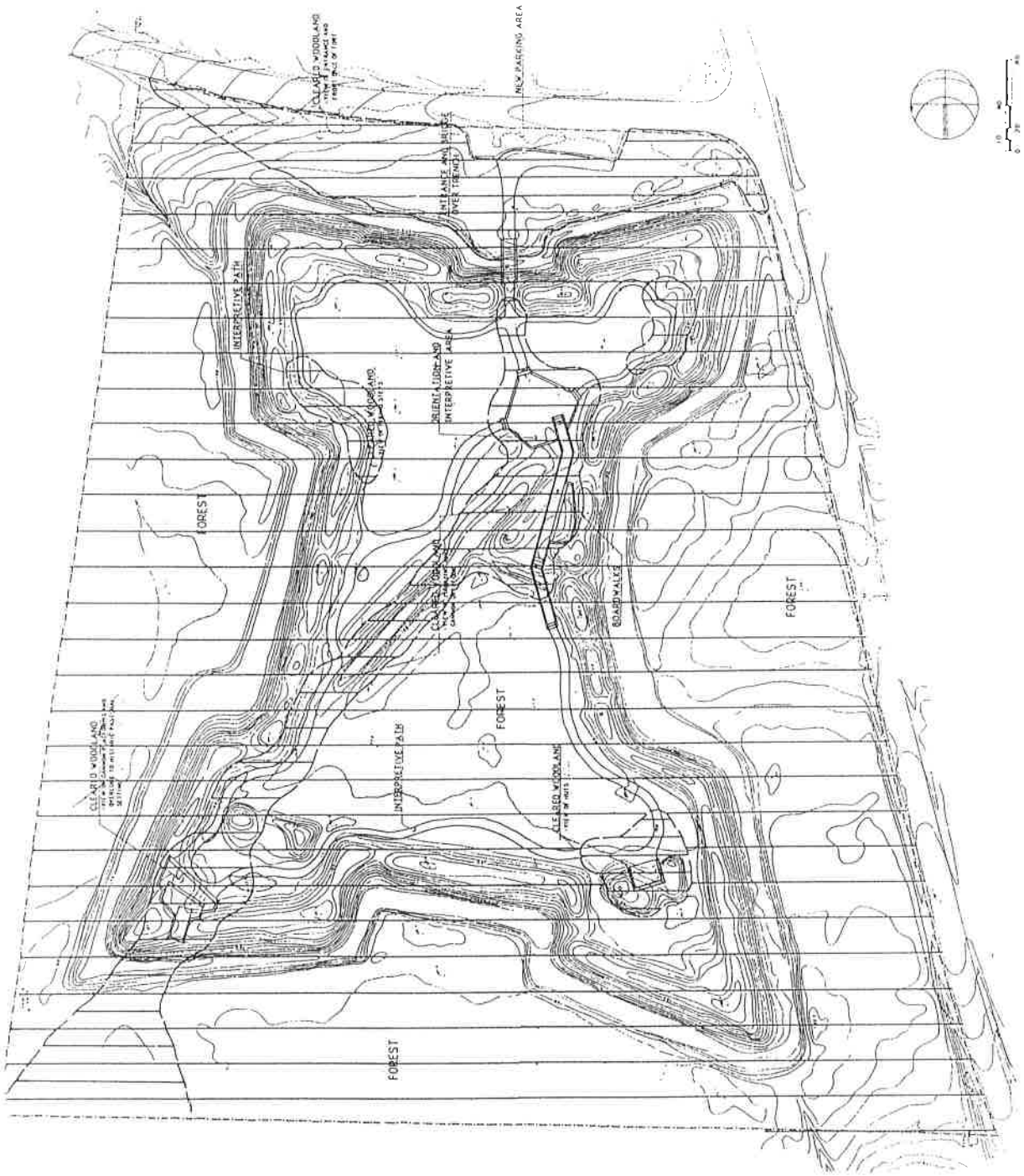


Figure 17: Fort Fisher, Long-Range Program

H. MANAGEMENT GUIDELINES FOR RECOMMENDED FIELD COVER TYPES: TALL GRASS AND TURF

Before settlement, all of the earthworks parks region was forested with the exception of marshes, beaches, and rocky outcrops or balds and all of the park areas presently maintained as grasslands, including turf, would now support forest if they had not been managed for other purposes. Under natural conditions, open landscapes are short-lived phenomena in this region. The primary object of grassland management is to maintain an open condition by arresting this natural succession in selected areas and prevent the sites' gradual return to forest.

Configuration

The configuration of virtually all the parks' open landscapes was initially determined by the patterns of agricultural use and has evolved to meet visitor and interpretive goals. Throughout the battlefield and earthworks parks, there has also been a consistent interest in retaining the historic pattern of forest and field wherever feasible. The open sites are sometimes farmed, or kept in tall or rough grass or turf. Lawn areas are commonly accepted and expected in parks, and are generally far more extensive than required to meet functional needs, and often consume a disproportionate amount of park maintenance budgets.

At this time, as budgets dwindle and other park problems command more attention, it is clear that the amount of lawn and other close-cropped grasses should be reduced. This does not, however, necessarily mean a return to forest. In many areas, the same configuration of field and forest can be retained by replacing lawns and rough grass with tall grasses and successional meadows. This will effect substantial cost savings and increase the diversity and health of native communities, while providing a greater aesthetic range to the park's landscape character. Virtually all areas which are presently rough grass, and much that is lawn, should be converted to tall native grasses. In addition, some of the areas where agricultural grasses are poorly established and require continuous maintenance could be converted to native grasses. The changes of cover type would provide an immediate and significant reduction in expenditures. The management effort required for the conversion from rough grass to tall grass should diminish within a period of two to three years, leaving a cover type that requires little maintenance beyond an annual mowing or prescribed burning and monitoring for exotics. Transition from turf to tall grass requires a slightly longer period and will require a higher level of management. However, because soils in this area are

slightly infertile and naturally acid -- conditions which favor native grasses -- a dense healthy stand should be established within three to five years; thereafter, little maintenance, beyond mowing or burning and monitoring, is required.

At Fort Necessity, for example, in Braddock PA, there is an extensive lawn area which has been left unmowed for the last two years due to financial constraints. A diverse and colorful wildflower meadow has developed, which is far closer in character to the historic site character than a neatly trimmed lawn. Effective management is, however, still required in Fort Necessity's meadow. Numerous tree saplings are developing and should be controlled if an open meadow is to be sustained over time. Similarly, at Colonial National Historic Park, just this past year lawn areas were left unmown over the earthworks. Tall grass meadows have developed rapidly. However, concurrent honeysuckle invasions must be controlled, the sooner the better.

A secondary problem is likely to be the need for reeducation of both the National Park Service staff and the visiting public to the aesthetic, historic, and ecological qualities of the tall native grasslands.

There are several kinds of tall native grasslands, requiring different levels of management, described later in this section:

1. Woody Meadow, which supports abundant young woody species in a matrix of grasses and wildflowers and requires selective clearing and monitoring.

2. Tall native grasslands, in which little bluestem is the most ubiquitous species, and which requires periodic mowing or burning, and monitoring.

3. Pasture, which includes hybrid species, both native and exotic, and typically requires both fertilization and liming in addition to mowing or burning, and monitoring.

4. Turf, which is comprised of hybrid species, again both native and exotic, and which requires the most intensive maintenance.

Continuity

Just as it is important for forest to be as continuous and unbroken as possible, the open landscapes should be as small and isolated as possible to minimize fragmentation of forest systems. This also serves interpretive needs. During the Revolutionary and Civil wars, views were almost always enclosed by forests and seen beyond the fields or past the edge of town. As suburban development coalesces, forested buffers are increasingly important; however, relatively broad expanses are required for effective screening. These younger landscapes also represent important natural values. Many support a remarkable diversity of plant species and provide habitat for many plants and animals which are limited to these transitional stages.

Present management in the parks and on most private properties is very restrictive, and sometimes more intensive than is appropriate. Beyond turf, pasture, tall grasses, and wildflowers, a variety of savannah landscapes, dotted with thickets and young groves, could be sustained. This would greatly improve wildlife habitat throughout the parks and permit the management of a full spectrum of natural communities.

Natural Processes

As stated for forest cover types, a major goal of management is to identify the minimal level of intervention necessary to achieve the desired cover type. The need for management can be reduced as natural processes are reestablished and more able to do the work of stabilization.

Hydrology

For the most part, areas maintained in grasses occur on former agricultural fields and are generally well-drained. However, there are some recurring drainage problems. In some places, drainage patterns have been altered and stormwater impacts are evident. Occasionally, the earthworks themselves act as a stormwater dam and have flooded some locations since the Civil War. Elsewhere, runoff may have been more recently diverted. Unless the flooding is problemmatic or contributes to the deterioration of the earthworks or other valued resources, wetland meadows provide excellent cover. Turf, however, will not withstand prolonged poor drainage.

Clearing for scene restoration can involve significant hydrologic alterations. Runoff rates are significantly higher from fields than from forested landscapes and the increase in runoff may create unforeseen problems unless a site is appropriately graded for runoff control and retention. Often the area proposed for clearing also supports small wetland areas which are protected by both state and federal laws, and should be left intact. In such cases, adequate visibility should be attained with selective clearing. These wetland pockets may also be useful for stormwater management and erosion control. Many of these smaller wetlands represent ancient drainage patterns and may provide valuable documentation of historic site conditions for coordinating with soldiers' journals and archives. Where it is desirable for interpretive reasons to convert a wooded wetland to an herbaceous or shrub wet meadow, a more gradual management process is advisable. The larger trees can be incrementally eliminated. At the same time, regrowth should be monitored and selected native species favored while disturbance vegetation is controlled, rather than clear cutting.

Fire

Grasslands throughout the region were managed by burning by both Native Americans and European settlers in the past. For all field cover types, except turf, prescribed burning can be an effective management method that eliminates the need for most other management, except for monitoring invasive exotics.

The effects of prescribed burning will vary with the existing conditions of a field and what species are present. In general, burning favors perennial native grasses and forbs while controlling the development of woody species. Woody plants which are already established before the onset of burning will be variously impacted. Sprouting of stoloniferous species such as sassafras and black locust may be stimulated by burning. Larger trees may be unimpacted while small seedling and saplings will be damaged. It is unlikely that prescribed burning will eliminate established invasive disturbance species, although it may inhibit their invasion of a site by fostering healthy native communities.

Field landscapes are typically burned once a year which is usually adequate to control woody growth. Where woody invasion is very limited, the burning frequency could be reduced.

Currently, prescribed burning is almost always undertaken in the winter, in an effort to reduce negative impacts on wildlife and to reduce the hazard of fire. This regimen also maintains tall protective cover during the months when visitorship is high. As with any new management technique it is important to begin on a small scale with test plots which are evaluated before proceeding to a larger scale.

It may also be useful to consider more frequent experimental burning in selected areas to control disturbance species as a possible alternate to herbicide management. If several burns in a season can be achieved, exotics control may be adequate to prepare a site for reseeding and vegetation reestablishment.

For all prescribed burning it is mandatory to follow safety precautions. It is also important to ensure that the firebreak system does not adversely impact any natural or cultural resources. In some fields, broad mown strips may sometimes be adequate for firebreaks. The implementation of prescribed burning may also be restricted by adverse public opinion or adjacent roadways and development.

Natural Checks and Balances

The control of invasive disturbance vegetation is as important in grasslands as in forests. Field management efforts in the past have fostered the widespread dispersal of exotic vegetation. Most of the exotics invaded the forest from surrounding fields and, like honeysuckle and kudzu were first planted on cleared forest areas too steep to

stabilize with herbaceous species. Both mowing and burning, which effectively check the development of forest canopy, are not necessarily adequate to control exotics and may, without careful monitoring, encourage invasives.

Herbicide management is usually required and should be selectively applied to the vulnerable new shoots which appear after mowing or burning thereby reducing the amount of herbicide needed for effective control, according to the National Park Service's Integrated Pest Management Information Manual.

Natural Structure

As noted earlier, the primary object of field management is to limit woody species, i.e., preventing the development of a natural forest structure. For woody meadows and native grassland, mowing and burning are generally sufficient to sustain the habitat as long as disturbance vegetation is controlled. For pasture and turf, repeated liming and some fertilizing is also required to alter the native soil conditions. These varying needs are reflected in the routine management requirements.

Woody Meadows

Many of the earliest woody species to appear in a successional landscape are species which send up numerous shoots and frequently form dense thickets, such as sassafras, sumac, and locust, amidst the little bluestem and forbes. Small fruiting and flowering trees, such as cherry and shadblow, are also abundant and many forest canopy species are present, at least as seedlings. These woody species form islands which without management would coalesce and close over time.

The amount and configuration of these woody islands can be determined and maintained by mowing around them. A simple annual mowing is generally sufficient to suppress most tree species and should be undertaken after several hard frosts have occurred in the fall to ensure that herbaceous seeds have fully ripened. The woody islands are likely sites for vine development and should be carefully monitored. Sites with excessively droughty or acid soils, and slow establishment of woody species, could be mown less frequently, possibly as little as every ten years if vines are not vigorous.

These woody meadows also can be maintained by burning. An annual burn generally will keep the amount of woody cover static over time, or less frequently if conditions permit. A significant exception to this are the stoloniferous species, such as sassafras, locust, and sumac, which are fire-increasers. They are stimulated to produce numerous shoots when burned and can rapidly overtake a meadow, which recently occurred at the Big Meadow in Shenandoah National Park after a controlled burn.

Tall Grass Cover Type

The tall grass meadows in this region are predominantly little bluestem, a ubiquitous native grass which thrives on a wide variety of soil conditions, although it is not tolerant of heavy shade. This long-lived, perennial grass requires no liming or fertilization and may vary in height from about eighteen inches on droughty sites to three feet on deep fertile soils. The growth pattern is clumpy on the drier soils. Typical meadows might also support any of the species found in rough grass, as well as a variety of taller native and introduced wildflowers and grasses.

Under natural conditions little bluestem meadows probably resulted more frequently from wildfire and therefore prescribed burning is the most desirable form of management. Once every one or two years is generally adequate, occasionally less. When burning is not feasible, mowing should be done as infrequently as is necessary for the control of woody species. In some areas, the hazard of naturally occurring fire is sufficient to require twice annual mowing to reduce accumulated fuels. The extra mowing should occur at the end of June or early July, after spring blooming species have set seed and before fall blooming species have sent up flowering stalks. When mowing, the blade should be set at least six inches high to avoid damaging the clump form of bluestem.

Whether management is by mowing or controlled burning, or a combination of both, the actual frequency of cutting or burning should be determined by observation, rather than by a rule of thumb. For example, if woody invasion in a field is minimal and the grass provides good cover, no additional management may be required that year. A midsummer cut might be advisable in one dry year, but not the next, and a fall cut not necessary on the heels of a summer one. Ultimately, developing real familiarity with the field landscapes is as important as getting to know the forests.

On a few extremely acid sites, grass cover may be sufficiently sparse to be of concern. In such cases, a single season of liming may be advisable to achieve better establishment. As with forests, lime should be applied only once in a great while to native grasslands. When testing for pH request recommendations for the application necessary to achieve a pH of 5.5, rather than for a specific crop. Do not use the Soil Conservation Service's commercial "native pasture" category, because this is geared for fescue and bluegrass, not little bluestem and switchgrass. Recommended amounts of lime for fescue, for instance, would be far too high for native tallgrass landscapes. On many of these sites, there are higher levels of magnesium (Mg) than calcium (Ca), which will be noted on the test results. In this case calcite limestone should be used instead of agricultural limestone, ground to the same sieve fineness.

Pasture Grasses

Pasture grasses today are generally comprised of 'cool season' grasses which have their major growth periods during the cooler, moister spring and fall seasons. Most are hybrid species, both native and exotic, which are not sustained without a regular routine of liming, especially on the sandier soils of this region.

While there is little or no grazing taking place in the parks, there is considerable area managed as pasture and for hay, while sometimes of poor quality. The least successful pastures have been established on land recently cleared of forest. These sites are unlikely to provide quality pasturage without more extensive management and may be more suited to native tall grasses. Similarly, the more acid sites, certainly any areas with a native pH less than 5.2, are not suited to pasturage.

The agricultural lease program enables local farmers to harvest hay and other crops from park land. This is sometimes a cost effective method of managing open landscapes, but cannot be used indiscriminantly to solve management problems. Effective lease programs require careful site selection careful selection of leasees limited to competent farmers, and close monitoring and supervision.

Fire is also a suitable management technique for pasture and hay fields. A light winter burn increases the available nutrients and raises the pH just before the spring growing season and may be used in combination with midsummer mowing. Twice annual cutting (or a winter burn and summer cut) is generally required to maintain pasture grass cover. Less frequent management will encourage the development of little bluestem and/or forbs, especially on more acid or droughty sites.

All pasture areas should be soil tested approximately once every three years and reliming and fertilizing may be necessary that often. At present, it is advisable to contact the local Agricultural Extension Service or Soil Conservation Service. It is important, however, to appraise them of overall National Park Service goals and the desire to support pasture only where it is most suited and appropriate.

Agricultural crops have occasionally been proposed as an alternate to pasture grasses. At this time, we strongly recommend against making this choice. Efforts to control erosion in crop fields have almost inevitably led to disturbance of wetland habitats and destruction of cultural resources.

The conflicts between agricultural needs and the preservation of natural and cultural resources are too severe and, as yet, unresolved, going beyond the scope of this Manual.

Turf Cover Type

Turf is the most difficult and expensive cover type to maintain because it requires a high level of maintenance, is susceptible to drought, and often sustains the heaviest foot and vehicular traffic load. Consequently, the areas chosen for turf should be only those that can be well maintained.

Turf Maintenance

There are three main tasks which must be done on a regular basis: adding soil amendments, mowing, and repairing damaged areas. These must be done consistently for turf to remain healthy. If let go for a couple of years, an expensive and lengthy rehabilitation process is necessary. It is both cheaper and takes less time in the long run to invest the required amount of management up front. Without proper maintenance, turf does not adequately protect the earthworks from deterioration.

Turf Soil Amendments

All turf areas should have a soil test every one or two years. Use the white commercial forms and indicate that the crop is "industrial lawn". It is generally recommended to use 1-1-1 or a 2-3-2 fertilizer, with slow release nitrogen, in three applications, each application being one-third of the recommended rate: one from August 15 to September 1, the second from October 1 to October 15, and the third from 1 to 15 December. Follow the rates recommended in the soil test results. As noted before, If there are higher levels of magnesium (Mg) than calcium (Ca) in the soil, use calcite limestone instead of agricultural limestone. If the recommended rate exceeds 25 pounds per 1,000 square feet (1,000 pounds per acre), apply half in November and the remainder in the spring. Turf recommendations do vary over time so be sure to maintain frequent contact with the local Agricultural Extension Service.

Turf Mowing

The frequency of mowing will vary depending on the weather, time of year, and maintenance practices. Basically, grass can be kept shorter in the spring and fall when it is growing fastest, and should be kept longer in the summer to protect the ground and turf from drying out. The following schedule provides general guidelines for mowing:

Time of Year	Frequency of Mowing	Height of Grass
Late March to early April	Once	2 to 3 inches
April to June	Weekly	2 to 3 inches
July to August	Every 12 to 17 days	3 inches or higher
September to November	Every 10 to 14 days	2 to 3 inches

Another general guideline is to cut higher rather than lower. Remember that loss of vegetation almost always leads to erosion and a low blade can skim the earthworks or cut into a slope. If the area is very uneven, with lots of holes, raise the blades 1/2" to 1" to be safe. Never cut more than one-third of the grass blade's total height. Letting the grass grow tall for an extended period, for example in the spring until seasonal help is available, and then mowing is very damaging to turf and results in bare patches. It is expecially important that vulnerable resources such as the earthworks not be subjected to this practice. Where budgets are limited and turf mowing must be temporarily restricted, large flat areas are more appropriate for such measures than earthworks.

Over time, old leaf blades and cuttings gradually accumulate and compact to form a layer at the ground called "thatch". Sometimes thatch build-up becomes excessive, inhibiting soil aeration and permeability. When this occurs the lawn can be "thatched", which removes built-up thatch throughout turf areas.

Repair of Damaged Turf Areas

It is very important to repair damaged or worn areas before they begin to erode. This can be done either by seeding or sodding. Seeding is appropriate on level areas, but sod should be installed on slopes, drainage swales, and embankments, and may require pegging. Overseeding may be adequate where damage is minimal.

Turf Overseeding

Where grass cover is thin but there is little sign of erosion, it is advisable to overseed the area with the following mix: 70% hard fescue, 25% chewings fescue, 5% alsike clover. This mix is measured by weight, not by volume. Consult with the Agricultural Extension Service agent on the proper application rate. Spread the mix over the existing turf with any soil amendments recommended by the soil test. If it does not rain, soak the area to a depth of 4" and let germinate. Continue watering for several weeks following germination, if there is no significant rainfall, to promote good growth. Do not

mow until the new grass is at least three inches tall. Make sure the blade is sharp, so it cuts and does not rip the new shoots. Overseeding should be done between March 1st and May 1st or October 1st to the 15th.

Turf Seeding

In areas that need complete rehabilitation, clear all debris and large clumps of dead grass. Scarify the soil to loosen the top three inches, and rough rake so no gully or rill is deeper than one-half inch. Where soil has been lost and scarifying to a depth of three inches might damage the resource, additional topsoil should be added. At least one inch of the original surface should be scarified to aid 'knitting' the old and new soil layers. Spread seed and tamp or hand roll to ensure that the seed has good contact with the soil. Follow the recommended seeding times, watering schedule, and mowing regimen for overseeding and consult with the Agricultural Extension Service agent to determine the proper application rate.

Cover the newly seeded area with a uniform 1-1/2 inch thickness of straw mulch (1-1/2 tons per acre). Spray with a tackifier according to the recommendations of the manufacturer or the Agricultural Extension Service agent, either by hand or machine sprayer. Do not mow until the new grass is at least three inches tall.

Turf Sodding

For steeper slopes and in swales, use sod instead of seed. For slopes steeper than 3:1 or where stormwater flow is anticipated, use 2' x 2' x 13" sod secured with hardwood pegs to initially hold the sod in place. Prepare the soil as for seeding, water lightly, and place the sod with less than 1/4-inch gaps between sections. Fill any gaps with soil and hand roll. Remember to place the strips with the long sides parallel to the slope and keep the sod moist. Dry pallets will have a poor germination rate and will tend to curl up around the edges.

Transitions

The field cover types are likely to involve significantly revised management procedures for the National Park Service during the next few years. Existing expanses of erratically maintained turf should be diminished as well as much of the pasture and rough grass, and replaced by native grasslands. Turf grasses require frequent mowing without which the quality of their coverage declines dramatically. Irregular and infrequent mowing inevitably degrades turf coverage, and those areas which will not be maintained in turf should be managed as tall grass meadows.

Establishing Tall Native Grasses

Existing pasture, rough grass, or turf can be managed gradually to develop into tall native grasses. Release of existing turf will result in an immediate 'tall grass' condition, but this will not necessarily be composed of perennial native grasses. The first stage of released turf is primarily the mature flowering form of the turf grasses themselves. There may be some native grasses and other perennials present and management of released turf should be designed to encourage those plants. There may also be woody plants present and invasive plants as well (particularly honeysuckle). The most vulnerable open landscapes in the earthworks parks are those presently in rough grass and those areas which have recently been released from mowing. In both cases, monitoring and treatment of exotics should be initiated as soon as possible, before they are well established. Rarely will there be a homogeneous response to turf release and management must be tailored to site specific circumstances. The key management goals are the control of invasive plants (especially vines) through more frequent mowing, herbicides, handpulling, fire, black plastic sheeting, or other means, and the encouragement of perennial native species.

The most favorable management for native tall grasses is controlled burning. Good access is generally already available at these sites and a perimeter fire break is relatively easy to establish. An important benefit of fire management is that fire raises the pH and makes essential soil nutrients more available. The standing crop and grasses will be immediately invigorated and the resource better stabilized. Fire management also eliminates the need to disturb the soil layers and possibly artifacts in order to reseed.

Where fire management is not feasible, a reduced mowing regimen and a simple lack of maintenance will eventually lead to development of native species if exotics are controlled. However, additional management is recommended to foster more rapid stabilization. Park personnel have consistently underestimated the amount of erosion occurring on a site, despite visible evidence. 'Flat' land was assumed not to erode and severe erosion after clearing was not observed. In this light, it is especially important not to underestimate the care a landscape requires wherever healthy native landscapes are not yet established. Unfortunately, there are, at present, no surefire methods for locally establishing little bluestem, the most predominant native grass, with the exception of fire management.

Little bluestem and other perennial native grasses develop slowly, whether seeded or vegetatively established. Further experimentation is required on park sites to determine the most effective establishment methods. The following guidelines are recommended:

Seeding Native Grasses

Overseed existing released turf late April or May with little bluestem at a rate of 3 to 5 lbs. PLS (pure live seed) per acre. No liming or fertilizing is necessary. On wetter sites,

sow switch grass in late April or May at the rate of 2 to 4 lbs. per acre PLS. Again, no lime or fertilizer is required. The soil surface should only be lightly scarified before overseeding. It is important to retain the major portion of the existing cover for erosion control.

During the first season, new seedlings will develop slowly and are likely to be overtopped by other vegetation by midsummer. At this time, one mowing is advisable. The blade should be set high enough to avoid severing the new growing tips of the bluestem, while removing top growth of other species to reduce competition with the new seedlings.

In the second season, a light liming, sufficient to raise the pH to 5.5, may be helpful on more acid soils if cover is still sparse. At this point, routine field management of an approximately annual burn or mow is generally adequate. It may take anywhere from two to five years for a healthy native grassland to be established.

Patching With Native Grasses

The most effective method to establish native grasses in small disturbed patches on earthworks is vegetatively. Plugs of little bluestem (collected locally, disturbing no more than 10% of any site area), measuring approximately 6" x 6" should be planted on about one foot centers and mulch. Alternately, large clumps can be divided into smaller slips which can be planted on six inch centers and mulched.

Establishing Native Grasses on Bare Soil

Plugs of Native Grasses

The most effective method for establishing native grasses on bare soil is by plugs which have been propagated from local stock. Although costly at the outset because it is so labor intensive, this method requires the least maintenance in following years because nearly complete cover is achieved in the first season. This approach is at present still fairly innovative and the plugs are available commercially on a very limited basis. For large area plantings, it is advisable to contract directly with a propagator to obtain adequate supplies at a reasonable price. Two-year-old plugs of little bluestem (Andropogon scoparius) in peat pots 2" in diameter and 2.5" deep currently being supplied to the National Park Service by North Creek Nurseries, RR #2, Box 33, Landenburg PA 19350; telephone: (215) 255-0100; contact: Dale Hendricks.

Arrangements should be made to contract grow this plant material in the fall prior to spring installation. Fall planting is not appropriate bacause of problems with frost heaving. Planting should be undertaken with a tree planting bar at one-foot on-center spacing. Insure soil is firmed around each plant and then mulch to a depth of 2" with weed-free, seed-free, unrotted clean straw. Barley, wheat, or rice straw is acceptable. Plugs should be watered every week or two during the first season. Where

honeysuckle was eradicated before planting, continued weeding of honeysuckle is required.

By Seed

Seeding and mulching are required to establish native grasses on bare soil. The soil should be sufficiently compacted to provide a clean firm seedbed. The recommended seeding rates 25-30 lbs. PLS per acre for little bluestem and 10-15 lbs. PLS per acre for switchgrass. Adding white clover to the grass mix at a rate of 25 lbs. per acre may also be advisable. Because seedling growth is so slow, a good mulch cover is critical to reduce erosion. A straw mulch, three inches deep, and punch-tacked or tackified is recommended.

Planting new meadows is best accomplished, where possible, by first cultivating a new seed bed. Repeated cultivations of the seed bed at 4-5 week intervals (2-3 times) will help to eliminate competing species. Broadcast seed at the above rate and mixing the seed with sawdust can help to obtain even distribution. Alternatively, the Brillion Seeder, a seed drill machine, can be used effectively to seed new meadows. A nurse crop of annual rye or oats will help to stabilize the soil surface as the grasses become established. Perennial grasses should not be used as a nurse crop as they typically out-compete with the slowly developing native grasses.

A recommended alternate source of mulch may also serve as an alternate seeding method as well -- little bluestem or switchgrass straw. An existing tall native grassland can be cut and baled when seeds are ripe. This can be applied as mulch to bare soil after seeding, with tackifier. Some experimental plots should be established to see if this also serves as an adequate seeding option.

Where bare soil on earthworks threatens the resource more expensive means such as erosion control blankets, can be used for temporary soil surface protection. Use blankets made of organic, biodegradable materials only. Seed with the same mix and at the same rates as above and then cover the area with the blanket and tack it to the soil as per the manufacturer's recommendations. Some erosion control blankets can be obtained with a custom seed mix contained in the mulch. Methods such as these provide immediate erosion protection and provide native grass seed as well.

Establishing a Woody Meadow

Healthy tall native grasslands with minimal invasion of disturbance species are suitable for developing woody meadows. Both mowing and burning should be stopped for two years at least and only invasive disturbance vegetation controlled. The new woody growth should then be evaluated to determine which areas should be released and which areas should be mown or burned as needed, no more than once a year, to retain the desired balance of woody and herbaceous vegetation.

Establishing Pasture

There were no sites identified which were recommended for conversion to pasture. If at a later date some pasture is required, both the Soil Conservation Service and the Agricultural Extension Service should be contacted, with soil tests as described earlier.

Establishing New Turf Areas

There were no sites identified which were recommended for conversion to turf. If at a later date new turf areas are required, soil tests should be taken and the Agricultural Extensive Service contacted for current recommendations. In the meantime, the directions for the repair of damaged turf areas are sufficient for establishing small turf areas.

Cold Harbor

Cold Harbor is the single largest piece of land in the Richmond National Battlefield Park. Historically forested, a central area has been cleared to expose two sets of earthworks. A ring road and private property access roads have also been built in the past twenty years. Since then, most of the exposed earthworks have been denuded and the tops and sides have begun to erode. In addition, relic hunters have damaged adjacent banks of earthworks, leaving large holes and destroying the soil stratigraphy.

Although there has been an increase in the level of use, neither the interpretive material nor the circulation system has provided adequate direction or perspective on the whole site. The visitor's journey is disjointed, preventing a clear picture of the site and its historic context. Parking lots, bridges, and paths all encourage visitors to walk along the tops of the earthworks on a tracery of dirt trails.

The goal of the proposed long-range program is to provide clear, controlled access to the earthworks and to develop a unified interpretive journey that reveals both the historic event in its landscape context and the structural artifacts of the battle at Cold Harbor.

Initially, the parking lots should be removed and could be replaced by a single lot built on the north side of the clearing. New roads and parking areas should be on grade to reduce destructive regrading. An orientation area adjacent to the parking lots could be the beginning and the end of a circular interpretive loop that would explore the site along the edges of the earthworks. Vegetation would prevent easy physical access to these structures while permitting uninterrupted visual access.

As funds become available, the ring road should be be removed and shortened. The private access road should be moved north below the crest of the hill. This would leave the entire interpretive area clear of cars and roads and provide a sense of unity to this

memorial. An orientation point could be built on the south side of the clearing, adjacent to the new parking lot, to provide an overview of the entire site.

Figure 18: Cold Harbor, Existing Conditions

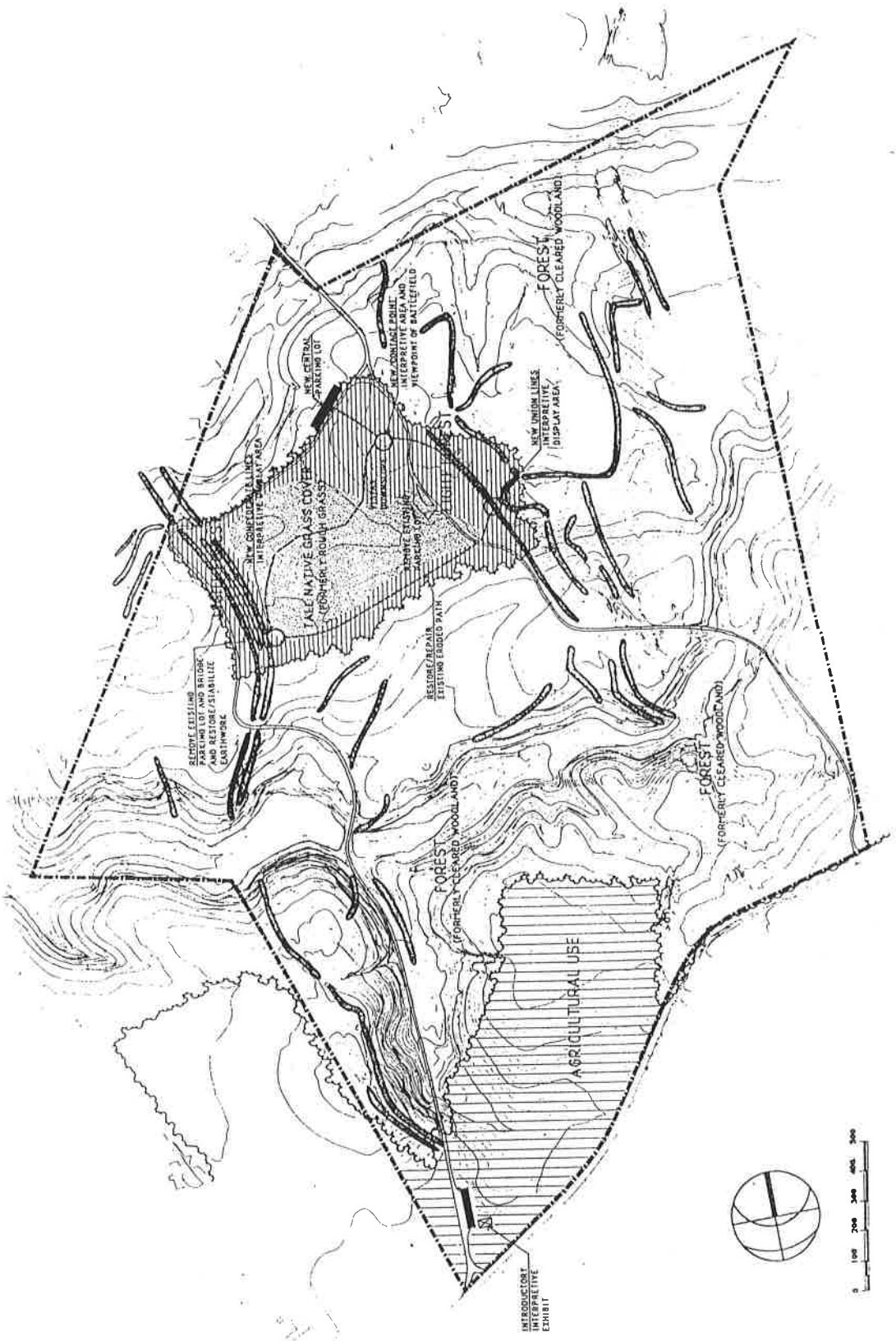


Figure 19: Cold Harbor, Interim Stabilization Program

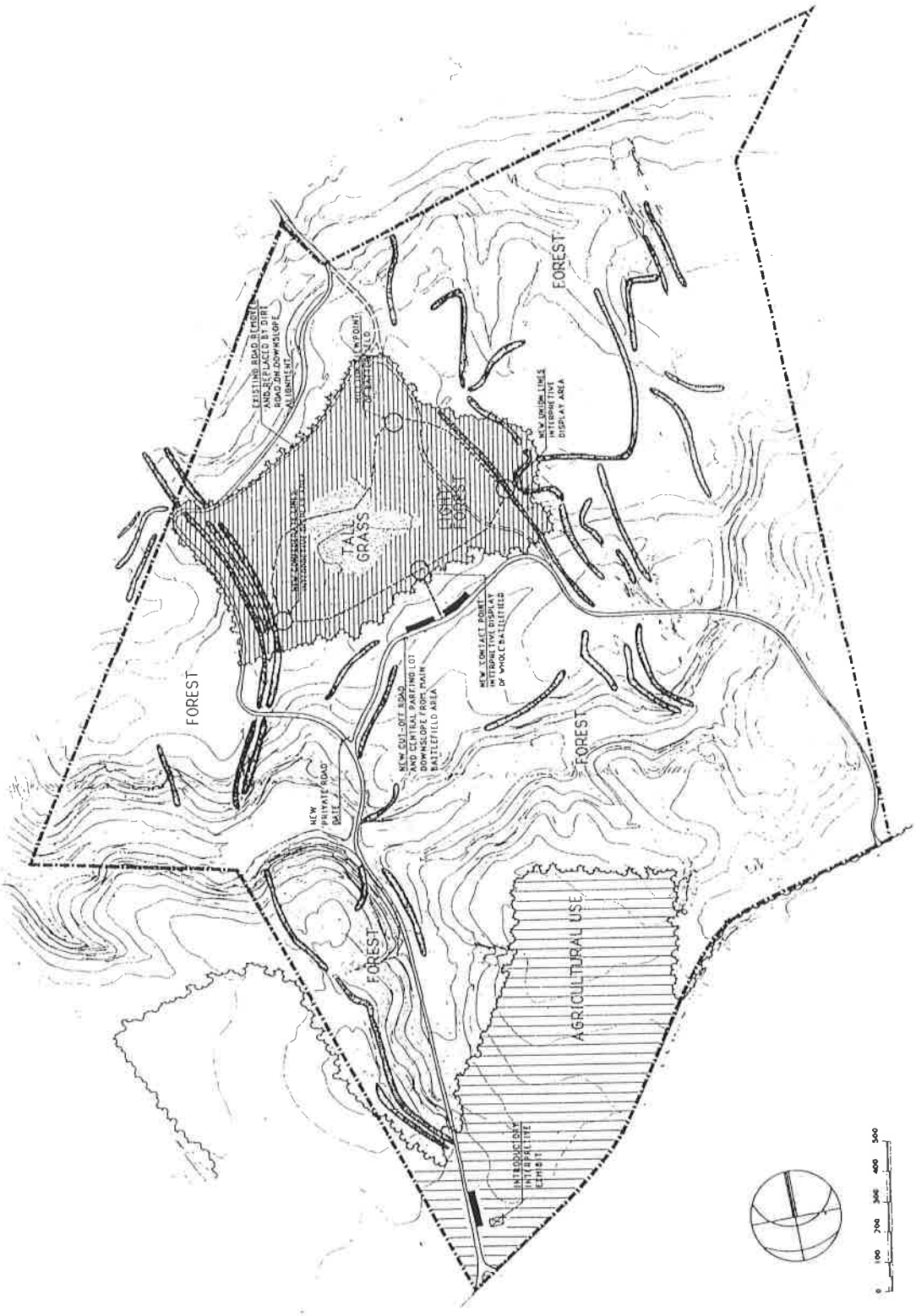


Figure 20: Cold Harbor, Long-Range Program

SECTION I

MANAGEMENT GUIDELINES FOR THE RESTABILIZATION AND REVEGETATION OF DAMAGED GROUND SURFACES

Prepared for:

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LIST OF PHOTOGRAPHS

PHOTO 1: Illustrates damage in the upper and mid sections along the sides of the earthworks.

PHOTO 2: Close up of the same damaged sited in Photo 1.

PHOTO 3: Typical example of severe side and top denudation damage. This case is due to motorized vehicles, which have been driven up the side of the earthworks.

PHOTO 4: Close-up of the same damage sited in Photo 3.

PHOTO 5: Typical example of a denuded foot trail over the earthworks.

PHOTO 6: Close-up of Photo 5 site. This view clearly illustrates the damage done to the roots of the existing vegetation.

PHOTO 7: Typical interconnecting minor foot trail systems. These conditions are found on the top and inbetween, throughout the earthworks. (Example 1)

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PHOTO 12: Typical example of trails which lead from parking lot facilities to the earthworks, view points or to relics within these structures.

PHOTO 13: Facilities which have been built into the earthwork systems. (Example 1)

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PHOTO 15: Drainage ditches at the base of the earthworks. (Full view)

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I. MANAGEMENT GUIDELINES FOR THE RESTABILIZATION AND REVEGETATION OF DAMAGED GROUND SURFACES

The Ground as a Guide

The ground is a guide to management priorities. The most visible management problems are apparent on the ground, such as excessive trampling which is a direct cause of the accelerated erosional rates, and therefore, damage to the earthworks. They indicate direct active damages to the precious resource. These problems should be given the highest priority for assessment, repair, continued monitoring and maintenance.

Nearly every example of ground disturbance requires some level of repair and may often indicate a deeper and still unresolved problem in the management of the resource--from uncontrolled, unrelated passive recreation and relic hunting, to poorly designed or inadequate visitor facilities. The more severe the damage, the higher the priority is for both repair and resolution cause of the problem.

The ground also provides important insights into opportunities for management successes. Highly used sites that do not show evidence of disturbance are clearly functioning well and may serve as models for developing appropriate management practices, and solutions on other areas where the limiting factors appear to be similar.

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IV. RESTABILIZATION AND REVEGETATION OF DAMAGED GROUND SURFACES

A. INTRODUCTION

It is intended that this section of the document be used directly in the field to repair the damaged sites, using specifically developed soil bioengineering revegetation and restoration systems. Each damaged condition has been specifically prepared with an appropriate living reconstruction unit.

The restabilization and revegetation of the surface erosion conditions which at the present directly affects the earthworks that are and have been man induced, shall be described herein. As discussed in the previous sections, all of the sites shall be carefully evaluated, monitored and maintained, (SEE SITE EVALUATION) restabilized and revegetated (SEE THIS SECTION) monitored and managed (SEE SECTION VEGETATION MANAGEMENT BY COVER TYPE) for discussions on existing vegetation health, which then translates into priority disturbance.

STABILIZATION SYSTEMS

As we discussed in the SITE EVALUATION SECTION, it is recommended that the NPS make regular inspections of the earthworks to detect signs of potential erosion or failure. When such observed conditions become evident, the NPS should immediately initiate stabilization measures. Taking steps as soon as possible to correct the problems will minimize damage, prevent the permanent loss of a resource and prevent the need for major expensive rehabilitation work later. It is extremely important for the NPS to be alert for signs of erosion, and be ready to implement stabilization techniques.

This section explains the observed problems, the recommended solutions, the attributes of utilizing the specifically developed soil bioengineering systems, the principles to follow and the construction techniques for each of the individual systems or techniques, which we recommend that NPS use to stabilize eroding and

damaged conditions on and around the earthworks. The major living structural systems have been developed using a soil bioengineering erosion control approach. These living systems are recommended as measures which are intended to reduce surface erosion, produce a naturally beautiful site. That blends into the landscape and improve the structural integrity of the earthworks. Many techniques exist, but the suggested ones seem to offer the best potential for the special requirements of the earthworks.

The methods recommended here are applicable on the various observed damaged earthwork failures. The scale of the recommended repair work, using soil bioengineering systems, is intended to be approached with previous workshop instruction experience. With the workshop training period, this document is then intended to be used as a practical field "How To" handbook by the NPS Staff to repair selected recurring generic site erosional problems.

LIVING RESTABILIZATION METHODS

In most instances, these eroded sites can be restored to stable, healthy condition through the establishment of native vegetation. Under natural conditions of equilibrium, within the earthworks project site, the undisturbed and stable sites are covered with woody vegetative growth. These then provide the model and, therefore, the opportunities for management successes mentioned earlier. This established living network of plants absorbs the water energy during rainfalls, provides habitat for wildlife, conserves soil moisture, and stabilizes the soil within the earthworks with roots. Vegetative soil bioengineering restoration also results in the most natural appearance of the landscape.

These living systems grow stronger and more beautiful with age. They are intended to serve to retain soil and structural integrity, but in the early establishment stages are extremely vulnerable to damage by visitor traffic especially, immediately after installation. Within weeks of the onset of the growing season roots will become established from properly installed cuttings. Within the first year of growth, a good brushy cover can be expected. The density and overall plant growth is dependent on the selected native plant species.

Integrated Planning Requirements - It is essential in designing and constructing these measures to consider biological and engineering requirements in tandem. This caveat is particularly important in the case of vegetating the earthwork structures. It would be important, for example, to use only plants whose stem diameters do not greatly increase. Typically, shrubs do not attain large diameter trunk systems and therefore, are good plant material choices. The backfill should also have certain specified mechanical and hydraulic properties if the reconstructed unit is to perform satisfactorily. These requirements have to be considered along with the biological requirements for plant growth if the earthwork structure is to be healthfully vegetated. All these problems will require certain strategies, procedures, and occasional compromises for satisfactory resolution. These considerations are discussed further in the next section.

ATTRIBUTES OF THE SOIL BIOENGINEERING VEGETATIVE APPROACH

A principle characteristic of the soil bioengineering approach to slope protection and erosion control is that plants and structures function together in a mutually reinforcing and complementary manner. The following specific attributes may also be cited as valuable to the NPS:

Cost Effectiveness - Studies have shown that under appropriate conditions, soil bioengineering vegetative slope protection systems are more cost effective than the use of structural solutions alone. Conventional vegetative treatments alone are usually much less expensive than concrete and steel earth retaining structures or other forms of inert construction. On the other hand, their effectiveness in terms of preventing soil loss or arresting slope movement under severe trampling conditions by visitor use may be much lower. Soil bioengineering vegetative methods often provide an acceptable level of protection at a more reasonable cost.

Labor/Skill Intensiveness - The vegetative methods tend to be more labor/skill intensive as opposed to energy/ capital intensive. The nature of these methods is such that well-supervised, unskilled labor can often be substituted for high-cost, energy intensive materials.

Use of Natural, Indigenous Materials - The soil bioengineering approach emphasizes the use of natural, locally available materials--earth, rock, timber, vegetation--in contrast to human made artificial materials. Such an approach is most compatible with NPS policy.

Environmental Compatibility - Soil bioengineering treatments blend into the landscape and do not intrude visually to the same extent as stark concrete and steel structures. Nor do they cause as much disruption and ground disturbance during installation or impose severe access requirements. These are important considerations where visual and aesthetic constraints govern environmentally sensitive areas such as the earthworks resources in these National parks. In fact, soil bioengineering puts in place the foundation upon which nature is given an opportunity to build the permanent long term structure.

Planting Times - The recommended soil bioengineering vegetative systems are most effective when they are installed during the dormant season. This is the time of year when vegetation is not concentrating energy on producing leaf growth. The plant in this state is considered dormant. This time also coincides with the winter season, a time in many areas when labor may be most abundant and therefore, somewhat less expensive.

Inaccessible Sites - The recommended systems will be useful for the small or steep sites where machinery can not have access. The use of hand labor, available within the park, becomes very attractive.

Plant Material Harvesting - The use of vegetation in the wild often produces very satisfactory results from two (2) points of view. 1) Cutting of an older stand of woody vegetation encourages new, fresh and healthy growth to occur. 2) By cutting material from the wild, only transportation costs are incurred. The material is not a direct cost item.

Low Maintenance Requirements - The effectiveness of the recommended soil bioengineering systems actually improve with time as vegetation becomes better established. In many instances, the primary role of the structural component will be to give the vegetation a better chance to gain a toe hold on the earthwork structure. Once established, selective trimming of vegetation every three (3) years will provide a stabilized structure, and a good supply of cuttings for other locations requiring repairs.

BASIC PRINCIPLES

The basic principles that apply to conventional soil erosion control also apply, in general, to the recommended soil bioengineering systems for the NPS sites as well. These principles are mostly common sense guidelines that have more to do with planning, timing, and minimizing site disturbance than they do with the design of individual measures themselves. Applicable principles can be summarized as follows:

1. Fit the development or construction plans to the site. The same holds true for any erosion control plan. This means taking the site topography, soils, hydrology, and most importantly the resource, into account and avoiding extensive grading in critical areas. It also means utilizing control measures that are compatible with the specific NPS site conditions and overall policies.

2. Retain natural vegetation whenever possible. Vegetation provides excellent protection against surficial erosion and shallow slope failures. The recommended measures are largely designed to aid and enhance the reestablishment of vegetation, so it makes good sense to save the original vegetation whenever possible.

3. Limit amount and duration of exposure. When the site must be cleared of vegetation:

   a. Limit exposed area to smallest practical size,
   b. Limit exposure time to shortest practical time, and
   c. Remove site shrubs to a temporary nursery area.

4. Stockpile and protect topsoil removed during grading and clearing operations.

5. Protect critical areas exposed during construction with temporary vegetation and/or mulch.

6. Divert, drain, or store excess surface and groundwater.

   a. Accommodate by suitable means increased and/or concentrated runoff caused by changed soil and surface conditions during and after development.

   b. Install subsurface drains to eliminate water logged conditions and high pore water pressures.

Basic Functions of the Recommended Soil Bioengineering Vegetative Systems

Role of Vegetation - Vegetation offers the best long-term protection against surficial erosion on slopes and provides some degree of protection against shallow mass-movement. Vegetation helps to prevent surficial (rainfall) erosion by:

1. Binding and restraining soil particles in place
2. Filtering soil particles out of runoff
3. Intercepting raindrops
4. Retarding velocity of runoff
5. Maintaining infiltration capacity

In general, herbaceous vegetation that provides good ground coverage and a dense root mat close to the surface is superior to woody vegetation in preventing surficial erosion.

Deeper rooted woody vegetation helps to prevent shallow mass-movement by:

1. Mechanical reinforcement from the root system
2. Soil water depletion through transpiration and interception
3. Buttressing and soil arching action from embedded stems

LIVING SYSTEM DESCRIPTION

A cutting is a branch pruned from a living plant, that is capable of regeneration. When placed in soil under proper conditions of sun, moisture and nutrients, these living branch cuttings taken from native shrubs are expected to root and grow. Cuttings used from native plants are very practical and economical, especially if they are available on-site or nearby.

Depending on the soil bioengineering design requirements of the particular installation, and upon the species used, cuttings can range from one half inch to one and one half inches (1/2" to 1-1/2") in diameter, and from one (1) foot to ten (10) feet in length. In all cases, the cuttings must be long enough to reach undisturbed soil, and must have buds for leaf development.

Cuttings must be installed during the dormant season. The dormant season normally extends from November to March, with some variation, depending on the particular year and the

plant species selected. Cuttings must be kept moist in a shaded area and placed in the soil within twenty-four (24) hours of having been cut. They usually do best when planted in a sunny location with moist soil.

The species most commonly used for erosion control has been the willow shrub. Willows are often found along streams, are usually available, root readily from cutting, are an excellent pioneer plant and grow quickly. Cuttings from other plant species that have also proven to be effective are privet, red stem dogwood and russian olive. Other native shrub species may also be effective if rooting can be successfully accomplished. It is important to utilize only native materials in the accomplishment of this work.

B. GENERIC PROBLEMS

The following typical examples of erosional conditions observed in the field, which directly affects the earthworks are as follows:

1. Along the sides of the structures; (sloughed damaged or otherwise denuded open eroded sites often caused by human use.) See Photos 3 & 4.

2. At the base of the earthworks. (Same as in 1.) See Photos 1 & 2.

3. On the tops/over the tops (longitudinal and at right right angles); (Same as outlined in 1.) See Photos 5, 6, 9, & 10.

4. Holes and slumps in the earthworks; (Similar to 1, but these may even be deeper and may have been caused by wind throw or human abuse.

5. Complete cut-throughs; (A condition which has been caused by the change in land use and interest.)

6. Connection paths between the earthworks; (Similar to 1, 2, & 3, but these are all caused by human use.) See Photos 7 & 8.

7. Disturbance around Civil War relics that are located within the earthworks system; This has been caused by the design location of the relics, and possibly the choice of ground surfaces.) (Same as 6.) See Photo 11.

8. Drainage ditches along the base; (These have been caused by reestabilished drainage patterns, some due to the earthworks themselves, other due to road system development, etc.) See Photos 15 & 16.

9. Facilities built into the earthen earthwork structures; (This has been caused by the design location) (Same as 6 & 7.) See Photo 13 & 14.

10. Trails to and from the various facilities; and (Same as 6, 7, & 9.) See Photo 12.

11. Finally trails that are part of the above descriptions, but appear to have developed due to lack of formal direction. (Same as 6, 7, 8, 9, & 10.)

PHOTOGRAPHS

PHOTO 1: Illustrates damage in the upper and mid sections along the sides of the earthworks.

PHOTO 2: Close up of the same damaged sited in Photo 1.

PHOTO 3: Typical example of severe side and top denudation damage. This case is due to motorized vehicles, which have been driven up the side of the earthworks.

PHOTO 4: Close-up of the same damage sited in Photo 3.

PHOTO 5: Typical example of a denuded foot trail over the earthworks.

PHOTO 6: Close-up of Photo 5 site. This view clearly illustrates the damage done to the roots of the existing vegetation.

PHOTO 7: Typical interconnecting minor foot trail systems. These conditions are found on the top and inbetween, throughout the earthworks. (Example 1)

PHOTO 8: Another illustration of the interconnecting trail conditions. (Example 2)

PHOTO 9: Interconnecting major trail systems which run primarily on top of the earthworks.

PHOTO 10: Interconnecting foot trail system close-up of Photo 9.

PHOTO 11: Severe disturbance around Civil War relics, which are located within the earthworks.

PHOTO 12: Typical example of trails which lead from parking lot facilities to the earthworks, view points or to relics within these structures.

PHOTO 13: Facilities which have been built into the earthwork systems. (Example 1)

PHOTO 14: Facilities which have been built into the earthwork structures. (Example 2)

PHOTO 15: Drainage ditches at the base of the earthworks. (Full view)

PHOTO 16: Drainage ditch close-up view from Photo 15.

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Illustrates damage in the upper and mid sections along the sides of the earthworks.

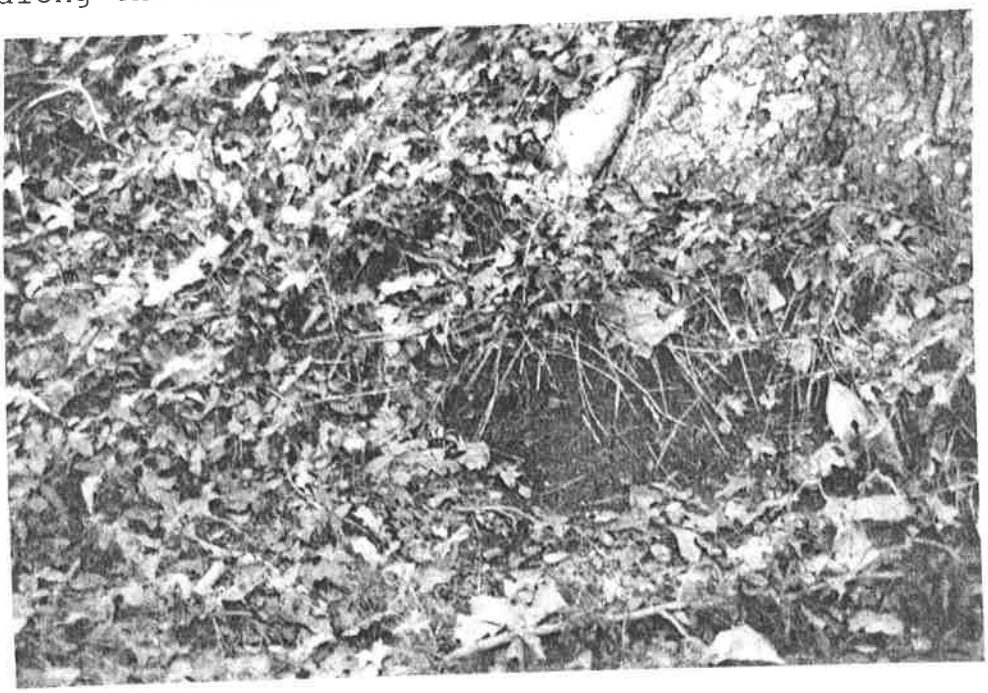

PHOTO 2:
Close up of the same damaged sited in Photo 1.

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Typical example of severe side and top denudation damage. This case is due to motorized vehicles, which have been driven up the side of the earthworks.

PHOTO 4:
Close-up of the same damage sited in Photo 3.

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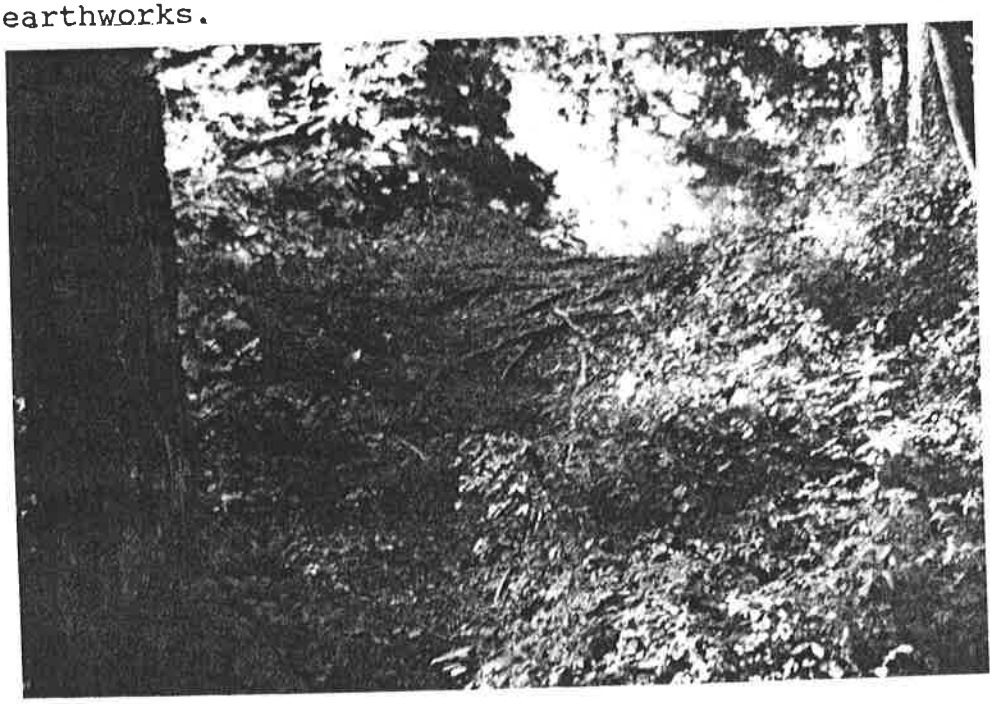
Typical example of a denuded foot trail over the earthworks.



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Close-up of Photo 5 site. This view clearly illustrates the damage done to the roots of the existing vegetation.

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Typical interconnecting minor foot trail systems. These conditions are found on the top and inbetween, throughout the earthworks. (Example 1)

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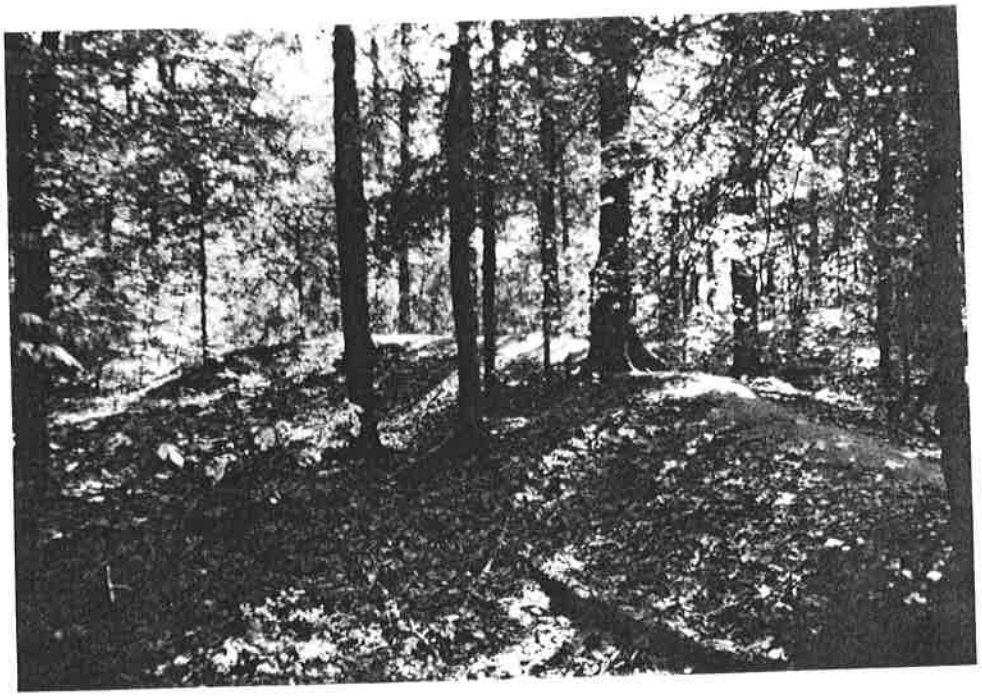
Another illustration of the interconnecting trail conditions. (Example 2)



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Interconnecting major trail systems which run primarily on top of the earthworks.

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Interconnecting foot trail system close-up of Photo 9.

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Severe disturbance around Civil War relics, which are located within the earthworks.

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Typical example of trails which lead from parking lot facilities to the earthworks, view points or to relics within these structures.

PHOTO 13:
Facilities which have been built into the earthwork systems. (Example 1)

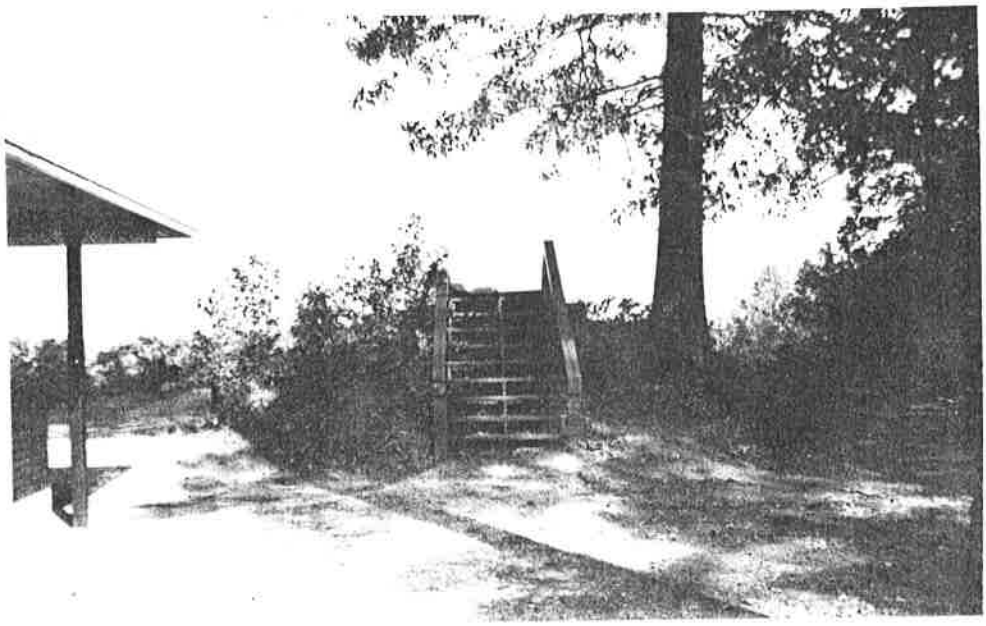


PHOTO 14:
Facilities which have been built into the earthwork structures. (Example 2)

PHOTO 15:
Drainage ditches at the base of the earthworks. (Full view)

PHOTO 16:
Drainage ditch close-up view from Photo 15.

C. GENERIC SOLUTIONS

The following types of restabilization and revegetation soil bioengineering systems shall be employed.

1. Live stakes, long straw and jute mesh (in grassed sites, the live stakes should be deleted). (See Solution 1, Figures 21 & 21A)

2. Live fascines with jute mesh. (See Solution 2, Figures 22 & 22A)

3. Live fascines with live stakes. (See Solution 3 Figure 23)

4. Branchpacking in existing slumps or holes in the earthworks. (See Solution 4, Figure 24)

5. Brushlayers to repair partial or complete cut-throughs in the earthworks. (See Solution 5, Figure 25)

FIGURES

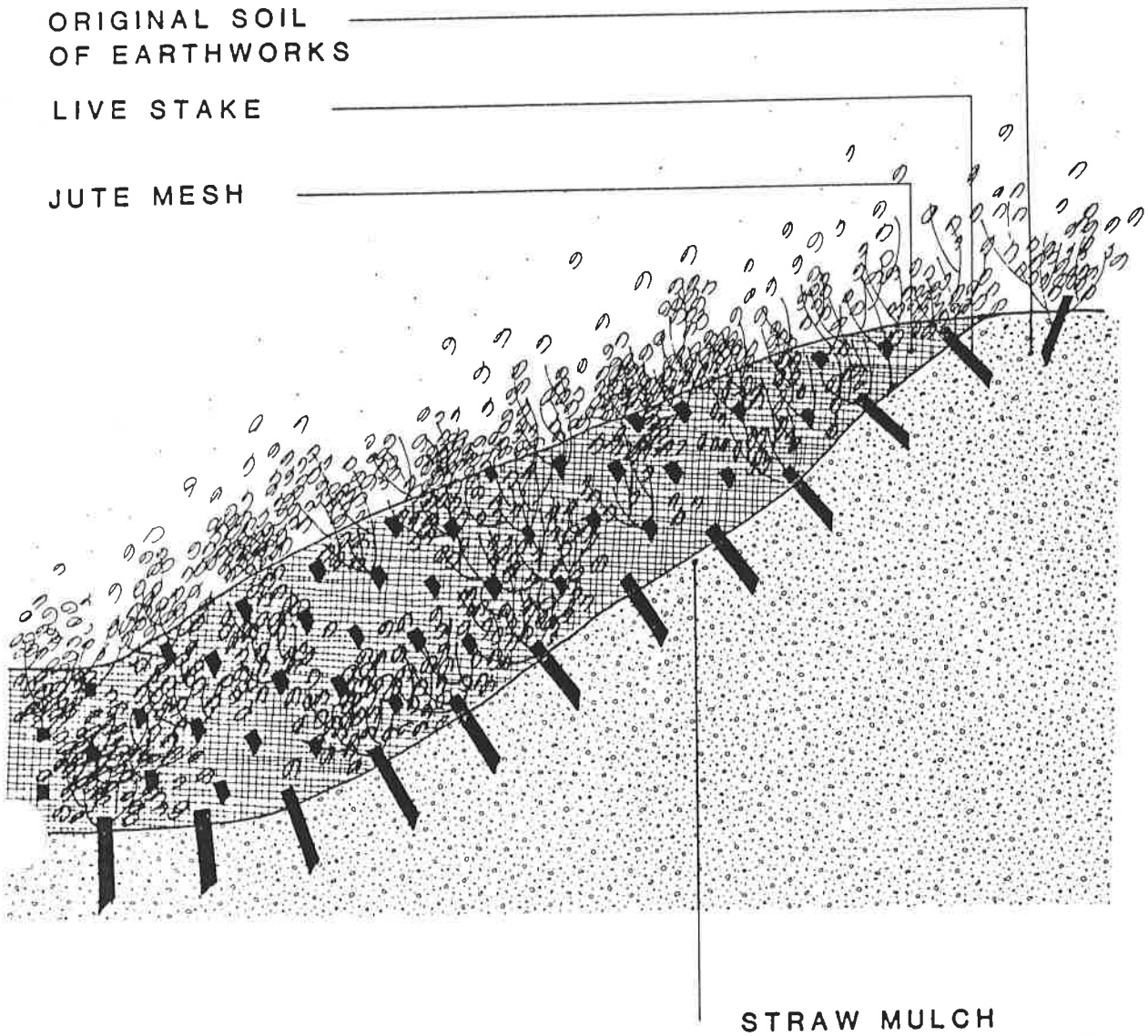
1. Solution 1.
   Live Stake, Jute Mesh - Figures 21 & 21A

2. Solution 2.
   Live Fascine and Jute Mesh - Figures 22 & 22A

3. Solution 3.
   Live Fascine and Live Stake - Figure 23

4. Solution 4.
   Branchpacking - Figure 24

5. Solution 5.
   Brushlayer in Fill - Figure 25



LIVE STAKE / JUTE MESH / STRAW MULCH

(Use in the repair of shallow open eroded areas)

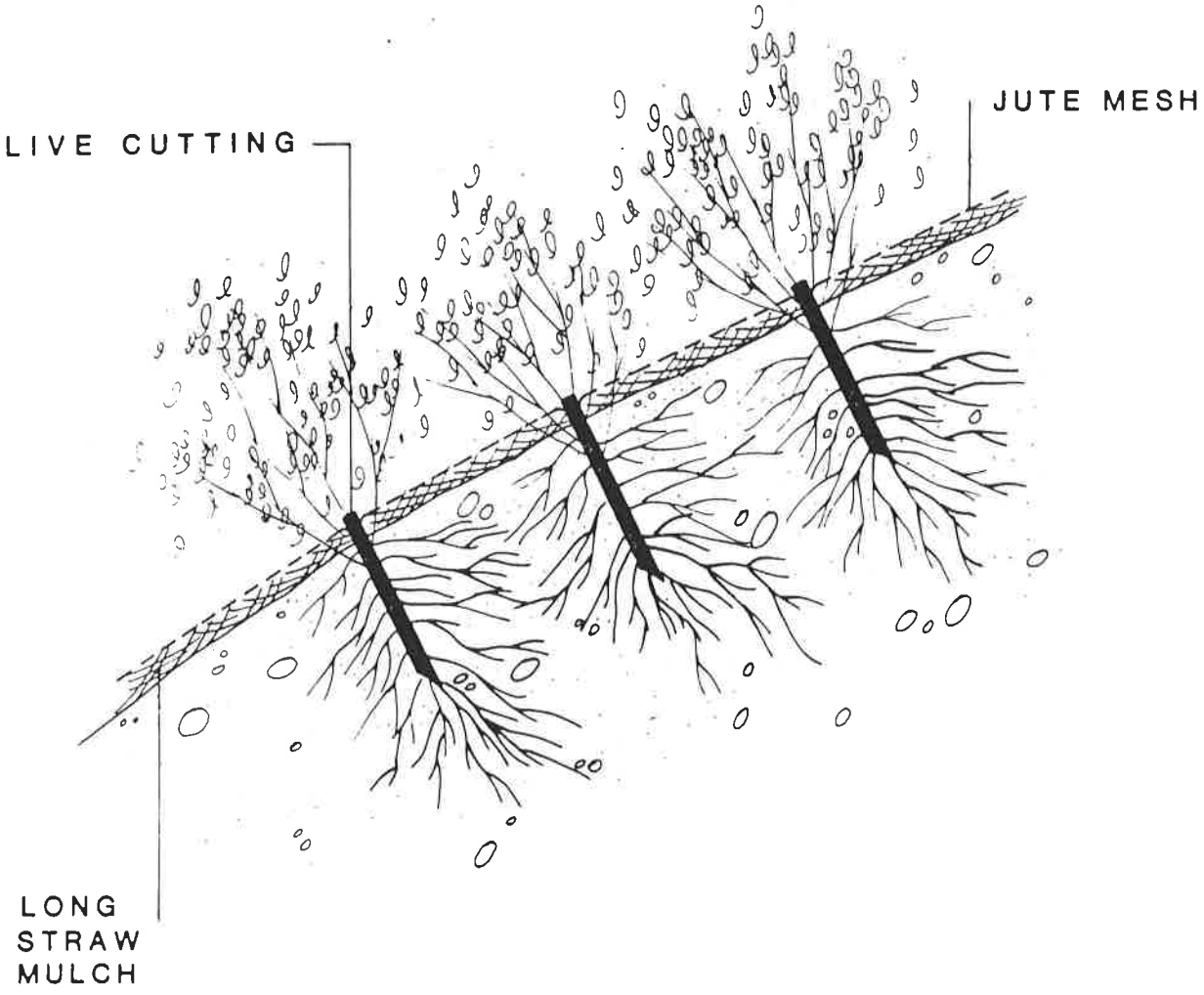
NTS

GENERIC SOLUTION 1

Figure 21

LIVE STAKE
(With Long Straw Mulch and Jute Mesh)

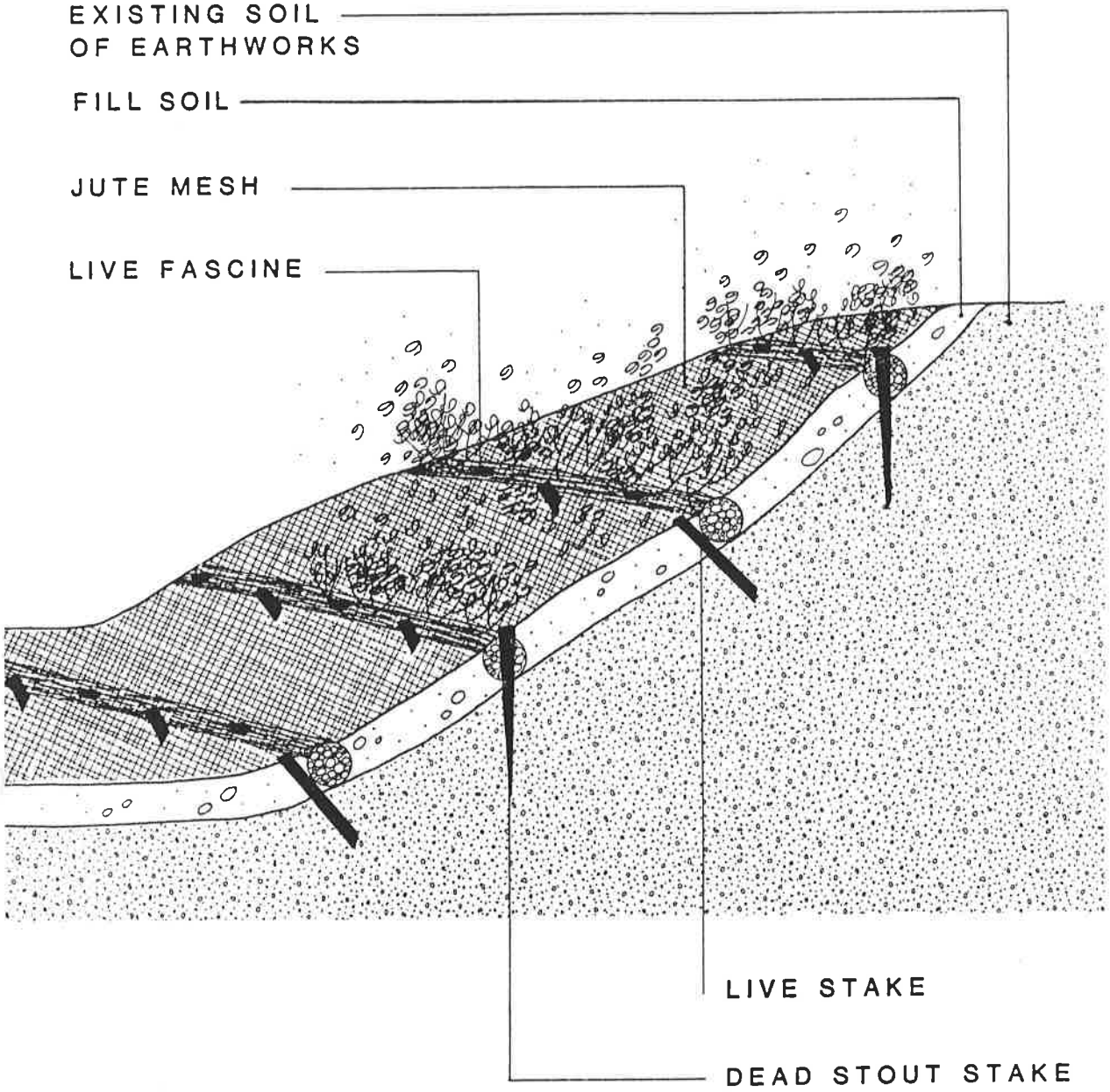
SECTION



NTS

GENERIC SOLUTION 1

Figure 21A



LIVE FASCINE / JUTE MESH

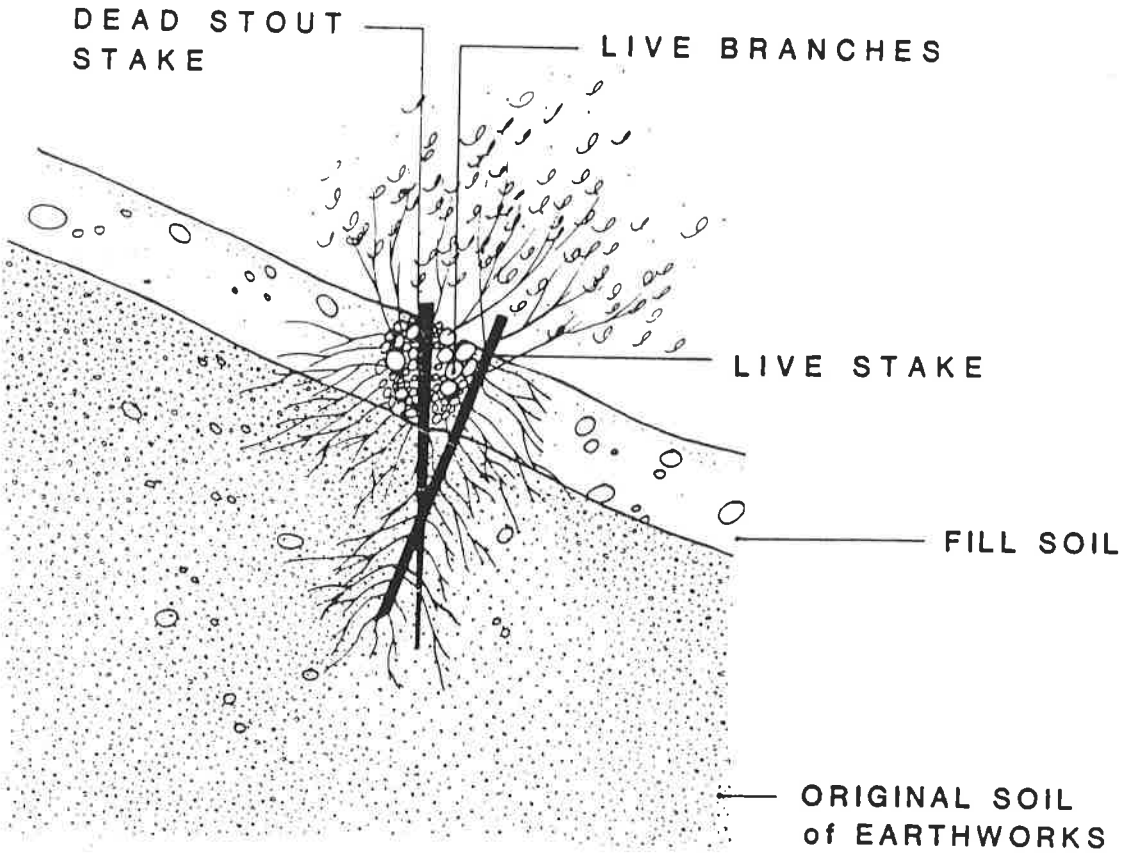
(Use in repair of deeper eroded areas)

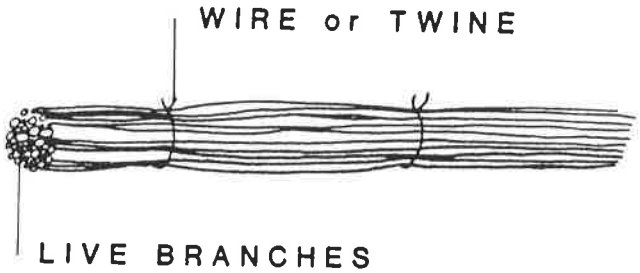
NTS

GENERIC SOLUTION 2

Figure 22

LIVE FASCINE

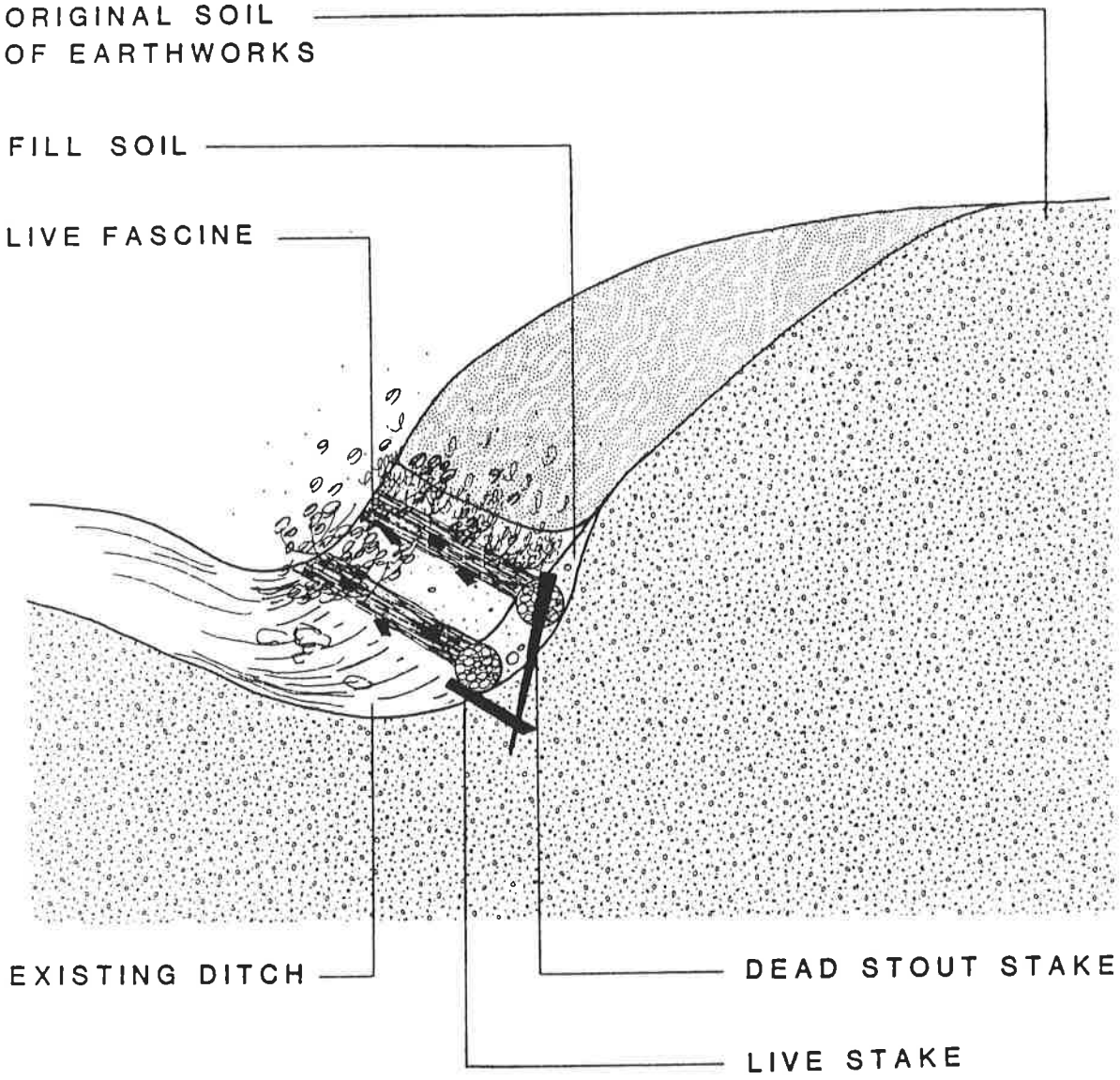




NTS

GENERIC SOLUTION 2

Figure 22A



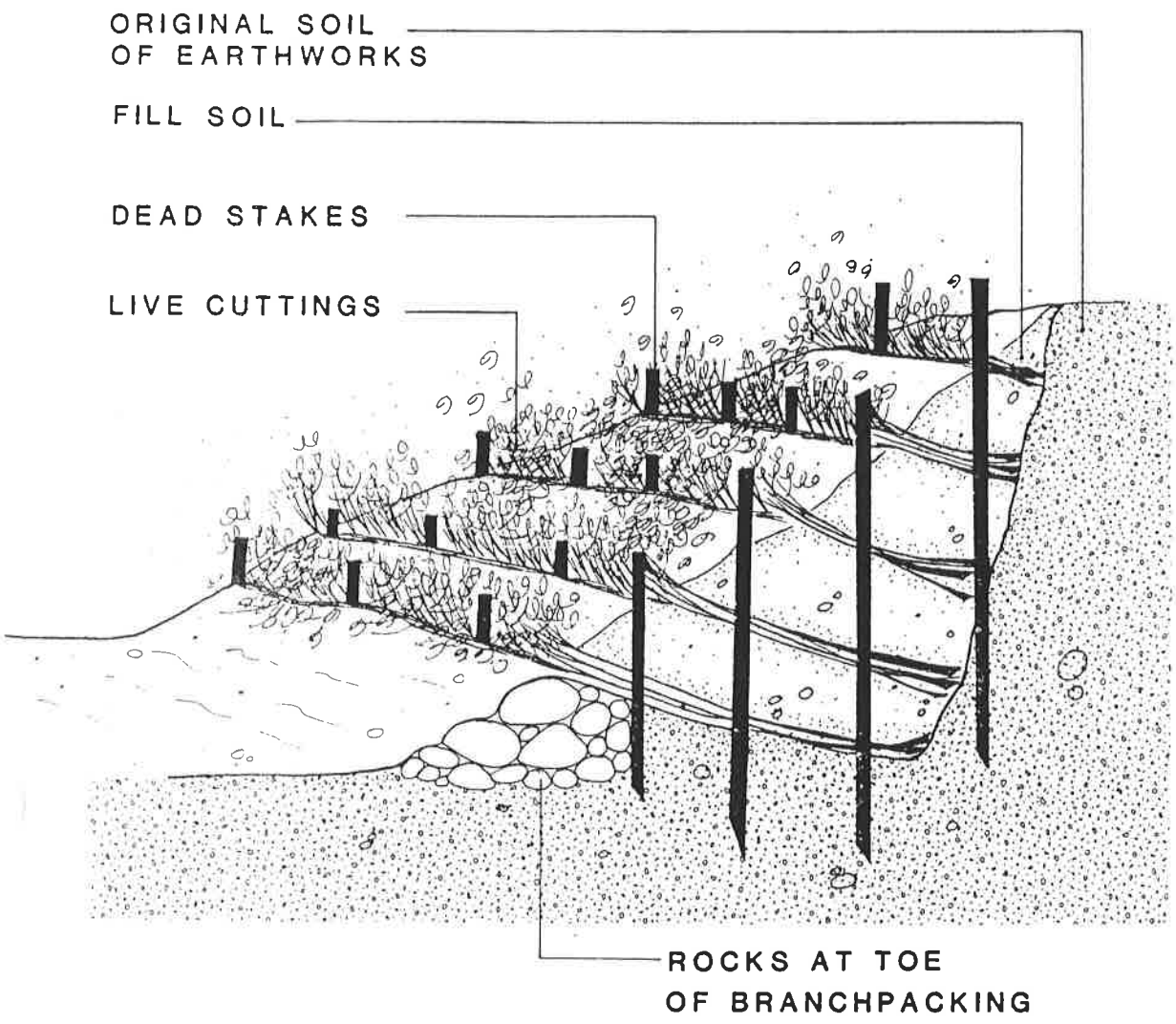
LIVE FASCINE / LIVE STAKE

(Use in stabilizing the base of ditches)

NTS

GENERIC SOLUTION 3

Figure 23



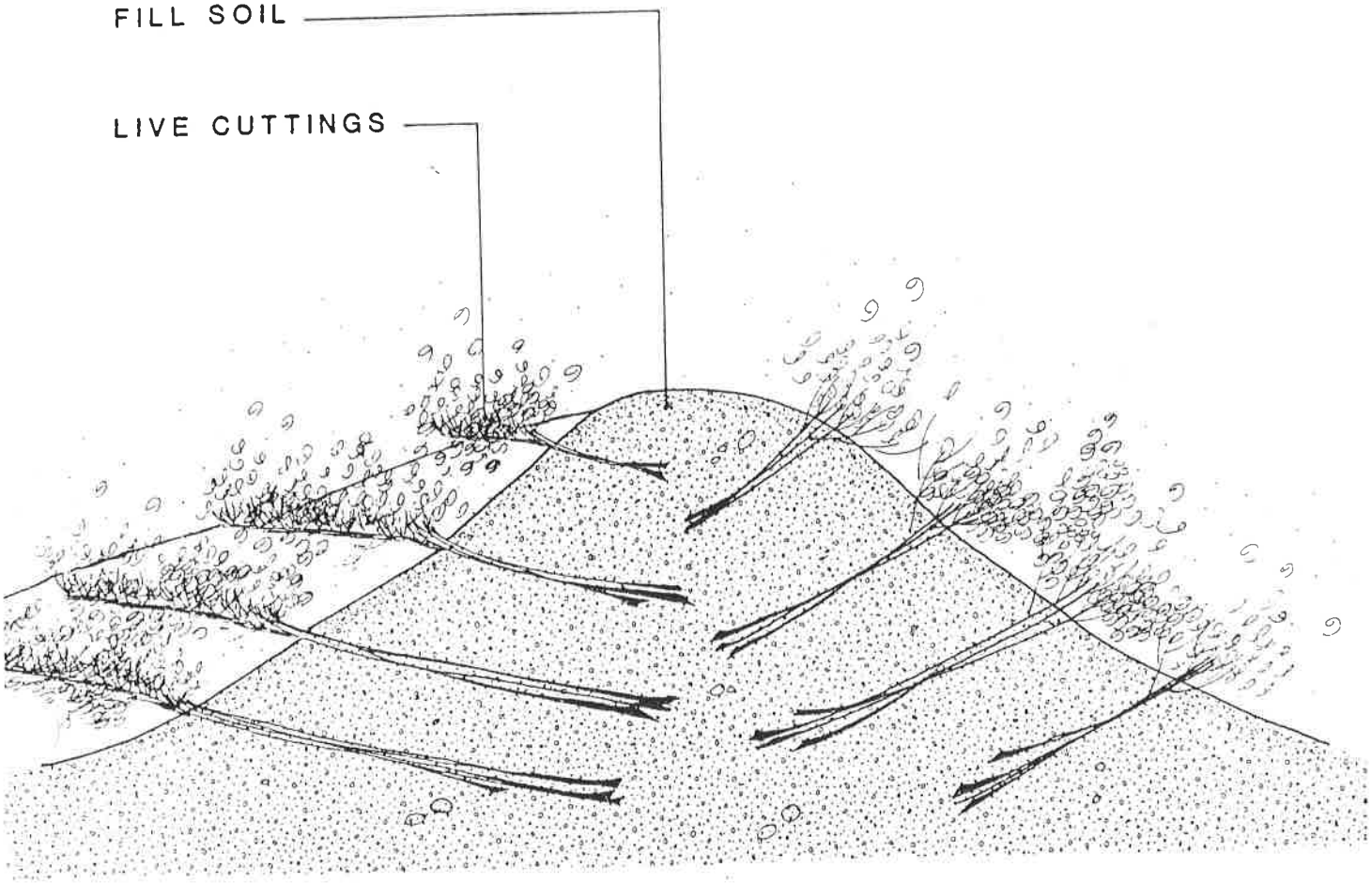
BRANCHPACKING

(Use in the repair of holes)

NTS

GENERIC SOLUTION 4

Figure 24



BRUSHLAYER IN FILL

(Use in the repair of cut throughs)

NTS

GENERIC SOLUTION 5

Figure 25

GENERIC SOLUTIONS SELECTION

To choose the correct repair, review the site situation to determine which recommended soil bioengineering technique will work the best. (SEE SECTIONS; BASIC PRINCIPLES and CONSTRUCTION PRINCIPLES) Keep clearly in mind the condition that needs to be changed. Each system is described in terms of its area of effectiveness, construction guidelines, live material sizes, live and dead materials and timing. Use all of the information in deciding on the best solution for the specific problem. The on-site workshop to demonstrate the work will greatly assist the first efforts. In time experience will be developed.

The soil bioengineering methods used should maintain the qualities of a natural setting or of the developed areas. Choose a method that fits the character of the particular location. For example, the revegetation techniques should in time blend totally into the natural environment, provided there is sufficient sunlight for the installed vegetation to become established. Often, live cuttings used in combination with non-living materials or structural devices, such as "dead stout stakes" or timbers, are the best alternative, since each enhances the other. This type of combination works particularly well where digging is not permitted, yet a stable site and a natural appearance are important.

In all cases choose a method that is unobtrusive in its setting. This can be done by using materials that are similar to those already found near the specific site. By matching the colors, textures and scale of the existing materials you will create a harmonious appearance between the earthworks, its adjacent surroundings, and the new stabilization installation.

SITE PREPARATION

Before a soil bioengineering restabilization and revegetation system is undertaken, the cause of the problem should be identified and if at all possible, corrected. The effort to incorporate vegetative cuttings into an earthwork as a restabilization material will be futile, for instance, where visitors continue to impact a site with foot traffic. Fence the earthwork repair area prior to attempting any vegetative rehabilitation. Due to the nature of these specific repairs, no regrading shall ever be done prior to the installation of these living systems on these historical structures.

The Generic Solutions shall be used as follows:

1. Live stakes, long straw and jute mesh. (See Solution 1, Figures 21 & 21A) This system shall be employed on trails and open areas that have eroded two (2) inches or less in depth. The following site situations may apply on the earthworks:

   a. Along the sides of the earth mounds;

   b. On the tops and over the tops (longitudinally and at right angles to the earthworks);

   c. Connection paths between the earthworks;

   d. Disturbances around the Civil War relics that are located within the earthwork systems; (This shall require continuous repair if a vegetative surface is desirable.)

   e. Along the sides of facilities which have been built into the earthworks;

   f. Trail systems to and from various facilities; and

   g. Various sporadic trail and damaged land sites within the earthworks systems.

   This system combination, without the live stakes, shall also be used when the season does not permit the use of woody plant living installation systems. It may also be used without the live stakes when a grassed site is most desirable.

2. Live fascine with jute mesh. (See Solution 2, Figures 22 & 22A)

   This reconstruction system shall be employed on trail, erosion sites and open areas that have eroded in excess of two (2) inches in depth, but not greater than ten (10) inches in depth.

   The following site situations may apply on the earthworks:

   a. Along the sides of the earth mounds;

   b. On the tops and over the tops (longitudinally and at right angles to the earthworks);

c. Trail systems to and from various facilities; and

d. Various sporadic trail and damaged land sites within the earthworks system.

3. Live fascines with live stakes. (See Solution 3, Figure 23)

This system shall be placed at the bottom of the earthworks:

a. In drainage ditch sites along the base of damaging or potentially damaging locations.

4. Branchpacking (See Solution 4, Figure 24)

This reconstruction system shall be placed in holes which have formed in the earthworks.

a. On the lowest points along the sides and on the ends of the earth mounds.

5. Brushlayers (See Solution 5, Figure 25)

This reconstruction system shall be used to rebuild earthworks which have been cut-through.

In shady areas it may be necessary to thin some upper tree limbs, in order to allow sunlight to penetrate the ground surface. In areas where this is not desirable or is impractical, the eroded section should be repaired using one of the above mentioned appropriate systems, such as long straw or jute mesh. Even if they do not grow and produce internal structural stability they will be capable of reducing surface erosion and thus allow for the invasion of an appropriate shade loving species.

In areas where earthworks have cut through and the desired result of revegetation is a tall grass cover, use only cuttings in the brushlayer system that will not root. The cuttings will provide structural stability to the slope that will allow for the establishment of grass species. To obtain non-rooting stock, use cuttings from species that do not root or use cuttings from rooting plant materials during the growing summer season.

CONSTRUCTION PRINCIPLES

Additionally, the following methods of soil bioengineering vegetative systems have certain common requirements. In all cases careful attention must be given to the control of water originating off-site to prevent overflow, undercutting, piping, etc. Culverts, drains, top of cut ditches and drop structures must be properly designed and installed.

Selection of plant species must be suitable for the site and intended use. Species must be adapted to the site's climate and soil conditions. Native species which root easily from cutting, such as willow, some dogwood, etc., are required for the vegetative measures such as brushlayering and live staking. Selected vegetation must be free from disease.

Plants and plant parts (as used here) are living and must be handled properly to avoid drying or exposure to excessive heat. Installation must be made in moist soil and adequate covering and compaction must be supplied to eliminate or minimize air pockets around the buried stems. If soil moisture is not at or near field capacity, installation must be delayed until such conditions exist or when irrigation can be promptly supplied during and following installation.

All fill areas shall be prepared with friable, well drained soils that are not toxic or in any way inhibiting to plant growth.

Installation of vegetative structures is best accomplished during specific time periods or planting windows during the fall at the onset of plant dormancy, winter, or early spring before growth begins. In some cases, installation may be successful after the initial spring flush of growth if extreme care is exercised, but the risks of failure are high. Summer installation is not recommended.

All installation should be inspected regularly and provisions made for prompt repair and reinstallation, if required. Initial failure of a small segment of a project normally can be repaired fairly easily. Neglect of small failures, however, can quickly result in the failure of large portions of a project.

Properly designed and installed vegetation portions of projects will become self-repairing to a large extent. These principles can not be over emphasized.

DESCRIPTIONS AND CONSTRUCTION

GUIDELINES OF GENERIC SOLUTIONS

LIVE STAKES

DESCRIPTION

Live stakes are living woody plant cuttings capable of rooting. The cuttings are large enough and long enough to be tamped into the ground as stakes. The live stakes are intended to root and grow into mature shrubs that will serve to stabilize the earthworks. (See Figures 21 & 21A)

EFFECTIVENESS

A very effective stabilization method once roots and vegetation are established.

An effective technique when construction time is limited and an inexpensive method is necessary.

An effective system for pegging.

Effective in quickly camouflaging an unwanted path system.

CONSTRUCTION GUIDELINES

Timing

Construction must occur in the dormant season, (generally November to March).

Live Material Sizes

The cuttings are usually 1/2" to 1-1/2" in diameter and 2′ to 2.5′ long.

Live Materials

The cuttings must be alive, with side branches cleanly removed, and with bark intact. These must be taken from a species that roots easily from cuttings.

The butt ends should be cleanly cut at an angle, for easy insertion into the soil. The top should be cut square or blunt.

Cuttings must be fresh and must be kept moist, after they have been prepared into appropriate lengths. They should be installed the same day that they are prepared.

Installation -

Tamp the cuttings into the ground at right angles to the slope.

4/5 of the length of the cutting should be tamped into the ground. The soil should be firmly packed around the cutting after it has been tamped into the ground.

Do not split the cuttings during tamping. Cuttings that split should be removed.

An iron bar can be used to make the pilot hole in firm soil. Tamping the cutting into the bank is best accomplished with a dead blow hammer. (hammer with the head filled with shot or sand)

The density of the installation depends on the specific site conditions, ranging from 2-4 cuttings per sq./yd. A spacing of 2' or greater is recommended.

The stakes should be placed in a random configuration.

LIVE FASCINES

DESCRIPTION

Live fascines are sausage like bundles of live cuttings wired or tied together and secured onto the earthworks with live and "dead stout stakes". (See Figures 22 & 22A & 23)

They are placed on contour in dry sections, or at an angle in wet sections on the slope faces.

EFFECTIVENESS

This method offers an inexpensive and immediate protection from erosion when properly anchored.

They work well to reduce erosion on shallow gully sites.

They are a very effective stabilization technique once rooting is established.

Live fascines are capable of holding fill soil on the face of the earthworks by creating mini dam structures. They reduce the slope into a series of smaller slopes.

They serve as pole drains when installed at an angle on the slope face.

They provide surface stability for the invasion of the surrounding vegetation.

CONSTRUCTION GUIDELINES

Timing -

Construction must occur in the dormant season (generally, November to March).

Live Material Sizes -

Fascines may be fabricated 5' to 15' long.

The bundles are 6" in diameter when prepared.

The branches which are contained in the bundle should have a maximum trunk diameter of 1 inch.

Live Materials -

Cuttings must be from a species that roots easily, and has long, straight branches. Material such as, young willows or red twig dogwoods are ideal for this method.

The cuttings are placed in bundles, and wired or tied together.

Live stakes should be 2' long. Live stakes should be tamped in below the live fascine bundle. "Dead stout stakes" shall be installed directly through the live fascine bundle.

Dead Materials -

Wire for bundling should be about the size of electrical fencing wire, or string for tying the bundles shall be bailing twine.

"Dead stout stakes" that shall be used to secure the live fascines shall be 2.5' long.

Installation -

Beginning at the base of the slope, place the live fascine.

Drive the "dead stout stakes" directly through the fascine bundles.

Next, one (1) to three (3) feet up the face of the slope, (depending upon the specific slope requirement) repeat the above procedure, to the top of the slope.

"Dead stout stakes" should be spaced approximately 18" to 2' apart. Extra stakes should be used at the conections or overaps. Leave the tops of the stakes flush with the installed bundle.

Place moist soil along the sides of the bundles. Walk on top of the bundles and on the soil in between.

Next, where appropriate, place jute mesh over the top of the live fascines and soil. Secure top and bottom with live stakes.

Tamp live stakes under the live fascines in between the "dead stout stakes", to secure the jute mesh to the face of the earthworks.

The live fascines and the live stakes should be prepared immediately before installation.

BRANCHPACKING

DESCRIPTION

Branchpacking is the process of alternating layers of live branches and soil incorporated into a hole or slump in the earthwork. The branches root to form a permanent reinforced installation while the tips produce vegetative top growth that is intended to reduce erosion. (See Figure 24)

EFFECTIVENESS

The installation produces an immediate filter barrier, reducing gully erosion and headcutting conditions.

One of the most effective and inexpensive methods for repairing holes in earthen embankments.

CONSTRUCTION GUIDELINES

Timing -

Construction must occur during the dormant season, (generally November to March).

Live Materials Sizes -

Branches may be 1/2" to 2" in diameter, and long enough to touch the original soil bank behind.

Live Materials -

Live cuttings, which root readily, are required.

Soil is used in alternate layers between the layers of placed brush.

Dead Materials -

Stakes, which are 2" x 4"s, should be 5' to 8' long.

Installation -

Starting at the lowest point, tamp dead stakes vertically into the soil 1' to 2' apart.

A layer of branches 4" to 6" thick is placed in the bottom of the hole between the vertical stakes, at right angles to the earthwork, and covered with a 8" to 12" layer of soil.

The following layers of branches are installed with the basal ends angled down, so that they are lower than the growing tip of the branches.

Each layer of branches must be followed by a layer of soil and compacted thoroughly, tamping by foot, in order to insure soil contact with the branch cuttings.

Succeeding layers of branches and fill are alternated until the hole is completely filled.

At the bottom, gravel should be placed for good drainage, where necessary.

BRUSHLAYERS

DESCRIPTION

Brushlayers are alternating layers of live branches and soil incorporated into a repair fill section of earthwork, where the earthwork requires reconstruction. (See Figure 25)

EFFECTIVENESS

The installation produces a rejoined and therefore continuous earthwork.

It retards gullying by producing filter systems on the slope face.

It serves to provide immediate reinforce the fill earth.

CONSTRUCTION GUIDELINES

Timing -

Construction must occur during the dormant season, (generally November to March).

Live Material Sizes -

Branches shall be 1/2" to 2" in diameter, and long enough to reach the center of the reconstruction.

Materials -

Live cuttings are required.

Soil is used in alternate layers between the brushlayers.

Installation -

Starting at the lowest point, the live cut brush is placed on the existing ground, at right angles to the earthwork.

The brushlayers should be 2" to 3" thick.

The basal ends of the brush should be lower than the tips.

The brush is then covered with 1' to 2' of fill soil depending upon the specific site requirement.

The soil should be foot compacted every 4" to 6" to ensure good soil contact.

The above described process continues until the earthwork is rebuilt to the original height.

D. SUMMARY

Each employed soil bioengineering vegetative system shall, wherever possible, reflect the existing vegetation landscape feature types (SEE RECOMMENDED GROUND COVER TYPES). Following repair, the sites must be protected against further damage from visitors foot and motorized traffic. The restabilization and revegetation systems are fragile in their initial growing stages and grow stronger with age, but if old patterns of use are restabilized at the earthwork sites, damage will again rapidly reoccur. These installed living soil bioengineering systems shall require monitoring and maintenance.

Carefully, assessed, properly installed and maintained soil bioengineering vegetative repair systems, normally produce excellent long lasting beautiful products.

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