

**FOREST VEGETATION AND ITS MANAGEMENT
FOR AESTHETICS, RECREATION,
AND HISTORIC INTERPRETATION**

Richmond National Battlefield Park, Virginia

Amy C. Helm, James E. Johnson

Technical Report NPS/MARRICH/NRTR-94/060

Department of Forestry
College of Forestry and Wildlife Resources
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061-0324

Final Report
July, 1994

Cooperative Agreement
4000-9-8014
Supplemental Agreement #8

National Park Service
Mid-Atlantic Regional Office
Division of Resource Management and Visitor Protection
143 South Third Street
Philadelphia, PA 19106-2878

Table of Contents

List of Figures	vii
List of Tables	ix
Summary	xi
Introduction	1
Historic and Current Forest Vegetation	3
Study Areas	3
Methods	7
Current Vegetation Data Collection Procedures	7
Forest Stand Designation and Plot Location	7
Forest Vegetation Inventory	8
Calculation of Vegetation Variables	9
Results	11
Vegetation of Chickahominy Bluff	11
Vegetation of Beaver Dam Creek	21
Vegetation of Watt House	23
Vegetation of Cold Harbor	31
Vegetation of Malvern Hill	45
Vegetation of Fort Harrison section of Chaffin's Farm	59
Vegetation of Drewry's Bluff	73
Vegetation of Parker's Battery	79
Vegetation Management Recommendations	85
General Management Activities	85
Management of Healthy Forests	85
Non-native Species: Identification and removal	89
Mowing: Schedules and Alternatives	95
Screening: Species and Methods	101

Earthwork Preservation	103
Vistas: Clearing and Maintenance	105
Agricultural Use Areas	109
Long-term Monitoring	111
Specific Management Activities	113
Vegetation Management at Chickahominy Bluff	113
Earthwork Vegetation Management	113
Screening	115
Exotic Species	116
Mowing	116
Vistas	116
Vegetation Management at Beaver Dam Creek	119
View and Vista Establishment	119
Screening	119
Vegetation Management at Watt House	121
Vista and View Establishment	121
Watt House Landscaping	121
Orchard Establishment	123
Scene Restoration	123
Agricultural Use	124
Vegetation Management at Cold Harbor	125
Vegetation Near Entrance	125
Open Woods Between Trenches/Earthwork Preservation--Tall grasses	125
Open Woods Outside of Loop Road/Earthwork Preservation--Light Forest Cover	127
Agricultural Use Area	128
Bloody Run Preservation	128
Vegetation Maintenance at Garthright House	129
Vegetation Maintenance at Malvern Hill	131
Historic Scene Restoration	131
Vista Establishment	131
Agricultural Use Area	131
Vegetation Management at Chaffin's Farm	133
<i>Fort Harrison, Visitor Center and Picnic Area on Picnic Road section</i>	133

Pine Removal, Hardwood Establishment	133
View and Vista Establishment	135
Earthwork Preservation	135
Screening	136
<i>Fort Brady section</i>	136
Earthwork Vegetation Management	136
Overlook Vista and Screening	136
Erosion Control	137
<i>Fort Brady to Kingsland section</i>	137
<i>Kingsland to Battery 3 section</i>	137
<i>Section from Battery 3 north to where Federal works cross Battlefield Park Road</i>	137
<i>Section from Federal works crossing Battlefield Park Road north to where Confederate works cross Battlefield Park Road</i>	138
<i>Section from Confederate works crossing Battlefield Park Road north to Battery 5</i>	138
<i>Fort Maury section</i>	138
<i>Fort Hoke section</i>	138
<i>Fort Hoke to Fort Harrison section</i>	138
<i>Maintenance Area/Residences</i>	139
<i>Fort Harrison to Fort Johnson section</i>	139
<i>Fort Johnson section</i>	139
<i>Fort Johnson to Fort Gregg section</i>	139
<i>Fort Gilmer section</i>	139
<i>Fort Gilmer to Route 5 section</i>	139
<i>Vegetation Management at Drewry's Bluff</i>	141
Vistas	141
Earthwork and Fort Vegetation Management	141
<i>Vegetation Management at Parker's Battery</i>	143
Literature Cited	145

Appendix II. Forest understory species at Richmond National Battlefield Park, Virginia. 149

Appendix III. Forest seedling species at Richmond National Battlefield Park, Virginia. 151

Appendix IV. Forest herbaceous and woody vine species at Richmond National Battlefield Park,
Virginia. 153

Appendix V. Overstory inventory and site data for 115 vegetation sample plots at Richmond
National Battlefield Park, Virginia. 157

Appendix VI. Biology of three woody exotic species at RICH, Virginia. 175

Appendix VII. Sources for warm season grasses and forbs for meadow plantings. 177

Appendix VIII. Native species for planting as vegetative screens 179

List of Figures

Figure 1. Location of Richmond National Battlefield Park, Virginia (RICH 1989).	4
Figure 2. Forest cover types and plot locations for Chickahominy Bluff, RICH, Virginia.	12
Figure 3. Forest cover types at Beaver Dam Creek, RICH, Virginia.	22
Figure 4. Forest cover types and plot locations at Watt House, RICH, Virginia.	24
Figure 5. Forest cover types and plot locations at Cold Harbor, RICH, Virginia.	32
Figure 6. Forest cover types and plot locations at Malvern Hill, RICH, Virginia.	46
Figure 7. Forest cover types and plot locations at the Fort Harrison section of Chaffin's Farm, RICH, Virginia.	60
Figure 8. Forest cover types and plot locations at Drewry's Bluff, RICH, Virginia.	74
Figure 9. Forest cover types and plot locations at Drewry's Bluff, RICH, Virginia.	80
Figure 10. Vegetation management objectives and locations at Chickahominy Bluff, RICH, Virginia.	114
Figure 11. Vegetation management objectives and locations at Beaver Dam Creek, RICH, Virginia.	120
Figure 12. Vegetation management objectives and locations at Watt House, RICH, Virginia.	122
Figure 13. Vegetation management objectives and locations at Cold Harbor, RICH, Virginia.	126
Figure 14. Vegetation management objectives and locations at Malvern Hill, RICH, Virginia.	132
Figure 15. Vegetation management objectives and locations at Fort Harrison section of Chaffin's Farm, RICH, Virginia.	134
Figure 16. Vegetation management objectives and locations at Drewry's Bluff, RICH, Virginia.	142
Figure 17. Vegetation management objectives and locations at Parker's Battery, RICH, Virginia.	144

List of Tables

Table 1. Overstory species basal area, density, frequency and importance values for five cover types at Chickahominy Bluff, RICH, Virginia.	13
Table 2. The average density and diameter breast height of the understory species in five cover types at Chickahominy Bluff, RICH, Virginia.	15
Table 3. Average number of seedlings/hectare in five cover types at Chickahominy Bluff, RICH, Virginia.	17
Table 4. The average percent cover of herbaceous and woody vine vegetation in five forest cover types at Chickahominy Bluff, RICH, Virginia.	19
Table 5. Overstory species basal area, density, frequency and importance values for three cover types at Watt House, RICH, Virginia.	25
Table 6. The average density and diameter breast height of the understory species in three cover types at Watt House, RICH, Virginia.	26
Table 7. Average number of seedlings/hectare in three cover types at Watt House, RICH, Virginia.	27
Table 8. The percent cover of herbaceous and woody vine vegetation in three forest cover types at Watt House, RICH, Virginia.	28
Table 9. Overstory species basal area, density, frequency and importance values for five cover types at Cold Harbor, RICH, Virginia.	33
Table 10. The average density and diameter breast height of the understory species in five cover types at Cold Harbor, RICH, Virginia.	37
Table 11. Average number of seedlings/hectare in five cover types at Cold Harbor, RICH, Virginia.	41
Table 12. The percent cover of herbaceous and woody vine vegetation in five forest cover types at Cold Harbor, RICH, Virginia.	43
Table 13. Overstory species basal area, density, frequency and importance values for five cover types at Malvern Hill, RICH, Virginia. Number of plots (n) are indicated for each cover type	47
Table 14. The average density and diameter breast height of the understory species in five cover types at Malvern Hill, RICH, Virginia.	51
Table 15. Average number of seedlings/hectare in five cover types at Malvern Hill, RICH, Virginia.	53
Table 16. The percent cover of herbaceous vegetation in five forest cover types at Malvern Hill, RICH, Virginia.	55
Table 17. Overstory species basal area, density, frequency and importance values for six cover types at Fort Harrison, RICH, Virginia. Number of plots (n) are indicated for each cover type.	61

Table 18. The average density and diameter breast height of the live understory species in six cover types at Fort Harrison, RICH, Virginia.	65
Table 19. Average number of seedlings/hectare in six cover types at Fort Harrison, RICH, Virginia. . . .	69
Table 20. The percent cover of herbaceous and woody vines vegetation in six forest cover types at Fort Harrison, RICH, Virginia.	71
Table 21. Overstory species basal area, density, frequency and importance values for two cover types at Drewry's Bluff, RICH, Virginia.	75
Table 22. The average density and diameter breast height of the understory species in two cover types at Drewry's Bluff, RICH, Virginia.	76
Table 23. Average number of seedlings/hectare in two cover types at Drewry's Bluff, RICH, Virginia.	77
Table 24. The percent cover of herbaceous and woody vine vegetation in two forest cover types at Drewry's Bluff, RICH, Virginia.	78
Table 25. Overstory species basal area, density, frequency and importance values for two cover types at Parker's Battery, RICH, Virginia. Number of plots (n) are indicated for each cover type1 . . .	81
Table 26. The average density and diameter breast height of the understory species in two cover types at Parker's Battery, RICH, Virginia.	82
Table 27. Average number of seedlings/hectare in two cover types at Parker's Battery, RICH, Virginia.	83
Table 28. The percent cover of herbaceous and woody vine vegetation in two forest cover types at Parker's Battery, RICH, Virginia.	84
Table 29. Forestry herbicides for foliar treatments and controlled woody exotic species (from Miller and Mitchell 1990)	91
Table 30. Warm season grasses and perennial forbs for meadow plantings at RICH, Virginia	97
Table 31. Forestry herbicides for stump spray treatments and controlled species that occur in RICH	106

Summary

The forests of Richmond National Battlefield Park are typical of the upper Coastal Plain. Mixed and pure stands of oak, pine, and mixed hardwoods cover the rolling topography that ranges from floodplains to uplands. The majority of the forest stands are mature, with scattered individual trees that were alive during the Civil War, such as the specimen oaks near the Watt House and yellow poplar in Bloody Run at Cold Harbor. Overall the forest is healthy, despite the occasional areas with bark beetle killed pine and windthrown oaks.

The vegetation management objectives for the park could be met with careful planning and professional application of the recommendations in this report and others prepared for the National Park Service such as the Earthworks Landscape Management Manual (Andropogon Associates Ltd. 1989). The management of the park forests, which are to remain in their natural states, will require silvicultural activities when situations occur that require action to reduce fire or safety hazards. These situations might include the death and falling of pines as the stand composition changes with succession, or disturbance such as insect or disease outbreaks.

The more intensely maintained vegetation of visitor areas and historic/cultural sites in the park will require management specific to the needs of and objectives for the site. Control of exotic species should be considered where the populations interfere with the native vegetation and the interpretation of the historical scene. Vegetation also needs to be controlled in vistas, on earthworks, and on paths used by visitors in order to promote understanding of the historical landscape and protect visitors from contact with insect pests and poisonous plants. Recommendations for chemical, mechanical and cultural control methods should be analyzed to determine the best option for each site. Care must be taken with exposing the earthworks for historical interpretation, as the vegetative cover is necessary for protecting them. The ideal earthwork vegetation is a low dense cover that does not hide the earthwork from viewers and has a root mass that will hold the soil in place. Where visitors do not walk, alternatives to mowing should be considered where possible to conserve resources. To enhance the park-like atmosphere at the visitor areas, vegetative screens to hide nearby developments should be planted and maintained.

Introduction

Richmond National Battlefield Park is a 309 ha park dedicated to conserving resources of the Civil War. The parklands are located in both urban and rural areas, with a high percentage of the land covered by undeveloped forest and wetlands. Vegetation management is essential to preserving and enhancing the historical resources of the Park. For example, vegetation management has two purposes on the earthworks: to maintain a vegetative cover, which protects the earthworks from erosion; and, to control the vegetation, which can interfere with interpretation of the scene for the visitors. In addition to managing the vegetation for the goals of the Park, healthy vegetation communities are beneficial to the overall environment. These communities should be promoted through careful management that considers the natural ecosystems and the effects of natural and man-caused disturbances, such as natural mortality, insect and disease outbreaks, storms, pollution, and forest practices.

This project is intended to contribute two elements to a Richmond National Battlefield Park Vegetation Management Plan: an assessment of the forest vegetation and management alternatives for meeting the vegetation objectives of the park. Specifically, this report includes the following:

- 1) forest cover type maps for the 6 park units with forest, developed from aerial photography;
- 2) a description of the cover types based on an inventory of the forest vegetation; and
- 3) recommendations for management of the forests, as well as alternatives for meeting vegetation objectives concerning exotic species, mowing, screening, earthwork preservation, and vistas.

Detailed recommendations were made for each unit when necessary. The objectives for the park vegetation were detailed by park resource managers and were based on natural, cultural, visitor protection, and law enforcement considerations (RICH 1991).

Historic and Current Forest Vegetation

Study Areas

The sites selected for studying the forest vegetation were located within undisturbed forests of the National Park Service Richmond National Battlefield Park (RICH). The park consists of ten units, totaling 309 ha located in a semicircle to the north, east, and south of Richmond, Virginia (Figure 1). Richmond is located at the western edge of the Coastal Plain physiographic province, at the fall line where the Coastal Plain meets the Piedmont Plateau. The area has a level to gently rolling topography that is drained by the James, Chickahominy, and Pamunky Rivers (Brown 1939). These rivers have built wide floodplains with terraces and steep valley sides, and the smaller tributaries have also cut paths through the landscape (Brown 1939). The bedrock around the Richmond area consists of partially consolidated sedimentary rocks of Cretaceous, Eocene, and Miocene marine sands, gravels, clays, shell marls, and diatomaceous sediment (Dietrich 1970). The soils are primarily sandy loams and silt loams, and agricultural sites range from those on productive bottomland to those on poorly- and well-drained uplands (Brown 1939). Summer and winter temperatures average 24° C and 3° C, respectively (N.O.A.A. 1983). Annual precipitation averages 112 cm, with most months averaging 8 or 9 cm except for June and July, which average 13 cm of rain.

During the Civil War, the battlefield sites were mostly agricultural areas comprised of woodlots, pasture, and crop fields. For the forty or so years after the war, before the National Park Service acquired the properties, these uses were continued as evidenced by the age of the current vegetation in some areas. After federal ownership, many areas were allowed to revert to forest, while some remained in agriculture through cooperation with local farmers. Remains of the military earthworks and forts are now covered with forest except where exposed for interpretive use by the park. Some of the battlefields have been maintained as open fields and cropland through the agricultural leasing program, but many are now covered by forest vegetation also (RICH 1989). The historic vegetation for Cold Harbor, Gaines Mill (Watt House), and Drewry's Bluff was mapped in 1988 and 1990 by C.R. Dickinson; information was interpreted from these historical maps for this report.

The general composition of the current overstory forest vegetation varies among pine (*Pinus* spp.),

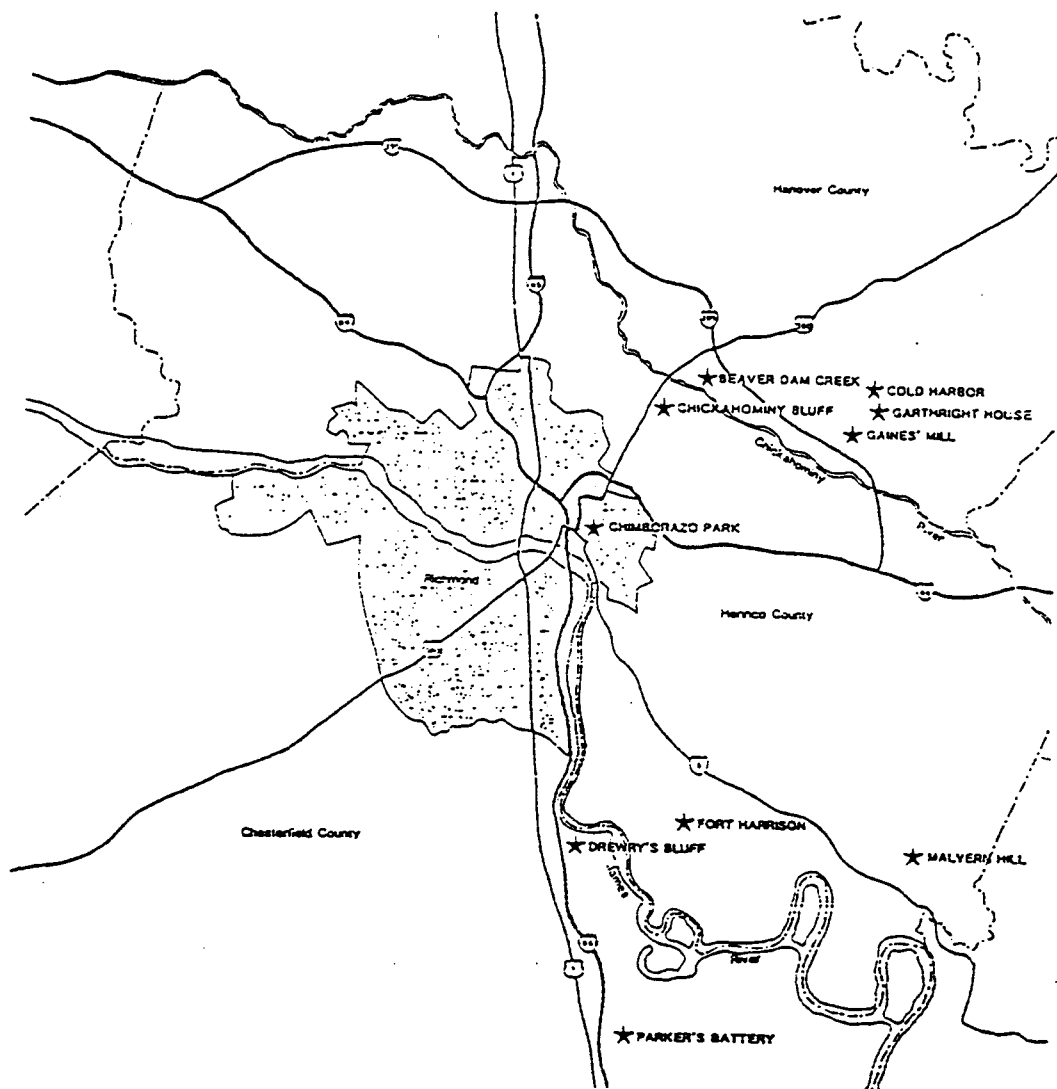


Figure 1. Location of Richmond National Battlefield Park, Virginia (from RBNBP 1989).

oak (*Quercus* spp.), and mixed hardwood species. No known federal or state endangered or threatened plant species have been identified within the Park. Collins sedge (*Carex collinsii* Nuttall.), a plant listed as rare in Virginia, has been found in the park. Approximately 24% of the plant species found are exotics, most notable of which are the widely present Japanese honeysuckle (*Lonicera japonica* Thunberg) and tree of heaven (*Ailanthus altissima* (Miller) Swingle) (Hayden and Johnson 1986).

Methods

Current Vegetation Data Collection Procedures

Forest Stand Designation and Plot Location: Forest stands in the 7 RICH units with forest (Chickahominy Bluff, Watt House, Cold Harbor, Malvern Hill, the Fort Harrison section of Chaffin's Farm, Drewry's Bluff, Parker's Battery) were sampled for forest vegetation and fuel loadings as part of an inventory for the park (Helm et al. 1994). The forest stands were distinguished and mapped for each unit according to cover type and age class from color-infrared aerial photographs (taken April 9, 1990, Scale: 1"=250'). The forest cover classifications, after those defined by Eyre (1980), were as follows:

Coniferous Cover Types: $\geq 20\%$ pine basal area

Conifer -- $> 50\%$ pine basal area.

Oak-Conifer -- 20-50% pine basal area with remaining basal area comprised by a majority of oak species, including the commonly associated hickory (*Carya* spp.) and beech (*Fagus grandifolia* Ehrh.).

Mixed hardwood-Conifer -- 20-50% pine basal area with remaining basal area comprised by a majority of mixed hardwood species: sweetgum (*Liquidambar styraciflua* L.), yellow poplar (*Liriodendron tulipifera* L.), black gum (*Nyssa sylvatica* Marshall), and red maple (*Acer rubrum* L.).

Deciduous Cover Types: $< 20\%$ pine basal area

Oak -- $> 50\%$ oak basal area, including commonly associated hickory and beech.

Mixed hardwood -- $> 50\%$ mixed hardwood basal area, comprised by sweetgum, yellow poplar, black gum, and red maple.

Oak-Mixed hardwood -- Oak $\leq 50\%$ and mixed hardwood $\leq 50\%$ but oak and mixed hardwood species collectively comprise $> 50\%$ of the basal area.

Age classes were as follows: Seedling/Sapling 0-20 years; Young 21-50 years; Immature/Intermediate 51-100 years; and Mature/Old 100+ years.

Forest data to describe the above designated stands was gathered at each unit. The hectares of a unit determined the approximate number of plots to be located among its stands; a plot for every 2 forested hectares was used to allow a comprehensive sample to be done within the budget. The percentage of area under each cover type on a unit then determined the number of plots to be located in stands that represented that cover type. Cover type alone was used to designate plot location, as most of the forest area to be

sampled appeared to fall within a narrow range of ages.

Every stand at a unit was not sampled due to the time constraints and other considerations. For example, some areas in stands, and at times whole stands, had to be avoided when earthworks and other historical relics, trails, old forest roads, or park vegetation management or interpretive activities were encountered. Stands that were too small to hold a plot, that had no overstory vegetation, or that were located on severe topography (steep slopes along James River, for example) were not sampled either. The plots were located at least 10 m into the forest from roads, trails, and park boundaries to avoid edge effects and any changes due to visitor and maintenance activities.

The sample plots were located in the easily found stands of smaller units (Parkers Battery, Drewry's Bluff) by walking to the stand and then pacing a random distance between 10-20 m on a randomly selected azimuth into the stand. In the other units, parallel transects were run on a random azimuth across the stand map and these transects were followed for fixed distances, usually of 100 meters between plots, to sample the necessary stands. A total of 115 plots were sampled within the 6 cover types for the vegetation inventory within the park. Stand boundaries, cover type, and age class designations were adjusted on the stand maps after the field work to correct mistakes in the aerial photo interpretation.

Forest Vegetation Inventory: The inventory of current forest vegetation involved the sampling of overstory, understory, seedling and herbaceous strata. At each plot site, general topographic and site information were recorded, including slope position, percent slope, aspect, and notes of any evidence of past disturbances, general tree health, and insect and disease problems.

Overstory trees were classified as stems > 5 m in height. Sample trees were those designated using a 2.5 m BAF prism plot. Each sample tree was identified to species and crown position, and measured for diameter at breast height (DBH, 1.37 m above the ground on the uphill side of the tree). Crown position was defined as follows: Dominant--trees with crowns above the general level of the canopy, receiving full light from above and partly from the side; Codominant--trees with crowns forming the general level of the canopy, receiving full light from above but moderate amounts from the side; Intermediate--trees shorter than those

making up the general canopy, with crowns extending into the canopy formed by dominants and codominants and receiving some direct light from above but little from the sides; Suppressed--trees with their crowns entirely below the general canopy level and receiving no direct light (Spurr and Barnes 1980). At each plot, age at breast height and total height were measured on three trees with dominant or codominant crown positions and showing no signs of crown dieback, disease, insect damage, or mechanical damage, and that were in the dominant (majority of basal area) genus groups (oaks, pines, or mixed hardwoods) of the stand, using an increment borer and clinometer. The species recorded in the overstory are listed in Appendix I.

The understory, consisting of stems ≥ 1.37 and ≤ 5 m in height, was sampled within two 2.3 m circular subplots (0.002 ha), located 10 m either direction from the plot center along a transect run through plot center on a random azimuth. Density and basal area by species of all woody understory stems were determined by counting stems by species and measuring their DBH with calipers. The species recorded in the understory are listed in Appendix II.

Seedling and herbaceous strata vegetation was sampled within four 1 meter square sub-subplots located 5 and 10 m from the plot center either direction along the transect. Seedlings (woody stems less than 1.37 m in height) were counted by species in each sub-subplot. Seedling species found at RICH are listed in Appendix III. Herbaceous layer cover was classified by species according to a pretransformed cover class scale, as follows: Class 1=0-4%, 2=5-25%, 3=26-50%, 4=51-75%, 5=76-95%, 6=96-100%. The often extensive cover of woody vines, including exotics, in this strata, were included in the sampled species along with the herbs. Species found in the herbaceous layer are listed in Appendix IV.

Calculation of Vegetation Variables: For each overstory plot, species basal area, density, and frequency were computed, along with species importance values (an average of the sum of relative dominance, density, and frequency values for a species). The understory subplot data were averaged for each plot to determine the number of understory stems and seedlings by species. Percent herbaceous cover per species was determined by using the median percent value of each cover class to convert from a class to percent coverage. The percent coverage value was then averaged by species over all the sub-subplots for herbaceous percent

cover. Mean age and height of the overstory were also computed for each plot. The overstory vegetation data for each plot is presented in Appendix V. Dominance, density, frequency, importance value, understory density, and herbaceous cover were also averaged by cover type in each unit for a representative vegetation description.

The vegetation data resulting from this study are very similar to that calculated from permanent plot vegetation sampling procedures of the National Park Service (Russell 1990). The classification of trees and understory are different, as the National Park Service manual bases classification on DBH as well as height, but in general the overstory and understory stems would have fallen in the same classes either way.

Results

Vegetation of Chickahominy Bluff

Chickahominy Bluff is a 15.9 ha unit occupying steep hillsides, eroded uplands, streambottoms, and a forested wetland along the edge of the Chickahominy River floodplain. This topographic variability allows a variety of forest cover types to grow in this unit. Today, almost 50% of the unit is covered by the mixed hardwood cover type, while another 22% is in the mixed hardwood-conifer type (Figure 2). The forest ranges from 30 to 100 years of age, with the wetland hardwoods at the younger end and the upland oaks and yellow poplar at the older end. The average height of the mixed hardwood and conifer cover was 20 m and 16 m, respectively.

The forest species are quite diverse, as expected, with loblolly pine (*Pinus taeda* L.) dominating among the coniferous species and sweetgum and red maple the most important among the mixed hardwoods. No recent pine beetle (*Dendroctonus frontalis* Zimm.) sign has been detected in these stands, although dead pine are standing in some places. Except for along the disturbed areas and forest edges near the roads and trail-head, the exotic species such as Japanese honeysuckle and tree of heaven are minimal within the forest. The wetland conditions at the north end of the unit increased the diversity of this unit's mixed hardwood cover type, with the unique understory and herbaceous flora found there.

The conifer cover type is dominated by loblolly pine (Table 1). The stand in the bottomland near the north border is approximately 28 years old; the other on the upland area is older. Red maple dominates the understory (Table 2), and vine species such as greenbrier (*Smilax rotundifolia* L.) and poison ivy (*Toxicodendron radicans* (L.) Kuntze) comprise most of the seedlings (Table 3). This type has little herbaceous layer cover (Table 4).

The mixed hardwood-conifer cover type is located both in the wetland and on the upland areas of the unit. Young sweetgum, yellow poplar, and the slightly older loblolly pine are the most important overstory species (Table 1). Mixed hardwoods make up the understory (Table 2), and few seedlings are found relative to the other types (Table 3). The sparse herbaceous layer cover is made up mostly of vines (Table 4).

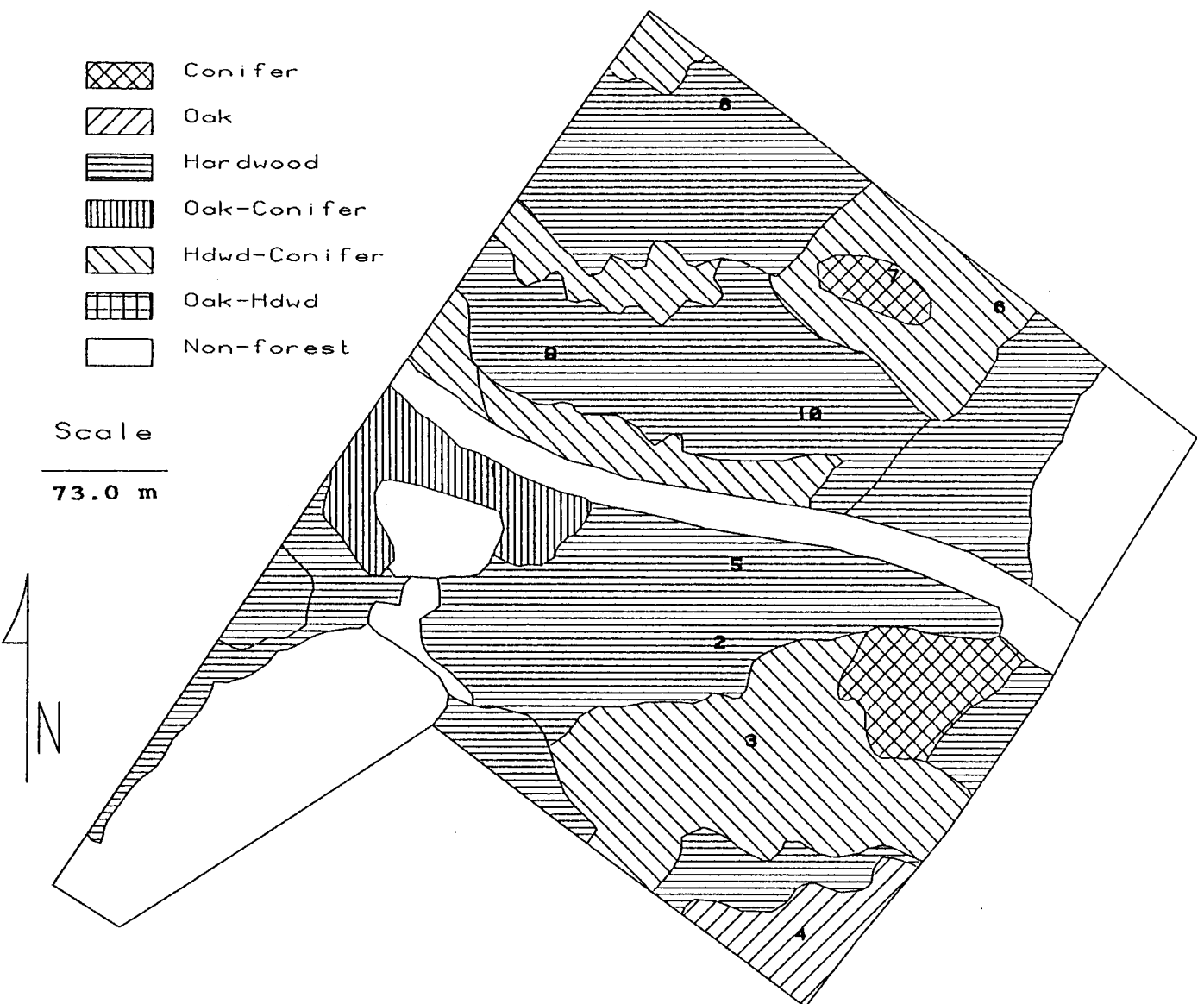


Figure 2. Forest cover types and plot locations for Chickahominy Bluff, RICH, Virginia. Numbers indicate plot locations. (Note: Lines within cover types signify a change in stand age that was noted from the aerial photo and included in the Geographic Information System files, from which this map is generated.)

Table 1. Overstory species basal area, density, frequency and importance values for five cover types at Chickahominy Bluff, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Conifer Cover Type (n=1)				
<i>Acer rubrum</i>	2.5	614	100	20
<i>Liquidambar styraciflua</i>	7.5	1,124	100	34
<i>Pinus taeda</i>	17.5	260	100	32
<i>Quercus rubra</i>	2.5	214	100	14
Total	20.0	2,212		100
Mixed Hardwood-Conifer Cover Type (n=2)				
<i>Acer rubrum</i>	3.8	354	50	14
<i>Cornus florida</i>	1.3	243	50	10
<i>Liquidambar styraciflua</i>	8.8	1,177	50	33
<i>Liriodendron tulipifera</i>	7.5	150	50	15
<i>Pinus taeda</i>	8.8	92	100	20
<i>Quercus velutina</i>	2.5	27	50	8
Total	32.7	2,043		100
Oak-Conifer Cover Type (n=1)				
<i>Carya tomentosa</i>	5.0	29	100	11
<i>Liriodendron tulipifera</i>	2.5	76	100	9
<i>Pinus taeda</i>	10.0	179	100	20
<i>Quercus coccinea</i>	2.5	113	100	10
<i>Quercus falcata</i>	2.5	376	100	14
<i>Quercus phellos</i>	2.5	669	100	19
<i>Quercus velutina</i>	2.5	631	100	18
Total	27.5	2,073		101
Mixed Hardwood Cover Type (n=5)				
<i>Acer rubrum</i>	11.0	439	60	26
<i>Carpinus caroliniana</i>	0.5	30	20	3
<i>Carya tomentosa</i>	1.0	37	40	5

Table 1. Continued.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Mixed Hardwood Cover Type (continued)				
<i>Cornus florida</i>	0.5	99	20	5
<i>Ilex opaca</i>	1.0	322	20	11
<i>Liquidambar styraciflua</i>	19.5	355	80	33
<i>Liriodendron tulipifera</i>	1.5	3	40	5
<i>Pinus taeda</i>	1.5	14	40	5
<i>Quercus falcata</i>	1.0	3	40	4
<i>Ulmus americana</i>	0.5	35	20	3
Total	38.0	1,337		100
Oak Cover Type (n=1)				
<i>Carpinus caroliniana</i>	2.5	393	100	29
<i>Carya tomentosa</i>	2.5	18	100	8
<i>Fagus grandifolia</i>	10.0	60	100	17
<i>Liquidambar styraciflua</i>	2.5	19	100	8
<i>Liriodendron tulipifera</i>	5.0	33	100	11
<i>Pinus taeda</i>	5.0	37	100	11
<i>Quercus alba</i>	5.0	29	100	11
<i>Quercus rubra</i>	2.5	7	100	7
Total	35.0	596		102

Table 2. The average density and diameter breast height of the understory species in five cover types at Chickahominy Bluff, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Density ----stems/ha---	DBH --cm--
Conifer Cover Type (n=1)		
<i>Acer rubrum</i>	4,250	1.6
<i>Liquidambar styraciflua</i>	500	2.4
Total	4,750	
Mixed Hardwood-Conifer Cover Type (n=2)		
<i>Acer rubrum</i>	1,250	1.3
<i>Liquidambar styraciflua</i>	250	2.0
<i>Liriodendron tulipifera</i>	125	1.4
<i>Quercus alba</i>	250	0.5
<i>Quercus rubra</i>	125	0.6
Total	2,000	
Oak-Conifer Cover Type (n=1)		
<i>Carya tomentosa</i>	500	2.3
<i>Cornus florida</i>	750	3.3
<i>Quercus alba</i>	250	2.1
Total	1,500	
Mixed Hardwood Cover Type (n=5)		
<i>Acer rubrum</i>	200	2.6
<i>Carpinus caroliniana</i>	100	1.8
<i>Clethra alnifolia</i>	3,650	0.6
<i>Cornus florida</i>	150	2.2
<i>Ilex opaca</i>	100	1.0
<i>Ilex verticillata</i>	150	1.6
<i>Leucothoe racemosa</i>	350	0.6
<i>Liquidambar styraciflua</i>	100	1.1
<i>Magnolia virginiana</i>	1,800	1.3
<i>Morus rubra</i>	50	1.0

Table 2. Continued.

Species	Density	DBH
	----stems/ha---	--cm--
Mixed Hardwood Cover Type continued		
<i>Nyssa sylvatica</i>	50	0.3
<i>Viburnum dentatum</i>	300	0.7
Total	7,000	
Oak Cover Type (n=1)		
<i>Carpinus caroliniana</i>	1,250	3.2
<i>Ilex opaca</i>	250	1.1
Total	1,500	

Table 3. Average number of seedlings/hectare in five cover types at Chickahominy Bluff, RICH, Virginia.

Species	Cover Types ^a				
	C	OC	HC	O	H
	-----seedlings/ha-----				
<i>Acer rubrum</i>	2,500	0	5,000	0	16,500
<i>Campsis radicans</i>	2,500	0	1,250	0	0
<i>Carpinus caroliniana</i>	0	0	0	0	500
<i>Carya tomentosa</i>	0	0	3,750	0	500
<i>Cephalanthus occidentalis</i>	0	0	0	0	2,000
<i>Clethra alnifolia</i>	0	0	0	0	102,500
<i>Cornus florida</i>	0	7,500	0	0	5,000
<i>Euonymus americanus</i>	0	0	12,500	47,500	0
<i>Fraxinus</i> sp.	2,500	0	0	0	0
<i>Ilex opaca</i>	0	0	0	10,000	500
<i>Ilex verticillata</i>	2,500	0	0	0	1,500
<i>Leucothoe racemosa</i>	0	0	0	0	2,000
<i>Lindera benzoin</i>	0	0	0	0	1,500
<i>Liquidambar styraciflua</i>	0	0	0	0	4,500
<i>Magnolia virginiana</i>	0	0	0	0	2,500
<i>Morus rubra</i>	0	0	1,250	0	0
<i>Nyssa sylvatica</i>	2,500	0	0	0	0
<i>Parthenocissus quinquefolia</i>	2,500	7,500	1,250	0	6,500
<i>Pinus taeda</i>	0	0	1,250	0	500
<i>Prunus serotina</i>	15,000	5,000	11,250	25,000	3,500
<i>Quercus alba</i>	0	0	0	2,500	1,000
<i>Quercus velutina</i>	0	0	1,250	0	0
<i>Rubus</i> sp.	0	0	3,750	0	0
<i>Sassafras albidum</i>	0	0	0	2,500	0
<i>Smilax rotundifolia</i>	22,500	22,500	16,250	2,500	8,000
<i>Toxicodendron radicans</i>	20,000	0	3,750	5,000	7,000

Table 3. Continued.

Species	Cover Types				
	C	OC	HC	O	H
	-----seedlings/ha-----				
<i>Viburnum dentatum</i>	0	0	0	5,000	4,500
<i>Vitis rotundifolia</i>	0	5,000	13,750	5,000	4,500
Total	72,500	47,500	76,250	105,000	175,000

^aC-Conifer (n=1), OC-Oak-Conifer (n=1), HC-Mixed Hardwoods-Conifer (n=2), O-Oak (n=1), H-Mixed Hardwoods (n=5)

Table 4. The average percent cover of herbaceous and woody vine vegetation in five forest cover types at Chickahominy Bluff, RICH, Virginia.

Species	Cover Type ^a				
	C	OC	HC	O	H
	-----percent cover-----				
<i>Asplenium platyneuron</i>	0	0	0	0	P ^b
<i>Botrychium</i> sp.	0	0	0	0	P
<i>Carex crinata</i>	0	0	0	0	3
<i>Carex</i> sp.	2	1	1	0	P
<i>Dioscorea villosa</i>	0	0	0	1	P
<i>Eupatorium</i> sp.	0	0	0	0	P
<i>Galium</i> sp.	0	0	0	0	P
<i>Lonicera japonica</i> **	1	2	5	0	2
<i>Lycopodium</i> sp.	0	0	0	0	P
<i>Lysimachia nummularia</i>	0	0	0	0	P
<i>Mitchella repens</i>	0	1	P	0	1
<i>Onoclea sensibilis</i>	0	0	0	0	4
<i>Osmunda regalis</i> var. <i>spectabilis</i>	0	0	0	0	2
<i>Panicum</i> sp.	0	0	0	0	1
<i>Parthenocissus quinquefolia</i>	1	1	P	0	1
<i>Peltandra virginica</i>	0	0	0	0	P
<i>Polygonatum biflorum</i>	0	0	0	1	0
<i>Polystichum acrostichoides</i>	0	0	P	0	P
<i>Saururus cernuus</i>	0	0	0	0	5
<i>Solidago</i> sp.	0	0	0	0	P
<i>Thelypteris palustris</i>	0	0	0	0	P
<i>Toxicodendron radicans</i>	1	0	0	1	2
<i>Vitis rotundifolia</i>	0	4	P	1	1
Total ^c	4	7	7	3	22

^aC-Conifer (n=1), OC-Oak-Conifer (n=1), HC-Mixed Hardwood-Conifer (n=2), O-Oak (n=1), H-Mixed Hardwood (n=5)

^bP-Present at <.5% coverage.

^cTotal coverage may not equal sum of species' coverages due to rounding of values.

**Non-native species.

The oak-conifer cover type is young at Chickahominy Bluff and dominated by loblolly pine, oak and hickory (Table 1). The understory is not dense (Table 2), and seedlings are dominated by vine species (Table 3), as is the herbaceous layer cover (Table 4). With a unique species composition for the unit, the oak cover type is dominated by old American beech and northern red (*Quercus rubra* L.) and white oak (*Quercus alba* L.) (Table 1). American hornbeam (*Carpinus caroliniana* Walter) is dominant in the understory (Table 2), and strawberry bush (*Euonymus americanus* L.) seedlings are common (Table 3). This type has the least herbaceous layer cover, again primarily vines (Table 4).

The mixed hardwood cover type spreads throughout the bottomland and onto the upland sites of Chickahominy Bluff. It is the most species rich type with regards to all vegetation layers. Sweetgum and red maple are the most important overstory species (Table 1). Most of the stands are intermediate in age (between 50-100 years); several older yellow poplar are growing in the upland areas (near plots 2 & 5, Figure 2). Sweet bay (*Magnolia virginiana* L.) is a common understory tree in the bottomlands, along with sweet pepperbush; many other hardwood species are in the understory also (Table 2). Shrub and vine species contribute most of the abundant seedlings to this type (Table 3). The herbaceous layer cover averages 22%, and is highest in the wetlands, where lizard's tail (*Saururus cernuus* L.), sensitive fern (*Onoclea sensibilis* L.), and sedges (*Carex* spp.) dominate (Table 4).

Vegetation of Beaver Dam Creek

The wetland within the floodplain of Beaver Dam Creek area is covered with herbaceous plants and vines. The mixed hardwood cover type bounds the edges of the creek, and the oak cover type dominates further away on the slopes leading down to the creek (Figure 3). The understory is dense in the mixed hardwood type, and the understory of the oak type is less dense. No forest data was collected at this unit due to the small size of the stands.

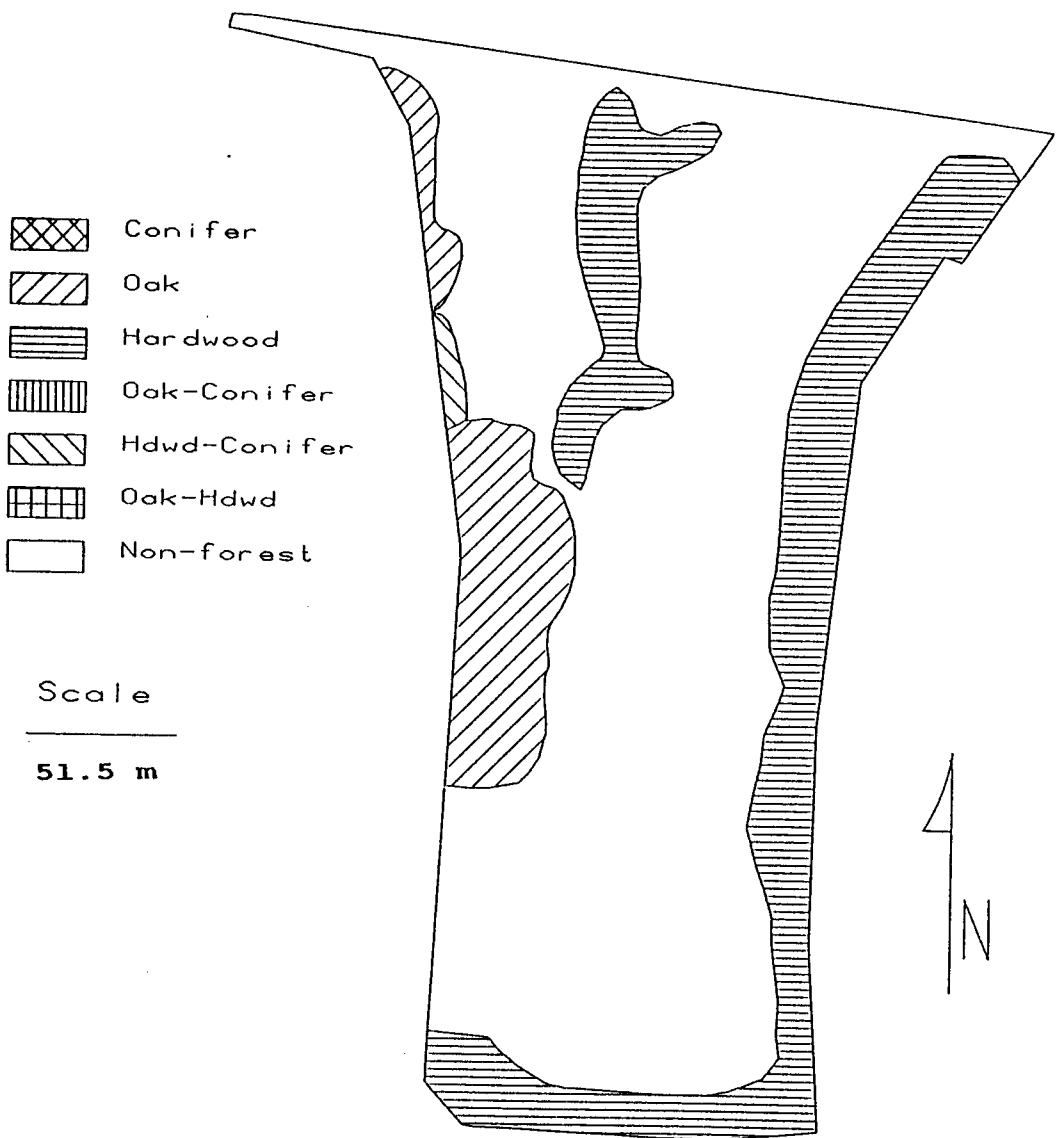


Figure 3. Forest cover types at Beaver Dam Creek, RICH, Virginia.

Vegetation of Watt House

The forest of the 24.4 ha Watt House unit is located on the hillside and hilltops that drain to the north into Boatswains Creek. The present cover types are a direct result of the past land-use. The historic vegetation along the creek and hillsides was very much as it is today; deciduous forest covered the steeper hillsides down to the creekbottom, where brush and trees grew. Today, white oak dominates the oak cover type that covers 40 %, or approximately 9.8 ha of the area (Figure 4). The hilltops, where loblolly pine and mixed hardwoods now cover 7.3 ha, were agricultural fields, some of which were abandoned 50 to 70 years ago. Scattered pines grew along the field edges. Drainage gullies, washed out by erosion when the hilltops were farmed, occasionally cut down the hillside. Scattered specimen white oaks along the trail are wonderful trees that witnessed pre-Civil war events at Watt House. Two very old and unique yellow poplar, with rotted out centers but full crowns in the canopy, grow at the northeast corner of the unit near the stream. The forest overall appears healthy, with no sign of pine beetle in the pine stems. The open, park-like nature of the mature oak stands make them ideal for viewing the topography as it relates to the battlefield interpretation. Although Japanese honeysuckle is prolific at the edges of the unit's forest, where sunlight easily penetrates the mixed hardwood-conifer type, the older oak stands towards the interior of the unit have much less of the vine.

The hardwood-conifer stands are 50-70 years old and located on the upper slopes of the unit (Figure 4). Average canopy height is 24 m. Loblolly pine, sweetgum, and yellow poplar are the only overstory species (Table 5). Mixed hardwoods dominate the understory also (Table 6). Besides a few tree seedlings, most of the seedlings are of poison ivy, Virginia creeper (*Parthenocissus quinquefolia* (L.) Planchon) and Muscadine grape (*Vitis rotundifolia* Michaux)(Table 7). This cover type has one of the most heavily covered forest floors with 47%. Ground cover is primarily vines, namely Japanese honeysuckle and poison ivy (Table 8).

White oak, American beech and holly (*Ilex opaca* Aiton) are the most important species in the oak cover type (Table 5). These stands spread along the side slopes and creek bottom of the Watt House unit. The overstory oaks are generally 85 to 105 years old, and the canopy is approximately 28 m above the

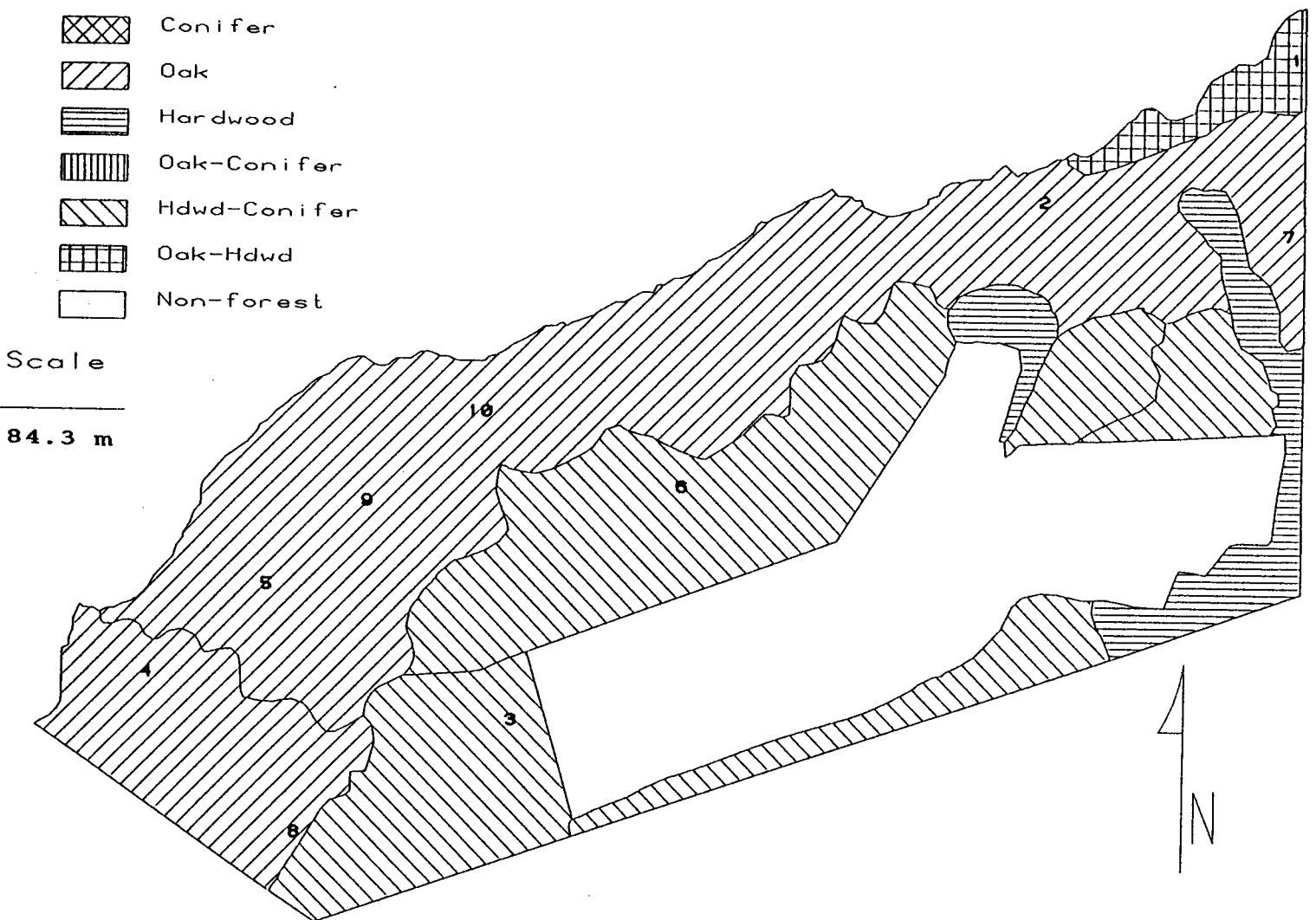


Figure 4. Forest cover types and plot locations at Watt House, RICH, Virginia. Numbers indicate plot locations. (Note: Lines within cover types signify a change in stand age that was noted from the aerial photo and included in the Geographic Information System files, from which this map is generated.)

Table 5. Overstory species basal area, density, frequency and importance values for three cover types at Watt House, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Mixed Hardwood-Conifer Cover Type (n=2)				
<i>Liquidambar styraciflua</i>	8.8	157	100	43
<i>Liriodendron tulipifera</i>	5.0	41	100	23
<i>Pinus taeda</i>	10.0	73	100	34
Total	23.8	271		100
Oak Cover Type (n=7)				
<i>Carya glabra</i>	0.4	42	14	3
<i>Fagus grandifolia</i>	6.4	239	86	22
<i>Ilex opaca</i>	2.9	341	57	20
<i>Liquidambar styraciflua</i>	1.4	8	29	4
<i>Liriodendron tulipifera</i>	3.2	11	57	8
<i>Quercus alba</i>	13.2	156	100	26
<i>Quercus coccinea</i>	0.4	1	14	1
<i>Quercus falcata</i>	0.4	3	14	2
<i>Quercus rubra</i>	5.4	20	43	9
<i>Quercus velutina</i>	2.5	10	43	6
Total	36.2	831		101
Oak-Mixed Hardwood Cover Type (n=1)				
<i>Fagus grandifolia</i>	2.5	4	100	10
<i>Ilex opaca</i>	5.0	489	100	41
<i>Liriodendron tulipifera</i>	10.0	41	100	21
<i>Quercus alba</i>	7.5	39	100	18
<i>Quercus coccinea</i>	2.5	14	100	10
Total	27.5	587		100

Table 6. The average density and diameter breast height of the understory species in three cover types at Watt House, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Density ----stems/ha---	DBH --cm--
Mixed Hardwood-Conifer Cover Type (n=2)		
<i>Acer rubrum</i>	250	2.0
<i>Carya tomentosa</i>	125	0.7
<i>Cornus florida</i>	250	0.8
<i>Fagus grandifolia</i>	125	1.0
<i>Ilex opaca</i>	500	2.2
<i>Liquidambar styraciflua</i>	500	2.3
Total	1,790	
Oak Cover Type (n=7)		
<i>Acer rubrum</i>	71	0.5
<i>Carya glabra</i>	36	3.4
<i>Cornus florida</i>	71	0.6
<i>Fagus grandifolia</i>	71	0.8
<i>Gaylussacia frondosa</i>	36	0.1
<i>Ilex opaca</i>	714	2.5
<i>Liquidambar styraciflua</i>	36	0.9
<i>Nyssa sylvatica</i>	179	1.4
<i>Quercus alba</i>	36	4.7
<i>Quercus rubra</i>	71	0.7
<i>Vaccinium formosum</i>	821	1.2
Total	2,142	
Oak-Mixed Hardwood Cover Type (n=1)		
<i>Fagus grandifolia</i>	750	1.9
<i>Ilex opaca</i>	250	1.2
Total	1,000	

Table 7. Average number of seedlings/hectare in three cover types at Watt House, RICH, Virginia.

Species	Cover Types ^a		
	HC	O	OH
	-----seedlings/ha-----		
	-		
<i>Acer rubrum</i>	0	1,071	0
<i>Azalea</i> sp.	0	4,643	0
<i>Carpinus caroliniana</i>	0	357	0
<i>Carya glabra</i>	0	357	0
<i>Carya tomentosa</i>	1,250	357	0
<i>Clethra alnifolia</i>	0	714	0
<i>Cornus florida</i>	0	9,642	0
<i>Euonymus americanus</i>	6,250	7,143	2,500
<i>Fagus grandifolia</i>	0	357	2,500
<i>Gaylussacia frondosa</i>	0	22,500	0
<i>Ilex opaca</i>	0	714	0
<i>Liquidambar styraciflua</i>	2,500	2,143	0
<i>Parthenocissus quinquefolia</i>	17,500	2,500	0
<i>Prunus serotina</i>	1,250	714	0
<i>Quercus alba</i>	0	2,143	2,500
<i>Quercus phellos</i>	1,250	0	0
<i>Quercus rubra</i>	0	2,143	0
<i>Smilax rotundifolia</i>	8,750	0	0
<i>Toxicodendron radicans</i>	85,000	0	0
<i>Vaccinium pallidum</i>	0	17,143	0
<i>Vitis rotundifolia</i>	43,750	24,286	2,500
Total	167,500	98,927	10,000

^aHC-Mixed Hardwoods-Conifer (n=2), O-Oak (n=7), OH-Oak-Mixed Hardwoods (n=1)

Table 8. The percent cover of herbaceous and woody vine vegetation in three forest cover types at Watt House, RICH, Virginia.

Species	Cover Type ^a		
	HC	O	OH
	-----percent cover-----		
<i>Dioscorea villosa</i>	0	P ^b	0
<i>Galium</i> sp.	1	P	0
<i>Lonicera japonica</i> **	30	3	0
<i>Medeola virginiana</i>	0	1	0
<i>Parthenocissus quinquefolia</i>	4	1	0
<i>Smilax rotundifolia</i>	P	0	0
<i>Toxicodendron radicans</i>	10	0	0
<i>Vitis rotundifolia</i>	2	3	1
Total ^c	47	8	1

^aHC-Mixed Hardwood-Conifer (n=2), O-Oak (n=7), OH-Oak-Mixed Hardwood (n=1)

^bP-Present at <.5% cover.

^cTotal coverage may not equal sum of species' coverages due to rounding of values.

**Non-native species.

ground. Holly and swamp highbush blueberry (*Vaccinium formosum* Andrews) are abundant in the understory (Table 6). The seedling layer is very species rich, with dangleberry (*Gaylussacia frondosa* (L.)T. & G.) and hillside lowbush blueberry (*Vaccinium pallidum* Aiton) very common (Table 7). The oak stands have more tree species seedlings than the other types at Watt House. The herbaceous layer cover in the oak stands is low and primarily vine species (Table 8).

The oak-mixed hardwood cover type along the creek bottom is dominated by yellow poplar and oaks, with holly also an important species in the lower canopy (Table 5). The sparse understory contains American beech and holly (Table 6). The density of the oak-mixed hardwood canopy prevents much seedling or herbaceous layer growth (Tables 7 & 8).

Vegetation of Cold Harbor

The 60.3 ha Cold Harbor battlefield is covered by a patchwork of forest cover types that vary with the rolling topography and past land use. Oak and oak-conifer cover types occupy 28 and 32% of the unit, respectively, in drier upland areas historically dominated by pines. The other types cover smaller areas around the unit, with approximately 6.1 ha in open agricultural fields (Figure 5). The creekbottoms are forested with the mixed hardwood type and contain the oldest trees found on the unit. Historically, Bloody Run was the same as it is now, with thick underbrush and deciduous trees in the overstory, which spread up the hill and eventually mixed with the pine on the uplands. Most of the south side of the unit was once cleared down to Bloody Run, where the oak cover type now dominates. The majority of the forest is older than 70 or 80 years and in fair health. Although the pure pine stands at Cold Harbor all appeared healthy, some loblolly pine in the conifer-oak stands were observed with signs of pine bark beetle, but these were scattered and infrequent. Mature oaks with stem and root disease were common, however, and the results of the disease are evident in the scattered blown down and broken-topped oaks around the unit (for example, near plots 14 & 15). These are natural occurrences though, and part of the expected turnover of a mature oak forest. New trees will fill in the gaps quickly, adding diversity and younger trees to the mature stand. Exotic species are rare at Cold Harbor in the basically undisturbed forest.

Just a small area is still covered by the pine type at Cold Harbor. Although dominated by loblolly pine, short-leaf pine (*Pinus echinata* L.), sweetgum, and black oak (*Quercus velutina* Lam.) are fairly important also (Table 9). Stands vary in age from 50 to 100 years and have an average height of 22 m. Black oak is the most common understory species, however, loblolly pine, mockernut hickory and sassafras (*Sassafras albidum* (Nuttall) Nees) are also present in good numbers (Table 10). Non-tree species, such as trumpet creeper (*Campsis radicans* (L.) Seeman) and dangleberry, are the most abundant seedlings (Table 11). The herbaceous layer is primarily Japanese honeysuckle and Virginia creeper (Table 12).

The oak-conifer type dominates much of the area, with loblolly pine, black oak, and southern red oak (*Quercus falcata* Michaux) as the most important species (Table 9). The majority of these stands are 70 years of age and older, with average canopy heights of 22 m. This type has the most diverse understory, with

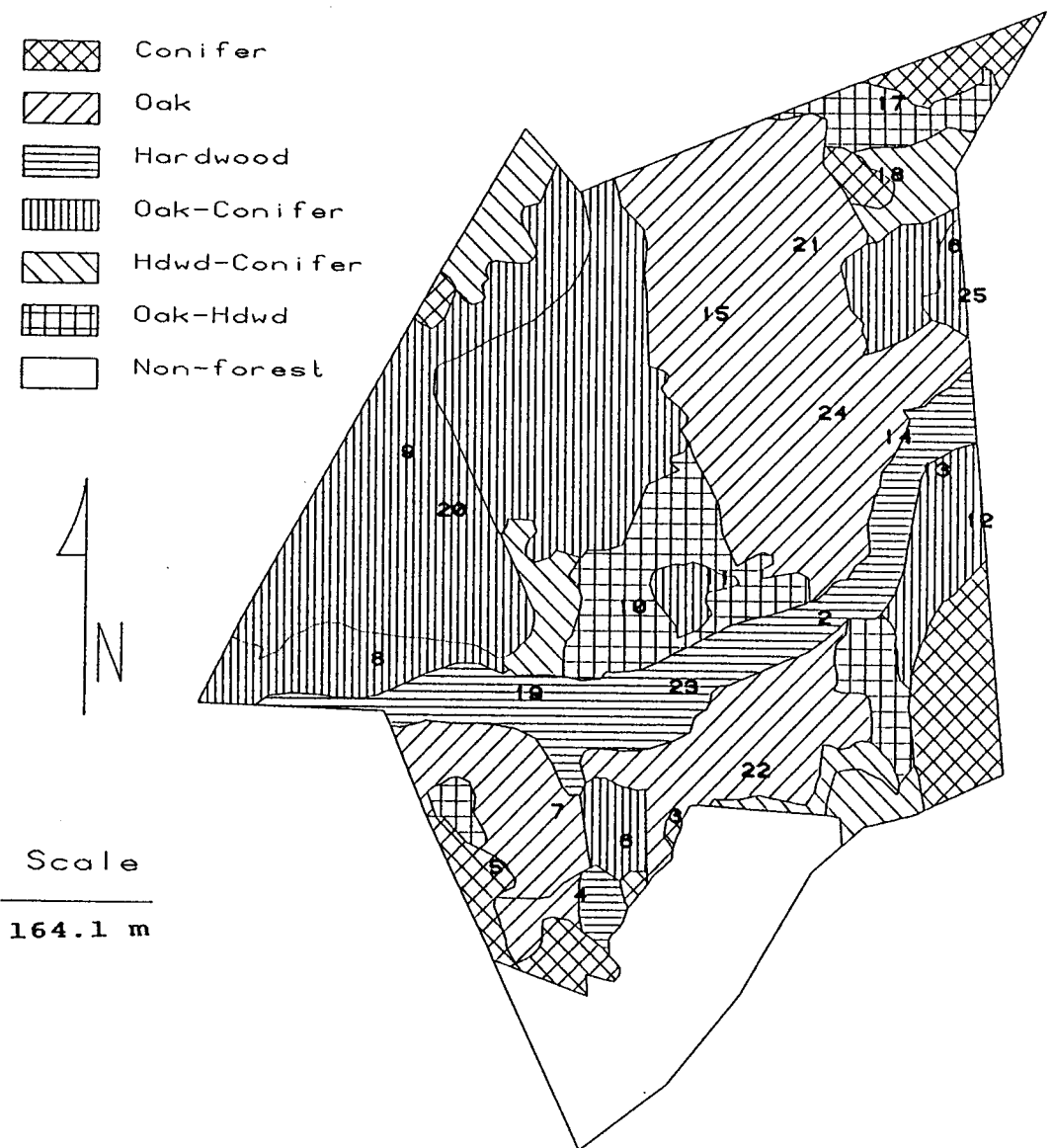


Figure 5. Forest cover types and plot locations at Cold Harbor, RICH, Virginia. Numbers indicate plot locations. (Note: Lines within cover types signify a change in stand age that was noted from the aerial photo and included in the Geographic Information System files, from which this map is generated.)

Table 9. Overstory species basal area, density, frequency and importance values for five cover types at Cold Harbor, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Conifer Cover Type (n=2)				
<i>Carya tomentosa</i>	1.3	27	50	6
<i>Liquidambar styraciflua</i>	5.0	134	50	14
<i>Pinus echinata</i>	6.3	91	50	14
<i>Pinus taeda</i>	17.5	285	100	36
<i>Quercus alba</i>	1.3	18	50	6
<i>Quercus falcata</i>	1.3	28	50	6
<i>Quercus velutina</i>	2.5	244	50	16
Total	35.2	827		98
Oak-Conifer Cover Type (n=8)				
<i>Cornus florida</i>	1.3	231	25	11
<i>Carya tomentosa</i>	0.3	11	13	2
<i>Ilex opaca</i>	0.6	209	25	10
<i>Liriodendron tulipifera</i>	1.3	26	25	5
<i>Pinus echinata</i>	0.6	8	25	3
<i>Pinus taeda</i>	6.6	87	100	20
<i>Quercus alba</i>	2.2	20	38	7
<i>Quercus coccinea</i>	0.3	19	13	2
<i>Quercus falcata</i>	4.1	195	63	17
<i>Quercus velutina</i>	7.2	189	100	24
Total	24.5	995		101
Mixed Hardwood Cover Type (n=4)				
<i>Acer rubrum</i>	4.4	33	100	14
<i>Carya glabra</i>	0.6	3	25	3
<i>Ilex opaca</i>	3.1	206	75	23
<i>Liriodendron tulipifera</i>	5.0	33	75	13
<i>Nyssa sylvatica</i>	11.9	109	75	26

Table 9. Continued.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Mixed Hardwood Cover Type continued				
<i>Pinus taeda</i>	1.3	6	50	5
<i>Quercus alba</i>	4.4	71	75	15
<i>Quercus rubra</i>	0.6	2	25	2
Total	31.3	463		101
Oak Cover Type (n=8)				
<i>Acer rubrum</i>	0.3	14	13	2
<i>Carya glabra</i>	0.9	12	25	4
<i>Carya tomentosa</i>	1.3	29	38	6
<i>Ilex opaca</i>	2.2	326	75	25
<i>Liriodendron tulipifera</i>	1.3	7	25	4
<i>Nyssa sylvatica</i>	0.6	22	13	3
<i>Pinus taeda</i>	0.3	1	13	1
<i>Quercus alba</i>	10.0	212	88	30
<i>Quercus coccinea</i>	0.3	2	13	1
<i>Quercus falcata</i>	2.8	20	75	10
<i>Quercus stellata</i>	0.6	4	25	3
<i>Quercus velutina</i>	5.6	28	38	11
Total	25.6	677		100
Oak-Mixed Hardwood Cover Type (n=3)				
<i>Acer rubrum</i>	0.8	4	33	3
<i>Cornus florida</i>	0.8	179	33	8
<i>Carya tomentosa</i>	2.5	96	100	12
<i>Ilex opaca</i>	3.3	221	33	12
<i>Liquidambar styraciflua</i>	0.8	305	33	12
<i>Liriodendron tulipifera</i>	11.7	119	100	22
<i>Nyssa sylvatica</i>	0.8	7	33	3
<i>Quercus alba</i>	3.3	88	33	8

Table 9. Continued.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Oak-Mixed Hardwood Cover Type Continued.				
<i>Quercus falcata</i>	0.8	10	33	3
<i>Quercus velutina</i>	6.7	56	100	15
Total	31.5	1,085		98

Table 10. The average density and diameter breast height of the understory species in five cover types at Cold Harbor, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Density	DBH
	----stems/ha---	--cm--
Conifer Cover Type (n=2)		
<i>Acer rubrum</i>	125	3.0
<i>Carya glabra</i>	125	1.5
<i>Carya tomentosa</i>	250	2.2
<i>Fagus grandifolia</i>	125	5.0
<i>Pinus taeda</i>	250	0.6
<i>Quercus alba</i>	125	1.8
<i>Quercus velutina</i>	375	2.1
<i>Sassafras albidum</i>	250	2.4
<i>Vaccinium formosum</i>	125	0.5
Total	1,750	
Oak-Conifer Cover Type (n=8)		
<i>Acer rubrum</i>	31	1.3
<i>Carya glabra</i>	94	1.6
<i>Carya tomentosa</i>	375	2.0
<i>Castanea pumila</i>	31	0.1
<i>Cornus florida</i>	31	2.1
<i>Diospyros virginiana</i>	63	2.5
<i>Fagus grandifolia</i>	63	2.6
<i>Ilex opaca</i>	313	2.4
<i>Liquidambar styraciflua</i>	31	3.7
<i>Pinus taeda</i>	125	0.6
<i>Quercus alba</i>	156	1.9
<i>Quercus falcata</i>	125	2.3
<i>Quercus rubra</i>	31	1.7
<i>Quercus velutina</i>	313	1.6
<i>Sassafras albidum</i>	219	2.0

Table 10. Continued.

Species	Density	DBH
	----stems/ha---	--cm--
Oak-Conifer Cover Type continued		
<i>Vaccinium formosum</i>	94	2.2
<i>Vaccinium stamineum</i>	63	0.4
Total	2,158	
Mixed Hardwood Cover Type (n=4)		
<i>Amelanchier arborea</i>	375	2.0
<i>Azalea</i> sp.	688	0.9
<i>Carya tomentosa</i>	63	1.0
<i>Cephalanthus occidentalis</i>	63	0.3
<i>Chionanthus virginicus</i>	63	3.6
<i>Clethra alnifolia</i>	12,563	0.5
<i>Diospyros virginiana</i>	63	3.4
<i>Ilex opaca</i>	875	1.6
<i>Ilex verticillata</i>	1,438	1.1
<i>Liquidambar styraciflua</i>	63	2.8
<i>Magnolia virginiana</i>	250	1.4
<i>Nyssa sylvatica</i>	625	1.6
<i>Sassafras albidum</i>	63	2.7
<i>Vaccinium corymbosum</i>	375	1.5
<i>Vaccinium formosum</i>	313	2.2
Total	17,880	
Oak Cover Type (n=8)		
<i>Acer rubrum</i>	63	1.2
<i>Carya glabra</i>	344	0.9
<i>Carya tomentosa</i>	375	1.6
<i>Castanea pumila</i>	31	0.2
<i>Cornus florida</i>	94	2.6
<i>Diospyros virginiana</i>	63	1.8

Table 10. Continued.

Species	Density	DBH
	----stems/ha---	--cm--
Oak Cover Type continued		
<i>Fagus grandifolia</i>	31	3.0
<i>Ilex opaca</i>	281	3.1
<i>Juniperus virginiana</i>	31	0.7
<i>Nyssa sylvatica</i>	94	3.9
<i>Prunus serotina</i>	31	2.9
<i>Quercus alba</i>	313	1.5
<i>Quercus velutina</i>	250	0.9
<i>Sassafras albidum</i>	63	3.3
<i>Vaccinium stamineum</i>	31	0.6
Total	2,095	
Oak-Mixed Hardwood Cover Type (n=3)		
<i>Carya tomentosa</i>	83	0.3
<i>Clethra alnifolia</i>	3,833	0.3
<i>Ilex opaca</i>	167	2.1
<i>Liriodendron tulipifera</i>	83	0.7
<i>Sassafras albidum</i>	83	0.4
<i>Vaccinium formosum</i>	250	1.0
Total	4,499	

Table 11. Average number of seedlings/hectare in five cover types at Cold Harbor, RICH, Virginia.

Species	Cover Types ^a				
	C	OC	O	H	OH
	-----seedlings/ha-----				
<i>Acer rubrum</i>	0	938	313	10,000	1,667
<i>Azalea</i> sp.	0	0	6,250	10,000	0
<i>Campsis radicans</i>	22,500	0	0	0	0
<i>Carya glabra</i>	0	0	313	0	0
<i>Carya tomentosa</i>	1,250	625	4,063	0	833
<i>Castanea pumila</i>	0	938	0	0	0
<i>Cephalanthus occidentalis</i>	0	0	0	4,375	0
<i>Clethra alnifolia</i>	0	0	0	170,000	148,333
<i>Cornus florida</i>	0	313	938	0	0
<i>Diospyros virginiana</i>	0	0	313	0	0
<i>Euonymus americanus</i>	0	0	0	0	833
<i>Gaylussacia frondosa</i>	17,500	49,688	59,376	3,750	58,333
<i>Ilex opaca</i>	0	625	1,875	4,375	0
<i>Ilex verticillata</i>	0	0	0	3,125	0
<i>Liquidambar styraciflua</i>	0	313	313	5,000	0
<i>Liriodendron tulipifera</i>	0	313	625	1,875	833
<i>Parthenocissus quinquefolia</i>	32,500	625	4,688	0	2,500
<i>Pinus taeda</i>	0	0	0	625	0
<i>Prunus serotina</i>	2,500	313	1,563	0	0
<i>Quercus alba</i>	0	0	3,126	1,250	0
<i>Quercus falcata</i>	6,250	3,125	938	625	0
<i>Quercus rubra</i>	0	625	0	0	0
<i>Quercus velutina</i>	0	3,438	625	625	0
<i>Quercus</i> sp.	0	0	0	625	0
<i>Rubus</i> sp.	1,250	0	0	0	0
<i>Sassafras albidum</i>	1,250	1,563	938	625	2,500
<i>Smilax rotundifolia</i>	1,250	313	4,063	9,375	1,666
<i>Smilax</i> sp.	1,250	0	0	0	0

Table 11. Continued.

Species	Cover Types				
	C	OC	O	H	OH
	-----seedlings/ha-----				
<i>Toxicodendron radicans</i>	1,250	0	313	0	0
<i>Vaccinium corymbosum</i>	0	0	0	625	0
<i>Vaccinium formosum</i>	0	0	625	0	0
<i>Vaccinium pallidum</i>	0	38,750	26,250	12,500	833
<i>Vaccinium stamineum</i>	0	10,000	1,563	1,250	8,333
<i>Vitis aestivalis</i>	0	313	313	0	0
<i>Vitis rotundifolia</i>	5,000	313	16,563	1,250	0
Total	93,750	113,131	135,947	271,877	226,664

^aC-Conifer (n=2), OC-Oak-Conifer (n=8), O-Oak (n=8), H-Mixed Hardwoods (n=4),
OH-Oak-Mixed Hardwoods (n=3)

Table 12. The percent cover of herbaceous and woody vine vegetation in five forest cover types at Cold Harbor, RICH, Virginia.

Species	Cover Type ^a				
	C	OC	O	H	OH
	-----percent cover-----				
<i>Arisaema triphyllum</i>	0	0	0	1	0
<i>Asclepias</i> sp.	P ^b	0	0	0	0
<i>Athyrium asplenoides</i>	0	0	0	P	0
<i>Carex</i> sp.	0	0	0	P	0
<i>Chimaphila maculata</i>	0	P	0	0	P
<i>Chimaphila umbellata</i>	P	0	0	0	0
<i>Cypripedium acaule</i>	0	0	0	P	0
<i>Dioscorea villosa</i>	0	0	0	P	0
<i>Lilium</i> sp.	0	0	0	P	0
<i>Lonicera japonica</i> **	3	0	P	2	0
<i>Medeola virginiana</i>	0	0	0	P	0
<i>Mitchella repens</i>	0	0	0	1	P
<i>Onoclea sensibilis</i>	0	0	0	P	0
<i>Osmunda cinnamomea</i>	0	0	0	P	0
<i>Panicum</i> sp.	0	0	P	0	0
<i>Parthenocissus quinquefolia</i>	2	P	1	0	P
<i>Polygonatum biflorum</i>	0	0	P	0	0
<i>Smilax rotundifolia</i>	0	0	0	P	P
<i>Stellaria</i> sp.	0	0	P	0	0
<i>Symplocarpus foetidus</i>	0	0	0	15	0
<i>Thelypteris noveboracensis</i>	0	0	0	3	0
<i>Toxicodendron radicans</i>	P	0	0	P	0
<i>Vitis aestivalis</i>	0	1	P	0	0
<i>Vitis rotundifolia</i>	P	P	2	0	0
Total ^c	6	1	3	23	1

^aC-Conifer (n=2), OC-Oak-Conifer (n=8), O-Oak (n=8), H-Mixed Hardwood (n=4), OH-Oak-Mixed Hardwood (n=3)

^bP-Present at <.5% cover.

**Non-native species.

^cTotal coverage may not equal sum of species' coverages due to rounding of values.

mockernut hickory, holly, and black oak comprising 46% of the stems (Table 10). Dangleberry, blueberry and deerberry (*Vaccinium* spp.) seedlings far outnumber the tree species seedlings, though oak seedlings are relatively dense (Table 11). Herbaceous cover is virtually non-existent (Table 12).

Along the streams and in the wetlands of Cold Harbor the mixed hardwood cover type dominates. The age of the overstory trees is 90 years and older and the average canopy height is 19 m; some of the black gum and yellow poplar, the dominant species (Table 9), were present during the Civil War. Besides the numerous sweet pepperbush, many small tree species are in the thick understory: winterberry (*Ilex verticillata* (L.) Gray), holly, black gum, serviceberry (*Amelanchier arborea* (Michaux f.) Fernald), and sweet bay. These stands also have the most number of seedlings of any type at Cold Harbor, with a mixture of both shrub and tree species (Table 11). The mixed hardwood type stands have up to 23% herbaceous cover, 65% of which is skunk cabbage (*Symplocarpus foetidus* (L.) Nuttall). These stands are the most species rich, due to their wetland locations (Table 12).

Another large section of Cold Harbor is covered by the 80 year old and older trees in the oak cover type. Five oak species are part of the 24 m high overstory, which was the most species rich of all cover types at the unit (Table 9). Tree species comprise most of the understory in these stands (Table 10). The majority of the seedlings, as with the other type containing oak, are dangleberry, blueberries and deerberry (Table 11). The herbaceous layer cover is very sparse (Table 12).

The oak-mixed hardwood type is generally in low-lying or north-facing, moist areas. Yellow poplar (90 years and older), sweetgum, black oak, and mockernut hickory (*Carya tomentosa* (Poiret) Nuttall) are the most important upper canopy tree species, averaging 25 m in height (Table 9). The somewhat thick understory contains shrubs and tree species (Table 10). A mixture of the moist site and drier site species grow in the seedling layer, such as moisture-loving sweet pepperbush (*Clethra alnifolia* L.) and the more upland dangleberry and blueberry species (Table 11). The thick seedling layer keeps the herbaceous layer to a minimum here also (Table 12).

Vegetation of Malvern Hill

Malvern Hill has a very diverse landscape which the vegetation and wildlife reflect (Figure 6). The topography ranges from flat uplands, to rich coves, drier sideslopes, moist bottomlands and wetlands; the vegetation follows these changes in landscape. Almost 50% of the forest, or approximately 24.9 ha, is of the mixed hardwood and mixed hardwood-conifer cover types, which dominate the large area of bottomland and hilltops. Sweetgum and loblolly pine dominate these types. The other cover types are found in the coves and on the sideslopes, where white and black oak share dominance with the previously mentioned species. Canopy heights range from relatively short mixed hardwood trees at 17 m to tall loblolly pines at 30 m. A total of 70% of the 52.9 ha unit is forested. The forest 20-50 years ago on this unit most likely had more pine within it, which would have been pioneer species replacing wheat fields that were in place during the Civil War. Scattered old oaks in the bottomland are evidence that deciduous forest probably dominated the moister sites. *Microstegium vimineum* (Trin.) A. Camus and Japanese honeysuckle are two exotic species found on the forest floor of the unit; however, their presence has not appeared to alter the health or appearance of the forest.

The relatively undisturbed nature of this unit promotes the use of these 50 to 100-year-old woods, surrounded by fields and clearcuts, by many species of wildlife. Immature bald eagles (*Haliaeetus leucocephalus* L.) were seen for two summers in the trees along the western boundary, as were great-blue herons (*Ardea herodias* L.) and several species of egrets. Numerous neo-tropical migrants were heard and seen, such as ovenbirds (nesting)(*Seiurus aurocapillus* L.), summer tanagers (*Piranga rubra* L.), great crested flycatchers (*Myiarchus crinitus* L.) and thrushes, as well as wild turkey (nesting)(*Meleagris gallopavo* L.), Carolina wrens (*Thryothorus ludovicianus* Latham), and red-headed (*Melanerpes erythrocephalus* L.) and pileated (*Dryocopus pileatus* L.) woodpeckers. Deer (*Odocoileus virginianus* Zimm.) and red fox (*Vulpes vulpes* L.) were also seen, as well as raccoon (*Procyon lotor* L.) sign, snakes, and turtles. The natural area zoning of part of this unit fits it well.

The conifer type is not common here, and where it occurs black oak is almost as important as loblolly pine (Table 13). The pines are approximately 64 years old. The understory and seedling tree species

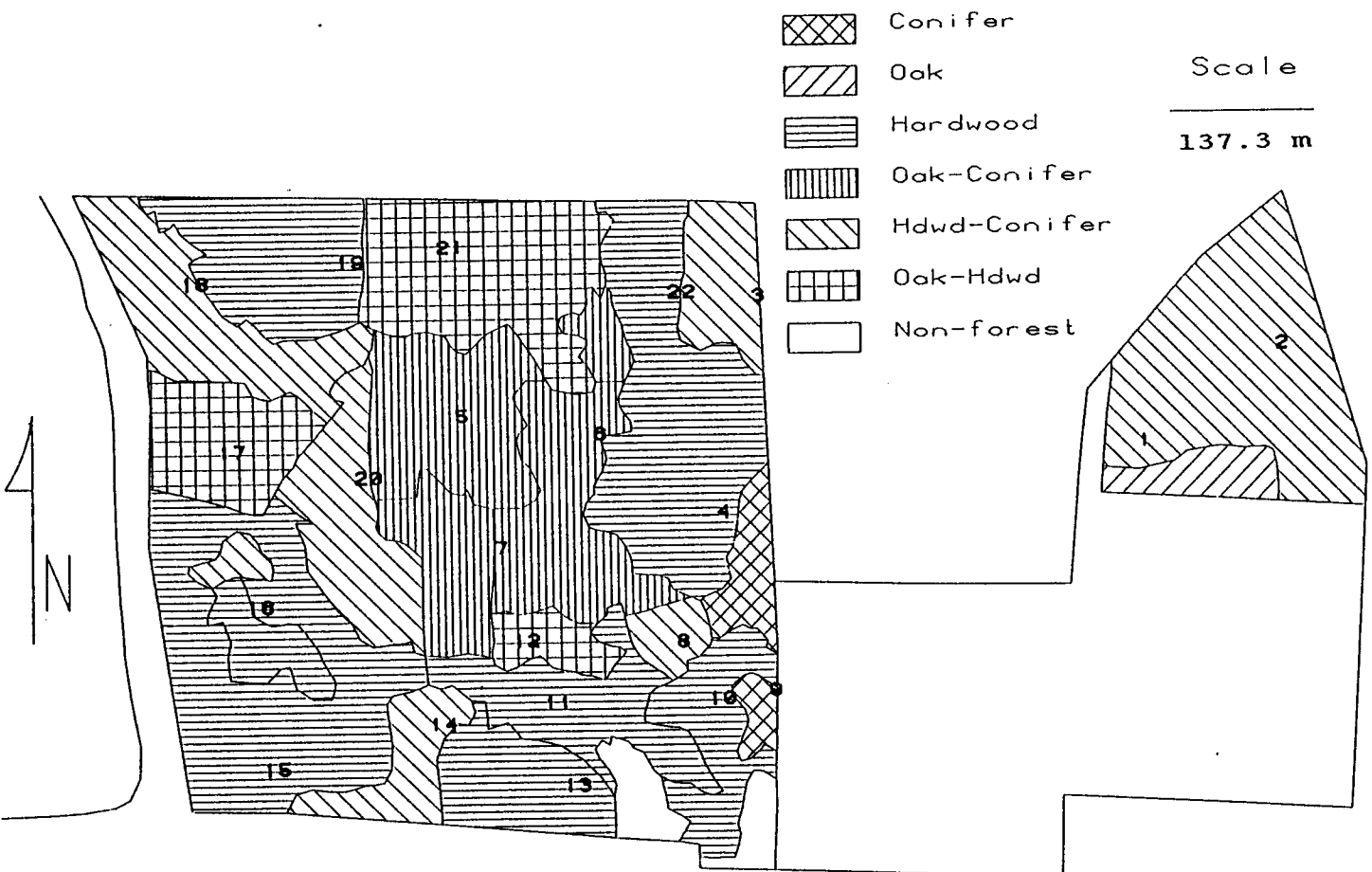


Figure 6. Forest cover types and plot locations at Malvern Hill, RICH, Virginia. Numbers indicate plot locations. (Note: Lines within cover types signify a change in stand age that was noted from the aerial photo and included in the Geographic Information System files, from which this map is generated.)

Table 13. Overstory species basal area, density, frequency and importance values for five cover types at Malvern Hill, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Conifer Cover Type (n=1)				
<i>Pinus taeda</i>	20.0	141	100	44
<i>Quercus velutina</i>	15.0	450	100	56
Total	35.0	591		100
Mixed Hardwood-Conifer Cover Type (n=7)				
<i>Acer rubrum</i>	2.5	64	57	8
<i>Carya tomentosa</i>	0.4	14	14	2
<i>Cornus florida</i>	0.7	281	29	11
<i>Fraxinus americana</i>	0.4	9	14	2
<i>Ilex opaca</i>	0.4	93	14	4
<i>Juniperus virginiana</i>	0.4	85	14	4
<i>Liquidambar styraciflua</i>	10.0	170	86	20
<i>Liriodendron tulipifera</i>	2.1	18	29	4
<i>Nyssa sylvatica</i>	0.4	15	14	2
<i>Pinus taeda</i>	12.5	105	100	22
<i>Quercus alba</i>	0.4	8	14	1
<i>Quercus falcata</i>	0.4	1	14	1
<i>Quercus phellos</i>	0.4	1	14	1
<i>Quercus rubra</i>	0.4	59	14	3
<i>Quercus velutina</i>	1.4	63	29	5
<i>Ulmus americana</i>	1.4	69	29	5
<i>Ulmus rubra</i>	1.1	48	29	4
Total	33.9	1,103		99
Oak-Conifer Cover Type (n=3)				
<i>Carya tomentosa</i>	0.8	32	33	6
<i>Juniperus virginiana</i>	0.8	315	33	20
<i>Liquidambar styraciflua</i>	3.3	242	100	26

Table 13. Continued.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Oak-Conifer Cover Type continued				
<i>Pinus taeda</i>	10.0	72	100	28
<i>Quercus alba</i>	5.8	26	66	16
<i>Quercus falcata</i>	0.8	2	33	4
Total	21.5	689		100
Mixed Hardwood Cover Type (n=8)				
<i>Acer rubrum</i>	2.2	48	50	9
<i>Carya tomentosa</i>	0.3	67	13	4
<i>Diospyros virginiana</i>	0.3	13	13	2
<i>Fagus grandifolia</i>	0.3	75	13	4
<i>Juniperus virginiana</i>	0.3	35	13	3
<i>Liquidambar styraciflua</i>	12.5	447	100	41
<i>Liriodendron tulipifera</i>	4.7	41	50	12
<i>Nyssa sylvatica</i>	0.6	26	25	4
<i>Prunus avium</i>	0.3	6	13	2
<i>Pinus taeda</i>	0.6	3	25	3
<i>Quercus falcata</i>	1.3	4	25	4
<i>Quercus phellos</i>	0.3	1	13	1
<i>Quercus velutina</i>	0.9	78	25	6
<i>Ulmus rubra</i>	1.3	24	38	6
Total	25.9	868		101
Oak-Mixed Hardwood Cover Type (n=3)				
<i>Acer rubrum</i>	0.8	18	33	3
<i>Carya tomentosa</i>	1.7	7	33	4
<i>Juniperus virginiana</i>	0.8	2	33	3
<i>Liquidambar styraciflua</i>	8.3	143	100	20
<i>Liriodendron tulipifera</i>	4.2	29	100	11
<i>Pinus taeda</i>	1.7	7	66	5

Table 13. Continued.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Oak-Mixed Hardwood Cover Type continued				
<i>Quercus alba</i>	7.5	172	66	19
<i>Quercus coccinea</i>	0.8	6	33	3
<i>Quercus falcata</i>	3.3	7	66	7
<i>Quercus velutina</i>	6.7	167	66	18
<i>Ulmus rubra</i>	1.7	71	33	7
Total	37.5	629		100

are mostly mixed hardwoods such as sweetgum, red maple, yellow poplar, and black cherry (*Prunus serotina* Ehrhart)(Tables 14 & 15). Herbaceous layer cover is scarce in this type (Table 16).

The mixed hardwood-conifer cover type occurs along the bottomland at the western end of the unit and in upland areas to the east. Although currently dominated by loblolly pine and sweetgum, these areas will soon be mostly mixed hardwoods. The pine, at 50 to 70 years of age, appears to be dropping out of the stand slowly, as dead pine snags and logs are common in these stands. The overstory hardwoods, ranging from 50 to 100 years of age, will most likely outlive the pines. Signs of disease were noticed on some of the pines; pine bark beetle was not. This loss of pine from these areas is also evidenced by the domination of the understory by hardwood trees such as sweetgum, holly, and black oak (Table 14). Although many vine species seedlings were present, white oak, red maple, and sweetgum are the most dense tree species (Table 15). Herbaceous cover is low in this type also (Table 16).

The oak-conifer cover type covers the center of the unit, on the upland areas. Loblolly pine and white oak are the dominant species, however sweetgum is an important species too (Table 13). Oaks, sweetgum, red maple, and elm (*Ulmus* sp.) are the most dense understory species (Table 14), and sweetgum and loblolly pine are the most common tree seedlings (Table 15). Pine bark beetle sign was noticed on some pines in this type. The pine and oak in these stands are between 70 and 90 years of age. The shorter-lived pine will continue to drop out, and the oaks and other hardwoods in the understory will soon dominate these areas. Grasses, sedges and vines are the predominant herbaceous layer cover (Table 16).

Mixed hardwood stands occur in the moister, less well-drained areas of the unit: in and near the wetland at the west end of the unit, and in coves and poorly-drained plateaus to the south and the east. The stands are from 70 to 95 years old in the bottomland and coves and 35 to 50 years elsewhere. Sweetgum, yellow poplar, and red maple are the most important species in the overstory (Table 13). Loblolly pine and black oak are actually the most common understory species (Table 14). Loblolly pine and sweetgum are abundant in the seedling layer in the canopy openings (Table 15). The type has the most diverse herbaceous layer. Two exotic species, the grass-like *Microstegium vimineum* and Japanese honeysuckle, cover most of the area; honeysuckle on the uplands and the grass in the wetland areas (Table 16).

Table 14. The average density and diameter breast height of the understory species in five cover types at Malvern Hill, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Density ----stems/ha---	DBH --cm--
Conifer Cover Type (n=1)		
<i>Ilex opaca</i>	750	1.7
<i>Liquidambar styraciflua</i>	250	0.5
<i>Quercus velutina</i>	250	5.3
Total	1,250	
Mixed Hardwood-Conifer Cover Type (n=7)		
<i>Carya glabra</i>	36	1.3
<i>Carpinus caroliniana</i>	36	3.3
<i>Diospyros virginiana</i>	71	0.5
<i>Euonymus americanus</i>	71	0.3
<i>Fagus grandifolia</i>	71	1.8
<i>Ilex opaca</i>	179	1.7
<i>Lindera benzoin</i>	107	0.2
<i>Liquidambar styraciflua</i>	179	1.8
<i>Nyssa sylvatica</i>	36	3.9
<i>Pinus taeda</i>	71	0.8
<i>Quercus alba</i>	71	2.1
<i>Quercus falcata</i>	71	2.7
<i>Quercus velutina</i>	107	2.7
<i>Ulmus americana</i>	71	2.7
<i>Vaccinium formosum</i>	36	1.0
Total	1,213	
Oak-Conifer Cover Type (n=3)		
<i>Acer rubrum</i>	250	1.1
<i>Carya tomentosa</i>	167	2.2
<i>Cornus florida</i>	83	2.6
<i>Ilex opaca</i>	167	3.5
<i>Liquidambar styraciflua</i>	500	3.0

Table 14. Continued.

Species	Density	DBH
	----stems/ha---	--cm--
Oak-Conifer Cover Type continued		
<i>Quercus alba</i>	500	1.4
<i>Quercus phellos</i>	83	0.2
<i>Quercus velutina</i>	83	0.2
<i>Ulmus americana</i>	250	0.9
Total	2,083	
Mixed Hardwood Cover Type (n=8)		
<i>Acer rubrum</i>	63	0.5
<i>Carya tomentosa</i>	125	1.0
<i>Cornus florida</i>	31	0.6
<i>Ilex opaca</i>	250	2.4
<i>Liquidambar styraciflua</i>	219	2.3
<i>Nyssa sylvatica</i>	31	6.7
<i>Pinus taeda</i>	344	1.0
<i>Quercus alba</i>	188	1.3
<i>Quercus velutina</i>	344	1.8
<i>Ulmus americana</i>	94	2.8
<i>Vaccinium corymbosum</i>	125	1.7
<i>Vaccinium formosum</i>	31	0.9
Total	1,845	
Oak-Mixed Hardwood Cover Type (n=3)		
<i>Celtis</i> sp.	83	3.4
<i>Cornus florida</i>	167	2.1
<i>Ilex opaca</i>	167	1.3
<i>Lindera benzoin</i>	1,000	0.5
<i>Liquidambar styraciflua</i>	83	1.0
<i>Ulmus americana</i>	83	3.8
Total	1,583	

Table 15. Average number of seedlings/hectare in five cover types at Malvern Hill, RICH, Virginia.

Species	Cover Types ^a				
	C	OC	HC	H	OH
	-----seedlings/ha-----				
<i>Acer rubrum</i>	2,500	7,500	6,071	9,375	4,167
<i>Amelanchier arborea</i>	0	833	0	0	6,667
<i>Campsis radicans</i>	0	833	1,071	3,125	833
<i>Carya tomentosa</i>	0	1,667	357	313	0
<i>Celtis</i> sp.	0	0	0	938	3,333
<i>Cornus florida</i>	0	0	0	2,500	0
<i>Diospyros virginiana</i>	0	1,667	0	0	0
<i>Euonymus americanus</i>	0	0	29,286	8,438	15,833
<i>Fraxinus pennsylvanica</i>	0	0	357	625	0
<i>Gaylussacia frondosa</i>	0	0	7,857	0	0
<i>Ilex opaca</i>	0	5,834	0	4,063	1,666
<i>Juniperus virginiana</i>	0	0	357	938	0
<i>Lindera benzoin</i>	0	833	1,429	0	15,000
<i>Liquidambar styraciflua</i>	0	7,500	58,215	15,625	1,667
<i>Liriodendron tulipifera</i>	2,500	833	3,928	6,876	35,000
<i>Parthenocissus quinquefolia</i>	0	5,000	714	2,813	15,833
<i>Pinus taeda</i>	0	2,500	8,929	38,438	833
<i>Prunus serotina</i>	5,000	833	1,071	1,875	833
<i>Prunus</i> sp.	0	0	0	1,250	0
<i>Quercus alba</i>	0	10,000	0	625	833
<i>Quercus falcata</i>	0	833	0	1,250	0
<i>Quercus phellos</i>	0	0	1,786	938	0
<i>Quercus rubra</i>	0	0	0	313	0
<i>Quercus velutina</i>	0	0	357	0	0
<i>Rubus</i> sp.	0	0	7,857	4,063	0
<i>Sassafras albidum</i>	0	0	357	313	0
<i>Smilax rotundifolia</i>	2,500	6,666	6,786	2,813	3,333
<i>Smilax</i> sp.	0	0	0	625	0

Table 15. Continued.

Species	Cover Types				
	C	OC	HC	H	OH
	-----seedlings/ha-----				
<i>Toxicodendron radicans</i>	0	833	3,929	1,563	2,500
<i>Ulmus</i> sp.	0	1,667	2,143	2,813	833
<i>Vaccinium corymbosum</i>	0	0	0	1,250	0
<i>Vaccinium stamineum</i>	0	0	1,429	0	0
<i>Viburnum dentatum</i>	0	0	357	0	0
<i>Vitis rotundifolia</i>	0	11,667	11,071	10,313	36,667
Total	12,500	67,499	155,714	124,071	145,831

^aC-Conifer (n=1), OC-Oak-Conifer (n=3), HC-Mixed Hardwoods-Conifer (n=7), H-Mixed Hardwoods (n=8), OH-Oak-Mixed Hardwoods (n=3)

Table 16. The percent cover of herbaceous vegetation in five forest cover types at Malvern Hill, RICH, Virginia.

Species	Cover Type ^a				
	C	OC	HC	H	OH
	-----percent cover-----				
<i>Anemone quinquefolia</i>	0	0	0	0	P ^b
<i>Athyrium asplenoides</i>	0	0	P	0	0
<i>Botrychium</i> sp.	0	0	0	P	0
<i>Carex albolutescens</i>	0	0	P	P	0
<i>Carex debilis</i>	0	0	3	0	0
<i>Carex</i> sp.	1	P	P	P	0
<i>Carex swanii</i>	0	0	P	0	0
<i>Desmodium nudiflorum</i>	0	0	P	P	P
<i>Eupatorium</i> sp.	1	0	P	P	1
<i>Galium</i> sp.	0	0	P	P	P
Grasses	0	0	P	0	0
<i>Impatiens</i> sp.	0	0	P	0	0
<i>Lobelia</i> sp.	0	0	0	P	0
<i>Lonicera japonica</i> **	2	P	4	3	1
<i>Microstegium vimineum</i> **	0	P	10	17	13
<i>Mitchella repens</i>	0	1	P	1	0
<i>Obolaria virginica</i>	0	0	0	P	0
<i>Onoclea sensibilis</i>	0	0	P	P	0
<i>Ophioglossum vulgatum</i> var. <i>pycnostichum</i>	0	0	0	P	0
<i>Osmunda cinnamomea</i>	0	0	1	0	0
<i>Oxalis</i> sp.	0	0	0	P	0
<i>Parthenocissus quinquefolia</i>	0	P	P	P	2
<i>Poa autumnalis</i>	0	0	0	P	0
<i>Polystichum acrostichoides</i>	0	0	P	0	1
<i>Potentilla</i> sp.	0	0	0	0	P
<i>Pteridium aquilinum</i>	0	2	0	0	0
<i>Rubus</i> sp.	0	0	0	P	0

Table 16. Continued.

Species	Cover Type ^a				
	C	OC	HC	H	OH
	-----percent cover-----				
<i>Solidago</i> sp.	0	P	0	P	0
<i>Stellaria</i> sp.	0	0	0	P	0
<i>Thelypteris noveboracensis</i>	0	0	0	P	0
<i>Toxicodendron radicans</i>	0	P	P	P	P
<i>Trachelospermum difforme</i>	0	0	P	0	0
<i>Viola</i> sp.	0	0	P	P	P
<i>Vitis rotundifolia</i>	0	1	2	1	4
Total ^c	3	5	22	24	27

^aC-Conifer (n=1), OC-Oak-Conifer (n=3), HC-Mixed Hardwood-Conifer (n=7), H-Mixed Hardwood (n=8), OH-Oak-Mixed Hardwood (n=3)

^bP-Present at <.5% cover.

^cTotal coverage may not equal sum of species' coverages due to rounding of values.

^{**}Non-native species.

The oak-mixed hardwood cover type is also found in bottomlands and uplands. The oaks, ranging from 50 to 85 years of age, are the most important species in these stands (Table 13). Spicebush (*Lindera benzoin* (L.) Blume) dominates the understory layer (Table 14), and yellow poplar is the most common tree species seedling (Table 15). One-half of the herbaceous cover is *Microstegium vimineum* (Table 16).

Vegetation of Fort Harrison section of Chaffin's Farm

The dry upland forest that now surrounds the actual Fort Harrison was historically more open. Along the streams and small wetland area, the mixed hardwood and oak-mixed hardwood types grow, the stands dominated by yellow poplar. Wildlife was plentiful in this unit, as few visitors enter the forest. Deer and raccoon were seen, as well as numerous birds such as yellow-billed cuckoos (*Coccyzus americanus* L.), ruby-throated hummingbirds (*Archilochus colubris* L.), and hawks. Most of the area is covered by the oak, oak-conifer, and hardwood-conifer cover types, with white and southern red oaks, loblolly pine, sweetgum and red maple dominating the overstory (Figure 7). Approximately 70 ha of undisturbed forestland makes up this central part of the Chaffin's Farm unit. Many of the stands were uneven-aged, with both hardwood and pine trees ranging from 40 to 100+ years in age throughout the unit. The oak canopy ranges from 16 to 26 m in height, depending on the species and site quality, while the mixed hardwoods and pines are generally taller. Although Japanese honeysuckle is common in the open areas and forest edges, the interior of the forests are relatively free from this pest.

Pines with sign of bark beetle were found in a majority of the stands that had older, dominant trees. Eventually most of the pine will drop out of the forest overstory in this unit, as succession takes course. Oaks with disease or root rot were also common, and occasional blow-downs of oaks were found in the forest. These gaps will be quickly filled by deciduous vines, seedlings and understory trees, adding structure to the relatively uniform forest canopy. Overall, the forest appears dynamic and healthy.

The conifer cover type is not very common, and only covers 5% of the area (Figure 7). The loblolly pines, the most important species (Table 17), are approximately 60 to 70 years old. Eastern red cedar (*Juniperus virginiana* L.) and red maple are the most common in the understory (Table 18). This type has the least number of seedlings; most are of tree species such as black cherry, black gum, loblolly pine, and sweetgum (Table 19). The forest floor is barely covered by any herbaceous species; only Japanese honeysuckle, Muscadine grape, and sedges occur (Table 20).

The mixed hardwood-conifer cover type extends over a fairly large area, approximately 20% of the unit. Loblolly pine, red maple, and sweetgum are the most important overstory species (Table 17), and are

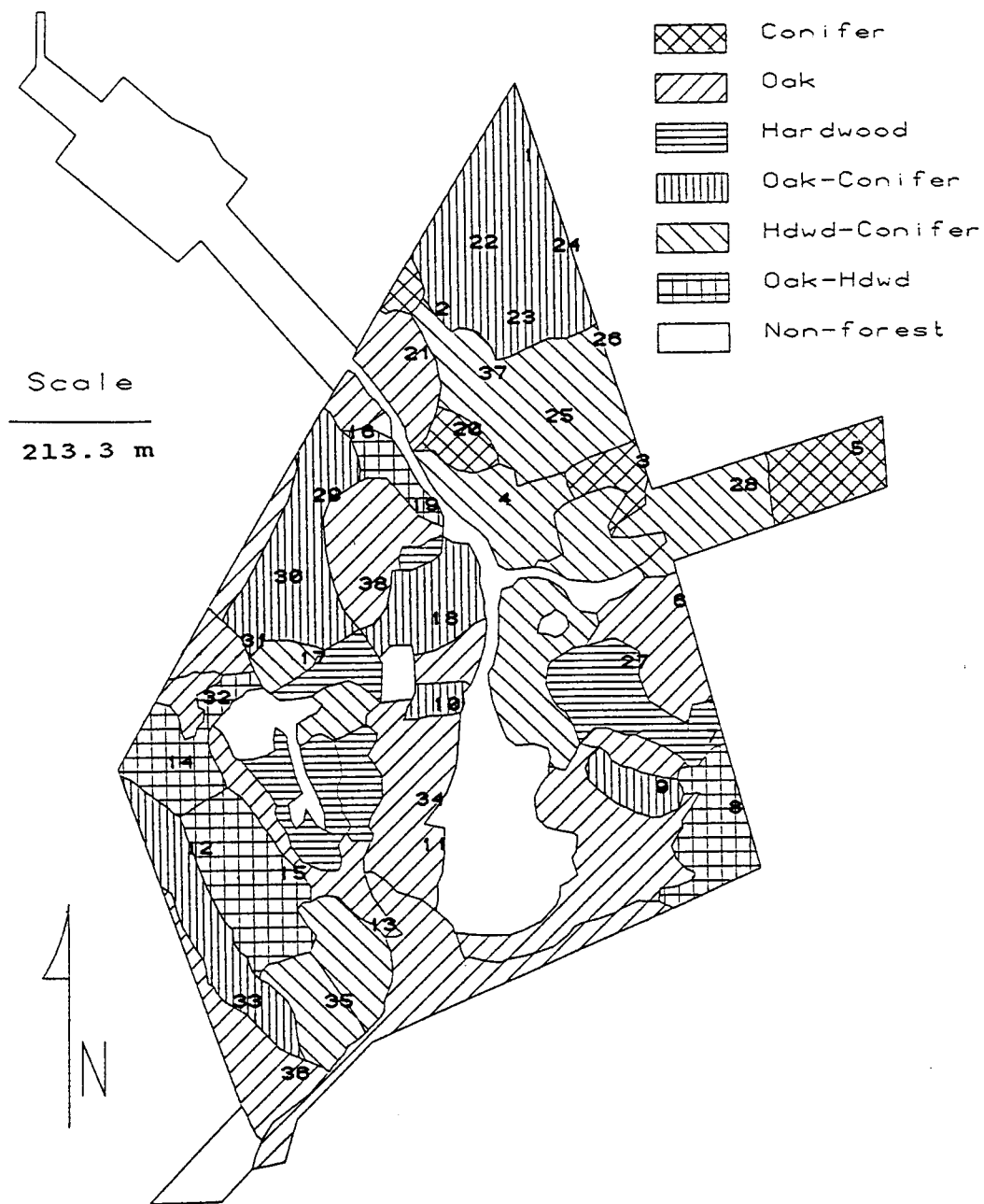


Figure 7. Forest cover types and plot locations at the Fort Harrison section of Chaffin's Farm, RICH, Virginia. Numbers indicate plot locations. (Note: Lines within cover types signify a change in stand age that was noted from the aerial photo and included in the Geographic Information System files, from which this map is generated.)

Table 17. Overstory species basal area, density, frequency and importance values for six cover types at Fort Harrison, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Conifer Cover Type (n=3)				
<i>Acer rubrum</i>	2.5	215	66	18
<i>Liquidambar styraciflua</i>	0.8	60	33	7
<i>Pinus taeda</i>	19.2	321	100	46
<i>Quercus falcata</i>	3.3	309	33	19
<i>Quercus stellata</i>	0.8	10	33	5
<i>Quercus velutina</i>	0.8	12	33	5
Total	27.4	927		100
Mixed Hardwood-Conifer Cover Type (n=9)				
<i>Acer rubrum</i>	5.6	440	78	25
<i>Juniperus virginiana</i>	0.3	26	11	2
<i>Liquidambar styraciflua</i>	5.8	306	67	21
<i>Nyssa sylvatica</i>	2.5	254	33	12
<i>Pinus taeda</i>	6.9	69	100	20
<i>Pinus virginiana</i>	0.3	25	11	2
<i>Quercus alba</i>	0.3	2	11	1
<i>Quercus falcata</i>	0.8	38	11	3
<i>Quercus rubra</i>	0.3	63	11	3
<i>Quercus velutina</i>	1.7	195	33	10
Total	24.5	1,418		99
Oak-Conifer Cover Type (n=10)				
<i>Carya glabra</i>	0.3	52	10	3
<i>Carya tomentosa</i>	1.0	119	10	7
<i>Diospyros virginiana</i>	0.3	113	10	5
<i>Liquidambar styraciflua</i>	2.8	158	90	17
<i>Nyssa sylvatica</i>	0.3	88	10	4
<i>Pinus taeda</i>	6.0	113	90	20
<i>Pinus virginiana</i>	0.3	3	10	1

Table 17. Continued.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Oak-Conifer Cover Type continued				
<i>Quercus alba</i>	4.5	94	70	16
<i>Quercus coccinea</i>	0.5	6	20	3
<i>Quercus falcata</i>	3.8	139	60	15
<i>Quercus phellos</i>	0.8	3	10	2
<i>Quercus stellata</i>	1.3	23	20	4
<i>Quercus velutina</i>	0.8	6	20	3
Total	22.7	917		100
Mixed Hardwood Cover Type (n=2)				
<i>Acer rubrum</i>	2.5	42	50	9
<i>Liquidambar styraciflua</i>	1.3	8	50	6
<i>Liriodendron tulipifera</i>	10.0	230	100	31
<i>Nyssa sylvatica</i>	1.3	162	50	11
<i>Quercus alba</i>	3.8	182	50	15
<i>Quercus falcata</i>	1.3	9	50	6
<i>Quercus velutina</i>	1.3	490	50	21
Total	21.5	1,123		99
Oak Cover Type (n=11)				
<i>Acer rubrum</i>	0.7	73	27	7
<i>Carya tomentosa</i>	0.2	22	9	2
<i>Ilex opaca</i>	0.2	7	9	1
<i>Liquidambar styraciflua</i>	2.5	106	45	13
<i>Liriodendron tulipifera</i>	0.5	55	18	5
<i>Nyssa sylvatica</i>	0.7	110	18	7
<i>Pinus taeda</i>	0.9	14	18	4
<i>Quercus alba</i>	6.1	136	82	23
<i>Quercus coccinea</i>	2.5	69	45	11
<i>Quercus falcata</i>	3.9	87	64	16

Table 17. Continued.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Oak Cover Type continued				
<i>Quercus phellos</i>	0.2	1	9	1
<i>Quercus stellata</i>	0.2	3	9	1
<i>Quercus velutina</i>	1.4	87	36	9
Total	20.0	770		100
Oak-Mixed Hardwood Cover Type (n=3)				
<i>Acer rubrum</i>	5.0	385	100	23
<i>Ilex opaca</i>	0.8	170	33	8
<i>Liquidambar styraciflua</i>	4.2	325	66	18
<i>Liriodendron tulipifera</i>	10.8	51	66	17
<i>Pinus taeda</i>	0.8	9	33	3
<i>Quercus alba</i>	5.8	113	100	16
<i>Quercus falcata</i>	1.7	12	33	4
<i>Quercus phellos</i>	1.7	24	33	5
<i>Quercus stellata</i>	0.8	8	33	3
<i>Quercus velutina</i>	0.8	9	33	3
Total	32.4	1,106		100

Table 18. The average density and diameter breast height of the live understory species in six cover types at Fort Harrison, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Density ----stems/ha---	DBH --cm--
Conifer Cover Type (n=3)		
<i>Acer rubrum</i>	417	0.3
<i>Carya glabra</i>	83	3.8
<i>Cornus florida</i>	250	2.1
<i>Ilex opaca</i>	83	6.0
<i>Juniperus virginiana</i>	667	3.0
<i>Leucothoe racemosa</i>	83	0.5
<i>Liquidambar styraciflua</i>	83	4.3
<i>Quercus falcata</i>	83	1.4
<i>Quercus velutina</i>	83	0.3
<i>Sassafras albidum</i>	83	2.3
Total	1,915	
Mixed Hardwood-Conifer Cover Type (n=9)		
<i>Acer rubrum</i>	500	2.0
<i>Carya tomentosa</i>	28	0.9
<i>Clethra alnifolia</i>	194	0.2
<i>Cornus florida</i>	56	3.5
<i>Juniperus virginiana</i>	56	3.5
<i>Leucothoe racemosa</i>	56	0.5
<i>Liquidambar styraciflua</i>	333	1.1
<i>Magnolia virginiana</i>	28	0.8
<i>Nyssa sylvatica</i>	278	2.6
<i>Pinus taeda</i>	278	1.2
<i>Prunus serotina</i>	111	0.5
<i>Quercus alba</i>	139	1.7
<i>Quercus falcata</i>	111	1.5
<i>Quercus phellos</i>	83	3.6

Table 18. Continued.

Species	Density	DBH
	----stems/ha---	--cm--
Mixed Hardwood-Conifer Cover Type continued		
<i>Quercus velutina</i>	56	3.2
<i>Vaccinium corymbosum</i>	111	0.7
<i>Vaccinium formosum</i>	250	1.4
Total	2,668	
Oak-Conifer Cover Type (n=10)		
<i>Acer rubrum</i>	500	1.3
<i>Carya glabra</i>	25	2.8
<i>Carya tomentosa</i>	125	1.7
<i>Ilex opaca</i>	125	3.3
<i>Liquidambar styraciflua</i>	275	2.8
<i>Magnolia virginiana</i>	25	0.2
<i>Nyssa sylvatica</i>	850	1.6
<i>Pinus taeda</i>	25	0.4
<i>Quercus alba</i>	125	2.1
<i>Quercus falcata</i>	75	2.4
<i>Quercus rubra</i>	150	2.7
<i>Sassafras albidum</i>	125	1.5
<i>Vaccinium corymbosum</i>	100	0.6
<i>Vaccinium formosum</i>	175	0.8
<i>Vaccinium stamineum</i>	25	0.4
<i>Viburnum dentatum</i>	25	2.4
Total	2,750	
Mixed Hardwood Cover Type (n=2)		
<i>Acer rubrum</i>	250	0.6
<i>Amelanchier arborea</i>	250	0.9
<i>Clethra alnifolia</i>	12,625	0.5
<i>Ilex opaca</i>	250	0.3

Table 18. Continued.

Species	Density ----stems/ha---	DBH --cm--
Mixed Hardwood Cover Type continued		
<i>Juniperus virginiana</i>	250	1.9
<i>Liquidambar styraciflua</i>	750	2.3
<i>Magnolia virginiana</i>	1,125	1.2
<i>Quercus falcata</i>	250	4.0
<i>Vaccinium corymbosum</i>	1,000	1.6
Total	16,750	
Oak Cover Type (n=11)		
<i>Acer rubrum</i>	364	2.5
<i>Azalea</i> sp.	23	0.1
<i>Carya tomentosa</i>	136	2.4
<i>Clethra alnifolia</i>	659	0.3
<i>Cornus florida</i>	91	3.5
<i>Diospyros virginiana</i>	23	1.7
<i>Ilex opaca</i>	205	1.4
<i>Juniperus virginiana</i>	23	1.5
<i>Liquidambar styraciflua</i>	341	1.7
<i>Liriodendron tulipifera</i>	45	4.3
<i>Magnolia virginiana</i>	114	1.2
<i>Nyssa sylvatica</i>	727	2.1
<i>Quercus alba</i>	68	1.6
<i>Quercus rubra</i>	68	1.5
<i>Quercus velutina</i>	68	2.2
<i>Sassafras albidum</i>	23	0.6
<i>Vaccinium corymbosum</i>	159	0.7
<i>Vaccinium formosum</i>	91	0.5
<i>Vaccinium stamineum</i>	136	0.6
Total	3,364	

Table 18. Continued.

Species	Density	DBH
	----stems/ha----	--cm--
Oak-Mixed Hardwood Cover Type (n=3)		
<i>Acer rubrum</i>	167	3.0
<i>Carya tomentosa</i>	250	0.9
<i>Clethra alnifolia</i>	4,083	0.4
<i>Ilex opaca</i>	167	2.4
<i>Liquidambar styraciflua</i>	167	2.3
<i>Nyssa sylvatica</i>	83	3.6
<i>Quercus alba</i>	83	3.3
<i>Vaccinium formosum</i>	250	0.9
<i>Vaccinium stamineum</i>	83	1.2
Total	5,330	

Table 19. Average number of seedlings/hectare in six cover types at Fort Harrison, RICH, Virginia.

Species	Cover Types ^a					
	C	OC	HC	O	H	OH
	-----seedlings/ha-----					
<i>Acer rubrum</i>	2,500	8,500	20,556	7,727	11,250	10,000
<i>Amelanchier arborea</i>	0	0	833	0	2,500	0
<i>Aronia arbutifolia</i>	0	0	0	0	1,250	0
<i>Azalea</i> sp.	0	71,250	17,222	22,955	5,000	21,667
<i>Campsis radicans</i>	0	500	2,778	455	0	0
<i>Carya tomentosa</i>	0	500	278	227	0	833
<i>Cephalanthus occidentalis</i>	0	0	0	0	7,500	0
<i>Clethra alnifolia</i>	0	500	29,722	15,682	300,000	139,167
<i>Cornus florida</i>	0	0	0	455	0	0
<i>Diospyros virginiana</i>	0	250	0	227	0	0
<i>Gaylussacia frondosa</i>	5,000	47,250	8,889	34,091	1,250	27,500
<i>Ilex opaca</i>	1,666	250	2,779	909	0	833
<i>Leucothoe racemosa</i>	833	750	14,444	1,364	6,250	20,833
<i>Liquidambar styraciflua</i>	4,166	6,250	12,222	2,955	5,000	20,000
<i>Liriodendron tulipifera</i>	0	250	0	227	12,500	1,667
<i>Magnolia virginiana</i>	0	250	0	0	1,250	0
<i>Nyssa sylvatica</i>	5,833	1,750	1,944	4,091	0	0
<i>Parthenocissus quinquefolia</i>	0	0	3,056	0	0	1,667
<i>Pinus taeda</i>	5,000	2,000	12,222	454	0	0
<i>Prunus serotina</i>	54,167	500	1,944	1,364	5,000	3,333
<i>Prunus</i> sp.	0	0	0	1,591	0	0
<i>Quercus alba</i>	0	750	0	2,273	0	0
<i>Quercus falcata</i>	0	2,250	833	1,818	1,250	833
<i>Quercus phellos</i>	833	1,000	1,111	455	1,250	1,667
<i>Quercus rubra</i>	0	1,250	278	682	0	833
<i>Quercus stellata</i>	0	250	0	0	0	0
<i>Quercus velutina</i>	0	500	556	455	0	833
<i>Sassafras albidum</i>	0	1,250	833	0	0	0

Table 19. Continued.

Species	Cover Types					
	C	OC	HC	O	H	OH
	-----seedlings/ha-----					
<i>Smilax rotundifolia</i>	8,333	8,500	15,556	682	5,000	4,167
<i>Smilax</i> sp.	0	0	556	0	0	0
<i>Toxicodendron radicans</i>	0	0	278	0	0	0
<i>Vaccinium corymbosum</i>	0	0	556	455	0	0
<i>Vaccinium formosum</i>	0	0	5,278	0	5,000	10,833
<i>Vaccinium pallidum</i>	0	9,750	3,611	24,773	53,750	0
<i>Vaccinium stamineum</i>	0	15,250	10,556	11,818	0	7,500
<i>Viburnum dentatum</i>	0	250	0	0	0	0
<i>Vitis rotundifolia</i>	6,667	6,000	14,444	10,000	12,500	14,167
Total	94,998	187,750	183,335	148,185	436,250	288,333

^aC-Conifer (n=3), OC-Oak-Conifer (n=10), HC-Mixed Hardwoods-Conifer (n=9), O-Oak (n=11), H-Mixed Hardwoods (n=2), OH-Oak-Mixed Hardwoods (n=3)

Table 20. The percent cover of herbaceous and woody vines vegetation in six forest cover types at Fort Harrison, RICH, Virginia.

Species	Cover Type ^a					
	C	OC	HC	O	H	OH
	-----percent cover-----					
<i>Carex</i> sp.	P ^b	P	0	0	P	P
<i>Chimaphila maculata</i>	0	P	0	P	0	0
<i>Dioscorea villosa</i>	0	0	0	0	0	P
Grasses	0	0	1	0	1	P
<i>Lespedeza repens</i>	0	0	P	0	0	0
<i>Lilium</i> sp.	0	0	0	0	P	0
<i>Lonicera japonica</i> ^{**}	1	P	1	1	0	2
<i>Lycopodium</i> sp.	0	0	1	0	0	0
<i>Mitchella repens</i>	0	P	0	P	2	2
<i>Parthenocissus quinquefolia</i>	0	0	0	0	0	P
<i>Polygonatum biflorum</i>	0	0	0	0	0	P
<i>Vitis rotundifolia</i>	1	1	1	1	P	1
Total ^c	2	2	4	3	3	6

^aC-Conifer (n=3), OC-Oak-Conifer (n=10), HC-Mixed Hardwood-Conifer (n=9), O-Oak (n=11), H-Mixed Hardwood (n=2), OH-Oak-Mixed Hardwood (n=3)

^bP-Present at <.5% cover.

^cTotal coverage may not equal sum of species' coverages due to rounding of values.

^{**}Non-native species.

very common in the understory as well (Table 18). One-half of the cover type has even-aged hardwoods and pines, approximately 50-60 years old, and the other has 40-65 year old hardwoods and pines in their 90's. These stands have one of the richest seedling layers, with numerous trees and shrubs (Table 19). The herbaceous cover in these stands is low also, most likely due to the dryness of the sites (Table 20).

The oak-conifer cover type extends over approximately 20% of this part of Fort Harrison also. Six oak species and loblolly pine are the most important trees in the overstory. In most of these stands the oaks are older than the pines, where past disturbance opened up gaps large enough for pine to become established. Both oaks and mixed hardwood trees are common in the understory (Table 18). With one of the most species rich seedling layers, shrub species contributed the most seedlings (Table 19). Herbaceous species, however, are not a large part of the vegetation in this type (Table 20).

The mixed hardwood cover type grows along the drainages of this unit. Yellow poplar dominates this type (Table 17), whose trees ranged from 70 to 130 years in age. Sweet pepperbush and sweet bay make this the densest understory of all types at Fort Harrison (Table 18). These stands also have the highest number of seedlings, most of which are sweet pepperbush and blueberry (Table 19). The dense understory and seedling layers prevent an herbaceous layer from thriving (Table 20).

White and southern red oak dominate the oak cover type (Table 17), which has stands which range from young (40's) to old (100 + years) and have the richest overstory of all types. Mixed hardwoods are the most common trees in the understory though (Table 18). Shrubs species make up most of the seedling layer (Table 19), and herbaceous species are scarce (Table 20).

The oak-hardwood cover type also grows in the moister areas, often close to mixed hardwood stands. The oaks and yellow poplar which dominate this type (Table 17) range in age from 70 years to approximately 130. Shrub species make up most of the understory and seedling layers (Table 18 & 19). These stands have the most species rich herbaceous layers, though only 6% of the forest floor is covered by herbs (Table 20).

Vegetation of Drewry's Bluff

Drewry's Bluff is a small, 15.7 ha unit, 66% of which is forested, that overlooks the James River to the northeast. Behind the steep bluff the topography is fairly even except where a stream cuts across the unit and then down towards the river. The fort, and its light forest cover of oaks and mixed hardwoods, occupies a large portion of the unit. Historically, the fort and the surrounding uplands were relatively clear, with scattered trees, and pines grew where the Exxon industrial complex now is to the west of the unit. The stream that drains the area was covered by hardwoods and brush, similar to today. The forest at Drewry's Bluff is now primarily oak and oak-mixed hardwood of intermediate-aged and old-aged stands (Figure 8). Loblolly pine, sweetgum, and several oak species dominate. Overall, the forest was healthy at this unit, and exotic species were not common in the forest. Pine beetle sign was frequently seen around the unit, but its occurrence was scattered.

The oak-mixed hardwood cover type covered the actual fort area and the steep slopes along the drainage and the river. The oak cover type, dominated by white oak, other oaks, and sweetgum (Table 21), was on the upland sites, and had an average canopy height of 21 m. Several tree species occupy the understory (Table 22). Strawberry bush and muscadine grape seedlings are the most numerous, however, tree species also grew in the seedling layer (Table 23). The herbaceous layer is not very dense (Table 24).

A 55-year-old loblolly pine plantation near the entrance of the unit has no understory species due to the dense overstory, although its only 13 m high (Tables 21 & 22). Sweetgum is the most numerous tree species in the seedling layer (Table 23); as the pine die off sweetgum may take its place. Japanese honeysuckle dominates the herbaceous layer of this stand (Table 24).

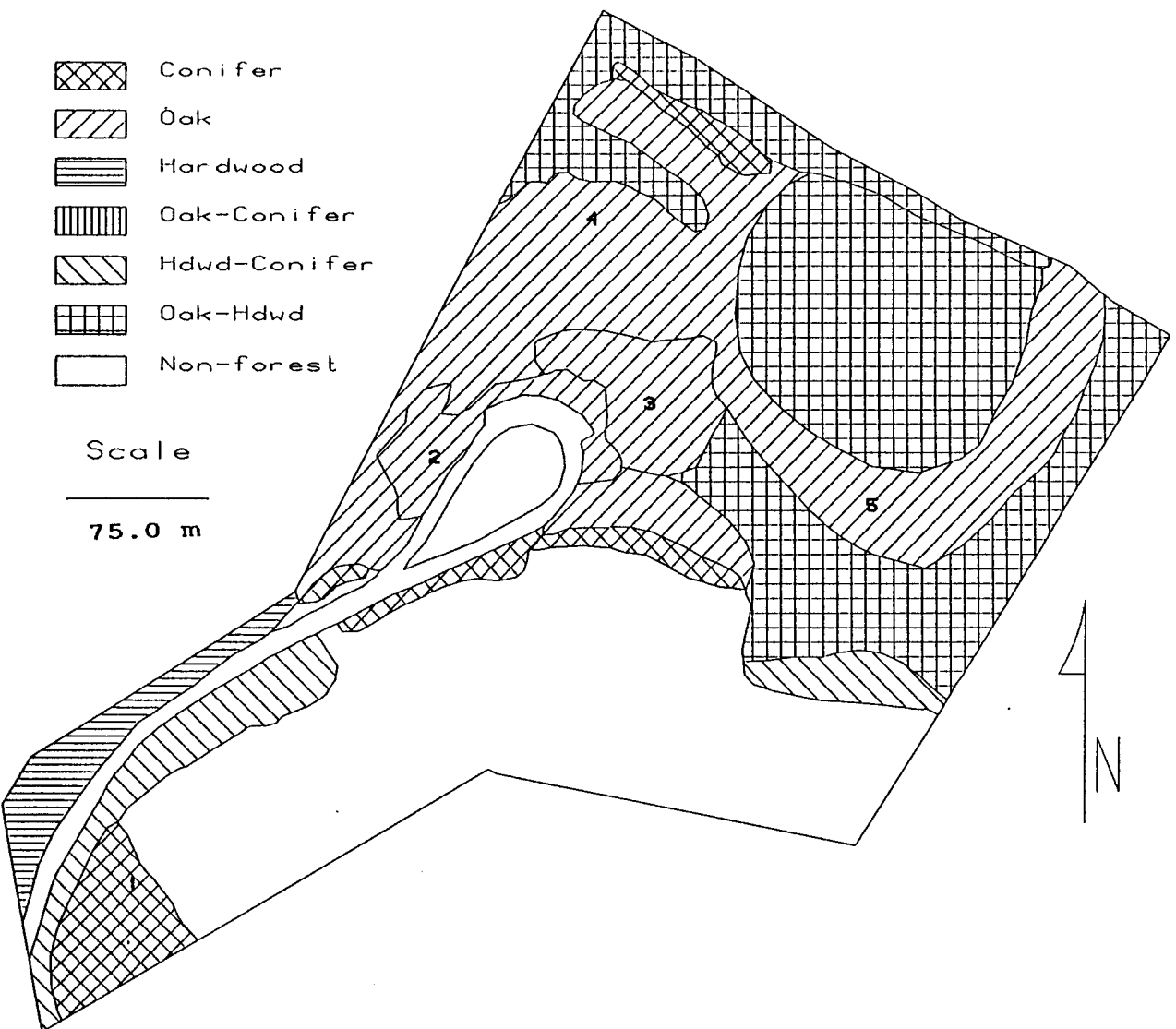


Figure 8. Forest cover types and plot locations at Drewry's Bluff, RICH, Virginia. Numbers indicate plot locations. (Note: Lines within cover types signify a change in stand age that was noted from the aerial photo and included in the Geographic Information System files, from which this map is generated.)

Table 21. Overstory species basal area, density, frequency and importance values for two cover types at Drewry's Bluff, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Conifer Cover Type (n=1)				
<i>Pinus taeda</i>	35.0	2,905	100	100
Total	35.0	2,905		100
Oak Cover Type (n=4)				
<i>Carya glabra</i>	0.6	8	25	3
<i>Fagus grandifolia</i>	1.3	6	25	3
<i>Liquidambar styraciflua</i>	5.0	516	100	31
<i>Liriodendron tulipifera</i>	0.6	6	25	2
<i>Nyssa sylvatica</i>	1.9	41	50	7
<i>Pinus taeda</i>	2.5	40	75	9
<i>Quercus alba</i>	8.1	85	75	17
<i>Quercus prinus</i>	0.6	59	25	4
<i>Quercus rubra</i>	3.1	50	75	10
<i>Quercus velutina</i>	4.4	82	50	11
<i>Ulmus alata</i>	0.6	16	25	3
Total	28.7	909		100

Table 22. The average density and diameter breast height of the understory species in two cover types at Drewry's Bluff, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Density ----stems/ha---	DBH --cm--
Conifer Cover Type (n=1)		
Total	0	--
Oak Cover Type (n=4)		
<i>Acer rubrum</i>	1,125	1.4
<i>Carya tomentosa</i>	563	2.1
<i>Cornus florida</i>	125	3.4
<i>Diospyros virginiana</i>	63	0.7
<i>Euonymus americanus</i>	125	0.2
<i>Fagus grandifolia</i>	63	3.2
<i>Juniperus virginiana</i>	63	0.3
<i>Liquidambar styraciflua</i>	313	2.9
<i>Nyssa sylvatica</i>	125	1.9
<i>Prunus serotina</i>	63	1.2
<i>Quercus alba</i>	625	2.3
<i>Quercus rubra</i>	125	2.3
<i>Quercus velutina</i>	125	1.4
<i>Vaccinium formosum</i>	63	1.6
Total	3,566	

Table 23. Average number of seedlings/hectare in two cover types at Drewry's Bluff, RICH, Virginia.

Species	Cover Types ^a	
	C	O
	-----seedlings/ha-----	
<i>Acer rubrum</i>	0	2,500
<i>Azalea</i> sp.	0	3,125
<i>Campsis radicans</i>	5,000	625
<i>Carya tomentosa</i>	0	5,625
<i>Euonymus americanus</i>	0	36,875
<i>Fagus grandifolia</i>	0	625
<i>Liquidambar styraciflua</i>	12,500	2,500
<i>Liriodendron tulipifera</i>	0	625
<i>Nyssa sylvatica</i>	0	625
<i>Pinus taeda</i>	2,500	0
<i>Prunus serotina</i>	0	4,375
<i>Quercus alba</i>	0	8,750
<i>Quercus falcata</i>	0	625
<i>Quercus rubra</i>	0	625
<i>Smilax rotundifolia</i>	5,000	1,875
<i>Toxicodendron radicans</i>	0	625
<i>Vitis rotundifolia</i>	12,500	16,875
Total	37,500	86,875

^aC-Conifer (n=1), O-Oak (n=4)

Table 24. The percent cover of herbaceous and woody vine vegetation in two forest cover types at Drewry's Bluff, RICH, Virginia.

Species	Cover Type ^a	
	C	O
	-----percent cover-----	
<i>Carex</i> spp.	1	P ^b
<i>Chimaphila maculata</i>	0	P
<i>Galium</i> sp.	0	P
<i>Lonicera japonica</i> ^{**}	5	0
<i>Polygonatum biflorum</i>	0	P
<i>Polystichum acrostichoides</i>	0	2
<i>Toxicodendron radicans</i>	0	P
<i>Uvularia</i> sp.	0	1
<i>Vitis rotundifolia</i>	1	3
Total ^c	7	7

^aC-Conifer (n=1), O-Oak (n=4)

^bP-Present at <.5% cover.

^cTotal coverage may not equal sum of species' coverages due to rounding of values.

^{**}Non-native species.

Vegetation of Parker's Battery

Parker's Battery is a 4.0 ha forested unit with a flat topography that has been dissected with earthworks and bounded by railroad tracks and power lines. Light oak-conifer forest covers the main area once cleared for interpretation purposes. The remaining forest is a mixture of young and intermediated-aged conifer and oak-conifer cover types dominated by loblolly pine and southern red oak (Figure 9). The canopy averaged 21 m in height. Pine bark beetle was noted in all these stands, but the trees appeared healthy overall. Several 100 + year-old oaks were scattered around this unit, and are remnants of the previous vegetation, which historically was probably open except for scattered hardwoods and pines. Exotic species were not noticed in the forest of this unit.

Loblolly pine, 50 to 60 years old, and southern red oak, approximately 40 years old, are the most important species of the overstory in the conifer cover type (Table 25). Oak and mixed hardwood species make up the understory (Table 26) and some of the seedlings (Table 27). The majority of the seedling layer and herbaceous cover in the pine stands was Muscadine grape and Virginia creeper (Table 27 & 28).

The intermediate-aged oak-conifer stands are also dominated by loblolly pine and southern red oak (Table 25). Mixed hardwoods and small tree species, such as sassafras and dogwood (*Cornus florida* L.), make up the understory (Table 26) and along with Muscadine grape, the seedling layer (Table 27). Vine species comprise most of the sparse herbaceous cover in these stands as well (Table 28).

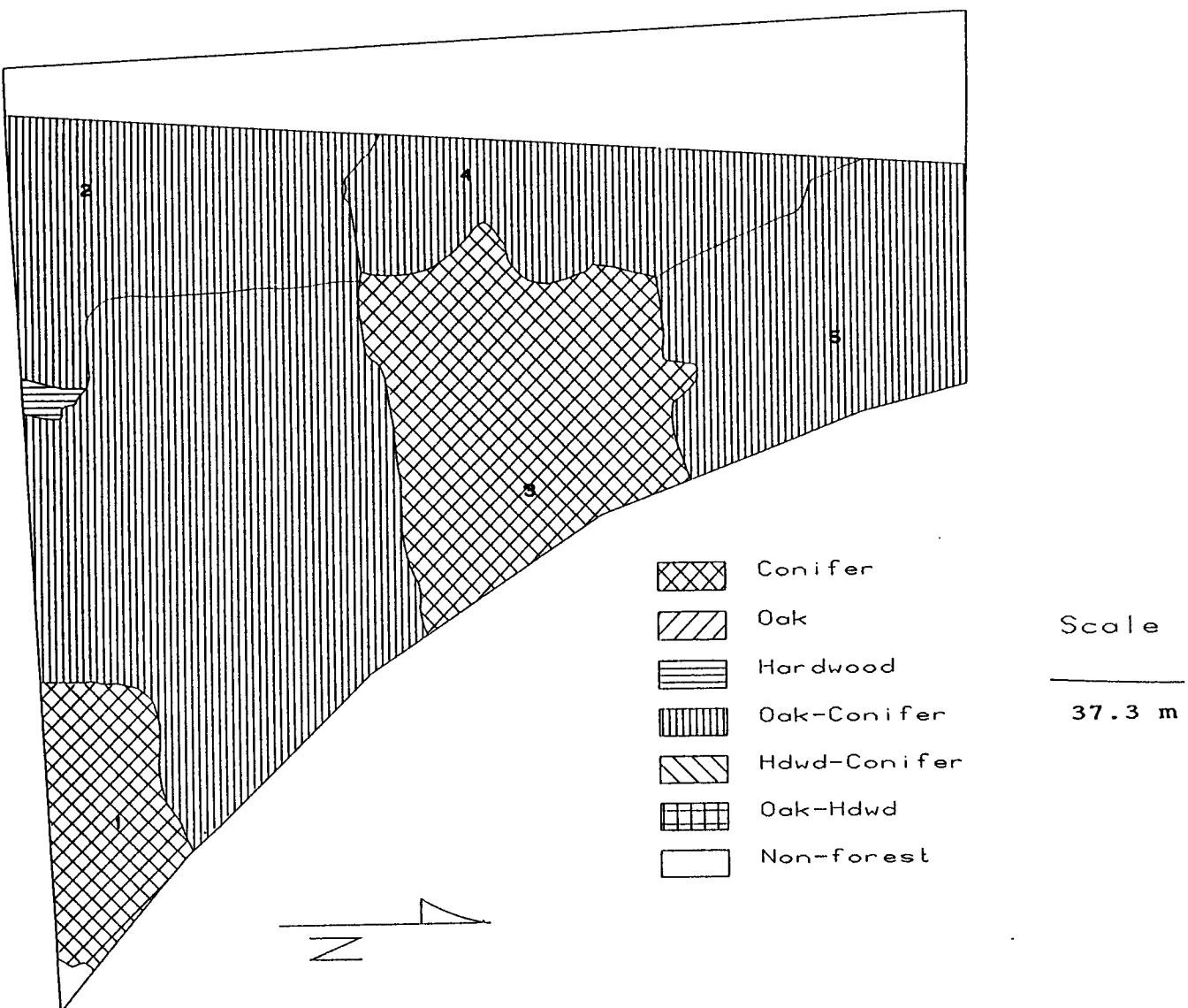


Figure 9. Forest cover types and plot locations at Drewry's Bluff, RICH, Virginia. Numbers indicate plot locations. (Note: Lines within cover types signify a change in stand age that was noted from the aerial photo and included in the Geographic Information System files, from which this map is generated.)

Table 25. Overstory species basal area, density, frequency and importance values for two cover types at Parker's Battery, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Basal Area (m ² /ha)	Density (stems/ha)	Frequency (% plots)	Importance Value (percent)
Conifer Cover Type (n=2)				
<i>Acer rubrum</i>	1.3	17	50	6
<i>Liquidambar styraciflua</i>	1.3	34	50	6
<i>Nyssa sylvatica</i>	1.3	104	50	8
<i>Pinus echinata</i>	1.3	32	50	6
<i>Pinus taeda</i>	20.0	335	100	39
<i>Quercus falcata</i>	3.8	620	100	29
<i>Quercus velutina</i>	1.3	31	50	6
Total	30.3	1,173		100
Oak-Conifer Cover Type (n=3)				
<i>Acer rubrum</i>	0.8	16	33	4
<i>Cornus florida</i>	0.8	52	33	6
<i>Carya tomentosa</i>	0.8	71	33	7
<i>Liquidambar styraciflua</i>	1.7	61	33	7
<i>Nyssa sylvatica</i>	0.8	229	33	13
<i>Pinus echinata</i>	0.8	6	33	4
<i>Pinus taeda</i>	9.2	169	100	26
<i>Quercus falcata</i>	8.3	170	100	25
<i>Quercus velutina</i>	2.5	52	33	8
Total	25.7	826		100

Table 26. The average density and diameter breast height of the understory species in two cover types at Parker's Battery, RICH, Virginia. Number of plots (n) are indicated for each cover type.

Species	Density	DBH
	----stems/ha---	--cm--
Conifer Cover Type (n=2)		
<i>Acer rubrum</i>	375	0.5
<i>Carya tomentosa</i>	125	0.8
<i>Ilex opaca</i>	250	1.6
<i>Nyssa sylvatica</i>	125	1.8
<i>Prunus serotina</i>	125	0.1
<i>Quercus alba</i>	250	1.0
<i>Quercus falcata</i>	125	1.8
<i>Quercus velutina</i>	125	2.7
<i>Vaccinium stamineum</i>	250	0.8
Total	1,750	
Oak-Conifer Cover Type (n=3)		
<i>Acer rubrum</i>	167	1.8
<i>Cornus florida</i>	167	2.4
<i>Ilex opaca</i>	83	7.2
<i>Juniperus virginiana</i>	167	3.6
<i>Liquidambar styraciflua</i>	83	1.1
<i>Nyssa sylvatica</i>	167	0.6
<i>Quercus velutina</i>	83	3.4
<i>Sassafras albidum</i>	250	3.3
<i>Vaccinium formosum</i>	83	1.6
Total	1,250	

Table 27. Average number of seedlings/hectare in two cover types at Parker's Battery, RICH, Virginia.

Species	Cover Types ^a	
	C	OC
	-----seedlings/ha-----	
<i>Acer rubrum</i>	0	833
<i>Amalanchier arborea</i>	0	833
<i>Campsis radicans</i>	3,750	0
<i>Carya tomentosa</i>	0	833
<i>Cornus florida</i>	0	1,667
<i>Crataegus</i> sp.	1,250	0
<i>Diospyros virginiana</i>	1,250	0
<i>Nyssa sylvatica</i>	3,750	833
<i>Parthenocissus quinquefolia</i>	8,750	0
<i>Prunus serotina</i>	0	1,667
<i>Quercus alba</i>	1,250	0
<i>Quercus stellata</i>	0	3,333
<i>Quercus velutina</i>	2,500	0
<i>Sassafras albidum</i>	0	2,500
<i>Smilax rotundifolia</i>	1,250	3,333
<i>Smilax</i> sp.	0	1,667
<i>Toxicodendron radicans</i>	0	1,667
<i>Vaccinium corymbosum</i>	0	1,667
<i>Vaccinium pallidum</i>	3,750	0
<i>Vaccinium stamineum</i>	0	3,333
<i>Vitis rotundifolia</i>	52,500	18,333
Total	80,000	42,499

^aC-Conifer (n=2), OC-Oak-Conifer (n=3)

Table 28. The percent cover of herbaceous and woody vine vegetation in two forest cover types at Parker's Battery, RICH, Virginia.

Species	Cover Type ^a	
	C	OC
	---percent cover---	
<i>Carex</i> sp.	0	P ^b
<i>Chimaphila maculata</i>	P	0
<i>Lonicera</i> sp.	0	P
<i>Parthenocissus quinquefolia</i>	2	0
<i>Toxicodendron radicans</i>	0	P
<i>Vitis rotundifolia</i>	5	3
Total ^c	7	6

^aC-Conifer (n=2), OC-Oak-Conifer (n=3)

^bP-Present at <.5% cover.

^cTotal coverage may not equal sum of species' coverages due to rounding of coverage values.

Vegetation Management Recommendations

General Management Activities

Management of Healthy Forests

The management of forests requires an awareness of the "natural processes" that occur in forest ecosystems with the incorporation of environmentally responsible vegetation maintenance and protection activities. Forest succession is natural, and changes of stand composition and structure can be allowed to follow natural courses when they coincide with park objectives. Fire, insects, and disease, however, although "natural" and part of the dynamics that maintain healthy forests, need to be carefully monitored and controlled in forests managed for most objectives other than wilderness. In forests surrounded by development, such as those in RICH, these natural forest maintenance forces must often be continually monitored and carefully controlled or eliminated. The first step for managing healthy park forests is to become familiar with the current forest in the Park, by noting the species, size, density, age, and health of the trees in the stands, and regularly visiting the stands to notice recent disturbances due to natural or man-made forces. Following this, the manager must determine the objectives for the forest and park, understand the natural processes affecting the forest, and determine if human interaction is needed to reach the desired forest condition. The actual silvicultural activities, and monitoring their impacts, are the final steps.

In managing the forest of RICH, it should be recognized that dead or dying trees due to succession are part of natural changes in healthy forest stands. Natural forest stands will always contain dead or dying trees as they move from pioneer to climax stages of succession. The "climax" vegetation of the upper coastal plain in Virginia is deciduous hardwoods. Many of the stands in RICH are dominated by these species already, with both mature stands or younger ones that have entered the climax stage. Where pines dominated the pioneer stage in these stands, the pine stems are now either dead snags or decomposing on the forest floor, depending on the time since the transition from pine to the more advanced successional stage was initiated. The appearance of these stands should not be labelled unhealthy but rather transitional. Young trees and seedlings in the understory should be evidence that the forest is still growing vigorously. Dead standing trees and logs on the ground are more than signs of death; they are sources of food and shelter for

wildlife, numerous invertebrates, and countless species of microorganisms. They also hold nutrients for the young forest vegetation that are released as they decompose.

Toward the objective of RICH to maintain healthy forests, the natural process of succession should be allowed to proceed throughout the park without human intervention, except where other objectives, such as fuel hazard reduction, require additional maintenance activities. Insects and diseases that infest a stand, killing the dominant trees prematurely, are short-term disturbances that often simply move the stand towards its next stage of succession. Natural disturbances such as these, plus windstorms, ice storms, and other events, are nature's way of cleaning, opening up and regenerating forest stands.

Forest management can determine how forests react to disturbances. For example, pine stands may have been more resistant to bark beetle attacks before forest fire control was the norm. When fire regularly occurred in the stands, it thinned out understory hardwoods and pines and promoted the healthiest pine trees. Fire suppression in the south has resulted in denser pine stands with more potentially unhealthy individuals that are less able to resist beetle attacks today. Prescribed fire is an excellent management tool for southern pine forests and should be used in maintenance activities when possible.

Where results of disturbances cannot be tolerated for reasons of public safety, visual appearance (dead trees can look unhealthy to visitors), fuel buildup problems, or large-scale occurrences, they can be controlled by eliminating the disturbance. Spraying insects, cutting diseased trees, and putting out fires are common practices in intensely managed forests. Carefully planning activities, and not proceeding with them until the consequences of today's actions on tomorrow's forest are known, will promote healthy and vigorous forests for the future.

The season when such silvicultural practices are performed can affect their impact and success, and should be considered when planning work to meet a forest vegetation management objective. In general, the effects of the activity on the residual vegetation is the main concern. When the objective is to clear out dead or dying trees, such as for fuel hazard reduction, usually a healthy, well-stocked and undamaged residual stand is desired after the work. To remove trees and logs with the least damage to the residual stand, the fall and winter seasons are recommended for the work. The bark and cambial layer of dormant vegetation is less

easily damaged, compared to when it is actively growing, and damaged stems will quickly resprout in the spring. Also, working conditions are usually more pleasant than in spring and summer months.

An additional consideration for planning the timing of silvicultural activities is the impact and impression the work will have on the visitors. The high number of visitors in the summer months may make this time of year undesirable for major forest cutting activities such as scene restoration or vista opening. Late summer or early fall are alternatives to the summer months, but additional work will be needed to control those stems with their root reserves already built up. However, the visibility of a silvicultural activity done during the summer months might be an excellent opportunity for education about forest management practices.

The continued existence and establishment of tree regeneration is key to a healthy future stand. Where forest cover is to remain "natural", succession and an undisturbed understory and forest floor should produce the next generation of overstory trees. In areas to be maintained as light forest cover, as described in the Earthworks Landscape Management Manual (Andropogon Associates, Ltd. 1989), for example, over some areas of earthworks, the regeneration of shade tolerant species should be selectively promoted and protected when understory thinning operations are undertaken. Since these areas typically cover small sites, the identification of individual trees as replacements of the current overstory is possible. In areas with thinned canopies of pines and hardwoods that are to be planted with tall native grasses and maintained with fire, trees will need to be planted to maintain forest cover. To continue to partially shade and diversify the landscape in these areas, plant pine species that will survive the maintenance burning of the forest floor. Longleaf pine (*Pinus palustris* Miller) scattered over the battlefields would lessen the sharp edges between the open battlefield and the hardwood forest. Promoting longleaf pine in the parts of the park that are open and will be managed in a way to support them will maintain a species that may have historically been there, as well as provide an enhanced degree of biological diversity. Loblolly and shortleaf, pine species already found in RICH, are alternative species that would survive regular burning once they are established.

Individual trees, whether they be old-growth specimen trees in the forest or landscape/shade trees near visitors areas, can be cared for intensively to insure good health since these individuals are more

valuable to the park. The scattered old-growth oak and yellow poplar at Watt House are unique in their age and form, and in addition to inspecting them for insect and disease problems, care should be taken with any activities around them that might result in damage or increased stress. Specially planted shade or landscaping trees and shrubs, such as around visitor's centers and historic buildings, should be carefully selected to match the site and appropriately cared for. Intense care with young plants improves the chances of planting success.

Non-native Species: Identification and removal

Due to the long history of non-native American intervention on the lands of the eastern U.S., 21% of the species in the park are exotic, ie. species that were not native to the landscape in pre-European times (Hayden et al. 1988). The National Park Service Natural Resource Guidelines for Exotic Species Management states that control or eradication of exotic species will be undertaken, where feasible, if exotic species cause certain problems (N.P.S. 1991). Control of exotic species can be justified at RICH where they meet specific criteria: threaten to alter natural ecosystems; seriously restrict, prey on, or compete with native populations; cause a major scenic or aesthetic intrusion; or disrupt the integrity of an historic site. Exotic species that are known to reflect the historic landscape in cultural zones may be managed as desirable species however.

Despite the high number of exotic species found in the park, there are actually only a few that are abundant enough to be causing changes in the appearance and plant dynamics of the park's forests, fields and historic sites. These species are Japanese honeysuckle, tree of heaven (*Ailanthus altissima* (Miller) Swingle), princess-tree (*Paulownia tomentosa* (Thunb.) Sieb. & Zucc. ex Steud.), and *Microsegium vimineum* ((Trinius) A. Camus). For example, tree of heaven in the forest edges can block the view of the native species in the stand and crowd out the growth of native edge species, which are important to wildlife and part of healthy forest habitat. The tendency of Japanese honeysuckle to form continuous cover over the forest edge and forest floor, preventing the establishment and growth of native seedlings and herbs, is another example. The best sources for identifying the exotic species in the park are the Flora of Richmond National Battlefield Park publications by Hayden and Johnson (1986) and Hayden et al. (1988), which list the exotic species and the park unit where they were found. Vascular plant manuals, such as Radford et al. 1968, and shrub, tree and flower field guides are useful for identification purposes. The biology of Japanese honeysuckle, tree of heaven, and princess-tree is summarized in Appendix VI.

Due to the small land area and high amount of edge in RICH, control of exotics is only feasible for a few species and in small, highly used areas of the park, where intensive control efforts are cost-effective and will help the park meet its major objective; that of interpreting the historical scene. Most of the park's exotic

species are widespread in the southeastern U.S. and complete extermination of these species on RICH lands will be unlikely. Several exotic species should be considered unwelcome but permanent members of the Park forests for two reasons. The first is that some are not very obvious to visitors and not very influential on the forest ecosystem, being small herbaceous plants, such as money-wort (*Lysimachis nummularia* L.). The second is that some are too difficult to eradicate without harming the environment more than they do, because of their numbers, location and nature, such as *Microsegium vimineum* (Trinius) A. Camus, the short, soft grass carpeting the forest floor in the Malvern Hill bottomland. Intermittent flooding and the extensive coverage of the species on the wetland site make control by herbicides unlikely and undesirable. Other exotics are present in small numbers but not spreading rapidly, such as tree of heaven or princess-tree, found along the road at Chickahominy Bluff. These can be controlled if desired, and frequent monitoring will be necessary to insure complete removal due to their persistence and hardiness. Species which spread rapidly and are altering the landscape and displacing native plants, such as Japanese honeysuckle, are the most destructive exotic species in the park forests and warrant control in selected areas.

Control of many exotic species is difficult because of their ability to sprout when damaged. Cutting tree stems and leaving root systems results in numerous sprouts where one stem once stood, and even pulling up smaller ones by the roots is ineffective when small pieces of root are left to regrow. Herbicides offer an effective control with some species, killing the whole plant including the roots. Herbicides labeled for forestry use in the United States are listed in Table 29 along with woody exotic species that are susceptible to specific herbicide control. Japanese honeysuckle is effectively controlled by foliar applications of herbicide, since it has such a great percentage of foliage compared to stems and roots. On the other hand, tree of heaven is not completely controlled by herbicides, as its root system is so extensive that the chemical is not transported throughout the whole system.

The National Park Service's Integrated Pest Management Information Manual (N.P.S. 1984) contains the policy statement on the use of chemicals for pest control and information on specific pest, disease, or problem vegetation species. The section on exotic weeds addresses species such as Japanese honeysuckle and its control by chemical, mechanical and environmental techniques. Herbicides should only be used as

Table 29. Forestry herbicides for foliar treatments and controlled woody exotic species (from Miller and Mitchell 1990). Note: Labels often change yearly. It is the users responsibility to obtain and consult the most recent herbicide labels available.

Herbicide: ACCORD

Manufacturer: Monsanto

Formulation: glyphosate 4 lb ai/gal 3 lb ae/gal 41.5 percent ai

water-soluble liquid (contains NO surfactants)
foliar active (bound and inactivated in soil)

Controlled species: Honeysuckle (*Lonicera* spp.), young Kudzu (*Pueraria lobata*), Multiflora rose (*Rosa multiflora* (Thunberg))

Herbicide: ARSENAL APPLICATOR CONCENTRATE

Manufacturer: American Cyanamid

Formulation: imazapyr 4 lb ae/gal 43.3 percent ae 54 percent ai

water-soluble liquid
foliar and soil active

Controlled species: Honeysuckle, Kudzu, Multiflora rose

Herbicide: BANVEL 720

Manufacturer: Sandox Crop Protection Corporation

Formulation: dicamba 1.0 lb/gal 13.0 percent ai
+
2,4-D amine 1.9 lb/gal 24.5 percent ai

water-soluble liquid
foliar and soil active

Controlled species: Honeysuckle, Kudzu, Multiflora rose

Herbicide: OUST

Manufacturer: DuPont

Formulation: sulfometuron methyl 75% ai

dispersible granule (to be mixed with water)
soil and foliar active

Susceptible species: Honeysuckle, Kudzu

Table 29. Continued.

Herbicide: ROUNDUP

Manufacturer: Monsanto

Formulation: glyphosate 4 lb ai/gal 3 lb ae/gal 41 percent ai

water-soluble liquid (containing a non-ionic surfactant)
foliar active (bound and inactivated on soil)

Controlled species: Honeysuckle, Kudzu

Herbicide: TORDON 101 MIXTURE

Manufacturer: Dow Agricultural Chemicals

Formulation: picloram 0.5 lb ae/gal 10 percent ai
+
2,4-D amine 2 lb ae/gal 40 percent ai

water-soluble liquid
foliar and soil active

Controlled species: Tree of heaven, Honeysuckle, Kudzu

Herbicide: VELPAR L

Manufacturer: DuPont

Formulation: hexazinone 2 lb ai/gal 25 percent ai

water-soluble liquid
soil active (with some contact activity)

Controlled species: Honeysuckle

directed on the labels, and applicators must be trained and licensed for the specific work they intend to do.

Cultural treatments such as cutting, mowing, or burning are alternative methods of controlling exotics. The small sites near visitor's areas suggested for exotic species control at RICH lend themselves to mechanical methods, which are more labor intensive than chemical applications. Cutting or mowing is an effective way to control tree of heaven if the treatments are persistently done until the root system has run out of reserves and can no longer sprout. Cutting may be necessary every few weeks, therefore these sites must be monitored frequently until the trees have died.

Japanese honeysuckle is not tolerant of fire and prescribed burning used to maintain tallgrasses can control it. The Earthworks Manual (Andropogon Associates, Ltd. 1989) summarizes these recommendations as they relate to earthwork vegetation management, addressing the occurrence of exotic species on park earthworks. This information is found in the "Herbicide Management" section of Management Guidelines for Recommended Forest Cover Types: Forest and Light Forest. Changes in vegetation management activities on earthworks should indirectly lead to exotic species control, especially if fire is incorporated in most areas.

Exotic species control activities should be monitored and documented. Document the activities for future reference in other areas of the park, so that the effectiveness of various control measures can be determined. See the "Exotic Plant Control" section of the Natural Resource Guidelines for Exotic Species Management (N.P.S. 1991) for details on monitoring. In general, the exotic species population should be mapped before treatment, and the monitored after treatment to determine effectiveness. The Guidelines also contain details on determining which species to control and the extent of control, whether it be total eradication or control of population size. For the purposes of RICH, with limited resources and a never-ending flow of plant materials into the small units by animals, birds, wind, and humans, control of exotic species where they interrupt the historic landscape and visitor interpretation is important.

Mowing: Schedules and Alternatives

Mowing is a maintenance activity that is done on many acres of RICH. Primarily roadsides and visitor areas are mowed, but mowing is also used to control woody vegetation within forts and on earthworks. Mowing schedules, or the frequency of mowing, are usually a function of aesthetics. Flowering weeds and grass growing at different rates in an area mowed monthly may look natural to some but neglected to others. If an area of rough grass (native and exotic grasses, weeds, and vines) is supposed to look like turf, it must be mowed weekly. This heavy use of resources (manpower, time, gasoline) is justified in heavily used areas, as it encourages visitors to use the area while protecting them from contact with ticks, chiggers, and poison ivy. However, along roadsides where no visitors are walking, and within the forts and open earthworks, alternatives to intensively mowing every 1-2 weeks should be explored.

One alternative is to mow less frequently; once each month for most areas will easily control most woody plants. Problem plants, such as Japanese honeysuckle or poison ivy, could be controlled by more efficient herbicide treatments, which will kill them rather than prune and stimulate their growth as mowing does. The large areas where reduced mowing is proposed could be converted to "meadows", eliminating the idea that the park is neglecting its duty to keep the open spaces of turf neat and clean.

The mowing of earthworks is a practice that is being phased out. The "rough", grasses and annual weeds, currently growing on the works are being replaced by native tall grass species such as big bluestem or little bluestem (*Andropogon gerardii* Vitman, *A. scoparium* Michx.)(Andropogon Associates Ltd. 1991). The tall grass community is managed with prescribed fire, eliminating the physical disturbance of mowing and also indirectly controlling the spread of exotics such as Japanese honeysuckle. The conversion to native tall grass or other native meadow species is an alternative cover for much of the open areas within the park. Native warm season grasses were once more common in Virginia and North Carolina, but their populations were reduced by plowing, overgrazing, and fire protection (Capel 1992). Perennial grasses and flowers, annually maintained with prescribed burning or bush-hogging, would add a new plant community to the park, increasing the plant diversity of the park without requiring natural zoning. Bird, insect, and small mammal communities would benefit from the additional undisturbed habitat, visitors would have a new example of

native plants to observe growing and blooming, and the expense of maintenance would be considerably reduced after the meadows are established.

In larger areas, like Cold Harbor and Fort Harrison, prairie plants benefitted by fire could be established among and along the earthworks revegetated with *Andropogon*, and these areas included in the annual controlled fires used for managing the *Andropogon* species. Small parts of these areas could be maintained at a time to break up the blackened areas for aesthetic and erosion prevention reasons. Burning is not necessary for maintaining these prairie plants, however, so roadsides, where burning is not an option, could also be planted with these species. Annual bush-hogging will control the invasive woody plants once the perennial species are well established.

The following are some general recommendations by Smith (1980) for establishing a meadow, or prairie, with native tall grasses and flowering herbs. A prairie is primarily a grassland, with 59 to 85 percent of the area covered by grasses.

Planning:

1. Select plant species that match the soil, topography and exposure of the site. The site should have 70 to 100 percent full sunlight. Sandy soil with good drainage is preferable. Prairie plants will tolerate a wide range of soil fertility and acidity. For suggestions of species for RICH see Table 30. Capel (1992) lists the best cultivars of the warm season grasses for Virginia. Before purchasing seeds or plants, discuss the species selection with the nursery to confirm that the variety to be planted matches the particular site and soils.
2. Select plant species to try for continuous color throughout the growing season, plan to plant species so they dominate small areas, then flow into another species' area, giving an unmanaged look. Smith (1980) lists species by color and flowering time, and nurseries and seed suppliers can also supply this information for the particular species they sell.
3. On large areas, leave space for a firebreak.

Site Preparation:

1. Site preparation should begin in late summer, the year before establishment is to done. This gives parts of two growing seasons to eliminate species that compete with prairie plants. The most persistent of these are the cool-season grasses.
2. The roots and rhizomes of cool-season grasses must be exposed to sun or frost to be killed. On large areas, plowing plus periodic cultivation with a spring-tooth harrow will work them to the surface and exposure. Herbicides are an alternative to disturbing the soil surface with a plow. Proper selection and timing of application should kill the undesirable plants and not

Table 30. Warm season grasses and perennial forbs for meadow plantings at RICH, Virginia*.

Scientific Name	Common Name
Warm Season Grasses	
<i>Andropogon gerardii</i> Vitman	Big Bluestem
<i>Andropogon scoparium</i> Michaux	Little Bluestem
<i>Andropogon virginicus</i> L.	Broom Sedge
<i>Bouteloua curtipendula</i> (Michaux) Torrey	Side-oats Grama
<i>Panicum virgatum</i> L.	Switch Grass
<i>Sorghastrum nutans</i> (L.) Nash.	Indian Grass
<i>Tripsacum dactyloides</i> L.	Eastern Gamma Grass
Forbs	
<i>Aquilegia canadensis</i> L.	Wild Columbine
<i>Asclepias incarnata</i> L.	Swamp Milkweed
<i>Asclepias tuberosa</i> L.	Butterfly-weed
<i>Aster pilosus</i> Willd.	Frost Aster
<i>Aster vimineus</i> Lam.	Small White Aster
<i>Echinacea purpurea</i> (L.) Moench.	Purple Coneflower
<i>Helianthus tomentosus</i> Michaux	Sunflower
<i>Heuchera americana</i> L.	Alumroot
<i>Liastris spicata</i> (L.) Willd.	Dense Blazing Star
<i>Monarda fistulosa</i> L.	Wild Bergamot
<i>Monarda punctata</i> L.	Spotted Horsemint
<i>Oenothera fruticosa</i> L.	Sundrops
<i>Solidago juncea</i> Aiton	Early Goldenrod
<i>Solidago nemoralis</i> Aiton	Grey Goldenrod
<i>Solidago speciosa</i> Nuttall	Showy Goldenrod

*Suggestions taken from Capel (1992), Smith (1980), and catalogs from eastern nurseries specializing in native plants.

harm the young prairie plants the following planting season. The dead sod should be broken up to expose the soil where it forms thick mats before planting.

Collecting Seed and Plants:

1. There are nurseries in and near Virginia that specialize in native perennial meadow plants. Purchasing seed from nearby sources is preferable, to improve the chances that the plants are adapted to the soil and climate of RICH. The costs involved will vary with the seed company and mixes purchased; sources should be contacted for estimated costs.
2. See Appendix VII for lists of sources for seed and young plants of prairie grasses and forbs.

Planting and Maintaining a Prairie Site:

1. Attempt to plant a ratio of 70-80% grasses to 30-20% forbs. Combining 5 to 7 grass species with 15 to 20 forb species is suggested; a study of prairie relics in Wisconsin found that only 19 species, of the 237 species found in the prairies, occurred in most of the stands. Daisy family and legume species are suggested, as they are sturdy and dependable. Plus, the legumes improve the soil with their nitrogen-fixing capacity.
2. Seeding rates vary with species and location. Survival and germination are affected by seed quality, site, rainfall, erosion, and temperature. Sowing of grasses on large areas can be done mechanically. Hand-broadcasting of forbs in smaller areas will break up the lines created by the mechanical planters. Handplanting should be done in no more than a slight breeze, throwing seeds in a half-circle ahead of the sower. A hand-operated whirlwind seeder is useful in sowing dense seeds, such as legumes, but not fluffy ones. After handplanting, the soil surface should be dragged with a cultipacker. Seeding should be timed for fast germination and early growth before the hot dry part of summer begins. Allow annual weeds, whose seeds were stored in the soil, to act as an early nurse crop for the prairie plants, and to protect the soil surface from wind and rain.
3. Transplants are practical in small areas (700 square meters or less). Transplanting should be done when the plants are dormant in the fall. Soil should be worked deeply, and kept moist. Protect the new transplants from the sun. If the young plants show a lack of vigor, treat them with a liquid fertilizer.
4. Weed control is most important during the first summer. Mowing may be done with a rotary mower set 5 to 8 inches or high enough to not injure the prairie species. Weeds should be mowed before they become too tall or dense, or set seed, about 30 days after planting. Expect to mow 3 or 4 times during the first summer. On large areas surrounded by cool-season grasses that will invade, a disked or plowed strip 6-10 feet wide will control invaders and serve as a firebreak. Do not disturb the soil in the planted prairie, as this will only encourage more annual weeds.
5. By the second year, the site should begin to look like a prairie, with grasses and forbs blooming and bearing seed. Replanting of missing species or additional species should be added now. Again, mow back the annual weeds in May-June back to 5-8 inches, before the prairie plants reach a height that they will be affected by mowing. Control woody species selectively with herbicides.
6. By the third year, the prairie plants should be crowding out the competition. After the third year, or fourth, burning can be considered to stimulate growth, break-up organic matter for

fertilizer, and kill woody invaders and cool-season grasses. Burning is usually done in the early spring every 3 to 4 years; on light soils it may be less often. Burning only half of the prairie at a time protects wildlife. Redisk the firebreak before burning. On small sites where burning is not desirable, remove accumulated waste by cutting and raking in the early spring.

Methods are also described for establishing warm season grasses by Capel (1992), and most seed company catalogs have useful establishment information. Lyons (1993) also produced a summary of techniques for a wildflower meadow that have been successful in Virginia. In summary, although the initial establishment phase is labor-intensive, meadows are low maintenance over the long-term, requiring a prescribed burn every few years or annual mowing.

Screening: Species and Methods

Vegetation screens are attractive and simple ways to create a park-like feeling for visitors by blocking views of development with thick masses of trees and shrubs. This is especially desirable in areas of RICH where housing developments and businesses on nearby properties disrupt the scene to be interpreted for historical reference. Most screens need to be planted, but some are already partially present in areas that have seeded in naturally with forest or fence-row vegetation. Species selection should be based on the qualities of the sites: whether they receive full, partial or no sun, whether the soil is well- or poorly- drained, soil moisture, soil pH, and the suitability of the soil for forest and field plants. All of the sites recommended for screening plantings have soil pH's in the 4.5-7 range, which is suitable for all the plants referenced in this report (U.S.D.A. 1975, U.S.D.A. 1978, U.S.D.A. 1980). Evergreens are preferred as screens as they have foliage year-round. Some species are faster growing than others, and the site quality affects growth rates also. Few species grow quickly in the shade, even when they are tolerant of low light levels. It will take several years before the newly planted screens are effective. Appendix VIII lists deciduous shrubs and small trees with dense foliage, as well as evergreen shrubs, small and large trees that may be used for screens.

American holly and southern magnolia are small to medium-sized trees that grow in the understory of mature forests at RICH, and these would provide a screen in shaded areas if planted at heavy enough densities. Screens will be established quicker and more easily in the sun, since most species recommended for screening grow best in full sun (Flint 1983). Eastern red cedar is an "old field" species that is typically found on abandoned fields and in sunny, disturbed edges. This species has already formed partial screen in places at RICH, such as along the drive into Chickahominy Bluff. Areas such as these will need some additional plants to create a total screen. Holly and magnolia do best in full sun also, so these could be planted along with additional red cedar to create a diverse screen. In addition, shrubs can be planted among the trees for structural diversity and a more complete screen. Many shrubs reach sufficient heights to be effective screens.

Considerations when planting screens are the same as those for planting most seedlings, shrubs, trees, grasses, or forbs. Never allow the roots to dry out by exposing them to wind and sun. Plant on cool days in

the fall and winter seasons, ideally when rain is expected soon. Otherwise, expect to water the plants for a few weeks until the roots get established and/or it rains. Planting dormant seedlings will prevent them from being too stressed by the move. Spacing will depend on the size of the plants; consult with the nursery where purchasing seedlings to learn specific spacings for the species. In general, plant small, bare-root seedlings approximately 1.5-2 meters apart in 3 rows that are offset to prevent holes in the screen when viewed from a distance. Imagine how the trees will fill in as they grow, perhaps finding some in the understory of the forest for examples, using this information to adjust spacing. Plant larger, more expensive trees and shrubs close to their final mature spacing to avoid thinning. If larger trees are to be used for planting, select balled and burlapped over those in containers as the root mass in the balls contains a few days of moisture, unlike those grown in potting material, and the root systems are much less disturbed in the planting process. The costs of establishing vegetation screens will vary with species and size of plants purchased; contact nurseries for estimated costs of plant materials. Monitor the trees monthly after planting to make sure they are well established before the dry, hot months arrive, and replace any that die as early as possible to maintain the density of the screen. As the plants mature, their crowns should intersect and begin to crowd each other. As the screen ages, occasional careful thinnings of a few individuals, those that appear unhealthy or are suppressed, will improve the growth of the remaining and keep them healthy and vigorous.

Earthwork Preservation

The earthworks central to much of the Civil War battlefield interpretation were built in fields and forests during the war. Today, much of the earthworks at RICH are under forest cover, except where regular mowing and clearing has kept them exposed for the public to view. Preservation of these fragile earth mounds depends on the control of erosion and other activities that disturb the soil such as trees on the mounds uprooting or people walking on footpaths over the earthworks. Under undisturbed forest conditions, the sheltering effects of the overstory and understory vegetation have protected the integrity of many of the earthworks. The undisturbed forest also discourages many visitors from entering and exploring the earthworks, resulting in fewer footpaths and less trampling of vegetation and compaction of soil. Problems do exist with earthworks under this cover, however. In some places, the poor soil and dry conditions have prevented total cover from forming, and erosion has occurred. In others, mature trees that have blown over took earthwork soil with their root systems, leaving a gap in the mound. According to the Earthworks Landscape Management Manual (Andropogon Associates Ltd. 1991), however, the forest cover type is one of the best, and least expensive, preservers of the earthworks, and the continued use of forest cover is recommended for the undeveloped areas of RICH. The Earthworks Manual contains excellent information on the various cover types, their establishment and maintenance for earthworks and the areas surrounding them. This publication should be regularly used as a reference for managing earthworks vegetation.

The primary objective for vegetation management on the earthworks is to develop and maintain a cover of plants with a fibrous root system and continuous vegetation to control erosion. Recent decisions to replace labor-intensive mowing that impacts earthworks with less disturbing techniques for earthwork preservation has led to the use of tall grasses for covering earthworks in open areas. Tall grasses such as Andropogon species are replacing areas formerly kept in "rough" grass and annual weeds, and regular burning will be used for maintenance rather than mowing. In areas where burning is not a desirable maintenance option, bushhogging once a year is another tool to maintain the tall grass. Other perennial meadow species, such as those mentioned in Table 30, can be planted along with the Andropogon species to add diversity and color to the works that are also managed by burning or bushhogging. The Earthworks Manual (Andropogon

Associates 1991) and the information in the Mowing section of this report contain details on establishing tall grasses on earthworks, and this can be used for other plants as well.

Earthworks under light forest cover may be the hardest areas to keep vegetated. The understory and forest floor is usually disturbed, trampled or cleared, so the shrubs and herbs naturally found in the forest are not present. The forest overstory shades the works enough to prevent the growth of the shade-intolerant tall grasses. Reclamation of the forest understory is recommended for these areas where the vegetative cover on the earthworks is sparse or non-existent. By selecting and planting shade-tolerant forest shrubs and herbs that are typically found in the forest understory and on the forest floor, a vegetative cover could become established that will protect the earthworks from direct impacts from rain and trespassers. For example, hillside lowbush blueberry, strawberry bush, and partridge berry (*Mitchella repens* L.) are low-growing, shade-tolerant plants found at RICH. Although these species may not be available through nurseries, similar species or cultivars may be found. One consideration is that it may be best not to plant species with edible berries, such as blueberry, that might encourage people to walk on the earthworks. The SCS Plant Materials Centers may assist RICH in propagating some new seedlings from the mature forest plants. Additional plant sources are listed in Appendix VII.

Vistas: Clearing and Maintenance

The maintenance of vistas for interpretation purposes is labor-intensive, as vegetation is continuously regenerating and growing in the areas cleared. The target vegetation should be determined for the area below a vista according to the type of maintenance possible (prescribed burning, mowing, bushhogging, hand-cutting), and then action taken to achieve and maintain the desired condition. At RICH, vista vegetation can be either woody shrubs or meadow. Clearing of the current woody vegetation requires cutting and stump spraying to prevent sprouting. Table 31 contains forestry herbicides that are used for stump treatments. Herbicides approved for use in the park should be applied as directed on the label.

Maintenance of vistas will depend on the target vegetation. If shrub vegetation that naturally regenerates is desired, it will often sprout and grow from the cut stumps of the cleared vegetation. Maintenance will simply consist of cutting the plants back once they are too large for the vista. If shorter shrubs are desired, there may be a need for planting after the current vegetation is cleared and the roots killed. Species such as huckleberry, blueberry, mountain laurel etc., are medium to short-stature shrubs that will dominate an area if given time to become established and shade out the competition. Monitoring and control of exotics such as Japanese honeysuckle would be necessary in these open areas.

Some vistas would be best maintained as meadow. Most perennial meadow plants can be maintained mechanically, by an annual/biannual mowing or bush-hogging, or by prescribed fire. Some vistas, bounded by earthworks, could easily be rehabilitated to meadow along with the nearby earthworks, and maintained at the same schedule. Others may not be suitable for meadowland, and cutting and/or herbiciding of the plants will be required every few years as necessary.

The summer months, when vegetation is actively growing and energy reserves in the roots are low, will be the best time to perform clearing activities for vista creation or other objectives such as scene restoration. Sprouting from damaged or cut stems will not be as great as if the stems were cut or girdled from fire during the winter. By killing small woody stems and herbs while their root reserves are low, their chance of recovery is lessened. This would be beneficial if the objective was to clean out non-desirable species before establishing new species.

Table 31. Forestry herbicides for stump spray treatments and controlled species that occur in RICH (from Miller and Miller 1990). Note: Labels often change yearly. It is the users responsibility to obtain and consult the most recent herbicide labels available.

Herbicide: BANVEL CST

Manufacturer: Sandoz Crop Protection Corporation

Formulation: dicamba 1 lb ae/gal 13 percent ai

water-soluble liquid
foliar and soil active

Rates for stumps: Spray or paint freshly-cut stumps, thoroughly wetting the outside edge

Controlled species: Tree of heaven, cedar, cherry, dogwood, elm, black gum, hawthorne, hickory, hornbeam, maple, oak, persimmon, sassafras, serviceberry

Note: Do not use near desirable plants unless possible injury can be tolerated. Herbicides may contact roots of desirable plants from downward movement in the soil, surface washing, or from excretion by roots of nearby treated trees.

Herbicide: GARLON 3A

Manufacturer: Dow Agricultural Chemicals

Formulation: triclopyr amine 3 lb ae/gal 44 percent ai

water-soluble liquid
foliar active

Rates for stumps: Spray or paint the outer edge of cut surfaces and stubs within 2 hours of cutting

Controlled species: beech, black gum, buttonbush (*Ceanothus* spp.), cherry, chinquapin, choke cherry, hawthorne, dogwood, elm, hornbeam, locust, maples, mulberry, oaks, persimmon, pine, poison oak, sassafras, sweetbay magnolia, sweetgum, sycamore, yellow poplar

Table 31. Continued.

Herbicide: TORDON 101R / TORDON RTU

Manufacturer: Dow Agricultural Chemicals

Formulation: picloram .25 lb ae/gal 5 percent ai
+
2,4-D amine 1 lb ae/gal 21 percent ai

water-soluble liquid
applied to cut surface
both formulations contain anti-freeze

Rates for stumps: Spray freshly cut stumps with undiluted herbicide.

Controlled species: Tree of heaven, cedar, cherry, dogwood, elm, black gum, hawthorne, hickory, hornbeam, maples, oaks, persimmon, serviceberry, sweetbay magnolia

Note: Untreated trees are occasionally affected by root uptake of herbicide leached from treated trees.

Herbicide: TORDON 101 Mixture

Manufacturer: Dow Agricultural Chemicals

Formulation: picloram 0.5 lb ae/gal 10 percent ai
+
2,4-D amine 2 lb ae/gal 40 percent ai

water-soluble liquid
foliar and soil active

Rates for stumps: Spray to wet freshly cut stump with undiluted or 1:1 mixture with water.

Controlled species: Tree of heaven, buttonbush, cherry, elm, black gum, locust, maple, oak, persimmon, pine sassafras, yellow poplar

Note: Untreated trees within a few feet of the treated stumps may be killed or injured.

Agricultural Use Areas

The maintenance of the historic vegetation and landscape through the agricultural leasing program is an economical way to achieve the park's goals to maintain the historical scene. By leasing the land to local farmers, the park forgoes the responsibility of maintaining equipment and expertise on agricultural practices, as well as the actual work of planting and harvesting. The areas are maintained in the historical landscape uses while providing the local community with additional farm products and income. Some of the crops and farming practices on park agricultural leases are not similar to those of the Civil War however. What is important is that the crops selected are consistent with the cultural landscape needs and with the maintenance of a sound environment (N.P.S. 1991). Historic varieties should be considered for use when possible to support genetic variety and the perpetuation of historic species (N.P.S. 1991). Ideally, the planted crops should be similar to those that may have been planted during the Civil War. Hay fields and grains seem most appropriate for the areas around Richmond. Pasture is also appropriate for agricultural areas. Additional considerations for Agricultural Use areas on parklands can be found in the Natural Resources Management Guidelines (N.P.S. 1991).

The current program seems to be working well at RICH. Inspections of the fields should be made occasionally to check for erosion. The farming practices should protect the soil from erosion, not allowing the soil to remain bare for more than a week or two. Also consider having the farmers leave some rows of crop along field borders when harvesting to encourage a wildlife habitat as existed in the days before mechanical harvesters.

Long-term Monitoring

Long-term forest vegetation monitoring for the purpose of assessing change in the forests of RICH could be accomplished through a resurvey of the plots sampled for this study. Although permanent, monumented plots are typically recommended for long-term monitoring in the national parks, as documented in the Vegetation Monitoring with Permanent Plots manual (Russell 1990), this may not be the best method for RICH. Forest stands large enough to harbor permanent plots unaffected by "edge" are rare due to the small size of the units and the stands within them. Another disadvantage to permanent plots at RICH is the high number of visitors at the park that could potentially disturb the forest or the plot monuments within the easily accessed units. However, if consistency in forest monitoring between national parks is desired, permanent plots could be installed in the largest stands in the park following Russell's (1990) manual.

Specific Management Activities

Vegetation Management at Chickahominy Bluff

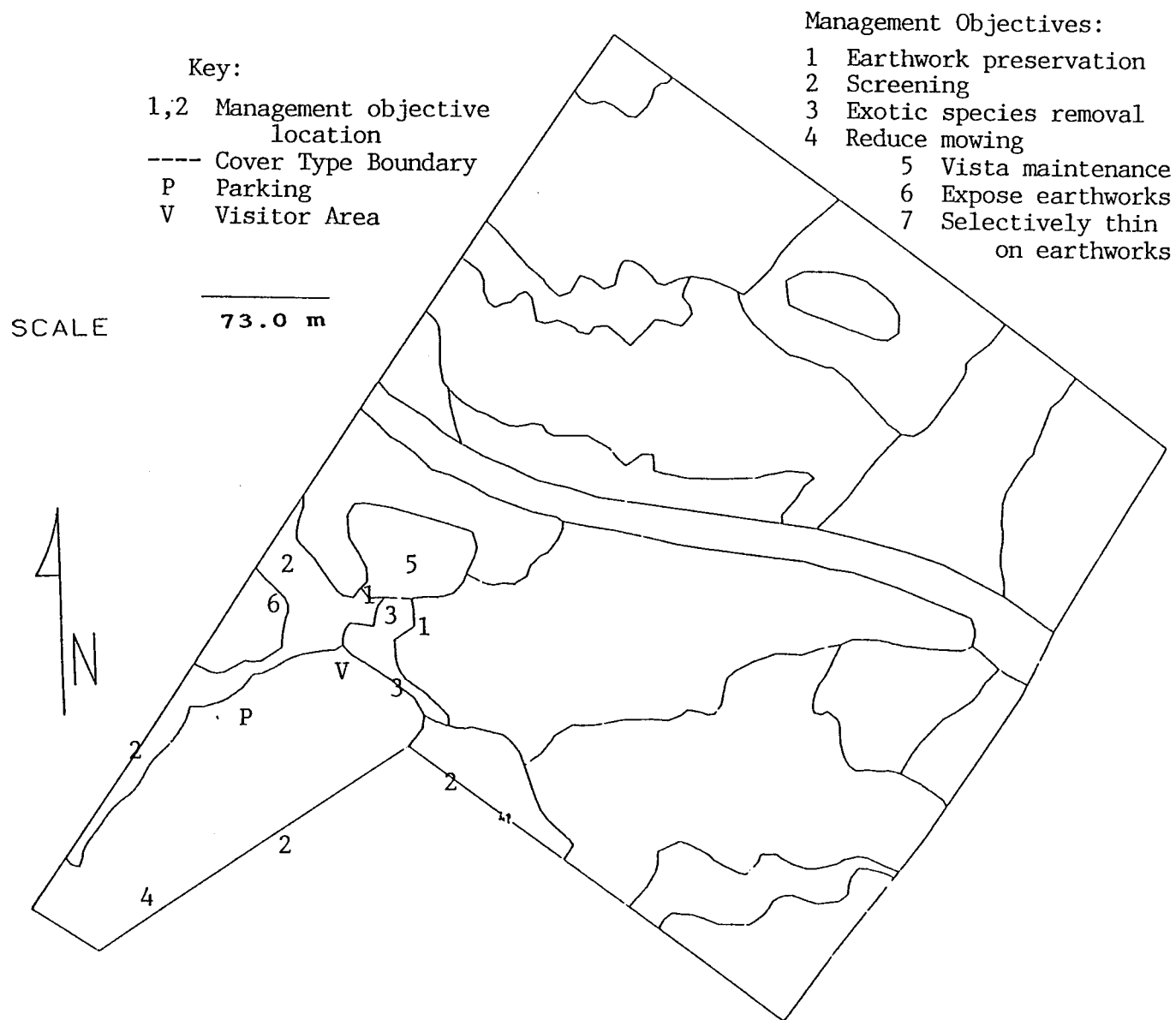
The majority of the vegetation management objectives at Chickahominy Bluff focus on the area where visitor use is high. The following are the main vegetation objectives for the unit:

1. Earthwork preservation;
2. Screening along Rt. 360 and any new development on land to the south;
3. Selective removal of exotic species;
4. Reduced mowing; and
5. Vista maintenance, including maintaining the vista toward Mechanicsville and cutting a vista towards Beaver Dam Creek.
6. Exposure of the earthwork running parallel with Rt. 360 and to the northwest of the observation platform; and
7. Selective thinning of the gun emplacement immediately southeast of the platform (Figure 10).

Earthwork Vegetation Management: Light forest cover occurs over most of the earthworks at Chickahominy Bluff. This is due to both management for this cover type in some areas and visitor impacts, which have trampled forest seedlings and shrubs, in others. Where the earthworks receive almost full sun, near the parking area, earthwork preservation based on tall grasses should be done using the guidelines from the Earthworks Manual (Andropogon Associates Ltd. 1991). Where light forest cover is to be maintained over the long term, consider reestablishing the forest understory where sites have been too disturbed and impacted to regenerate themselves. Increased enforcement of park rules for staying off the earthworks is essential for this effort to be successful. Where the soil is compacted on footpaths, it should be loosened and planted with shade-tolerant understory shrubs and herbs. Consider blueberry or huckleberry, strawberry bush, Christmas fern or any other species seen growing in the local undisturbed forest that are attainable at a nursery. Transplanting a few individuals from a nearby natural forest population is a possibility also. Another alternative is to collect seed and grow new plants, perhaps with the Soil Conservation Service/NPS Cooperative Plant Materials Program. All planting should be done in the fall or early spring, during cool, damp days. Mulch the new plantings with shredded woody material to help keep the soil aerated and moist until the forest litter can naturally accumulate on the sites.

One specific earthwork project at this unit is to expose the earthwork that runs parallel with Route

Figure 10. Vegetation management objectives and locations at Chickahominy Bluff, RICH, Virginia.



360 and to the northwest of the observation platform. When planning which vegetation to remove to expose the earthwork, remember that natural forest cover is one of the best for earthworks (Andropogon Associates Ltd. 1991), and removing it may encourage more visitors to walk upon the works. Consider only thinning small trees and shrubs to the sides of the earthwork, taking care to not disturb the vegetation on the earthwork itself. Select the trees and shrubs that should be left according to their form, species and spacing. Favor tall, straight, trees of native forest species that are spaced well to allow the earthwork to be seen. Cutting should be done after the leaves have come out on the woody stems, and herbicide should be immediately sprayed on the cut stumps to prevent resprouting of the woody plants. By only thinning the trees next to the earthworks, some of the current overstory plus tree regeneration is left to provide future forest vegetation. Also, a forest edge with some understory vegetation between the forested earthworks and the visitor area will form a green barrier to discourage visitors from approaching the earthworks.

The specific objective to selectively thin the gun emplacement to the southeast of the platform should be based on the recommendations for maintaining the target vegetation in the Earthworks Manual (Andropogon Associates Ltd. 1991). Any trees that are thinned will need to be stump treated with an herbicide immediately to prevent sprouting. Ideally, only unhealthy trees, or those that are leaning and may die, fall, and uproot the earthwork, should be removed. Removal of too much of the forest cover lessens the chance that healthy forest will cover will remain on the earthwork in the future. If this earthwork is to be vegetated with tall grasses, the thinning of the overstory may need to be heavier to allow sufficient light to reach the grass.

Screening: Vegetative screening along Rt 360 is fairly adequate at this time. The narrow forest stand that makes up the screen should be left to grow near the parking area and entrance for this purpose. Near the entrance, consider adding additional plants to thicken the screen. In reference to exposing the earthwork along Rt. 360, by only thinning the inner edge of the earthwork that runs along Rt. 360, the vegetation should remain thick enough there to continue as a screen without additional planting. Screening plants should be established along the southern border across from the parking area also, as the development potential of that

piece of property is high. By planting and tending a screen now, it should be effective by the time the lot is developed. Eastern red cedar is recommended for interplanting with those already along the southern fenceline. See the Screening section for additional suggestions.

Exotic Species: Although exotic species occur at Chickahominy Bluff, intense control of them may not be immediately desirable unless they are established where they intrude on the historical scene. Some stems of tree of heaven, white mulberry (*Morus alba* L.) and princess-tree grow along the forest edges, but their presence in the stand along the roadside adds to its screening ability. Plus, control of these few trees may be more trouble than its worth. Japanese honeysuckle is more noticeable along the earthworks and forest trails. The plan to establish tall grasses on some of the earthworks will include weed control measures. Once established, the tall grass maintenance should help control the honeysuckle on the earthworks. Within the forest, openings in the canopy allow honeysuckle to thrive. Control could be attempted with herbicides, but native vegetation around the patches would most likely also be harmed. Manually pulling up the honeysuckle is an alternative in small areas, but its complete eradication in the forest is unlikely as birds can carry and deposit the seeds from other nearby populations.

Mowing: Mowing at Chickahominy Bluff can be reduced to the heavily used visitor areas near the platform, trailhead, and along the sides of the trail, to keep visitor contact with insect pests to a minimum. Establishing meadow species in the field along the road and in the center of the parking area is an alternative to allowing annual weeds and cool-season grasses from getting "weedy" looking and going to seed. See the Mowing section for details on meadow establishment and maintenance.

Vistas: To maintain the vista towards Mechanicsville with less maintenance in the long run, it is suggested that the slope in front of the platform be seeded with native warm-season grasses and forbs, as described in the mowing alternatives section, as an extension of the earthwork tallgrass plantings. Annual mowing, rather than fire, can be used to keep down the woody vegetation and promote the meadow, since this unit is within

the city limits and near a highway. To open a vista towards Beaver Dam Creek, a few of the trees along the eastern edge of the Mechanicsville vista would need to be limbed. It is not recommended that entire trees be cut, as this will encourage more vegetation to grow up along that edge. Consult with a professional tree-cutter for this work.

Vegetation Management at Beaver Dam Creek

The vegetation objectives for this unit are as follows:

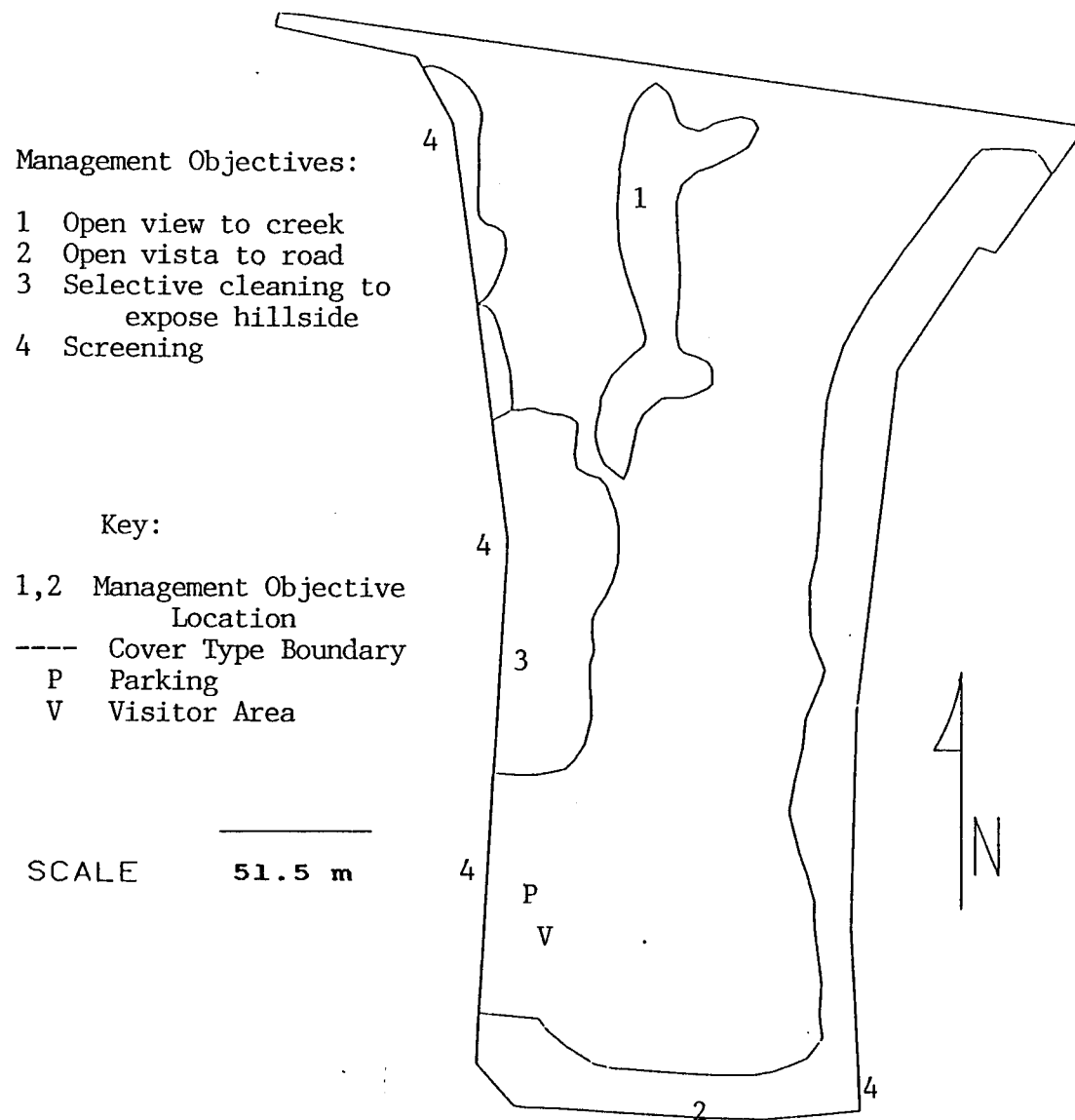
1. Create a view of the creek from the park road;
2. Open vista to road immediately east of creek
3. Selectively clear forest west of parking area to expose the slope to view; and
4. Maintain screening along boundaries (Figure 11).

View and Vista Establishment: The long-term, or "target", vegetation for this unit should be considered before any clearing is done for views through the forest. Although removing the shrubs and woody growth along the banks of Beaver Dam Creek will expose the slope and creekbed to visitors, it will also remove all of the young forest trees that will someday replace those that are now in the overstory. Consider cleaning out strips of vegetation between the road and creek instead of the whole hillside, to keep some regeneration for a future forest in place. Or, try cleaning out only the vines, exotic trees, and small shrub species, such as Japanese honeysuckle, trumpet creeper, poison ivy, and tree of heaven. This may open up the understory enough in places to allow a view of the creek.

Consult the section on vistas for recommendations on establishing this unit's vista to the east of the creek. The selective clearing west of the parking area to expose the slope to view must be done lightly, or the screening already in place from the natural understory shrubs will be lost. Consider just clearing brush and herbaceous plants near the road where disturbance has caused them to grow up, and leave the forest understory as it is to act as a screen.

Screening: Near the top of the western slope and at the park boundary, plant additional evergreen holly or magnolia in the understory to complete the screening where necessary.

Figure 11. Vegetation management objectives and locations at Beaver Dam Creek, RICH, Virginia.



Vegetation Management at Watt House

The main goal of vegetation management at this battlefield is to restore the landscape to the Civil War condition. Specifically, the vegetation objectives are as follows:

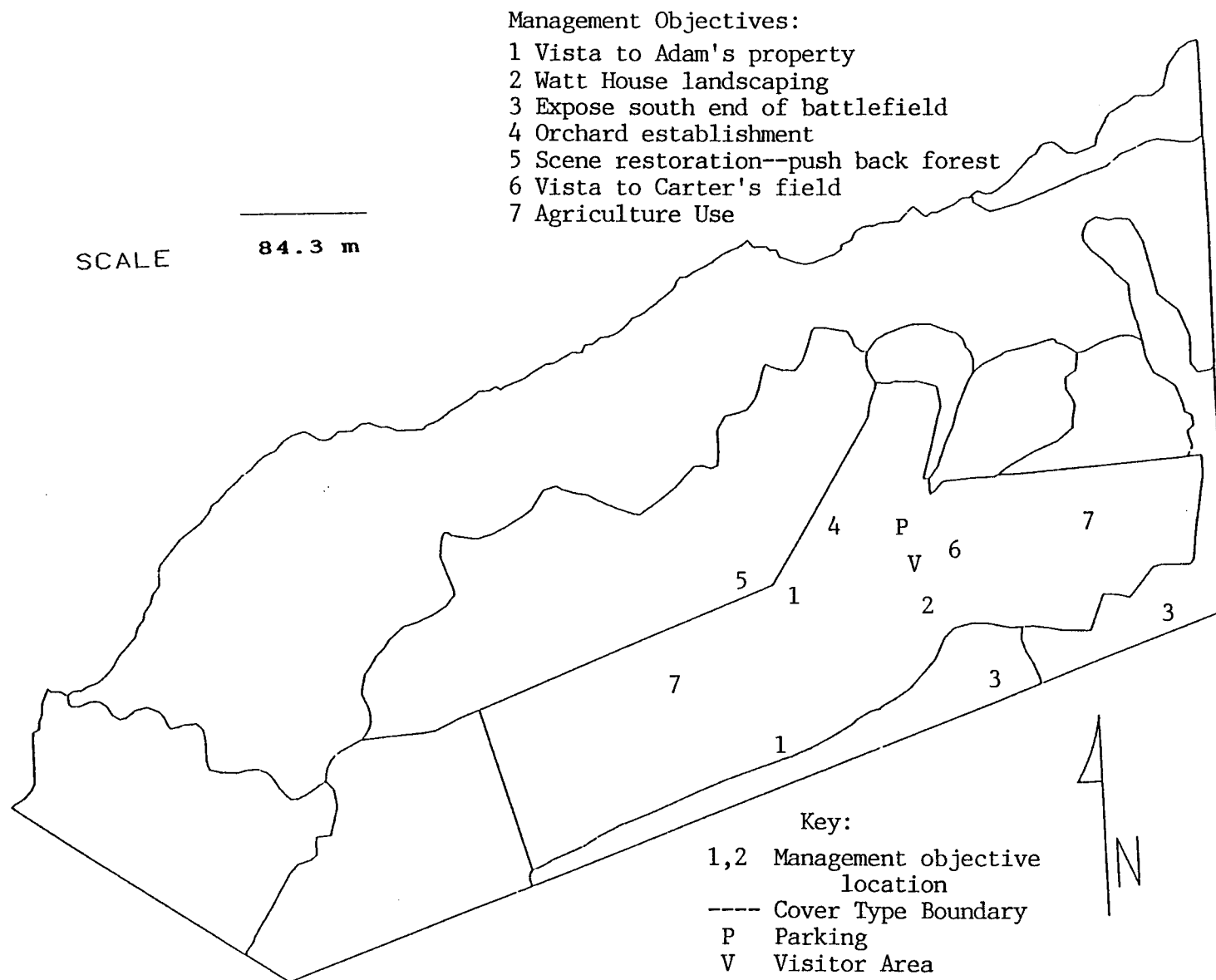
1. Open vista towards Adam's property;
2. Establish historically appropriate vegetation around the Watt House;
3. Expose the southern end of the battlefield through selective removal of screening plants;
4. Establish a peach/apple orchard
5. Scene restoration by returning the forest edge to its 1863 location
6. Open vista between parking area and Carter's field; and
7. Continue the agricultural leasing program (Figure 12).

Vista and View Establishment: Refer to the general recommendations on vista maintenance for this work.

The view of Carter's field is already opened, and the vista towards Adam's property has been improved with the rerouting of the trail. To expose the southern end of the battlefield, "clean" the forest understory, removing vines and controlling the tree of heaven first. Do not remove all of the understory shrubs and tree saplings, as this will eliminate the forest regeneration and replacements for the current overstory trees. The forest edges will require the most work in clearing and maintaining the view, since the area has good growing conditions for fast-growing, weedy species and has species already established that will be difficult to eliminate completely.

Watt House Landscaping: Three old catalpas (*Catalpa speciosa* Engelm.) stand in the yard of the Watt House, along with several mature overcup oaks (*Quercus lyrata* Walter) and eastern red cedar. These trees appeared healthy, however, the catalpa trees have been infested and completely defoliated by the catalpa sphinx moth (*Ceratomia catalpae* Bdv.) larvae for at least two summers. Although the catalpas have refoliated themselves each summer, their age may preclude their surviving such energy drains as this for too many more summers. Consider controlling this pest. Adults appear as early as March in the south, from overwintering as pupa in the soil. They lay eggs on the undersides of leaves or in smaller masses on twigs and branches (Baker 1972). Young larvae feed gregariously; the fast defoliation of the catalpas is evidence of this. Ideally, a control method that would kill the pupa in the ground would be used as an alternative to

Figure 12. Vegetation management objectives and locations at Watt House, RICH, Virginia.



spraying the foliage of these large trees during the summer, when numerous songbirds, some neo-tropical migrants such as summer tanagers and wood thrushes, use them for feeding and perching.

Another alternative is to let "nature take its course", and prepare for the eventual decline and death of these old trees, from age, insects, disease, or lightning (which took one of the oaks in 1991), by planting young shade trees in the yard now. This could be done in conjunction with planting historically accurate shrubbery. Seedlings from the old specimen oaks in the woods have been propagated, and the yard would be an ideal place for planting some of their progeny. Protect the young seedlings from browsing animals and mowers for a few years with plastic tubes, which will also encourage height growth on the trees. In addition, historically appropriate shrubs could be planted around the house.

Orchard Establishment: An orchard with peach trees grown from historic stock is already established and growing well near the Watt House. Consider expanding the orchard into the field created from the scene restoration near the Watt House. This would eliminate the need to make the field suitable for plowing by removing all of the tree stumps and surface roots, as if it was to be used for other crops.

Scene Restoration: Before beginning the work to restore the forest edge to its 1863 location, the consequences of such activity must be considered and the method, timing, and extent of the action decided. The quickest and most efficient method of removing the young stand along the hilltop near the parking area is with a clearcut. Thinning the stand slowly would create an abundance of sprouts and prolong the disturbance of the area by tree-cutters and their equipment. However, thinning and gradually removing the overstory over 5-10 years would not be as drastic a change to the landscape, and may disturb the visitors less than the sight of a clearcut on National Park Service land. Either way, woody regeneration will sprout up after any of the canopy is removed and it will need to be controlled. Herbicide treatment on the cut stumps and sprouts is an effective method of doing this, and will make reverting the area to field possible. The best time for cutting in this stand would be in the late fall and winter for several reasons: visitor numbers are less, trees are less likely to be damaged as they are dormant, no birds or animals are nesting in the stand, and there would be

time to "clean" up the ground vegetation before it began to actively grow and spread in the spring. Sprouting of cut stems will be greater if the cutting is done in the winter though. After the leaves came out and the plants are actively growing in the spring, additional control of the woody vegetation could be done with herbicides as necessary.

By removing this stand, the mature oak stand will be on the edge of a field, and much more sunlight will be entering the old stand. This direct sunlight will stimulate the growth of vines, shrubs and young trees along the forest edge, changing the open, park-like appearance of the areas where the old oaks now grow. Exotic species, such as Japanese honeysuckle, will have access to the crowns of the trees in the stand as well. Basically, what the edge of the young forest now looks like will most likely occur at the new edge. Therefore, consider leaving a border of the young stand, about two trees wide at least, around the edge of the old stand to act as a buffer from the disturbance. This buffer will also protect the old trees from direct exposure to high winds and storms. The crowns of these old specimen trees have been protected for the last 60 years. Opening them up to direct sunlight and weather will stress them, something that should be avoided at their old age. Often, trees suddenly exposed to sunlight and weather will sprout epicormic branches or their crowns will dieback as they are not conditioned to the light and temperature changes of open canopies.

Agricultural Use: The pasture and grain fields grown in the Watt House fields seem suitable for creating historic scenery, and should be continued.

Vegetation Management at Cold Harbor

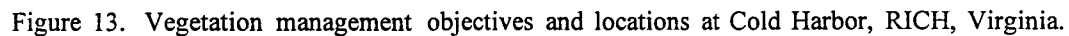
The main vegetation management objectives for Cold Harbor deal with creating a "park-like" atmosphere for the visitors and exposing and maintaining the earthworks for interpretation. Specifically, the following are desired:

1. Around the exhibit shelter, remove shrubbery and screen along Rt. 156 and the fence line to the west;
2. Between the trenches, maintain and expand open woods;
3. Maintain clearing 15 m on either side of loop road where trench lines are visible;
4. Earthworks maintenance;
5. Continue agricultural leasing program;
6. Maintain the shrubby growth along Bloody Run (Figure 13).

Vegetation Near Entrance: For screening around the entrance of the loop road near the exhibit shelter, consider a mixture of evergreens and deciduous trees and shrubs. For instance, start with a line of eastern red cedars that will grow quickly in this open site. Inside the row of cedars, consider planting deciduous shrubs and trees that are adapted to full sun to make the screen more attractive and thicker during the summer months when visitation is higher. Both evergreen and deciduous plants should be considered. Seedlings from the old oak trees at Watt House, which are being propagated, could be used for this project. Seedlings planted now will someday replace the old oaks now standing near the Cold Harbor shelter.

Open Woods Between Trenches/Earthwork Preservation--Tall grasses: The goals of maintaining open woods between the trenches and preserving the earthworks with tall grasses can be met together. The scattered overstory pines at the Cold Harbor trenches should provide enough light to the forest floor for these species to get established. Recommendations for establishing tall grasses on the earthworks of the area can be found in the Earthworks Manual (Andropogon Associates Ltd. 1991). Eventually, the maintenance of this area will be accomplished with prescribed fire or annual mowing. These methods will control woody vegetation between the trenches. Consider converting all of the open area between the trenches to warm-season grasses and fire-tolerant meadow forbs. Different species could be used between the works to profile the trenches and battlefield areas. This would allow the whole area to be maintained with annual mowing or prescribed burns every few years. The taller stature of the perennial meadow plants on and around the

- 1 Screening; Exhibit shelter landscaping
- 2 Maintenance of open pine woods
- 3 Maintenance of clearing outside road loop
- 4 Earthwork preservation -- a) Tallgrass b) Light Forest Cover c) Forest Cover
- 5 Agricultural use
- 6 Preservation of Bloody Run vegetation



earthworks should discourage visitors from walking on them also. Another benefit is that the weekly mowing of the open areas between the trenches could be stopped, freeing up labor and resources for other projects.

If trees are to remain as part of this area's cover, new trees will need to be promoted in between the trenches. Young hardwoods and scattered loblolly and short-leaf pines should be protected for the overstory. If fire is to be a regular part of the maintenance, hardwoods cannot be the target overstory vegetation as they would not survive regular ground fires. Rather, take advantage of the fire regime and consider planting a pine species that is not found in the park, long-leaf pine. Regular ground fires enable long-leaf pine to be a successful competitor in a forest habitat. Long-leaf pine has a grass stage will survive the burning, and can be ready to replace the loblolly and short-leaf pine in the current overstory as they die off. If young pine can be protected from fire, loblolly and shortleaf can be planted also. The promotion of pine in this area will have a secondary benefit as wildlife habitat for Cold Harbor. As the pines die off in most of the natural forest at Cold Harbor, the species that use them will be losing habitat. Pines were the historic vegetation where these trenches now lay. Planting and maintaining pine where possible will add species diversity to the park, ensuring that species that used the pines present during the Civil War may still find a home in the park.

Open Woods Outside of Loop Road/Earthwork Preservation--Light Forest Cover: Most of the understory vegetation 15 m to the sides of the loop road has already been cleared and is maintained by cutting as necessary. The earthworks that fall in this area can be considered to be under the light forest cover type (Andropogon Associates Ltd. 1991). Maintaining this light forest cover on the earthworks outside of the roadloop is recommended, rather than basing all of the earthwork preservation on tall grass cover. Small shrubs and forest herbs can be encouraged and planted where necessary, rather than continuously mowed, to increase the cover on these works and have young trees available for the future cover. See the section on Earthwork Preservation for additional suggestions. For those earthworks further away from the road still in undeveloped forest, the forest cover type is recommended (Andropogon Associates 1991). Tall grasses need full or partial sun, and this is not feasible or desirable in the closed forest.

Agricultural Use Area: The hay being grown on the field of the unit seems appropriate for the historical landscape. The agricultural leasing here maintains the open field and should be continued.

Bloody Run Preservation: The shrubby growth along Bloody Run consists of woody shrubs and small trees of the mixed hardwood cover type. Left undisturbed, this cover type will maintain itself. Disturbances in the form of increased or decreased water flow down the run could change the composition of the understory, but most likely the vegetation will remain thick as its location in a drainage provides it with continual moisture. The identification of a rare Virginia plant, Collins' sedge (*Carex collinsii* Nuttall.) here, and the value of the vegetation for streambank stabilization and water quality maintenance, justify preserving this area indefinitely.

Vegetation Maintenance at Garthright House

The land around Garthright House is maintained as open fields and cropland. Vegetation objectives here are to screen the houses along Boatswain's Lane, limit mowing to visitor/resident use areas, expand the agricultural permit to include the area along the entrance road, and to reach a cooperative agreement with Hanover County to maintain the cemetery across Rt. 156. Red cedar is recommended as a screening species along the western boundary of this area, as it will do well in the fields and not require a lot of space to be taken from the agricultural areas. Consult the section on screening for additional advice and species. An expanded agricultural use area will eliminate the need for mowing beyond the residence while keeping the land open and in a historically appropriate usage.

Vegetation Maintenance at Malvern Hill

Malvern Hill is a fairly undeveloped unit with regards to visitor access into the park forest.

Vegetation management objectives focus on improving the interpretive value of the landscape from the visitor/parking area located in the agricultural fields. Specifically, the following are proposed:

1. Historic scene restoration;
2. Continuation of the agricultural leasing program; and
3. The opening of a vista toward's the Crewe House (Figure 14).

Historic Scene Restoration: Historic scene restoration will require that the present forest boundary to the west of the hayfields be pushed back to the top of the slope that parallels the floodplain of Crewe's Run. The young mixed hardwood and pine stands on this area could be sold for pulpwood and clearcut, with chemical control of the remaining vegetation done prior to converting the land to agricultural fields. This will be an expensive project if the goal is to be able to plow and harvest crops from the area, as the tree stumps will need to be removed, probably with a bulldozer. Even establishing a meadow or hayfield on the site would require the stumps to be removed for annual mowing. However, the proximity of the area to places where bald eagles were sighted along Crewe's Run may preclude any extensive forest operations here.

An alternative to cutting forest is to establish a new forest trail, with interpretive stops and signs that would guide visitors around the slope so they can appreciate the significance of the "Hill". This might be a more impressive action for interpretive purposes than just pushing the forest edge back.

Vista Establishment: The vista towards the Crewe House can be accomplished with the selective cutting of a few trees and cleaning of the forest edge of vines and conifers. Utilize the overgrown old-field near this corner as part of the vista. This work should open it up sufficiently to view the house but not remove the privacy desired by the residents. Annually bush-hogging the area should sufficiently maintain the vista.

Agricultural Use Area: The fields of Malvern Hill are currently in hay, and are harvested twice a summer. This use seems compatible to the interpretation purposes of the Park and should be continued.

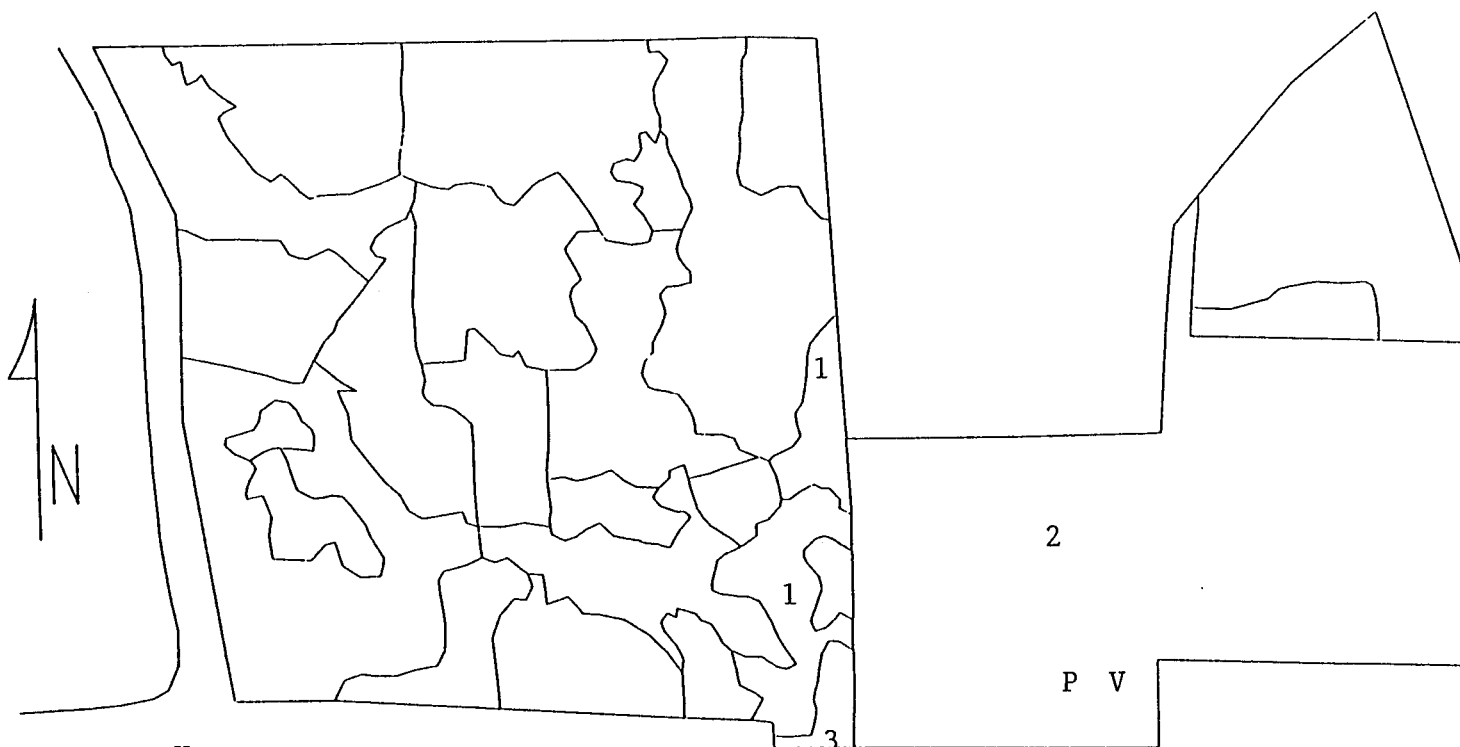
Figure 14. Vegetation management objectives and locations at Malvern Hill, RICH, Virginia.

Management Objectives:

- 1 Scene restoration (push back forest edge)
- 2 Agricultural use
- 3 Vista opening to Crewe House

SCALE

137.3 m



Key:

- 1,2 Management objective location
- Cover Type Boundary
- P Parking
- V Visitor Area

Vegetation Management at Chaffin's Farm

This entire unit consists of roadside earthworks, forts and batteries, with extensive forestland only at the Fort Harrison section. Specific objectives for the vegetation of each section of Chaffin's Farm have been detailed by the park. The main concerns are for screening nearby homes and developments, opening views and vistas for interpretation, and managing the vegetation on the earthworks. Recommendations to achieve these can be found within the sections on screening, vistas, and earthwork management. Following are the specific vegetation objectives for each section of the unit. Additional comments are made after each section's objectives to assist with particular goals.

Fort Harrison, Visitor Center and Picnic Area on Picnic Road section

1. Fort Harrison vegetation management
 - a. Establish open woods between Confederate wall of Fort Harrison and maintenance access road
 - b. Establish interpretive trail outside fort highlighting Federal attack
 - c. Continue cutting grass inside works
 - d. Remove dogwoods, cedars and hollies inside fort
 - e. Cut vista to emphasize Federal assault of 9/29/64
 - f. Profile all ditches and walls, plant tall grasses
 - g. Plant magazines and platforms with alternate grass
 - h. Expose outer Federal Trench to view.
2. Visitor center vegetation management
 - a. Remove/replace holly hedge surrounding visitor center
 - b. Remove pines, replant hardwoods near visitor center
 - c. Maintain grassy area at EARTH site
 - d. Initiate landscape plan for GMP
3. Earthwork preservation--Remove trees from works between Picnic Rd. and Fort Harrison, plant tall grasses
4. Picnic area vegetation management
 - a. Eliminate mowing between the access road and earthworks near picnic area
 - b. Remove all pines and plant hardwoods at picnic area
 - c. Encourage screening along Picnic Rd. next to housing development (Figure 15).

Pine Removal, Hardwood Establishment: One objective recommended by the park for this area is to remove the pines and replant hardwoods, such as oaks, around the visitor center and picnic area. The pines are now mature and healthy; consider leaving them to grow until young hardwoods are established and

Management Objectives:

- 1 Fort Harrison vegetation mgmt.
- 2 Visitor Center vegetation mgmt.
- 3 Earthwork preservation
- 4 Picnic area vegetation mgmt.
- 5 Screening

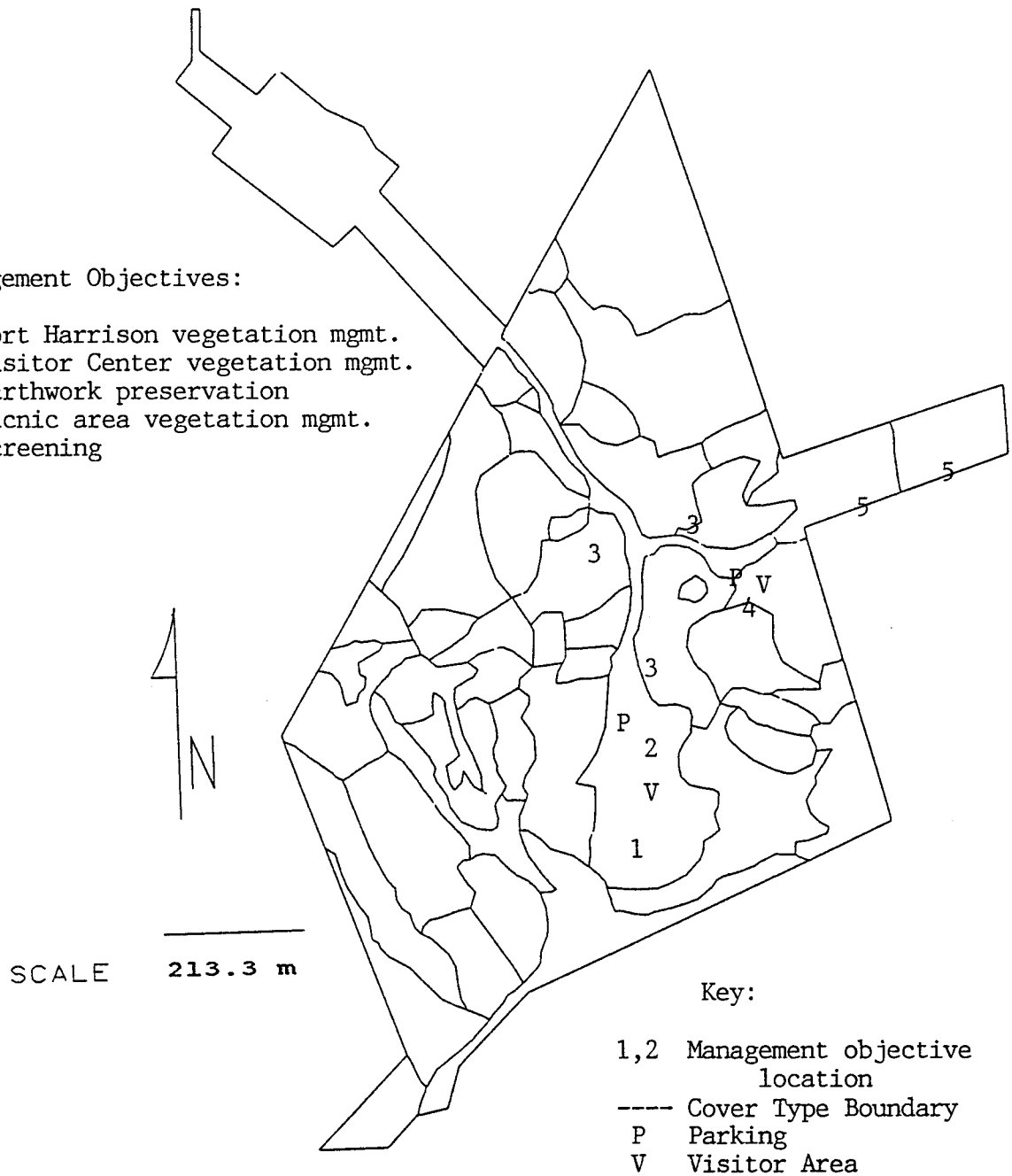


Figure 15. Vegetation management objectives and locations at Fort Harrison section of Chaffin's Farm, RICH, Virginia.

several meters high. This will keep the areas partially shaded for the visitors and the seedlings rather than opening them up to direct, hot sun while the young hardwoods grow from seedling to sapling stage. The historic vegetation maps, once completed, should be consulted to determine whether pines or hardwoods stood around the forts; however, hardwoods are a better "target" vegetation, as they are longer-lived than pine.

View and Vista Establishment: When opening up the forest for better views, such as for establishing open woods around Fort Harrison and exposing trenches, the future cover of the site should be determined before cutting begins. If forest cover is desired as the "target" vegetation, all saplings and seedlings should not be removed. If the goal is to eventually have an open meadow, then the whole understory can be removed, and the overstory gradually thinned to meet the objectives of the activity. If a vista can be cleared and planted as meadow, perhaps connecting it with adjacent earthworks, this is recommended as it will eliminate the majority of the woody vegetation and the need to control it.

Earthwork Preservation: All of the vegetation work done on the earthworks should be as suggested by the Earthworks Manual (Andropogon Associates Ltd. 1991). The focus of earthwork preservation activities at Fort Harrison is to remove trees from them and plant tall grasses such as Andropogon. An alternative to continually mowing the rough grass surrounding these tall grass areas is to plant other warm-season grasses and meadow forbs. This would allow the management of the areas to be combined into a tall grass/meadow maintenance area. Tall grass and meadow species on the grounds of the fort and outer fields would be attractive, easy to maintain after established with annual mowing or prescribed burning, and it may encourage visitors to stay on the designated paths. Different tall grass species can also be used to profile the works, and along with selective thinning of the trees and cleaning the understory, the fort will have a very open landscape. The small trees within the fort, such as dogwoods, hollies, and eastern red cedars, would be good nurse trees for the young perennials, providing some protection for the young forbs and grasses while they are being established. Leave occasional pines for shade trees rather than hardwoods, as the hardwoods will not survive the heat of prescribed burning should that tool be used in managing the fort vegetation. Care should

be taken in exposing the Federal Trench also, so that too much vegetation is not removed, encouraging visitors to enter the trench.

Screening: For screening along Picnic Road, plant shrubs and small trees to block the view of the development from the view of passing cars. The partially shaded area already has some red cedar trees, so these should be the base of the screen. Holly and some deciduous shrubs, mentioned in the screening section, would provide a screen beneath these trees, attractive to both the visitors and the homeowners. The screen should be planted wide enough to eliminate all but one strip of mowing along the road.

Fort Brady section

1. Earthwork Vegetation Management
 - a. Profile outer walls of fort
 - b. Remove shrubby growth between new access trail and fort
2. Cut vista at overlook
3. Screen marina
4. Identify/correct erosion problems at overlook

Earthwork Vegetation Management: Care should be taken when cleaning and thinning the forest vegetation around the earthworks to "profile" and expose them if forest cover is to be the "target" vegetation. Do not remove so much of the understory that the forest cover is no longer an adequate cover that can be maintained into the future as discussed in the Earthwork Manual (Andropogon Associates 1991). If grasses are to be eventually be planted, then opening up the overstory is acceptable.

Overlook Vista and Screening: The vista to the river is blocked by the foliage of the forest on the hillside. Rather than cutting trees and creating an opening that will require continuous maintenance, try limbing a few of the trees or lightly thinning a section of the forest. This will retain enough overstory to keep the forest floor shaded and new trees from quickly filling in the view, and ensure that none of the forest floor is exposed, which would allow erosion to begin on this steep slope. To further screen the marina, small

evergreen trees could be planted below the overlook to block the view to that part of the river. Consider holly, with its prickly leaves, as it should discourage visitors from walking around it and down the hillside on the earthworks.

Erosion Control: Erosion problems can be addressed by planting grasses or shrubs to protect the soil surface from rain and visitor disturbances. If light forest cover is to be maintained at this fort, then planting understory shrubs and herbs would be suitable to improve the protective vegetation. Low-bush blueberry, strawberry bush, partridge berry, and ferns are all potential low ground covers that would survive under the light forest cover of this fort, and are alternatives to exotic grasses that now must be used.

Fort Brady to Kingsland section

1. Remove trees (>25 cm) from works
2. Open view between earthworks and park road
3. Screen housing development
4. Profile gun positions
5. Open vista at power lines

Species for screening the housing development from the park road should be selected with the site and neighbors in mind. Red cedar trees may be fine in some old field areas, but more attractive shrubs, such as viburnum, may be better for bordering neighbors lawns. A vista at the power lines may be turned over to the electric company for easy maintenance, if it falls on their right-of-way and is easily added to their maintenance of the area. This cooperation would benefit the park and be a good public gesture for the company.

Kingsland to Battery 3 section

1. Hazard tree removal at Battery 4
2. Selective clearing between road and earthworks

Section from Battery 3 north to where Federal works cross Battlefield Park Road

1. Clear vegetation, profile battery

2. Open vista where works cross road

Section from Federal works crossing Battlefield Park Road north to where Confederate works cross Battlefield Park Road

1. Selective clearing to works/boundary
2. Encourage screening adjacent to development

Section from Confederate works crossing Battlefield Park Road north to Battery 5

1. Selective clearing to works/boundary
2. Continue hazard tree removal
3. Reduce roadside mowing to 8 '
4. Reduce all other mowing (2X/year)

Where mowing is to be reduced, consider planting native perennial forbs and grasses that will spread and be attractive as they grow tall, and are easily maintained by annual mowing. Otherwise, annual weeds and grasses will dominate and look "unkept" as they flower. Perennial meadow plants will better protect the soil from erosion with their more extensive root systems also.

Fort Maury section

1. Hazard tree removal only

Fort Hoke section

1. Maintain profile of ditch and outer walls in grass

Fort Hoke to Fort Harrison section

1. Identify/open line of site from Battery 10 to Fort Harrison
2. Profile Batteries 10 and White
3. Link lines of sight to driving tour
4. Remove hazard trees (>25 cm)
5. Selective clearing along earthworks
6. Use selective plantings to reduce foot/bicycle travel along works
7. Selective clearing along slope between Fort Harrison and Battlefield Park Road

Again, any clearing of the forest and its understory for views should be done with its impact on the

future vegetation in mind. Shade tolerant species of trees and shrubs should be promoted and established among the earthworks to maintain the light forest cover and discourage visitor traffic upon them.

Maintenance Area/Residences

1. Maintain/increase screening between houses
2. Maintain leach field in turf

Fort Harrison to Fort Johnson section

1. Profile works
2. Selective clearing at "Smith" Battery (near intersection of Battlefield Park and Picnic Road)
3. Maintain screen between Battlefield Park and housing development

Fort Johnson section

1. Profile outer walls/ditch to match photo exhibit
2. Clear/maintain drainage ditch
3. Selective clearing between Battlefield Park Road and fort

Fort Johnson to Fort Gregg section

1. Selective clearing to expose works, provide protection and maintain screening
2. Contact owner concerning preservation maintenance of Gregg

Fort Gilmer section

1. Address/correct earthwork erosion
2. Selective clearing along outer walls
3. Profile ditch view from Battlefield Park Road

Fort Gilmer to Route 5 section

1. Identify/remove hazard trees both in & out of Park
2. Increase screening near housing development
3. Profile Battery Alexander

Vegetation Management at Drewry's Bluff

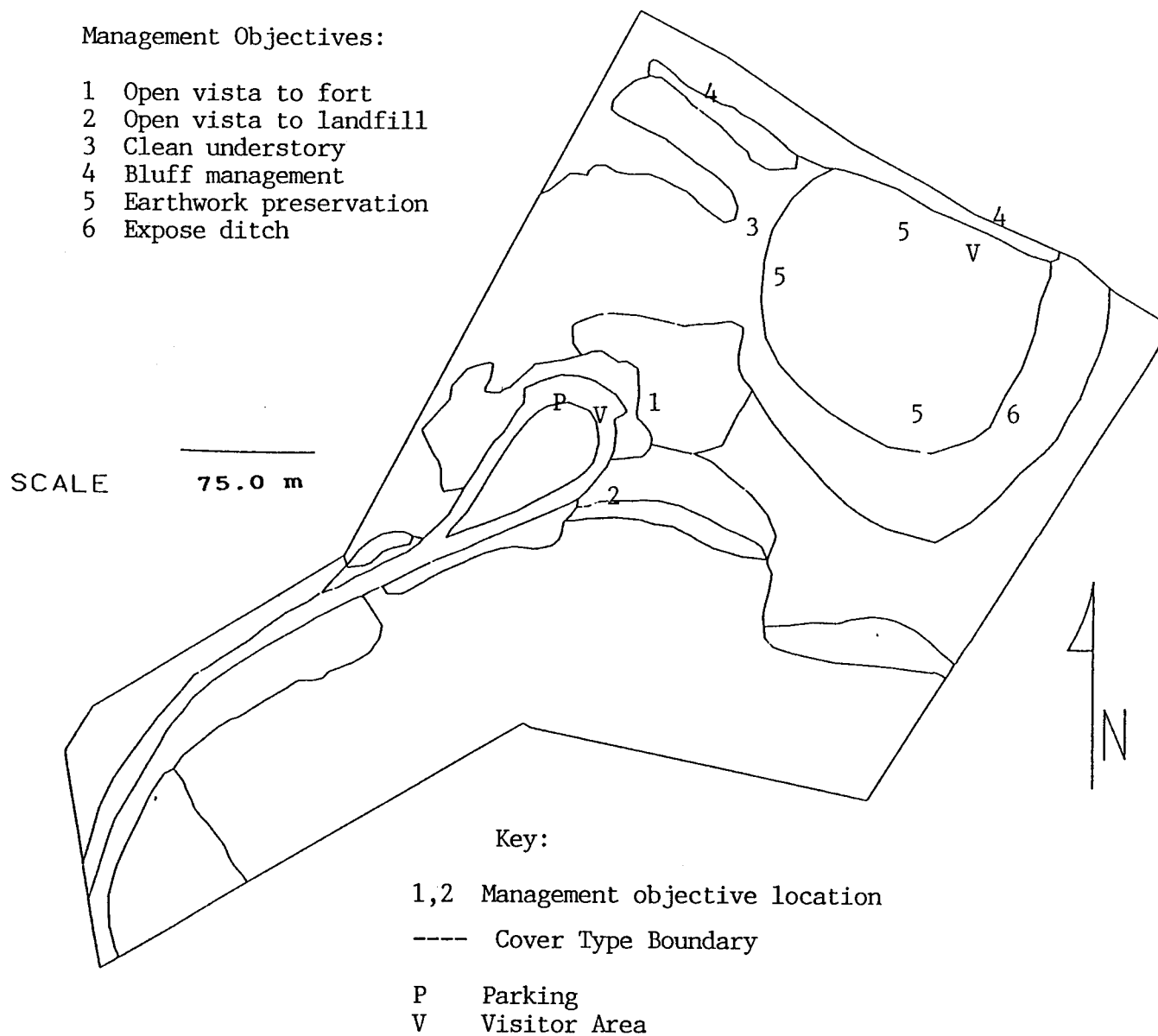
The management activities at Drewry's Bluff primarily concern improving the views for interpretation and earthwork preservation. Specifically the objectives are:

1. Clear line of sight from parking area to fort
2. Open vista from parking area toward landfill
3. Remove woody growth between walking path and west wall of fort
4. Preserve the bluff as recommended in the Bluff Analysis Study
5. Earthwork preservation based on tall grasses
6. Expose view of ditch along east wall of fort (Figure 16).

Vistas: The view to the fort may be accomplished by selectively removing a few mature trees within the woodlot between the parking area and fort. It is not recommended that trees within the drainage be removed, as they aid in holding the soil when water flow is heavy in the creek. Try to select trees with sign of disease, or dieback, and without any nests or woodpecker holes. The vista towards the landfill can be opened by simply removing the small trees and shrubs and vines along the fencerow. Meadow grasses and forbs can be established from the parking area across the landfill for a pleasant open area, and maintained by mowing annually in the fall. Fire is not an option at this unit due to gases emitted from the landfill and the Exxon storage facility nearby.

Earthwork and Fort Vegetation Management: Before removing understory vegetation around the fort, the target vegetation for the earthworks should be determined. Unless enough trees are to be cut down to allow sunlight on the works for Andropogon and other warm-season grasses to grow, the light-forest cover type described in the Earthworks Manual (Andropogon Associates Ltd. 1991) should be considered, as that is generally what the cover is now. Removing shrubs may encourage visitors to walk on the works more often; shrubs are not really thick enough to impede the viewing of the works anyway. Rather than cleaning out more plants, consider adding to the understory with low growing shrubs and herbs to increase the ground cover.

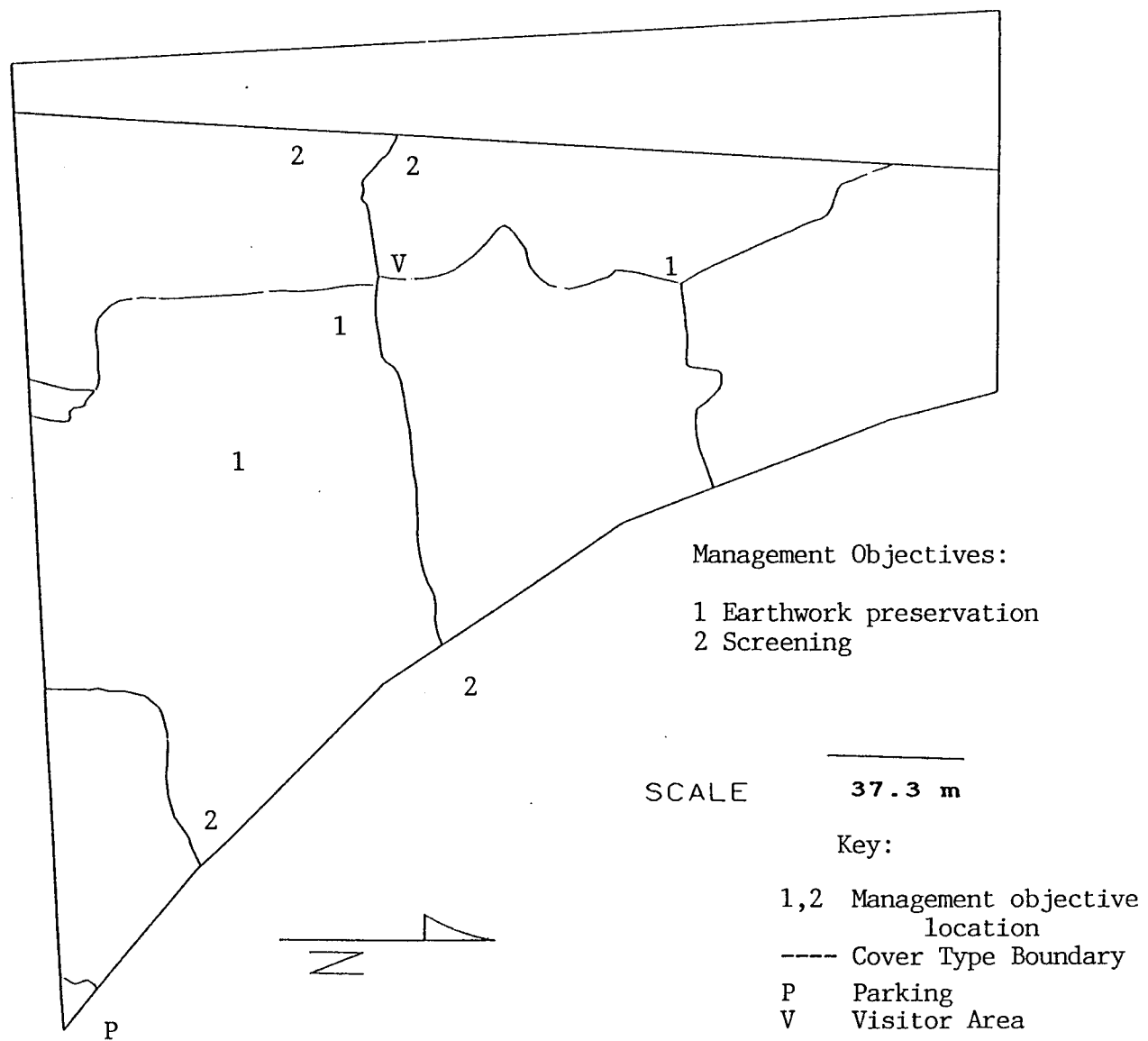
Figure 16. Vegetation management objectives and locations at Drewry's Bluff, RICH, Virginia.



Vegetation Management at Parker's Battery

Minimal management activities are suggested for this unit, as few visitors see it. To maintain the site for future development and visitors, screening of the boundaries and earthwork preservation are recommended (Figure 17). Much of the screening exists and can be maintained by preserving the forest undisturbed along the edges of the unit. Where proposed visitor areas will be, consider planting a few shade-tolerant evergreen shrubs or trees now to mix into the vegetation present. All of the earthworks are under light forest or forest cover. Unless major clearing and maintenance is intended, these should be left as the target cover and problem areas addressed for planting of forest understory, for example, on old trails that cross the works. Consult the Earthworks Manual (Andropogon Associates Ltd. 1991) for details.

Figure 17. Vegetation management objectives and locations at Parker's Battery, RICH, Virginia.



Literature Cited

- Andropogon Associates, Ltd. 1989. Earthworks Landscape Management Manual. Park Historic Architecture Division, Cultural Resources. USDI National Park Service, Washington, D.C. 131 pp.
- Baker, W.L. 1972. Eastern forest insects. USDA For. Ser. Misc. Publ. No. 1175. 641 pp.
- Brown, W.R. 1939. Coastal plain geology of the Richmond area, Virginia. Master of Arts Thesis, University of Virginia, Charlottesville, VA. 110 pp.
- Burns, R.M., and B.H. Honkala. 1990. Silvics of North America. Vol. 2, Hardwoods. USDA For. Ser. Agric. Handbk. 654. 877 pp.
- Capel, S. 1992. Warm season grasses for Virginia and North Carolina. Benefits for livestock and wildlife. Virginia Dept. Game & Inland Fisheries. Richmond, VA. 10 pp.
- Dietrich, R.V. 1970. Geology and Virginia. The University Press of Virginia, Charlottesville, VA. 213 pp.
- Dirr, M.A. 1990. Manual of Woody Landscape Plants--Their Identification, Ornamental Characteristics, Culture, Propagation, and Uses. Stipes Publishing Co., Champaign, IL. 1007 pp.
- Eyre, F.H. 1980. Forest cover types of the United States and Canada. Soc. Amer. For., Washington, D.C. 148 pp.
- Flint, H.L. 1983. Landscape Plants for Eastern North America. John Wiley & Sons, New York, NY. 677 pp.
- Hayden, W.J., and M.F. Johnson. 1986. Flora of Richmond National Battlefield Park (Chickahominy Bluff, Cold Harbor, Fort Darling, Fort Harrison, Garthright House, and Watt House Units). USDI National Park Service. Mid-Atlantic Region Research/Resources Management Report #16. 40 pp.
- Hayden, W.J., M.L. Haskins, M.F. Johnson. 1988. Flora of Richmond National Battlefield Park (Beaver Dam Creek, Malvern Hill, and Parker's Battery Units). USDI National Park Service. Mid-Atlantic Region Research/Resources Management Report #27. 34 pp.
- Helm, A.C., J.E. Johnson, D.O. Mitchem. 1994. Fire history and fuel loads of upper coastal plain forests. Richmond National Battlefield Park, VA. Tech. Rpt. NPS/MARRICH/NRTR-94/059, Philadelphia, PA. 138 pp.
- Hightshoe, G.L. 1988. Native Trees, Shrubs, and Vines for Urban and Rural America. A Planting Design Manual for Environmental Designers. Van Nostrand Reinhold, New York, NY. 819 pp.
- Lyons, R.E. 1993. The direct-seeded "meadow". A summary of techniques. Dept. of Horticulture, Virginia Polytechnic Institute and State University. Blacksburg, VA. 3 p.
- Miller, J.H., and R.J. Mitchell. 1990. A Manual on Ground Applications of Forestry Herbicides. USDA For. Ser. Manage. Bull. R8-MB 21.
- N.O.A.A. 1983. Climate normals for the U.S. 1951-1980, 1st ed. Compiled by National Climatic Center, Environmental Data and Information Service, National Oceanic and Atmospheric Administration. 712 pp.

- N.P.S. 1984. Integrated Pest Management Informational Manual. USDI National Park Service. Washington, D.C.
- N.P.S. 1991. Natural Resource Management Guidelines. NPS-77. USDI National Park Service, Washington, D.C.
- Radford, A.E., H.E. Ahles, C.R. Bell. 1968. Manual of the vascular flora of the Carolinas. The University of North Carolina Press, Chapel Hill, NC. 1183 pp.
- RICH. 1989. Richmond National Battlefield Park Statement for Management and Outline of Planning Requirements. Richmond National Battlefield Park, Virginia. 104 pp.
- RICH. 1991. Parkwide Vegetation Objectives (compiled by E. Gasser, C. Dickinson, and M. Andrus, January 18, 1991). Richmond National Battlefield Park, Virginia. 5 p.
- Russell, E.W.B. 1990. Vegetation monitoring with permanent plots: a procedural manual for the mid-Atlantic region. USDI National Park Service. Technical Rpt. NPS/MAR/NRTR - 90/046. 30 pp.
- Smith, J.R. 1980. The Prairie Garden. The University of Wisconsin Press, Madison, WI. 219 pp.
- U.S.D.A. 1975. Soil survey of Henrico County. U.S.D.A. Soil Conservation Service in cooperation with Virginia Polytechnic Institute and State University. 119 pp.
- U.S.D.A. 1978. Soil survey of Chesterfield County. U.S.D.A. Soil Conservation Service in cooperation with Virginia Polytechnic Institute and State University. 115 pp.
- U.S.D.A. 1980. Soil survey of Hanover County. U.S.D.A. Soil Conservation Service in cooperation with Virginia Polytechnic Institute and State University. 217 pp.
- Walthen, S. 1977. Maximum insolation on a surface as an estimator of site quality in the Appalachians. M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 39 pp.
- Whitcomb, C.E. 1983. Know it and grow it, II. A Guide to the Identification and Use of Landscape Plants. Lacebark Publ., Stillwater, OK. 739 pp.

Appendix I. Forest overstory species at Richmond National Battlefield Park, Virginia.

Scientific Name	Common Name
<i>Acer rubrum</i> L.	Red Maple
<i>Carpinus caroliniana</i> Walter	American Hornbeam
<i>Carya glabra</i> (Miller) Sweet	Pignut Hickory
<i>Carya tomentosa</i> (Poiret) Nuttall	Mockernut Hickory
<i>Cornus florida</i> L.	Flowering Dogwood
<i>Diospyros virginiana</i> L.	Common Persimmon
<i>Fagus grandifolia</i> Ehrhart	American Beech
<i>Ilex opaca</i> Aiton	American Holly
<i>Juniperus virginiana</i> L.	Eastern Red Cedar
<i>Liquidambar styraciflua</i> L.	Sweet-gum
<i>Liriodendron tulipifera</i> L.	Yellow Poplar
<i>Magnolia virginiana</i> L.	Sweet Bay
<i>Nyssa sylvatica</i> Marshall	Black Gum
<i>Pinus echinata</i> Miller	Short-leaf Pine
<i>Pinus taeda</i> L.	Loblolly Pine
<i>Pinus virginiana</i> Miller	Virginia Pine
<i>Prunus avium</i> L.	Sweet Cherry
<i>Quercus alba</i> L.	White Oak
<i>Quercus coccinea</i> Muenchh.	Scarlet Oak
<i>Quercus falcata</i> Michaux	Southern Red Oak
<i>Quercus palustris</i> Muenchh.	Pin Oak
<i>Quercus phellos</i> L.	Willow Oak
<i>Quercus prinus</i> L.	Chestnut Oak
<i>Quercus rubra</i> L.	Northern Red Oak
<i>Quercus stellata</i> Wang.	Post Oak
<i>Quercus velutina</i> Lam.	Black Oak
<i>Ulmus alata</i> Michaux	Winged Elm
<i>Ulmus americana</i> L.	American Elm
<i>Ulmus rubra</i> Muhl.	Slippery Elm

Appendix II. Forest understory species at Richmond National Battlefield Park, Virginia.

Scientific Name	Common Name
<i>Acer rubrum</i> L.	Red Maple
<i>Amelanchier arborea</i> (Michaux f.) Fernald	Serviceberry
<i>Azalea</i> sp. Michaux	Azalea
<i>Campsis radicans</i> (L.) Seemann	Trumpet Vine
<i>Carpinus caroliniana</i> Walter	American Hornbeam
<i>Carya glabra</i> (Mill.) Sweet	Pignut Hickory
<i>Carya tomentosa</i> (Poiret) Nuttall	Mockernut Hickory
<i>Castanea pumila</i> (L.) Miller	Chinquapin
<i>Celtis</i> sp. L.	Hackberry
<i>Cephalanthus occidentalis</i> L.	Button Bush
<i>Chionanthus virginicus</i> L.	Fringe-tree
<i>Clethra alnifolia</i> L.	Sweet Pepperbush
<i>Cornus florida</i> L.	Flowering Dogwood
<i>Diospyros virginiana</i> L.	Common Persimmon
<i>Euonymus americanus</i> L.	Strawberry Bush
<i>Fagus grandifolia</i> Ehrhart	American Beech
<i>Gaylussacia frondosa</i> (L.) T. & G	Dangleberry
<i>Ilex opaca</i> Aiton	American Holly
<i>Ilex verticillata</i> (L.) Gray	Winterberry
<i>Juniperus virginiana</i> L.	Eastern Red Cedar
<i>Leucothoe racemosa</i> (L.) Gray	Fetter-bush
<i>Lindera benzoin</i> (L.) Blume	Spicebush
<i>Liquidambar styraciflua</i> L.	Sweet-gum
<i>Liriodendron tulipifera</i> L.	Yellow Poplar
<i>Magnolia virginiana</i> L.	Sweet Bay
<i>Morus rubra</i> L.	Red Mulberry
<i>Nyssa sylvatica</i> Marshall	Black Gum
<i>Pinus taeda</i> L.	Loblolly Pine
<i>Prunus serotina</i> Ehrhart	Black Cherry

Appendix II. Continued.

Scientific Name	Common Name
<i>Quercus alba</i> L.	White Oak
<i>Quercus falcata</i> Michaux	Southern Red Oak
<i>Quercus phellos</i> L.	Willow Oak
<i>Quercus rubra</i> L.	Northern Red Oak
<i>Quercus velutina</i> Lam.	Black Oak
<i>Sassafras albidum</i> (Nuttall) Nees	Sassafras
<i>Ulmus americana</i> L.	American Elm
<i>Vaccinium corymbosum</i> L.	Highbush Blueberry
<i>Vaccinium formosum</i> Andrews	Swamp Highbush Blueberry
<i>Vaccinium stamineum</i> L.	Deerberry
<i>Viburnum dentatum</i> L.	Viburnum

Appendix III. Forest seedling species at Richmond National Battlefield Park, Virginia.

Scientific Name	Common Name
<i>Acer rubrum</i> L.	Red Maple
<i>Amelanchier arborea</i> (Michaux f.) Fernald	Serviceberry
<i>Aronia arbutifolia</i> (L.) Ell.	Red Chokeberry
<i>Azalea</i> sp. Michaux	Azalea
<i>Campsis radicans</i> (L.) Seemann	Trumpet Vine
<i>Carpinus caroliniana</i> Walter	American Hornbeam
<i>Carya glabra</i> (Mill.) Sweet	Pignut Hickory
<i>Carya tomentosa</i> (Poir.) Nuttall	Mockernut Hickory
<i>Castanea pumila</i> (L.) Miller	Chinquapin
<i>Celtis</i> sp. L.	Hackberry
<i>Cephalanthus occidentalis</i> L.	Button Bush
<i>Clethra alnifolia</i> L.	Sweet Pepperbush
<i>Cornus florida</i> L.	Flowering Dogwood
<i>Crataegus</i> sp. L.	Hawthorn
<i>Diospyros virginiana</i> L.	Common Persimmon
<i>Euonymus americanus</i> L.	Strawberry Bush
<i>Fagus grandifolia</i> Ehrhart	American Beech
<i>Fraxinus pennsylvanica</i> Marshall	Red Ash
<i>Gaylussacia frondosa</i> (L.) T. & G	Dangleberry
<i>Ilex opaca</i> Aiton	American Holly
<i>Ilex verticillata</i> (L.) Gray	Winterberry
<i>Juniperus virginiana</i> L.	Eastern Red Cedar
<i>Leucothoe racemosa</i> (L.) Gray	Fetter-bush
<i>Lindera benzoin</i> (L.) Blume	Spicebush
<i>Liquidambar styraciflua</i> L.	Sweet-gum
<i>Liriodendron tulipifera</i> L.	Yellow Poplar
<i>Magnolia virginiana</i> L.	Sweet Bay
<i>Morus rubra</i> L.	Red Mulberry
<i>Nyssa sylvatica</i> Marshall	Black Gum

Appendix III. Continued.

Scientific Name	Common Name
<i>Parthenocissus quinquefolia</i> (L.) Planchon	Virginia Creeper
<i>Pinus taeda</i> L.	Loblolly Pine
<i>Prunus serotina</i> Ehrhart	Black Cherry
<i>Quercus alba</i> L.	White Oak
<i>Quercus falcata</i> Michaux	Southern Red Oak
<i>Quercus phellos</i> L.	Willow Oak
<i>Quercus rubra</i> L.	Northern Red Oak
<i>Quercus stellata</i> Wang.	Post Oak
<i>Quercus velutina</i> Lam.	Black Oak
<i>Rubus</i> sp. L.	Blackberry, Raspberry
<i>Sassafras albidum</i> (Nuttall) Nees	Sassafras
<i>Smilax rotundifolia</i> L.	Greenbrier
<i>Toxicodendron radicans</i> (L.) Kuntze	Poison Ivy
<i>Ulmus</i> spp. L.	Elm
<i>Vaccinium corymbosum</i> L.	Highbush Blueberry
<i>Vaccinium formosum</i> Andrews	Swamp Highbush Blueberry
<i>Vaccinium pallidum</i> Aiton	Hillside Lowbush Blueberry
<i>Vaccinium stamineum</i> L.	Deerberry
<i>Viburnum dentatum</i> L.	Viburnum
<i>Vitis aestivalis</i> Michaux	Summer Grape
<i>Vitis rotundifolia</i> Michaux	Muscadine Grape

Appendix IV. Forest herbaceous and woody vine species at Richmond National Battlefield Park, Virginia.

Scientific Name	Common Name
<i>Aneilema keisak</i> Hasskarl ^{@@}	
<i>Anemone quinquefolia</i> L.	Windflower
<i>Arisaema triphyllum</i> (L.) Schott	Jack in the Pulpit
<i>Asclepias</i> L.	Milkweed
<i>Asplenium platyneuron</i> (L.) Oakes	Ebony Spleenwort
<i>Athyrium asplenoides</i> (Michaux) A.A. Eaton	Southern Lady Fern
<i>Bidens tripartita</i> L. ^{@@}	Beggar Ticks
<i>Boehmeria cylindrica</i> (L.) Swartz ^{@@}	False Nettle
<i>Botrychium</i> sp. Swartz	Grapefern
<i>Carex albolutescens</i> Schweinitz	Sedge
<i>Carex crinata</i> Lam.	Sedge
<i>Carex debilis</i> Michaux	Sedge
<i>Carex lurida</i> Wahlenberg ^{@@}	Sedge
<i>Carex</i> sp. L.	Sedge
<i>Carex stricta</i> Lam. [@]	Sedge
<i>Carex swanii</i> (Fernald) Mackenzie	Sedge
<i>Chimaphila maculata</i> (L.) Pursh	Spotted Wintergreen
<i>Chimaphila umbellata</i> (L.) Barton	Pipsissewa
<i>Commelina virginica</i> L. ^{@@}	Dayflower
<i>Cuscuta campestris</i> Yuncker ^{@@}	Field Dodder
<i>Cyperus strigosus</i> L. ^{@@}	
<i>Cypripedium acaule</i> Aiton	Pink Lady's Slipper
<i>Desmodium nudiflorum</i> (L.) DC.	Beggar's Ticks
<i>Dioscorea villosa</i> L.	Wild Yam
<i>Eupatorium</i> sp. L.	Thoroughwort
<i>Eupatorium perfoliatum</i> L. ^{@@}	Boneset
<i>Galium</i> sp. L.	Bedstraw
<i>Galium tinctorium</i> L. ^{@@}	Bedstraw
<i>Glyceria septentrionalis</i> Hitchcock [@]	Manna Grass
<i>Heteranthera reniformis</i> R. & P. ^{@@}	Mud Plantain

Appendix IV. Continued.

Scientific Name	Common Name
<i>Hexastylis</i> sp. Raf. [@]	Wild Ginger
<i>Impatiens capensis</i> Meerb. ^{@@}	Spotted Touch-Me-Not
<i>Impatiens</i> sp. L.	Touch-Me-Not
<i>Juncus coriaceus</i> Mackenzie ^{@@}	
<i>Juncus effusus</i> L. ^{@@}	
<i>Leersia oryzoides</i> (L.) Swartz ^{@@}	Cut Grass
<i>Lespedeza repens</i> (L.) Barton	Lespedeza
<i>Lilium</i> sp. L.	Lily
<i>Lobelia</i> sp. L.	Lobelia
<i>Lonicera japonica</i> Thunberg ^{**}	Japanese Honeysuckle
<i>Lonicera</i> sp. L.	Honeysuckle
<i>Ludwigia palustris</i> (L.) Ell. ^{@@}	
<i>Lycopodium</i> sp. L.	Clubmoss
<i>Lysimachia nummularia</i> L. ^{**}	Moneywort
<i>Medeola virginiana</i> L.	Indian Cucumber-Root
<i>Microstegium vimineum</i> (Trinius) A. Camus ^{**}	
<i>Mitchella repens</i> L.	Partridge Berry
<i>Obolaria virginica</i> L.	Pennywort
<i>Onoclea sensibilis</i> L.	Sensitive Fern
<i>Ophioglossum vulgatum</i> var. <i>pycnostichum</i> Fernald	Southern Adder's-Tongue
<i>Osmunda cinnamomea</i> L.	Cinnamon Fern
<i>Osmunda regalis</i> var. <i>spectabilis</i> (Willd.) Gray	Royal Fern
<i>Oxalis</i> sp. L.	Wood Sorrell
<i>Panicum</i> sp. L.	Panic Grass
<i>Parthenocissus quinquefolia</i> (L.) Planchon	Virginia Creeper
<i>Peltandra virginica</i> (L.) Kunth ^{@@}	Arrow Arum
<i>Poa autumnalis</i> Muhl. ex. Ell.	Blue Grass
<i>Polygonatum biflorum</i> (Walter) Ell.	Solomon's Seal
<i>Polygonum sagittatum</i> L. ^{@@}	Tearthumb
<i>Polystichum acrostichoides</i> (Michaux) Schott	Christmas Fern

Appendix IV. Continued.

Scientific Name	Common Name
<i>Potamogeton epihydrus</i> Raf. ^{@@}	Pondweed
<i>Potentilla</i> sp. L.	
<i>Pteridium aquilinum</i> (L.) Kuhn	Bracken Fern
<i>Rubus</i> sp.	Blackberry, Raspberry
<i>Saururus cernuus</i> L.	Lizard's Tail
<i>Scirpus cyperinus</i> (L.) Kunth	Bulrush
<i>Smilacina racemosa</i> (L.) Desf. ^{@@@}	False Solomon's-Seal
<i>Smilax rotundifolia</i> L.	Greenbrier
<i>Solidago</i> sp. L.	Goldenrod
<i>Stellaria</i> sp. L.	Chickweed
<i>Symplocarpus foetidus</i> (L.) Nuttall	Skunk Cabbage
<i>Thelypteris noveboracensis</i> (L.) Nieuwland	New York Fern
<i>Thelypteris palustris</i> Schott	Marsh Fern
<i>Toxicodendron radicans</i> (L.) Kuntze	Poison Ivy
<i>Trachelospermum difforme</i> (Walter) Gray	
<i>Trillium</i> sp. L. ^{@@}	Trillium
<i>Uvularia</i> sp. L.	Bellwort
<i>Viola</i> sp. L.	Violet
<i>Vitis aestivalis</i> Michaux	Summer Grape
<i>Vitis rotundifolia</i> Michaux	Muscadine Grape

^{**}Non-native species.

[@]Seen at Chickahominy Bluff.

^{@@}Seen at Beaver Dam Creek.

^{@@@}Seen at Cold Harbor.

Appendix V. Overstory inventory and site data for 115 vegetation sample plots at Richmond National Battlefield Park, Virginia. Definitions of variables on the data sheets are as follows:

Standard Plot Inventory Identification Variables

Unit -- 1 - Chickahominy Bluff
 3 - Watt House
 4 - Cold Harbor
 6 - Malvern Hill
 7 - Fort Harrison, section with fort
 8 - Drewry's Bluff
 9 - Parker's Battery

Standnum -- Stand number in G.I.S. database

Plot -- Plot number within unit

Appendix V-1. Overstory basal area data.

<u>Variable</u>	<u>Definition</u>
LPINBA	Live pine basal area, m ² /ha
DPINBA	Dead pine basal area, m ² /ha
LOAKBA	Live oak/beech/hickory basal area, m ² /ha
DOAKBA	Dead oak/beech/hickory basal area, m ² /ha
LOTHBA	Live other hardwoods basal area, m ² /ha
DOTHBA	Dead other hardwoods basal area, m ² /ha

Appendix V-2. Overstory density data.

<u>Variable</u>	<u>Definition</u>
LPINDN	Live pine density, stems/ha
DPINDN	Dead pine density, stems/ha
LOAKDN	Live oak/beech/hickory density, stems/ha
DPINDN	Dead oak/beech/hickory density, stems/ha
LOTHDN	Live other hardwoods density, stems/ha
DOTHDN	Dead other hardwoods density, stems/ha

Appendix V-3. Overstory DBH and age data.

<u>Variable</u>	<u>Definition</u>
PINEDBH	Diameter breast height, pines, cm
OAKDBH	Diameter breast height, oaks, beech, hickory, cm
OTHDBH	Diameter breast height, other hardwoods, cm
PINEAGE	Age of pines, years
OAKAGE	Age of oaks, beech, hickory, years
OTHAGE	Age of other hardwoods, years

Appendix V-4. Overstory height and pine beetle presence data.

<u>Variable</u>	<u>Definition</u>
PINEHEIGHT	Height of pines, m
OAKHEIGHT	Height of oak, beech, hickory, m
OTHHEIGHT	Height of other hardwoods, m
PINEBEETLE	Presence of pine beetle sign, (Y)es or (N)o

Appendix V-1. Overstory basal area data.

UNIT	STANDNUM	PLOT	LPINBA	DPINBA	LOAKBA	DOAKBA	LOTHBA	DOTHBA
-----square meters/ha-----								
1	6	1	10.0	0.0	10.0	0.0	7.5	0.0
1	7	2	5.0	2.5	2.5	0.0	22.5	0.0
1	9	3	7.5	7.5	5.0	0.0	17.5	0.0
1	13	4	5.0	0.0	7.5	0.0	22.5	0.0
1	7	5	0.0	2.5	2.5	0.0	42.5	0.0
1	24	6	10.0	0.0	0.0	0.0	25.0	0.0
1	21	7	17.5	0.0	2.5	0.0	10.0	0.0
1	19	8	0.0	0.0	0.0	0.0	35.0	2.5
1	17	9	2.5	0.0	0.0	0.0	32.5	0.0
1	17	10	0.0	0.0	0.0	0.0	45.0	2.5
3	1	1	0.0	0.0	10.0	5.0	17.5	0.0
3	2	2	0.0	0.0	17.5	0.0	17.5	0.0
3	10	3	15.0	0.0	0.0	0.0	7.5	0.0
3	11	4	0.0	0.0	25.0	2.5	17.5	0.0
3	2	5	0.0	0.0	32.5	2.5	7.5	0.0
3	9	6	5.0	5.0	0.0	0.0	20.0	5.0
3	2	7	0.0	0.0	10.0	7.5	5.0	0.0
3	11	8	0.0	0.0	37.5	0.0	5.0	0.0
3	2	9	0.0	0.0	20.0	0.0	15.0	0.0
3	22	10	0.0	0.0	10.0	0.0	32.5	2.5
4	12	1	0.0	0.0	7.5	0.0	27.5	0.0
4	16	2	2.5	0.0	2.5	0.0	35.0	0.0
4	11	3	2.5	0.0	17.5	0.0	2.5	0.0
4	4	4	0.0	2.5	10.0	0.0	7.5	0.0
4	3	5	25.0	10.0	0.0	0.0	12.5	0.0
4	9	6	10.0	0.0	15.0	0.0	2.5	0.0
4	8	7	0.0	0.0	22.5	7.5	10.0	0.0
4	17	8	5.0	0.0	20.0	0.0	0.0	0.0
4	23	9	5.0	2.5	15.0	0.0	10.0	0.0
4	19	10	0.0	0.0	12.5	0.0	10.0	0.0
4	20	11	7.5	2.5	12.5	0.0	0.0	0.0
4	15	12	5.0	0.0	12.5	7.5	5.0	2.5
4	16	13	0.0	0.0	10.0	0.0	17.5	0.0
4	22	14	0.0	0.0	22.5	2.5	2.5	0.0
4	22	15	0.0	0.0	15.0	0.0	10.0	0.0
4	26	16	7.5	7.5	15.0	0.0	0.0	0.0
4	30	17	0.0	0.0	12.5	0.0	25.0	0.0
4	29	18	22.5	0.0	10.0	0.0	0.0	0.0
4	16	19	0.0	0.0	7.5	0.0	12.5	0.0
4	23	20	7.5	2.5	7.5	0.0	10.0	2.5
4	22	21	0.0	0.0	17.5	2.5	10.0	0.0
4	11	22	0.0	0.0	27.5	2.5	5.0	0.0
4	16	23	2.5	0.0	0.0	0.0	35.0	2.5
4	22	24	0.0	0.0	20.0	0.0	5.0	0.0
4	26	25	10.0	5.0	12.5	0.0	0.0	0.0
6	27	1	2.5	0.0	5.0	0.0	12.5	0.0
6	27	2	27.5	2.5	2.5	0.0	7.5	0.0
6	24	3	2.5	0.0	7.5	0.0	12.5	2.5
6	23	4	0.0	0.0	5.0	0.0	10.0	5.0
6	12	5	15.0	5.0	0.0	0.0	5.0	0.0
6	15	6	7.5	0.0	5.0	0.0	2.5	0.0
6	11	7	7.5	0.0	15.0	0.0	7.5	0.0

Appendix V-1. Continued.

UNIT	STANDNUM	PLOT	LPINBA	DPINBA	LOAKBA	DOAKBA	LOTHBA	DOTHBA
-----square meters/ha-----								
6	21	8	15.0	2.5	0.0	0.0	27.5	2.5
6	20	9	20.0	2.5	15.0	0.0	0.0	0.0
6	18	10	2.5	5.0	0.0	0.0	27.5	0.0
6	10	11	0.0	0.0	5.0	0.0	25.0	2.5
6	16	12	2.5	0.0	22.5	0.0	20.0	0.0
6	9	13	0.0	0.0	0.0	0.0	22.5	0.0
6	8	14	15.0	0.0	2.5	0.0	22.5	0.0
6	1	15	0.0	0.0	5.0	0.0	32.5	0.0
6	2	16	0.0	0.0	2.5	0.0	30.0	0.0
6	4	17	2.5	0.0	10.0	0.0	27.5	0.0
6	5	18	5.0	0.0	0.0	0.0	37.5	0.0
6	6	19	2.5	2.5	0.0	0.0	20.0	0.0
6	7	20	20.0	0.0	2.5	0.0	17.5	0.0
6	13	21	0.0	2.5	22.5	2.5	5.0	2.5
6	23	22	0.0	0.0	2.5	0.0	15.0	2.5
7	2	1	5.0	2.5	10.0	0.0	2.5	0.0
7	5	2	7.5	5.0	2.5	2.5	10.0	0.0
7	8	3	17.5	7.5	10.0	0.0	2.5	0.0
7	7	4	2.5	5.0	2.5	0.0	7.5	0.0
7	11	5	25.0	0.0	0.0	0.0	2.5	0.0
7	12	6	0.0	0.0	10.0	0.0	5.0	0.0
7	16	7	0.0	0.0	12.5	0.0	10.0	0.0
7	19	8	0.0	0.0	15.0	2.5	27.5	2.5
7	18	9	2.5	2.5	7.5	0.0	12.5	0.0
7	39	10	5.0	10.0	15.0	0.0	2.5	0.0
7	29	11	0.0	2.5	7.5	2.5	7.5	0.0
7	24	12	5.0	5.0	7.5	0.0	2.5	0.0
7	26	13	2.5	2.5	0.0	0.0	25.0	2.5
7	30	14	2.5	2.5	10.0	2.5	12.5	0.0
7	27	15	0.0	0.0	7.5	5.0	22.5	5.0
7	49	16	0.0	0.0	15.0	2.5	5.0	0.0
7	36	17	5.0	2.5	10.0	0.0	10.0	0.0
7	41	18	10.0	5.0	10.0	0.0	5.0	2.5
7	43	19	0.0	0.0	15.0	2.5	2.5	0.0
7	6	20	15.0	2.5	2.5	2.5	7.5	0.0
7	4	21	0.0	0.0	12.5	2.5	0.0	0.0
7	2	22	5.0	0.0	15.0	7.5	5.0	0.0
7	2	23	2.5	0.0	17.5	0.0	2.5	0.0
7	2	24	12.5	0.0	15.0	5.0	2.5	0.0
7	5	25	2.5	12.5	5.0	2.5	0.0	0.0
7	5	26	15.0	0.0	7.5	2.5	7.5	0.0
7	15	27	0.0	0.0	0.0	0.0	20.0	2.5
7	10	28	7.5	15.0	0.0	0.0	15.0	0.0
7	45	29	7.5	0.0	7.5	0.0	2.5	0.0
7	45	30	7.5	7.5	10.0	0.0	7.5	0.0
7	44	31	2.5	0.0	12.5	0.0	12.5	0.0
7	31	32	0.0	0.0	17.5	0.0	5.0	0.0
7	24	33	7.5	0.0	12.5	0.0	2.5	0.0
7	29	34	0.0	0.0	17.5	2.5	5.0	0.0
7	25	35	15.0	0.0	0.0	0.0	35.0	0.0
7	23	36	0.0	0.0	20.0	2.5	5.0	0.0
7	5	37	7.5	2.5	0.0	2.5	17.5	0.0

Appendix V-1. Continued.

UNIT	STANDNUM	PLOT	LPINBA	DPINBA	LOAKBA	DOAKBA	LOTHBA	DOTHBA
-----square meters/ha-----								
7	43	38	0.0	0.0	17.5	2.5	2.5	0.0
8	1	1	35.0	5.0	0.0	0.0	0.0	0.0
8	14	2	2.5	0.0	17.5	2.5	7.5	0.0
8	7	3	0.0	0.0	12.5	0.0	22.5	0.0
8	13	4	5.0	0.0	17.5	2.5	10.0	0.0
8	13	5	2.5	2.5	15.0	0.0	2.5	0.0
9	2	1	17.5	2.5	5.0	0.0	0.0	0.0
9	5	2	15.0	2.5	5.0	0.0	10.0	0.0
9	7	3	25.0	0.0	5.0	0.0	7.5	0.0
9	6	4	7.5	0.0	15.0	2.5	5.0	0.0
9	8	5	7.5	0.0	12.5	0.0	0.0	0.0

Appendix V-2. Overstory density data.

UNIT	STANDNUM	PLOT	LPINDN	DPINDN	LOAKDN	DOAKDN	LOTHDN	DOTHDN
-----stems/ha-----								
1	6	1	178.9	0.0	1788.9	0.0	105.9	0.0
1	7	2	46.0	20.1	10.0	0.0	581.6	0.0
1	9	3	39.2	71.7	53.8	0.0	785.8	0.0
1	13	4	36.7	0.0	36.4	0.0	522.2	0.0
1	7	5	0.0	352.7	4.6	0.0	2439.0	0.0
1	24	6	144.1	0.0	0.0	0.0	3063.2	0.0
1	21	7	259.9	0.0	213.9	0.0	1737.6	0.0
1	19	8	0.0	0.0	0.0	0.0	1136.4	34.2
1	17	9	26.1	0.0	0.0	0.0	1417.4	0.0
1	17	10	0.0	0.0	0.0	0.0	1026.7	288.7
3	1	1	0.0	0.0	53.0	136.6	533.8	0.0
3	2	2	0.0	0.0	58.7	0.0	1283.8	0.0
3	10	3	100.4	0.0	0.0	0.0	108.4	0.0
3	11	4	0.0	0.0	114.4	33.6	250.3	0.0
3	2	5	0.0	0.0	155.7	32.3	721.3	0.0
3	9	6	45.1	40.3	0.0	0.0	289.1	543.1
3	2	7	0.0	0.0	96.5	27.2	438.5	0.0
3	11	8	0.0	0.0	790.9	0.0	270.8	0.0
3	2	9	0.0	0.0	83.9	0.0	1070.1	0.0
3	22	10	0.0	0.0	32.9	0.0	446.8	105.1
4	12	1	0.0	0.0	41.3	0.0	1554.2	0.0
4	16	2	10.4	0.0	21.9	0.0	554.2	0.0
4	11	3	5.8	0.0	208.0	0.0	78.8	0.0
4	4	4	0.0	48.2	57.5	0.0	1302.8	0.0
4	3	5	419.8	263.4	0.0	0.0	323.6	0.0
4	9	6	142.1	0.0	137.9	0.0	91.0	0.0
4	8	7	0.0	0.0	202.6	38.4	383.6	0.0
4	17	8	51.1	0.0	208.0	0.0	0.0	0.0
4	23	9	51.8	27.1	283.5	0.0	1770.2	0.0
4	19	10	0.0	0.0	141.4	0.0	108.2	0.0
4	20	11	66.3	33.8	148.9	0.0	0.0	0.0
4	15	12	114.9	0.0	114.2	87.1	26.4	47.1
4	16	13	0.0	0.0	89.5	0.0	93.8	0.0
4	22	14	0.0	0.0	100.2	8.3	338.3	0.0
4	22	15	0.0	0.0	64.6	0.0	62.0	0.0
4	26	16	124.7	94.1	780.7	0.0	0.0	0.0
4	30	17	0.0	0.0	280.2	0.0	1127.6	0.0
4	29	18	333.3	0.0	578.2	0.0	0.0	0.0
4	16	19	0.0	0.0	179.1	0.0	174.0	0.0
4	23	20	61.2	18.6	59.8	0.0	1932.3	440.6
4	22	21	0.0	0.0	1140.5	18.2	203.4	0.0
4	11	22	0.0	0.0	219.6	116.9	208.5	0.0
4	16	23	12.9	0.0	0.0	0.0	715.1	15.0
4	22	24	0.0	0.0	133.0	0.0	706.5	0.0
4	26	25	148.3	76.5	1649.5	0.0	0.0	0.0
6	27	1	28.5	0.0	142.1	0.0	1128.3	0.0
6	27	2	272.1	19.0	411.0	0.0	803.1	0.0
6	24	3	29.2	0.0	352.8	0.0	245.3	155.7
6	23	4	0.0	0.0	512.5	0.0	234.0	469.3
6	12	5	122.5	120.3	0.0	0.0	153.2	0.0
6	15	6	46.9	0.0	8.9	0.0	497.4	0.0
6	11	7	46.3	0.0	74.4	0.0	1117.7	0.0

Appendix V-2. Continued.

UNIT	STANDNUM	PLOT	LPINDN	DPINDN	LOAKDN	DOAKDN	LOTHDN	DOTHDN
-----stems/ha-----								
6	21	8	75.9	17.5	0.0	0.0	1332.0	306.0
6	20	9	140.5	28.4	449.8	0.0	0.0	0.0
6	18	10	12.5	34.1	0.0	0.0	952.3	0.0
6	10	11	0.0	0.0	20.6	0.0	362.5	12.4
6	16	12	7.7	0.0	262.1	0.0	102.2	0.0
6	9	13	0.0	0.0	0.0	0.0	935.3	0.0
6	8	14	110.1	0.0	4.0	0.0	1573.1	0.0
6	1	15	0.0	0.0	7.5	0.0	486.4	0.0
6	2	16	0.0	0.0	5.2	0.0	748.4	0.0
6	4	17	13.4	0.0	29.5	0.0	552.4	0.0
6	5	18	13.7	0.0	0.0	0.0	586.7	0.0
6	6	19	9.7	13.1	0.0	0.0	1406.5	0.0
6	7	20	205.9	0.0	7.0	0.0	399.0	0.0
6	13	21	0.0	16.4	762.2	9.4	154.8	51.3
6	23	22	0.0	0.0	107.6	0.0	1121.8	306.0
7	2	1	54.5	27.2	111.0	0.0	33.8	0.0
7	5	2	59.0	37.5	18.0	9.3	1454.9	0.0
7	8	3	153.3	56.7	925.9	0.0	47.1	0.0
7	7	4	16.1	108.8	523.2	0.0	667.1	0.0
7	11	5	677.9	0.0	0.0	0.0	34.7	0.0
7	12	6	0.0	0.0	995.6	0.0	48.8	0.0
7	16	7	0.0	0.0	1361.0	0.0	49.0	0.0
7	19	8	0.0	0.0	233.2	149.3	670.1	177.3
7	18	9	11.9	31.1	469.9	0.0	1237.8	0.0
7	39	10	39.2	97.7	576.6	0.0	65.2	0.0
7	29	11	0.0	34.4	436.9	884.2	338.6	0.0
7	24	12	60.1	62.5	32.2	0.0	61.2	0.0
7	26	13	26.3	18.3	0.0	0.0	1656.5	312.0
7	30	14	28.2	26.3	106.6	169.6	1774.3	0.0
7	27	15	0.0	0.0	161.1	615.9	348.5	44.3
7	49	16	0.0	0.0	418.1	497.4	523.3	0.0
7	36	17	50.5	39.5	906.5	0.0	761.1	0.0
7	41	18	105.9	28.3	439.3	0.0	1147.2	160.1
7	43	19	0.0	0.0	126.2	33.8	188.4	0.0
7	6	20	132.4	17.7	30.9	18.2	778.6	0.0
7	4	21	0.0	0.0	106.1	22.9	0.0	0.0
7	2	22	44.5	0.0	492.2	423.8	1105.2	0.0
7	2	23	26.7	0.0	151.9	0.0	411.0	0.0
7	2	24	604.7	0.0	126.0	151.4	523.2	0.0
7	5	25	15.9	157.0	260.1	162.4	0.0	0.0
7	5	26	403.1	0.0	969.4	1223.8	469.6	0.0
7	15	27	0.0	0.0	0.0	0.0	837.0	169.6
7	10	28	92.3	220.4	0.0	0.0	502.5	0.0
7	45	29	124.8	0.0	88.0	0.0	33.5	0.0
7	45	30	83.8	70.5	222.5	0.0	689.9	0.0
7	44	31	20.7	0.0	67.4	0.0	695.4	0.0
7	31	32	0.0	0.0	191.0	0.0	347.9	0.0
7	24	33	135.6	0.0	483.7	0.0	288.7	0.0
7	29	34	0.0	0.0	852.7	100.5	545.9	0.0
7	25	35	132.5	0.0	0.0	0.0	2307.0	0.0
7	23	36	0.0	0.0	456.0	55.3	715.1	0.0
7	5	37	56.6	14.3	0.0	17.7	1408.3	0.0

Appendix V-2. Continued.

UNIT	STANDNUM	PLOT	LPINDN	DPINDN	LOAKDN	DOAKDN	LOTHDN	DOTHDN
-----stems/ha-----								
7	43	38	0.0	0.0	78.9	49.7	420.6	0.0
8	1	1	2905.3	1249.9	0.0	0.0	0.0	0.0
8	14	2	30.7	0.0	180.9	11.9	936.7	0.0
8	7	3	0.0	0.0	244.3	0.0	579.8	0.0
8	13	4	88.2	0.0	375.7	709.1	742.9	0.0
8	13	5	40.6	16.7	71.1	0.0	345.4	0.0
9	2	1	496.3	26.9	1089.1	0.0	0.0	0.0
9	5	2	197.9	47.5	268.1	0.0	1084.9	0.0
9	7	3	236.9	0.0	213.7	0.0	309.3	0.0
9	6	4	0.0	0.0	305.2	86.3	203.1	0.0
9	8	5	224.4	0.0	93.1	0.0	0.0	0.0

Appendix V-3. Overstory DBH and age data.

UNIT	STANDNUM	PLOT	PINEDBH	OAKDBH	OTHDBH	PINEAGE	OAKAGE	OTHAGE
			cm			years		
1	6	1	27.5	10.0	35.5	28	0	0
1	7	2	38.1	56.4	33.8	98	0	125
1	9	3	45.8	50.7	17.8	82	0	47
1	13	4	41.7	57.4	37.3	0	0	99
1	7	5	9.5	83.0	35.9	0	0	99
1	24	6	29.9	0.0	12.2	32	0	23
1	21	7	30.1	12.2	8.7	24	0	0
1	19	8	0.0	0.0	19.5	0	0	69
1	17	9	34.9	0.0	19.0	0	0	91
1	17	10	0.0	0.0	26.5	0	0	88
3	1	1	0.0	44.1	53.5	0	0	116
3	2	2	0.0	66.2	32.8	0	0	111
3	10	3	45.0	0.0	30.2	52	0	56
3	11	4	0.0	75.3	44.9	0	90	0
3	2	5	0.0	60.5	39.9	0	86	0
3	9	6	38.7	0.0	37.7	50	0	61
3	2	7	0.0	58.2	12.1	0	105	0
3	11	8	0.0	41.1	30.8	0	88	0
3	2	9	0.0	61.2	33.8	0	86	0
3	22	10	0.0	74.9	49.1	0	0	111
4	12	1	0.0	49.3	18.7	0	86	102
4	16	2	55.3	38.1	35.6	0	0	142
4	11	3	74.2	41.9	20.1	0	70	0
4	4	4	25.7	49.6	18.2	0	86	102
4	3	5	27.4	0.0	25.6	51	0	0
4	9	6	32.8	41.2	18.7	52	96	0
4	8	7	0.0	34.6	18.2	0	79	0
4	17	8	35.4	43.6	0.0	0	118	0
4	23	9	34.9	27.6	12.7	95	71	0
4	19	10	0.0	38.7	34.6	0	75	91
4	20	11	35.2	32.8	0.0	115	94	0
4	15	12	26.3	35.8	41.8	0	104	0
4	16	13	0.0	45.4	50.1	0	0	114
4	22	14	0.0	47.6	9.7	0	117	0
4	22	15	0.0	55.3	46.7	0	122	107
4	26	16	31.8	15.5	0.0	75	29	0
4	30	17	0.0	35.2	32.3	0	0	90
4	29	18	32.5	22.4	0.0	96	0	0
4	16	19	0.0	45.4	33.5	0	0	88
4	23	20	41.2	39.8	8.7	95	73	0
4	22	21	0.0	42.2	33.6	0	93	0
4	11	22	0.0	42.1	18.7	0	109	0
4	16	23	49.6	0.0	32.8	0	0	142
4	22	24	0.0	47.9	13.9	0	91	0
4	26	25	30.1	11.2	0.0	80	29	0
6	27	1	33.4	21.7	26.6	59	64	84
6	27	2	37.0	8.8	16.0	60	0	0
6	24	3	33.0	21.9	20.8	58	0	46
6	23	4	0.0	11.7	16.9	0	0	34
6	12	5	29.2	0.0	20.8	72	0	0
6	15	6	49.1	84.7	8.0	90	91	0
6	11	7	47.0	52.2	14.9	75	88	0
6	21	8	50.8	0.0	27.1	76	0	91

Appendix V-3. Continued.

UNIT	STANDNUM	PLOT	PINEDBH	OAKDBH	OTHDBH	PINEAGE	OAKAGE	OTHAGE
			cm			years		
6	20	9	43.1	21.4	0.0	64	0	0
6	18	10	45.6	0.0	29.9	0	0	70
6	10	11	0.0	57.2	38.5	0	0	93
6	16	12	64.3	55.8	57.6	0	93	90
6	9	13	0.0	0.0	25.3	0	0	46
6	8	14	42.9	89.5	14.1	56	0	53
6	1	15	0.0	**.*	36.4	0	89	87
6	2	16	0.0	78.0	24.3	0	0	69
6	4	17	48.7	66.7	32.2	0	49	0
6	5	18	70.6	0.0	31.5	71	0	118
6	6	19	53.4	0.0	24.4	0	0	75
6	7	20	39.2	67.4	27.8	72	0	98
6	13	21	44.0	28.6	24.0	0	85	0
6	23	22	0.0	17.2	15.4	0	0	34
7	2	1	34.7	35.0	30.7	58	138	0
7	5	2	41.2	50.3	10.9	85	0	0
7	8	3	40.1	13.4	26.0	0	47	0
7	7	4	32.5	7.8	14.0	0	0	64
7	11	5	23.3	0.0	30.3	35	0	0
7	12	6	0.0	15.4	36.9	0	0	83
7	16	7	0.0	28.4	53.0	0	0	130
7	19	8	0.0	33.5	27.5	0	0	130
7	18	9	41.9	16.7	24.5	0	50	0
7	39	10	36.6	23.2	22.1	0	36	0
7	29	11	30.4	21.0	25.3	0	36	0
7	24	12	32.7	54.8	22.8	55	110	0
7	26	13	38.3	0.0	17.3	61	0	105
7	30	14	34.2	32.4	14.4	53	115	0
7	27	15	0.0	22.8	36.8	0	0	71
7	49	16	0.0	24.1	18.5	0	82	0
7	36	17	33.5	16.5	13.8	70	59	0
7	41	18	40.0	17.4	18.1	70	59	0
7	43	19	0.0	47.3	13.0	0	109	0
7	6	20	41.5	37.0	14.3	96	117	64
7	4	21	0.0	38.1	0.0	0	119	0
7	2	22	38.0	26.2	9.0	58	76	0
7	2	23	34.5	37.1	8.8	0	117	0
7	2	24	16.8	41.9	7.8	0	101	0
7	5	25	35.6	17.0	0.0	0	43	0
7	5	26	22.2	30.5	15.2	94	0	40
7	15	27	0.0	0.0	24.4	0	0	78
7	10	28	33.3	0.0	20.3	56	0	49
7	45	29	30.5	35.0	30.8	56	68	0
7	45	30	35.4	34.1	13.4	56	72	0
7	44	31	39.2	50.5	17.0	0	90	0
7	31	32	0.0	42.1	13.6	0	111	0
7	24	33	37.6	18.6	10.5	0	100	0
7	29	34	0.0	17.9	15.5	0	36	0
7	25	35	39.0	0.0	22.2	62	0	0
7	23	36	0.0	28.7	20.6	0	100	0
7	5	37	43.6	42.4	13.3	0	0	62
7	43	38	0.0	52.5	8.7	0	114	0
8	1	1	13.1	0.0	0.0	17	0	0

Appendix V-3. Continued.

UNIT	STANDNUM	PLOT	PINEDBH	OAKDBH	OTHDDBH	PINEAGE	OAKAGE	OTHAGE
			cm			years		
8	14	2	32.2	42.0	12.2	0	65	0
8	7	3	0.0	35.2	38.8	0	57	0
8	13	4	27.2	22.6	21.9	0	116	0
8	13	5	35.8	52.8	9.6	0	116	0
9	2	1	25.2	9.7	0.0	55	36	0
9	5	2	36.4	16.1	15.3	78	0	0
9	7	3	39.0	18.5	21.5	47	0	0
9	6	4	35.6	25.4	20.1	0	55	0
9	8	5	21.3	67.2	0.0	0	93	0

Appendix V-4. Overstory height and pine beetle presence.

UNIT	STANDNUM	PLOT	PINEHEIGHT	OAKHEIGHT	OTHHEIGHT	PINEBEETLE (presence)
			-----meters-----			
1	6	1	11.7	0.0	0.0	
1	7	2	18.4	0.0	23.3	
1	9	3	21.5	0.0	23.2	
1	13	4	0.0	0.0	18.9	
1	7	5	0.0	0.0	17.1	
1	24	6	15.0	0.0	12.1	
1	21	7	15.6	0.0	0.0	
1	19	8	0.0	0.0	16.0	
1	17	9	0.0	0.0	24.5	
1	17	10	0.0	0.0	22.6	
3	1	1	0.0	0.0	31.2	
3	2	2	0.0	0.0	20.9	
3	10	3	24.9	0.0	21.7	
3	11	4	0.0	26.0	0.0	
3	2	5	0.0	30.7	0.0	
3	9	6	24.8	0.0	25.8	
3	2	7	0.0	26.9	0.0	
3	11	8	0.0	27.2	0.0	
3	2	9	0.0	0.0	25.7	
3	22	10	0.0	0.0	25.7	
4	12	1	0.0	20.6	21.6	
4	16	2	0.0	0.0	17.9	
4	11	3	0.0	22.9	0.0	
4	4	4	0.0	21.6	0.0	
4	3	5	19.7	0.0	0.0	Y
4	9	6	19.2	20.2	0.0	Y
4	8	7	0.0	23.8	0.0	
4	17	8	0.0	23.4	0.0	
4	23	9	23.8	25.0	0.0	
4	19	10	0.0	24.4	27.5	
4	20	11	21.2	19.9	0.0	Y
4	15	12	0.0	19.5	0.0	
4	16	13	0.0	0.0	24.7	
4	22	14	0.0	27.6	0.0	
4	22	15	0.0	26.9	29.4	
4	26	16	23.8	15.4	0.0	
4	30	17	0.0	0.0	24.9	
4	29	18	22.9	0.0	0.0	
4	16	19	0.0	0.0	16.5	
4	23	20	23.9	27.8	0.0	
4	22	21	0.0	24.5	0.0	
4	11	22	0.0	21.8	0.0	
4	16	23	0.0	0.0	17.9	
4	22	24	0.0	31.9	0.0	
4	26	25	18.0	10.6	0.0	
6	27	1	25.0	17.2	26.3	
6	27	2	31.2	0.0	0.0	Y
6	24	3	23.9	0.0	19.7	
6	23	4	0.0	0.0	16.7	
6	12	5	21.1	0.0	0.0	Y
6	15	6	27.4	27.3	0.0	Y
6	11	7	22.2	20.1	0.0	Y

Appendix V-4. Continued.

UNIT	STANDNUM	PLOT	PINEHEIGHT	OAKHEIGHT	OTHHEIGHT	PINEBEETLE (presence)
			-----meters-----			
6	21	8	24.0	0.0	32.8	Y
6	20	9	23.0	0.0	0.0	Y
6	18	10	0.0	0.0	20.8	Y
6	10	11	0.0	0.0	40.9	
6	16	12	0.0	29.9	29.5	Y
6	9	13	0.0	0.0	26.9	
6	8	14	30.2	0.0	22.4	
6	1	15	0.0	24.9	22.5	
6	2	16	0.0	0.0	23.8	
6	4	17	0.0	33.0	0.0	
6	5	18	33.8	0.0	31.0	
6	6	19	0.0	0.0	21.4	Y
6	7	20	30.3	0.0	28.9	
6	13	21	0.0	19.3	0.0	
6	23	22	0.0	0.0	16.7	
7	2	1	19.9	20.0	0.0	Y
7	5	2	24.6	0.0	0.0	Y
7	8	3	0.0	14.3	0.0	Y
7	7	4	0.0	0.0	13.2	
7	11	5	16.8	0.0	0.0	
7	12	6	0.0	0.0	22.5	
7	16	7	0.0	0.0	26.1	
7	19	8	0.0	0.0	0.0	
7	18	9	0.0	13.1	0.0	
7	39	10	0.0	15.7	0.0	Y
7	29	11	0.0	0.0	0.0	
7	24	12	21.9	25.2	0.0	Y
7	26	13	19.9	22.1	0.0	Y
7	30	14	18.9	22.0	0.0	
7	27	15	0.0	0.0	27.2	
7	49	16	0.0	20.0	0.0	
7	36	17	21.8	16.8	0.0	Y
7	41	18	23.3	15.5	0.0	Y
7	43	19	0.0	23.5	0.0	
7	6	20	25.0	24.3	15.4	Y
7	4	21	0.0	23.2	0.0	
7	2	22	18.5	17.1	0.0	Y
7	2	23	0.0	17.3	0.0	Y
7	2	24	0.0	21.1	0.0	Y
7	5	25	0.0	12.3	0.0	
7	5	26	20.6	11.4	0.0	Y
7	15	27	0.0	0.0	23.4	
7	10	28	24.0	0.0	20.4	Y
7	45	29	20.5	21.8	0.0	
7	45	30	20.0	21.2	0.0	Y
7	44	31	0.0	23.3	0.0	Y
7	31	32	0.0	19.5	0.0	
7	24	33	0.0	18.1	0.0	Y
7	29	34	0.0	16.1	0.0	
7	25	35	26.6	0.0	0.0	Y
7	23	36	0.0	19.6	0.0	
7	5	37	0.0	0.0	12.7	Y

Appendix V-4. Continued.

UNIT	STANDNUM	PLOT	PINEHEIGHT	OAKHEIGHT	OTHHEIGHT	PINEBEETLE
			-----meters-----			(presence)
7	43	38	0.0	22.5	0.0	
8	1	1	12.5	0.0	0.0	Y
8	14	2	0.0	24.6	0.0	Y
8	7	3	0.0	21.7	0.0	
8	13	4	0.0	0.0	0.0	
8	13	5	0.0	18.3	0.0	Y
9	2	1	19.0	6.9	0.0	Y
9	5	2	22.1	0.0	0.0	Y
9	7	3	23.5	0.0	0.0	Y
9	6	4	0.0	17.4	0.0	Y
9	8	5	0.0	22.4	0.0	Y

Appendix VI. Biology of three woody exotic species at RICH, Virginia.

Japanese honeysuckle (Whitcomb 1983)

Habitat

- native to a wide range of eastern Asia
- grows in nearly any soil condition under any moisture regime
- grows best in full sun and on good soils
- shade tolerant

Life History

- blooms from mid-May to Sept./Oct.
- small black berry
- rapid grower into twining, tangled, dense mass, particularly in full sun
- 60-76 cm tall without support, climbs on other vegetation
- semi-evergreen in north, evergreen in south
- no serious pests
- difficult weed in the south to eradicate

Princess-Tree/Royal Paulownia (Burns and Honkala 1990)

Habitat

- native of eastern Asia
- grows best in well-drained, moist soils, but will germinate and grow on almost any moist, bare soil.
- intolerant of shade
- highly adaptable "escapee"

Life History

- blooms in April and May
- woody capsules turn brown as they mature and persist on the tree through the winter
- bear seeds at 8-10 years prolifically
- seeds germinate quickly, seedlings require bare soil, sufficient moisture and full sunlight
- roots sprout easily
- 9-21 m height at maturity
- rapid grower on good sites, considerably slower on poor sites
- deciduous
- no major insect pests; minor damage from several foliage diseases

Tree of Heaven (Burns and Honkala 1990)

Habitat

- native of China
- grows best in loamy, moist soils but tolerates a wide range of textures, stoniness, and pH
- intolerant of shade

Appendix VI. Continued.

Tree of Heaven Continued.

Life History

- blooms in mid-April to July
- samaras persist on female tree through the winter
- bears seeds prolifically
- due to shade intolerance, reproduction in natural stands is sparse except by sprouting
- roots and stumps sprout prolifically when main stem is injured or killed
- 17-27 m at maturity
- first year growth of sprouts rapid (3-4 m)
- deciduous
- few insect pests or disease problems

Appendix VII. Sources for warm season grasses and forbs for meadow plantings.

Warm Season Grasses

Bamert Seed Co., RR 3, Box 1120, Muleshoe, TX 79347. (806) 272-5506

Bluestem Seed Co., 4045 Somerset Dr., Prairie Village, KS 66208. (816) 786-2401

C.P. Daniel's Sons, Inc., P.O. Box 119, Waynesboro, GA 30830. (404) 554-2446

Hamilton Seeds, HCR Rt. 9, Box 138, Elk Creek, MO 65464. (417) 967-2190.

J. & J. Seed Co., Route #3, Gallatin, MO 64640. (816) 663-3157.

Johnston Seed Co., West Chestnut, Box 1392, Enid, OK 73701. (405) 233-5800.

Miller Grass Seed Co., P.O. Box 81823, Lincoln, NE 68501. (402) 475-1232

National Wildlife Turkey Federation, P.O. Box 530, Edgefield, SC 29824. (803) 637-3106.

Osenbaugh Grass Seeds, RR 1, Box 106, Lucas, IA 50151. (515) 766-6792.

Sharp Brothers Seed Co., RR 4, Box 237A, Clinton, MO 64735. (800) 451-3779

Stock Seed Farms, Box 112, Murdock, NE 68407. (402) 867-3771.

Wildlife Nurseries, P.O. Box 2724, Oshkosh, WI 54903. (414) 231-3780.

Perennial Forbs

Applewood Seed Co., 5380 Vivian St., Arvada, CO 80002.

Environmental Seed Producers, 1851 W. Olive Ave., Lompoc, CA 93436.

Lofts Seed, 11417 Somerset Ave., Beltsville, MD 20705.

North Creek Nurseries, Inc., RR 2, Box 33, Landenberg, PA 19350. (215) 255-0100.

S & S Seeds, P.O. Box 1275, Carpinteria, CA 93013.

Virginia Natives, Wildside Farm, P.O. Box 18, Hume, VA 22639. (703) 364-1665

Wildseed, Inc., 1101 Campo Rosa Rd., P.O. Box 308. Eagle lake, TX 77434.

Federal Cooperatives

U.S.D.A. Soil Conservation Service Plant Materials Centers. NPS Technical Advisor, Denver Service Center, FTS 327-2310. SCS National Plant Materials Specialist, Washington, D.C., FTS 447-5667.

Appendix VIII. Native species for planting as vegetative screens (information from Flint 1983, with recommendations also from Dirr (1990) and Hightshoe (1988)).

Small-Medium Sized Deciduous (with dense canopies)

Amelanchier arborea Downy serviceberry

Amelanchier canadensis Shadblow serviceberry

Size and Habit: Shrub to small tree; 4 m in 15 yrs, 12 m in 40 yrs

Light: Full shade to full sun

Soil Moisture: Moist to average

Soil pH: 4-7

Comments: Select plants grown from material native to the same region where they will be used for best results. Subject to fire blight and mites which can be controlled without difficulty; scale insects can also be a problem in warmer areas, yet this is not considered a high maintenance tree.

Carpinus caroliniana American hornbeam

Size and Habit: Small tree; 5 m in 25 yrs, 10 m in 65+ yrs

Light: Full shade to full sun

Soil Moisture: Moist to average

Soil pH: 4-6.5

Comments: Relatively trouble-free and needs little maintenance.

Cornus florida Flowering dogwood

Size and Habit: Small tree; 4 m in 18 yrs, 9 m in 35 yrs

Light: Full shade to partial sun

Soil Moisture: Moist to average

Soil pH: 4-6.5

Comments: Susceptible to borers but less so with good maintenance (fertilization and irrigation in times of severe drought. Good soil drainage is essential. Transplanting is difficult at times and must be done carefully. Performs best with some shade in the south.

Corylus americana American hazelnut

Size and Habit: Shrub; < 3 m

Light: Partial shade to full sun

Soil Moisture: Moist to dry

Soil pH: 4-7

Comments: Grows well in poor, gravelly soils.

Crataegus crus-galli Cockspur hawthorne

Crataegus punctata Dotted hawthorne

Size and Habit: Small tree with strong horizontal branching; 3-4 m in 15 yrs, 7-9 m in 60 yrs

Light: Full sun

Soil Moisture: Moist to very dry

Soil pH: 4-7

Comments: Well adapted to environmental stresses, including urban environments. Moderately susceptible to infection by the cedar apple rust fungus; plant away from eastern red cedar and its varieties, which are alternate hosts of the causal fungus, or be prepared to tolerate a certain amount of disease. Planted dormant trees after a few days' activation in a warm, moist atmosphere; prevent drying of roots during handling. The very large thorns these trees bear preclude their use near heavily used areas.

Appendix VIII. Continued.

Diervilla sessilifolia Southern bush honeysuckle

Size and Habit: Shrub; 0.75 m in 2 yrs, 1.2 m in 5 yrs

Light: Partial shade to full sun

Soil Moisture: Moist to dry

Soil Ph: 4-7

Comments: Unusually widely adapted to soils, light, and moisture conditions. Spreads by underground stems to make a dense mass. Unusually free of insects and diseases. Requires pruning every 3 years to maintain form and density; cut off tops a short distance above ground level in spring.

Hamamelis virginiana Common witch hazel

Size and Habit: Shrub; 2 m in 10 yrs, 4 m in 25 yrs

Light: Full shade to partial sun

Soil Moisture: Average

Soil Ph: 4-7

Comments: Grows best with at least light shade in the south. Relatively trouble-free and requires little or no maintenance.

Ilex verticillata Common winterberry

Size and Habit: Shrub; 2 m in 15 yrs, 3 m in 25 yrs

Light: Partial shade to full sun

Soil Moisture: Wet to average

Soil Ph: 4-6

Comments: Foliage is frequently affected by leaf spots and mildew, but seldom completely disfigured. Otherwise is relatively trouble-free.

Morus rubra Red mulberry

Size and Habit: Small tree; 6 m in 12 yrs, 14 m in 40 yrs

Light: Full sun

Soil Moisture: Average

Soil pH: 4-8

Comments: Requires little or no maintenance.

Ostrya virginiana Hop hornbeam, ironwood

Size and Habit: Small tree; 6 m in 25 yrs, 18 m in 80 yrs

Light: Partial shade to full sun

Soil Moisture: Moist to average

Soil pH: 4-7

Comments: One of most trouble-free deciduous trees. Hard wood result of slow growth rate. Difficult to transplant, so move in small sizes using container grown seedlings if available.

Appendix VIII. Continued.

Vaccinium corymbosum Highbush blueberry

Size and Habit: Shrub; 1.5 m in 6 yrs, 3 m in 20 yrs

Light: Partial shade to full sun

Soil Moisture: Moist to average

Soil pH: 4-5.5

Comments: Tolerant of shade but requires full sun for best fruit production. For the fullness necessary for screening, the plants must grow vigorously; this requires sites where soil conditions are ideal. Several insects and diseases can be troublesome, depending on location. Iron chlorosis (leaf yellowing) is common in soils that are not sufficiently acidic; this can be corrected using chelated iron or foliage sprays.

Viburnum acerifolium Mapleleaf viburnum

Size and Habit: Shrub; 2 m in 8 yrs, 3.5 m in 15 yrs

Light: Full shade to partial sun

Soil Moisture: Moist to dry

Soil pH: 5-6

Viburnum dentatum, *V. pubescens*, *V. recognitum* Arrowwood

Size and Habit: Shrub; 2 m in 8 yrs, 3.5 m in 15 yrs

Light: Full shade to full sun

Soil Moisture: Moist to average

Soil pH: 4-7

Comments: One of the most trouble free viburnums.

Viburnum prunifolium Black haw

Size and Habit: Shrub or small tree; 2.5 m in 10 yrs, 4.5 m in 25 yrs

Light: Partial shade to full sun

Soil Moisture: Moist to average

Soil pH: 4-8

Comments: Unusually trouble free but occasionally subject to insect problems. Scale insects and borers can be serious enough to require control measures.

Viburnum rufidulum Rusty black haw

Size and Habit: Shrub or small tree; 8 m

Light: Partial shade to full sun

Soil Moisture: Moist to average

Soil pH: 4-6.5

Comments: Southern counterpart of *V. prunifolium*, with more irregular, spreading growth habit. Select appropriate genetic material for region of use.

Appendix VIII. Continued.

Small-Medium Sized Evergreen

Ilex opaca American holly

Size and Habit: Shrub or small tree; 3 m in 18 yrs, 12 m in 80 yrs

Light: Half shade to full sun

Soil Moisture: Moist to average

Soil pH: 4-6

Comments: Grows well in full sun to half shade in summer, but for most compact growth full sun is best. Leaf miner is a serious insect pest that can be controlled with carefully timed sprays. Leaf-spot diseases are also troublesome. Many cultivars exist of *I. opaca*; local experience should be relied upon to select the best one for the area of use.

Juniperus virginiana Eastern red cedar

Size and Habit: Shrub or tree; 4 m in 15 yrs, 20 m in 90 yrs

Light: Full sun

Soil Moisture: Moist to dry

Soil pH: 4.5-8

Comments: Susceptible to *Phomopsis* blight and is also a principal alternate host to the fungus causing cedar apple rust. This disease is a serious problem to the alternate host species (the pome fruits of apples and hawthornes), and selection of *J. virginiana* should be done with these susceptible species in mind. Avoid planting this species near commercial apple orchards.

Kalmia latifolia Mountain laurel

Size and Habit: Shrub; 1 m in 10 yrs, 3 m in 30 yrs

Light: Full shade to full sun

Soil Moisture: Moist to average

Soil pH: 4-5.5

Comments: In the south this is useful only in relatively cool sites--shaded northern exposures. Relatively trouble-free, given a cool site and acidic soil, but susceptible to leaf-spot disease. Foliage of this is toxic to cattle, sheep, and humans.

Myrica cerifera, *M. caroliniensis* Southern bayberry, Wax myrtle

Size and Habit: Shrub or small tree

Light: Full sun

Soil Moisture: Wet to average

Soil pH: 4-6.5

Comments: A low maintenance plant for the south. Salt-resistance makes it very useful in coastal areas.

Vaccinium arboreum Tree huckleberry, sparkleberry, farkleberry

Size and Habit: Small tree; 6-8 m; requires pruning as screen

Light: Full sun

Soil Moisture: Average

Soil pH: 4-5.5

Comments: Requires pruning to produce thick foliage for screen. Select appropriate genetic material for area of use. Fruits are not edible.

Appendix VIII. Continued.

Large-Scale Evergreen

Ilex opaca American holly

Size and Habit: Shrub or small tree; 3 m in 18 yrs, 12 m in 80 yrs
See information in last section.

Juniperus virginiana Eastern red cedar

Size and Habit: Shrub or tree; 4 m in 15 yrs, 20 m in 90 yrs
See information in last section.

Magnolia grandiflora Southern magnolia

Size and Habit: Tree; 8 m in 20 yrs, 24 m in 80 yrs

Light: Partial sun to full sun

Soil Moisture: Moist to average

Soil pH: 4-7

Comments: Free of problems. Many cultivars exist, so local experience should be consulted for the area of use. Foliage burn occurs in some winters in the northern part of its range (Virginia).

Pinus taeda Loblolly pine

Size and Habit: Tree; 8 m in 20 yrs, 30 m in 50 yrs

Light: Full sun

Soil Moisture: Moist to very dry

Soil pH: 4-7

Comments: Fast but temporary screen. Tolerates very poor soil and exposed sites. One of the most durable and trouble free of the southern pines in landscape use. Borers can be a problem on mechanically damaged trees. Difficult to transplant in larger sizes, so plant young seedlings or container-grown trees. Growth is so rapid that trees attain functional size even when started as young seedlings.

Prunus caroliniana Carolina laurelcherry, cherry laurel

Size and Habit: Tree; 3 m in 8 yrs, 9 m in 30 yrs

Light: Half shade to full sun

Soil Moisture: Moist to average

Soil pH: 4-7

Comments: Unusually sensitive to poorly drained soil, tolerant of salt at seashore conditions. Requires pruning for maximum fullness as a screen.

