National Park Service
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Natural Resource Stewardship and Science

Forest Vegetation Monitoring

Mid-Atlantic Network 2011 Summary Report

Natural Resource Data Series NPS/MIDN/NRDS— 2012/324

ON THE COVER
Red maple (*Acer rubrum*) leaves in early spring.
Photograph by: James A. Comiskey, National Park Service

Forest Vegetation Monitoring

Mid-Atlantic Network 2011 Summary Report

Natural Resource Data Series NPS/MIDN/NRDS—2012/324

James A. Comiskey and Sarah M. Wakamiya

National Park Service
120 Chatham Lane
Fredericksburg, VA, 22405

June 2012

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

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Please cite this publication as:

Comiskey, J. A., and S. M. Wakamiya. 2012. Forest vegetation monitoring: Mid-Atlantic Network 2011 summary report. Natural Resource Data Series NPS/MIDN/NRDS—2012/324. National Park Service, Fort Collins, Colorado.

NPS 962/114763, June 2012

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Executive Summary

In 2011, 75 forest vegetation monitoring plots that were established in 2007 in eight parks of the Mid-Atlantic Network were revisited. Sixteen new plots were established in three Northeast Coastal and Barrier Network parks. New plots were randomly selected using a generalized random-tessellation stratified (GRTS) approach from a 250-m grid that overlays the parks. The monitoring plots consist of a 20 m x 20 m square with three nested microplots and 12 quadrats. All trees and shrubs with a diameter at breast height (DBH) ≥ 10 cm in the main plot were identified, measured, tagged with a unique number, and marked with paint at the point of measurement, their locations were mapped using a laser rangefinder, and their condition was assessed. Trees and shrubs with a DBH ≥ 1 cm and < 10 cm were identified, measured, marked, and tagged in each of the three microplots. The number, height, and cover of tree seedlings, as well as cover of a list of native and invasive exotic indicator plants were measured in the quadrats. Coarse woody debris was measured along three 15-m transects. Soil sampling was conducted in all parks except Colonial NHP.

Acknowledgments

We would like to thank members of the National Park Service's Forest Vegetation Working Group who have spent the last seven years collaboratively developing the monitoring protocols for networks in the Northeast, National Capital, Midwest, and Southeast Regions. In particular we are indebted to the staff of the National Capital Region Network and Northeast Temperate Network whose protocols form a significant basis for the Mid-Atlantic Network protocol. Our thanks are also extended to Wendy Cass, Shenandoah National Park, for providing a wealth of valuable experience and insights into the development and maintenance of a long term vegetation monitoring program. Sarah Wakamiya, Adam Kozlowski, and Kristina Callahan have provided invaluable data management and field support, and we are very grateful to our field crews over the last five years including, James Burka, Carolyn Davis, Sophia DeMaio, Thomas Faust, Johanna Fickenscher, Erika Gorczyca, Nichole Lightle, John Martin, Lindsey Sloat, Dana Spontak, Andrew Vincello, Katherine Wilkin, Jesse Wheeler, Caitlin White, and Elizabeth Wright. Brian Mitchell developed the ecological integrity database used to calculate some of the metrics. Early database development was provided by Zach Arcaro and Kunsheng Fang. Botanical support was provided by John Kunsman, Kate Miller, and Timothy Draude. We would also like to thank John Karish, Regional I&M Program Manager, and Mary Foley, NER Chief Scientist, as well as the park resource managers, including Kristen Allen, Steve Ambrose, Tim Blumenschine, Zachary Bolitho, Brian Eick, Dorothy Geyer, Scott Gurney, Kristina Heister, Sara Koenig, Gregg Kneipp, Rijk Morawe, Dave Shockley, and Timbo Sims for their continued support for the implementation of all Mid-Atlantic Network inventory and monitoring activities. Support for the Northeast Coastal and Barrier Network parks was provided by Sara Stevens. Fagan Johnson provided guidance and templates for the document layout.

Acronyms

APCO: Appomattox Court House National Historical Park
BOWA: Booker T. Washington National Monument
COLO: Colonial National Historical Park
DBH: Diameter at breast height
DRC: Diameter at root crown
EISE: Eisenhower National Historic Site
EPMT: Exotic Plant Management Team
ERMN: Eastern Rivers and Mountains Network
FIA: Forest Inventory and Analysis Program of USFS
FRSP: Fredericksburg and Spotsylvania National Military Park
FRSP-FRED: Fredericksburg Battlefield unit of FRSP
FRSP-SPOT: Spotsylvania Battlefield unit of FRSP
FRSP-CHWILD: Chancellorsville Battlefield and Wilderness Battlefield units of FRSP
GETT: Gettysburg National Military Park
GEWA: George Washington Birthplace National Monument
GRTS: Generalized Random Tessellation Stratified Design
HOFU: Hopewell Furnace National Historic Site
I&M: Inventory and Monitoring Program
IVI: Importance Value Index
MIDN: Mid-Atlantic Network
NB: National Battlefield
NBP: National Battlefield Park
NCBN: Northeast Coastal and Barrier Network
NCRN: National Capital Region Network
NER: NPS Northeast Region
NETN: Northeast Temperate Network
NHP: National Historical Park
NHS: National Historic Site
NM: National Monument
NMP: National Military Park
NP: National Park
NPS: National Park Service
PETE: Petersburg National Battlefield
PETE-EAST: Eastern and Western Front units of PETE
PETE-FIVE: Five Forks unit of PETE
RICH: Richmond National Battlefield Park
SAHI: Sagamore Hill National Historic Site
SHEN: Shenandoah National Park
THST: Thomas Stone National Historic Site
USDA: U.S. Department of Agriculture
USFS: U.S. Forest Service
VAFO: Valley Forge National Historical Park

Introduction

The Mid-Atlantic region is primarily a forested ecoregion and all Mid-Atlantic Network (MIDN) parks have forests that form an essential part of the landscape and provide habitat for a diversity of wildlife. For this reason, the vital signs selection process highlighted forest vegetation and several associated indicators as being a high priority for monitoring (Comiskey et al. 2009). The network thus initiated forest monitoring in 2007, conducting an initial year of pilot plot implementation which helped refine the process for the subsequent establishment of monitoring plots between 2008 and 2010. Four Northeast Coastal and Barrier Network (NCBN) parks were incorporated, three in 2008 and one in 2011. The full forest vegetation monitoring protocol was finalized and published in 2009 (Comiskey et al. 2009). In 2011, the first set of plots established in 2007 was revisited, the final set of plots were established in three NCBN parks, and the first year of plot establishment was conducted at Colonial National Historical Park.

The overarching goal of the vegetation monitoring program is to provide a framework for monitoring long-term change over broad spatial scales of the forests in the parks.

Specific monitoring objectives include:

- Determine the status and trends in forest structure, composition, and dynamics of canopy and understory woody species.
- Determine the status and trends in the density and composition of tree seedlings and selected herbaceous species that are indicators of deer browse.
- Detect and monitor the presence of invasive exotic plants, exotic plant diseases and pathogens, and forest pests.
- Determine the status and trends in forest coarse woody debris and the availability of snags.
- Determine the status and trends in soil Ca:Al and C:N ratios to assess the extent of base cation depletion, increased aluminum availability and/or nitrogen saturation impacting MIDN forest soils.

The monitoring protocol calls for establishment of a network of vegetation plots across eight of the 10 MIDN parks (Shenandoah NP uses a separate protocol (Cass et al. 2011), and forest cover is low at Eisenhower NHS), and four NCBN parks (these were incorporated between 2008 to 2011 for three parks, and initiated in 2011 for one park) (Figure 1).

This report focuses on a subset of the data collected in 2011. Inferences are made on a park basis, but comparisons to Fredericksburg and Spotsylvania NMP and Petersburg NB, analyses, and summary statistics are reported for individual units. Table 1 shows the allocation of plots in relation to forest area in the MIDN and NCBN parks. The standardized approach will also facilitate comparisons across networks in future reports and publications.

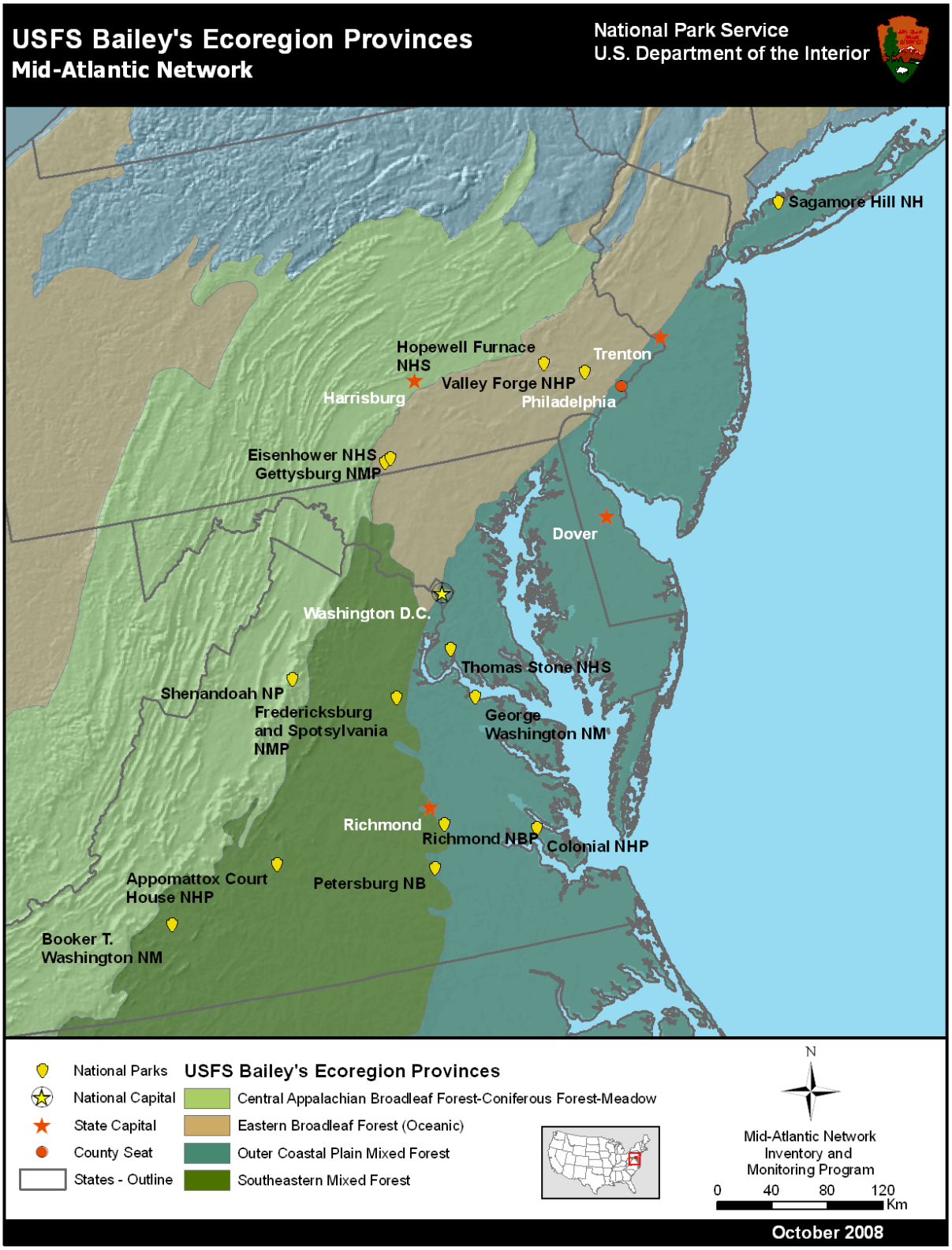

Figure 1. Location of parks included in the Mid-Atlantic Network's Forest Vegetation Monitoring protocol. Four parks from the Northeast Coastal and Barrier Network are also included in the monitoring program.

Table 1. Allocation of plots in Mid-Atlantic and Northeast Coastal and Barrier network parks in relation to forested area.

Park	Park unit	Park code	Established Plots	Forested Area (ha)
Mid-Atlantic Network				
Appomattox Court House National Historical Park (NHP)		APCO	28	442.0
Booker T. Washington National Monument (NM)		BOWA	8	62.4
Fredericksburg and Spotsylvania National Military Park (NMP)	Fredericksburg Battlefield	FRSP-FRED	28	459.6
	Spotsylvania Battlefield	FRSP-SPOT	28	430.0
	Chancellorsville Battlefield and Wilderness Battlefield	FRSP-CHWILD	48	1,397.9
Gettysburg National Military Park (NMP)		GETT	32	587.7
Hopewell Furnace National Historic Site (NHS)		HOFU	16	269.5
Petersburg National Battlefield (NB)	Eastern and Western Front	PETE-EAST	28	525.3
	Five Forks	PETE-FIVE	24	397.4
Richmond National Battlefield Park (NBP)		RICH	32	564.1
Valley Forge National Historical Park (NHP)		VAFO	28	427.3
Northeast Coastal and Barrier Network[2]				
Colonial National Historical Park (NHP)	Jamestown Island	COLO-JAMES	2[1]	243.4
	Yorktown	COLO-YORK	10[1]	1,290.2
George Washington Birthplace National Monument (NM)		GEWA	8	86.6
Sagamore Hill National Historic Site (NHS)		SAHI	4[3]	16.6
Thomas Stone National Historic Site (NHS)		THST	8	89.0
Total			332	7,289.0

[1] Colonial NHP plots were incorporated in 2011. An additional 12 plots per year will be established between 2012 and 2014. Sampling intensity is lower than in other parks due to funding constraints.
[2] George Washington Birthplace NM and Thomas Stone NHS plots were incorporated beginning in 2008.
[3] At Sagamore Hill NHS, the sampling design called for a minimum of eight plots, but due to the small size of the forested area in the park, only four plots could be established.

Methods

Field Methods

The target population is restricted to forested areas within each park. Plots were randomly selected using a generalized random-tessellation stratified (GRTS) approach from a 250-m grid that overlays the entire mid-Atlantic region (including all MIDN parks and those NCBN parks included in this protocol). Field crews navigated to the predetermined locations and rejected plot locations only for specific reasons and after having attempted alternate locations as outlined in the Table 5 of the forest vegetation protocol (Comiskey et al. 2009).

In 2007, one-fourth of the allocated plots in each of the eight MIDN parks were established by a crew of two people between May and September. In 2008 through 2010, the Mid-Atlantic Network shared a crew of four people with the Northeast Temperate Network (NETN). The crew worked in teams of two, starting the field season in NETN, and reaching the MIDN in August. In each of the three years, another one-fourth of the allocated plots were established, proceeding along the Pennsylvania parks from Valley Forge NHP to Hopewell Furnace NHS to Gettysburg NMP, followed by the Virginia parks starting with Appomattox Court House NHP and Booker T. Washington NM, and then Petersburg NB and Fredericksburg and Spotsylvania NMP. During the month of September, most of the work was conducted in Fredericksburg and Spotsylvania NMP, Richmond NBP, George Washington Birthplace NM, and Thomas Stone NHS. The latter two parks are part of the NCBN and were incorporated into the protocol in 2008, Another NCBN park, Colonial NHP, was added in 2011; 12 additional plots per year will be established in Colonial NHP between 2012 and 2014. Another NCBN park, Sagamore Hill NHS, was sampled only in 2009, primarily due to the small area of forest located in the park resulting in only four possible plots being established. Sagamore Hill NHS will only be revisited once every four years and all plots will be remeasured. For the remainder of the parks, one-fourth of the plots will be remeasured every four years, with the first set of remeasurments for plots established in 2007 being conducted in 2011. Appendix A provides maps showing locations of all plots and the year they were established in each of the parks.

Each plot consists of a 20 m x 20 m square with three nested microplots and 12 quadrats (Figure 2). A laser rangefinder was used to establish the plot boundaries so that the plot is a square in a horizontal plain (irrespective of the slope). PVC posts were used to mark the plot corners and the microplots (rebar was used in 2007); a survey marker attached to rebar was placed at the plot center. Site data were recorded for all plots (except in 2007) including slope, aspect, physiographic class, stand structure and height, crown closure, ground cover and disturbance, microtopography[1], and presence of water. Digital photographs were taken to provide a visual characterization of each plot.

[1] Microtopography is small-scale variation in the soil surface caused by tree tip-ups which create a pit and mound undulation. Microtopography indicates site history. Lack of microtopography indicates the site has been plowed prior to establishment of second-growth forest. Earthworks do not count as microtopography.

All trees and shrubs[2] with a diameter at breast height (DBH) ≥ 10 cm in the main plot were identified, measured, tagged with a unique number, and marked with paint at the point of measurement, their locations were mapped using the laser rangefinder, and their condition was assessed. All trees were also assigned to a canopy class based on their position in the canopy in relation to other individuals in the plot; canopy trees are those that are classified as belonging to the dominant, co-dominant, or intermediate crown classes. Trees[3] and shrubs with a DBH ≥ 1 cm and < 10 cm were identified, measured, marked, and tagged in each of the three microplots. Number, height, and cover of tree seedlings[4], as well as cover of a list of native and invasive exotic indicator plants and vines were measured in the quadrats. Coarse woody debris was measured along three transects. Soil sampling was incorporated in 2010.

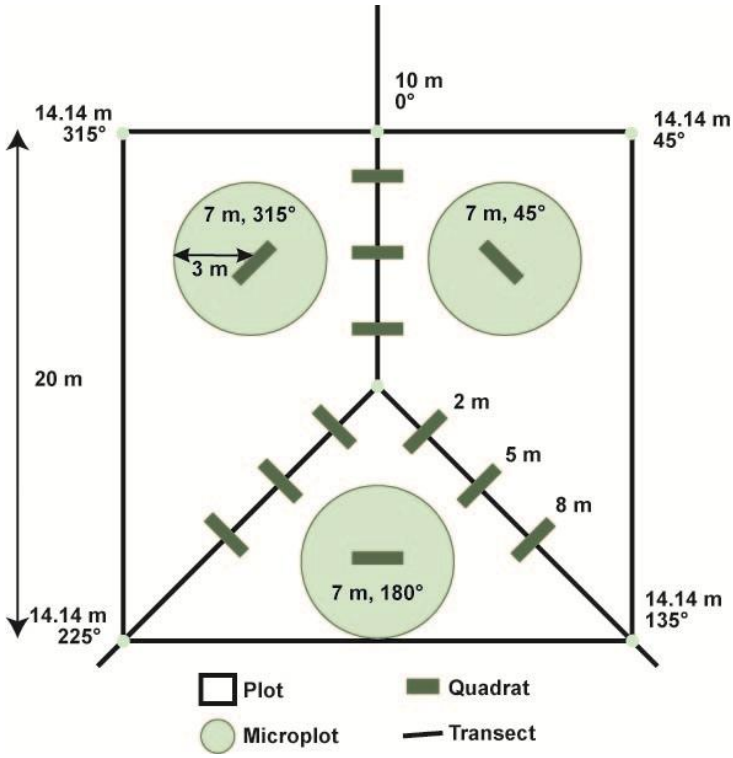

Figure 2. Layout of forest vegetation monitoring plot used in Mid-Atlantic and Northeast Coastal and Barrier network parks from 2007 to 2011.

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[2] Trees and shrubs are perennial woody plants, distinguished primarily by growth form. Trees generally have one main stem or trunk, while shrubs tend to have multiple stems and a shorter stature. However, the distinction between trees and shrubs can be difficult as shrubs may exhibit a variety of growth forms depending on species, location, and environmental conditions. For this reason, we have categorized all perennial woody plants as either being trees or shrubs based primarily on FIA (U.S. Department of Agriculture 2010), Plants Database (U.S. Department of Agriculture 2011), and personal observation. In addition, in the case of shrubs, we define how they should be measured.

[3] Trees with a DBH ≥1 cm and < 10 cm are also referred to as saplings.

[4] Tree seedlings include all individuals with a DBH < 1 cm and a height ≥ 15 cm (5 cm at VAFO). Shrub seedlings are excluded from measurement as this protocol focuses on determining regeneration of tree species that will reach the forest canopy.

Shrubs

Shrubs present a substantial challenge for consistent measurement due to their varied growth forms. Some species typically grow like trees, generally having a single stem and reaching heights where DBH can be measured. However, other species tend to sprout multiple stems from the base or branch extensively below DBH, and, if DBH were measured, the individuals (entire plant) would be grossly under-represented as most stems at DBH would be too small to be included. For this reason, between 2007 and 2010, the Mid-Atlantic Network quantified shrub basal area for such species by measuring the Diameter at Root Crown (DRC). For yet other shrub species, not even DRC is a practical measure, and the only option available has been to estimate total cover. In 2011, DRC measurements were dropped in favor of cover.

As the program was implemented, adjustments were made to how shrubs were treated:

- Between 2007 and 2010, all shrubs with a tree growth form and a DBH ≥ 10 cm were recorded, measured, marked, tagged, and mapped in the main plot (20 x 20 m area).
- In 2007 and 2008, <u>all</u> shrubs with a tree growth form that had a DBH ≥ 1 cm and < 10 cm were recorded, measured, marked, and tagged (Appendix B), and, for the appropriate subset of species, DRC was measured and tagged for <u>all</u> individuals with a DRC ≥ 1 cm in the microplots.
- In 2009 and 2010, <u>the</u> protocol was changed so that only the first <u>five</u> individuals of each species in the above two categories in each microplot were measured, marked, and tagged; additional individuals of the species were counted and the density recorded. In the results, we use the mean diameter of individuals that were measured for each species in each microplot to provide an estimate for individuals that were counted, thus enabling us to calculate an estimated total basal area. In 2009 to 2010, cover was measured in microplots for all shrubs that were not measured or counted.
- In 2011, the protocol for shrubs was standardized with NETN, where cover was measured for all shrubs except for a small subset (*Prunus* spp. and *Crataegus* spp.). For these species, DBH of the first five individuals of each species in each microplot was measured and the remainder counted.

Changes in the how shrubs have been measured over the past five years presents a challenge in analyzing temporal changes. For that reason, shrub dynamics will not be analyzed until all plots have been resampled.

Indicator Taxa

The Mid-Atlantic Network focuses on indicator species and taxa for monitoring in quadrats. The species have been selected as 1) invasive exotic indicators, 2) indicators of deer-browse effects, or 3) vines that may reach the forest canopy. In most cases, the indicators are 'species' (e.g. *Aralia nudicaulis*), while in other cases they are groups of species identified to the genus (e.g. *Rubus* spp. or *Vaccinium* spp.), family (e.g. Poaceae or Cyperaceae), or division (e.g. ferns) level. Throughout this report, the terms species and taxa may be used to indicate the indicators in the list.

The invasive exotic indicators have been selected in consultation with the NPS Mid-Atlantic Exotic Plant Management Team (EPMT) and park resource managers as being the top priority

for parks in the networks (29 taxa; Table 2). Of these, five are shrubs and nine are vines. A series of native species and taxa either preferred or avoided by deer are monitored as indicators of deer-browse effects (34 taxa; Table 3). Vines can indicate forest disturbance, and, in turn, may also cause disturbance when they reach the canopy by adding weight to and shading the host tree (16 taxa; Table 4). Nine of the indicator vines are invasive exotic and seven are native. In total (including vines), 34 native and 29 invasive exotic indicator taxa are monitored.

The indicators of deer browse are organized into those preferred by deer (20 taxa) and those avoided by deer (14 taxa; Table 3). The presence / absence of these indicators are used to evaluate the impact that deer may be having on the vegetation. When assessing potential deer browse there are a number of challenges, and the following section outlines how we address them in this report:

- Species vary in their distributions and abundance; the presence / absence of one species may reflect a variety of edaphic (e.g. soil chemistry) and biotic (e.g. displacement by invasive exotic plant species) conditions at a site, not just deer-browse pressure. The indicator data are reviewed as a group, with no single species being an indicator on its own.

- Growth form varies between indicator species and sites. Large values of percent cover at a site may result from a single individual of a species with dense growth which may skew the results. This is particularly the case if shrubs are included in the analyses, and may not necessarily reflect browse pressure. For this reason we present the data for shrub indicators (one preferred and three avoided taxa) separate from that of the herbaceous indicators (18 preferred and eight avoided taxa).

- Some taxa, such as ferns and grasses, are generally avoided by deer and thus may be indicators of high deer-browse pressure; furthermore, they may also impede seedling regeneration due to heavy growth cover, thus compounding the selective pressure by deer (e.g. Latham et al. 2005, Diefenbach and Fritsky 2007).

- Other species, e.g. *Rubus* spp., are preferred deer-browse, however, they do not tolerate shade, and thus, their absence from a plot may not necessarily indicate heavy deer browse (Diefenbach and Fritsky 2007). Therefore, the absence of *Rubus* is not used as an indicator on its own.

- Lastly, there are some challenges specific to our data, primarily that we have incorporated additional indicator species between 2007 and 2010. Plots established in the first few years were sampled for fewer species than the plots sampled in the latter years. This will become more of an issue when comparing temporal changes within the same plots.

Repeated visits to the same plots are the most effective way to overcome many of the issues addressed above. Evaluating temporal changes in the composition and cover of the indicator species at each plot will provide a clearer picture; for example, a decline in deer-preferred versus deer-avoided species will suggest that deer pressure may be increasing at that site. In future analyses we will use a metric that evaluates changes in frequency and cover over time.

Table 2. Invasive exotic indicator species chosen for monitoring in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Species	Common Name	Comments
Akebia quinata [v]	five-leaved akebia	
Alliaria petiolata	garlic mustard	
Ampelopsis brevipedunculata [v]	porcelain berry	
Berberis thunbergii [s]	Japanese barberry	
Cardamine impatiens	narrowleaf bittercress	
Celastrus orbiculatus [v]	Oriental bittersweet	
Centaurea biebersteinii	spotted knapweed	
Cirsium arvense	Canada thistle	
Clematis ternifolia [v]	yam-leaf clematis	
Duchesnea indica	mock strawberry	
Euonymus fortunei [v]	creeping euonymus	
Glechoma hederacea	ground ivy	
Hedera helix [v]	English ivy	
Hemerocallis fulva	common daylily	
Lespedeza cuneata	Chinese lespedeza	*Sericea lespedeza*
Ligustrum spp. [1,s]	privet	
Lonicera japonica [v]	Japanese honeysuckle	
Lonicera spp.[s]	bush honeysuckles	
Microstegium vimineum	Japanese stiltgrass	
Oplismenus hirtellus spp. undulatifolius [1]	wavy-leafed basketgrass	
Polygonum caespitosum [1]	Oriental lady's thumb	
Polygonum cuspidatum	Japanese knotweed	
Polygonum perfoliatum	mile-a-minute	
Pueraria montana [v]	kudzu	
Ranunculus ficaria	lesser celandine	
Rosa multiflora [s]	multi-flora rose	
Rubus phoenicolasius [s]	wineberry	
Vinca minor	periwinkle	
Wisteria sinensis [1,v]	wisteria vine	

[1] Species added in 2009. [s] Shrubs. [v] Vines.

Table 3. Native deer-browse indicator taxa chosen for monitoring the Mid-Atlantic and Northeast Coastal and Barrier networks.

Latin Name	Common	Deer Preference	Reference
Aralia nudicaulis [1]	wild sarsaparilla	Preferred	Balgooyen and Waller (1995)
Arisaema triphyllum [1]	jack in the pulpit	Avoided	Ruhren and Handel (2000), Heckel et al (2010)
Campsis radicans [v]	trumpet creeper	Avoided	Castleberry et al. (1999)
Cyperaceae [5]	sedges	Avoided	Latham et al. (2005), Diefenbach and Fritsky (2007)
Dennstaedtia punctilobula[1]	eastern hayscented fern	Avoided / Impede Regeneration	Horsley et al. (2003), Diefenbach and Fritsky (2007)
Eurybia divaricata [1]	white wood aster	Preferred	Williams et al. (2000)
Ferns [5]	ferns	Avoided / Impede Regeneration	Latham et al. (2005), Diefenbach and Fritsky (2007)
Impatiens capensis	jewelweed	Preferred	Williams et al. (2000)
Laportea canadensis [1]	Canadian woodnettle	Preferred	Augustine and Jordan (1998)
Lilium spp. [5]	lilies	Preferred	Miller et al. (1992)
Maianthemum racemosum	feathery false lily of the valley	Preferred	Fletcher et al. (2001), Augustine and DeCalesta (2003)
Medeola virginiana [1]	Indian cucumber	Preferred	Diefenbach and Fritsky (2007), Royo et al. (2010)
Orchids [5]	orchids	Preferred	Miller et al. (1992)
Parthenocissus quinquefolia [v]	Virginia creeper	Avoided	Castleberry et al. (1999)
Poaceae [5]	grasses	Avoided / Impede Regeneration	Latham et al. (2005), Diefenbach and Fritsky (2007)
Podophyllum peltatum	may apple	Avoided	Webster and Parker (2000)
Polygonatum biflorum [1]	smooth Solomon's seal	Preferred	Fletcher et al. (2001), Augustine and DeCalesta (2003), Kraft et al. (2004), Webster et al. (2005)
Polygonatum pubescens	hairy Solomon's seal	Preferred	
Polystichum acrostichoides	Christmas fern	Avoided	Diefenbach and Fritsky (2007)
Rubus spp. [6,s]	blackberry	Preferred [2]	Horsley et al. (2003), Diefenbach and Fritsky (2007)
Sanguinaria canadensis [3]	bloodroot	Preferred	Augustine and DeCalesta (2003)
Smilax spp. [7,v]	Common greenbrier	Preferred	Maxey (1976), Blair and Brunett (1980), Diefenbach and Fritsky (2007)
Smilax glauca [2,v]	cat greenbrier	Preferred	
Smilax rotundifolia [2,v]	roundleaf greenbrier	Preferred	
Thelypteris noveboracensis	New York fern	Avoided / Impede Regeneration	Williams et al. 2000, Horsley et al. (2003)
Toxicodendron radicans [v]	eastern poison ivy	Avoided	Castleberry et al. (1999)
Trillium cernuum	nodding trillium	Preferred	Anderson (1994), Augustine and Frelich (1998), Rooney (2001), Augustine and DeCalesta (2003), Webster et al. (2005)
Trillium erectum	red trillium	Preferred	
Uvularia perfoliata [1]	perfoliate bellwort	Preferred	Fletcher et al. (2001), Augustine and DeCalesta (2003), Webster et al. (2005)
Uvularia sessilifolia [1]	sessileleaf bellwort	Preferred	
Vaccinium [8,s]	blueberries	Avoided / Impede Regeneration	Diefenbach and Fritsky (2007)
Vaccinium corymbosum [s]	highbush blueberry		
Vaccinium stamineum [s]	deer berry		
Vitis spp. [v]	grape	Preferred	Castleberry et al. (1999)

[1] Species added in 2008. [2] Species added in 2009. [3] Species added in 2010. [4] Species added in 2011. [5] All species grouped. [6] *Rubus* is preferred deer browse but it may be absent from the understory as it does not tolerate shade, and thus may not be a good indicator (Diefenbach and Fritsky 2007). [7] Excluding *S. glauca* and *S. rotundifolia* that are identified to species. [8] Includes *Gaylussacia* spp but excludes *V. corymbosum* and *V. stamineum*. . [s] Shrubs. [v] Vines.

Table 4. Vine indicator species chosen for monitoring the Mid-Atlantic and Northeast Coastal and Barrier networks.

Species	Common Name
Akebia quinata [i]	five-leaved akebia
Ampelopsis brevipedunculata [i]	porcelain berry
Campsis radicans	common trumpet creeper
Celastrus orbiculatus [i]	oriental bittersweet
Clematis ternifolia [i]	yam-leaf clematis
Euonymus fortunei [i]	climbing euonymus, winter creeper
Hedera helix [1,i]	English ivy
Lonicera japonica [i]	Japanese honeysuckle
Parthenocissus quinquefolia	Virginia creeper
Pueraria montana [i]	kudzu
Smilax glauca [2]	cat greenbrier
Smilax rotundifolia [2]	common greenbrier
Smilax spp. [1]	greenbrier
Toxicodendron radicans	poison ivy
Vitis spp.	grape vine
Wisteria sinensis [2,i]	wisteria vine

[1] Species added in 2008. [2] Species added in 2009. [i] Invasive exotic species.

Analyses

This report focuses primarily on descriptive statistics for the various vegetative components including mature trees, snags, saplings, tree seedlings, shrubs, vines, and native and invasive exotic indicator taxa. Data are presented for the park and compared the network level results.

Vegetation Communities

All vegetation monitoring plots (excluding those established in Colonial NHP in 2011) were grouped into vegetation community types based on cluster analysis of the mature tree data. Indicator species analysis was used to determine the optimum number of clusters or groups (community types), and to identify the species that best represented each group (Dufrêne and Legendre 1997, McCune and Grace 2002). The community types identified are characterized by two that are dominated by pines, loblolly and Virginia pine; two by oaks, white oak and a second represented by oaks and hickories; two successional communities ranging drier to more mesic forests, tulip poplar and sweetgum; one modified successional dominated by white ash. An additional group is a mixed community, providing a grouping for a variety of sites with diverse species assemblages and characteristics. A more extensive description of the methods used in classifying the vegetation communities as well as community descriptions and a cross-walk to the United States National Vegetation Classification (USNVC), the vegetation maps prepared for each park, is currently in preparation.

Forest Dynamics

Once plots are revisited, we are able to determine how the structure and composition is changing over time. The most commonly used metrics to determine forest dynamics are mortality, recruitment and growth. Mortality refers to the death of individuals, recruitment to the increase in individuals that attain the minimum diameter size class, and growth to the yearly mean diameter increment.

Annual mortality rate (m; % stems/year) is calculated from successive observations as the percent of stems that died during an interval converted to an annual basis. Mortality is calculated as:

$$m = \frac{N_d \times 100}{N_o \times t}$$

where N_o is the number of trees in the previous census , and N_d is the number oftrees that died after t years.

In a similar fashion, recruitment is calculated using annual recruitment (r):

$$r = \frac{N_r \times 100}{N_o \times t}$$

where and N_o is the number of trees in the previous census, and N_r is the number of recruitedtrees after t years.

The Mean Annual Diameter Increment (MADI) has been used extensively to measure growth rates. MADI is the sum of the annual diameter increment (in cm) for all stems in the plot:

$$MADI = \frac{\sum(DBH_2 - DBH_1)/t}{n}$$

where, for each stem, DBH_1 is the diameter of the tree in the first census, DBH_2 is the diameter in the next census after t years. Only stems that were present and alive in both censuses are used to calculate MADI; trees that died prior to the second census were not included.

The forest dynamics data (mortality, recruitment, and growth) are presented as a series of graphs in this report.

Results and Discussion

It is important to note that the trends presented here are for one-quarter of the total number of plots established in the network, and hence we have a relatively low level of confidence in the results. This is particularly the case when we present summaries for data subsets, for example, by species, where some of the groupings may be represented by only a few individuals. In the coming years as we remeasure more plots, our sample sizes will increase and with them our confidence in the detected trends. Once we have revisited all plots, we will present summaries for each park in comparison to the network means. At this stage, presenting such data is premature and may provide a misleading interpretation of the trends.

Trees

Live tree stems ≥ 10 cm DBH that occur within the 20 x 20 m plots represent mature individuals that may be present in the canopy and sub-canopy. In 2011, trees were measured in plots established in 2007 and in new plots established in three NCBN parks (Table 5). Tree mortality, recruitment, and growth are presented for vegetation community types and species across the Mid-Atlantic Network (Figures 3 to 6). Recruitment is excluded from the crown class and diameter size class results since most recruits generally fall within the smallest size class and lowest crown class (Figures 7 to 10).

Table 5. Summary of trees ≥ 10 cm DBH in forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Park	# of plots	Mean # of stems / plot	Stems / ha	Mean BA (m^2) / plot	BA (m^2) / ha	# of species	Mean # of species / plot
APCO	7	44.57	1114.29	1.76	44.11	23	8.0
BOWA	2	51.00	1275.00	2.03	50.79	11	6.0
COLO_JAMES	2	18.50	462.50	1.80	45.07	9	5.5
COLO_YORK	10	20.50	512.50	1.52	37.98	24	6.9
FRSP_CHWILD	12	37.67	941.67	2.43	60.63	23	6.4
FRSP_FRED	8	54.71	1367.86	3.03	75.72	16	5.1
FRSP_SPOT	7	41.29	1032.14	2.46	61.51	15	6.4
GETT	8	22.62	565.62	2.02	50.42	16	5.9
GEWA	2	27.50	687.50	1.72	43.09	7	4.0
HOFU	4	31.50	787.50	2.97	74.18	12	5.5
PETE_EAST	7	46.43	1160.71	3.13	78.32	24	6.9
PETE_FIVE	6	78.83	1970.83	2.47	61.80	16	7.3
RICH	8	62.62	1565.62	2.84	71.08	21	6.2
THST	2	15.50	387.50	1.44	35.95	8	5.5
VAFO	7	30.14	753.57	2.88	71.99	17	4.4

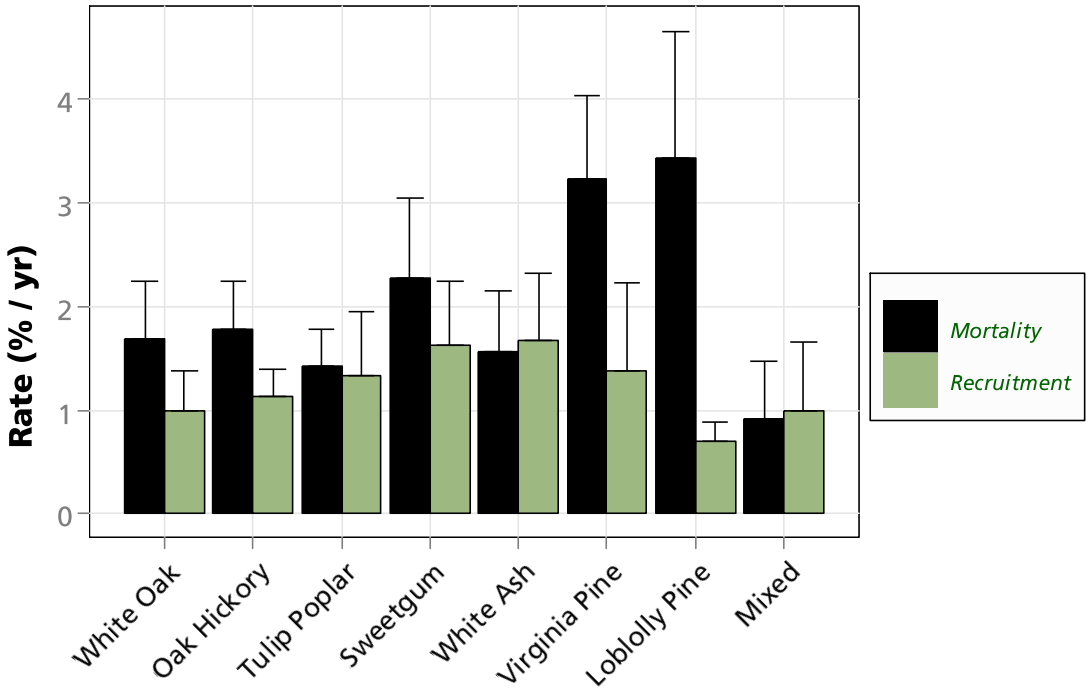


Figure 3. Mortality and recruitment of trees ≥ 10 cm DBH in different vegetation community types in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

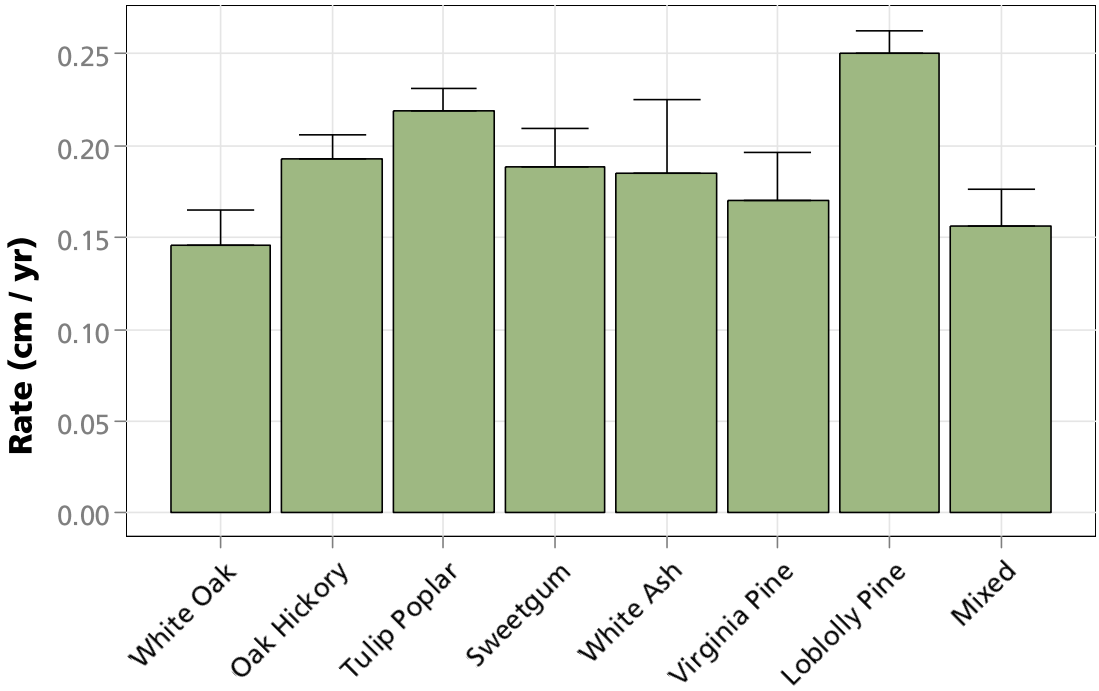


Figure 4. Growth rates of trees ≥ 10 cm DBH in different community types in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

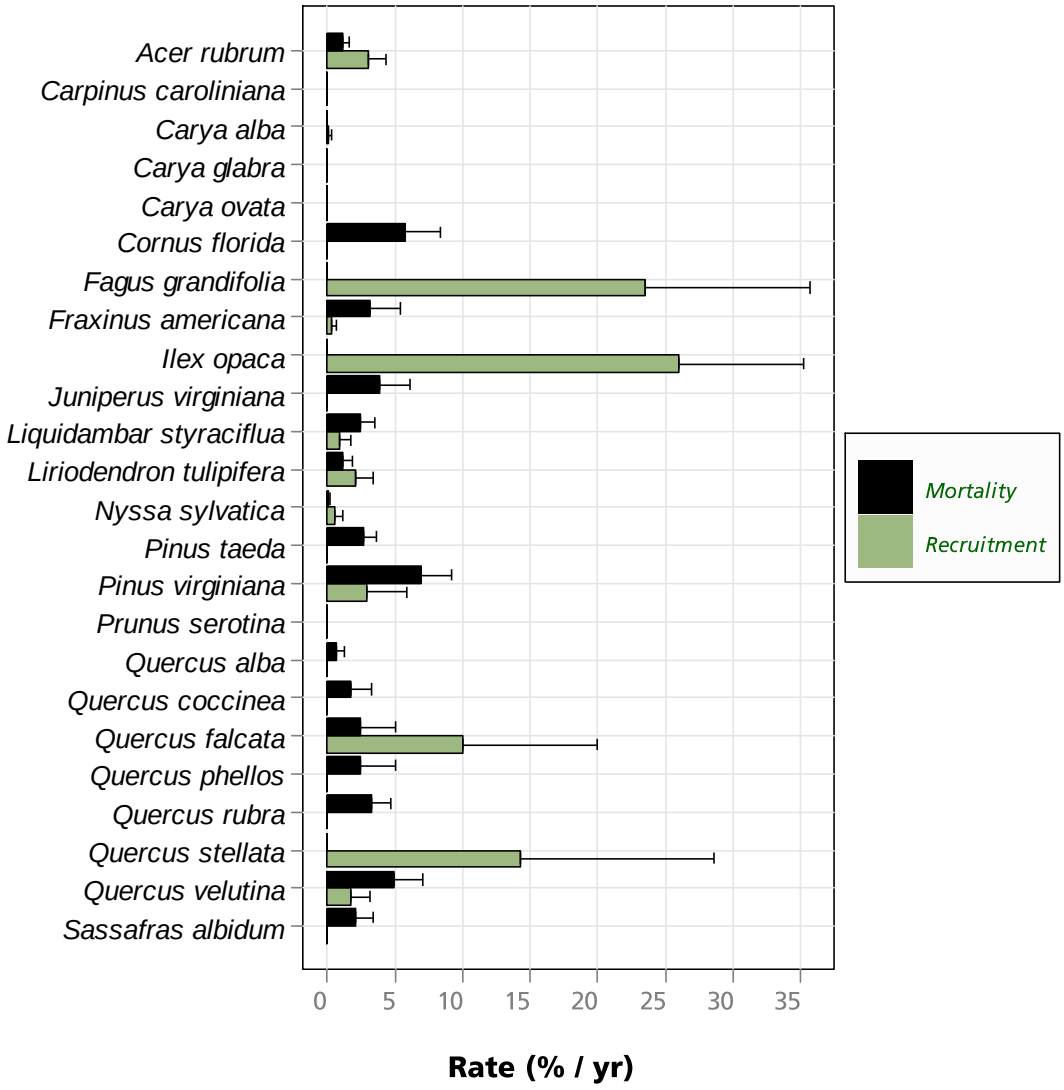


Figure 5. Mortality and recruitment of tree species ≥ 10 cm DBH in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

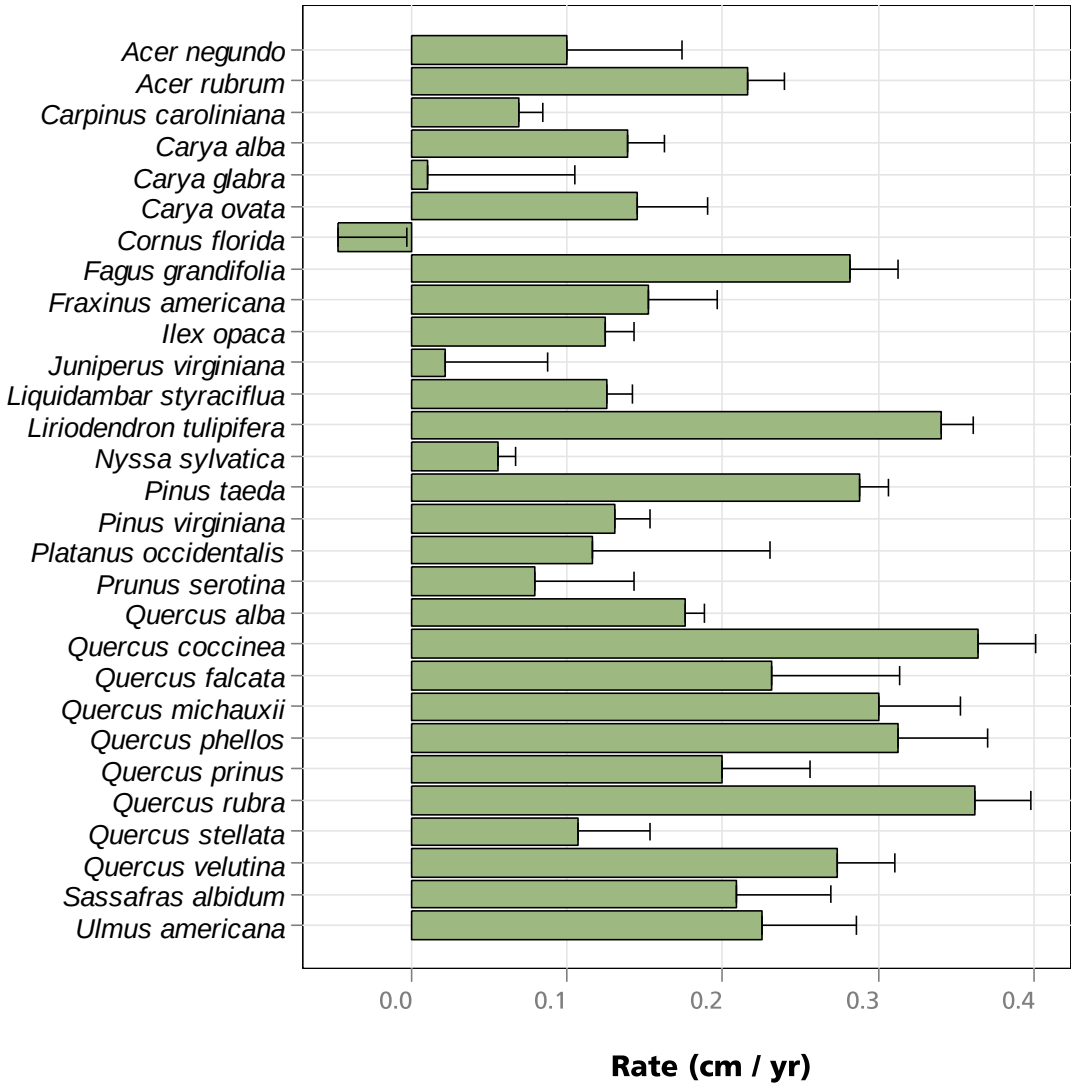


Figure 6. Growth rates of tree species ≥ 10 cm DBH in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

In Figure 6, flowering dogwood (*Cornus florida*) showed a mean negative growth rate. This value is based on 18 trees in eight park units, of which, 10 trees had negative growth rates. Most of the park units had dogwoods showing negative growth. It is not clear what is causing this negative growth rate but we will monitor individuals of the species closely as well as conducting additional quality control checks.

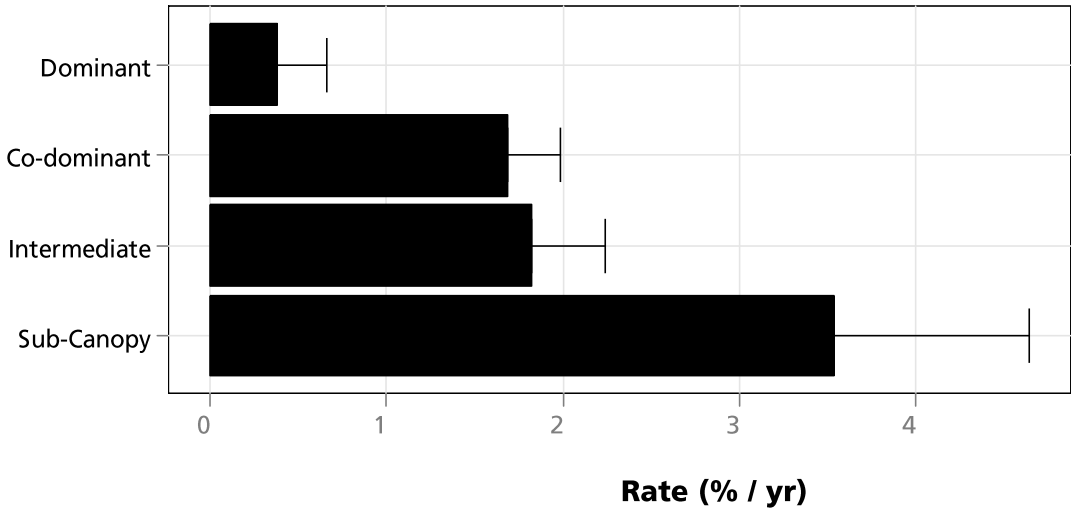


Figure 7. Crown class mortality rates of trees ≥ 10 cm DBH in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

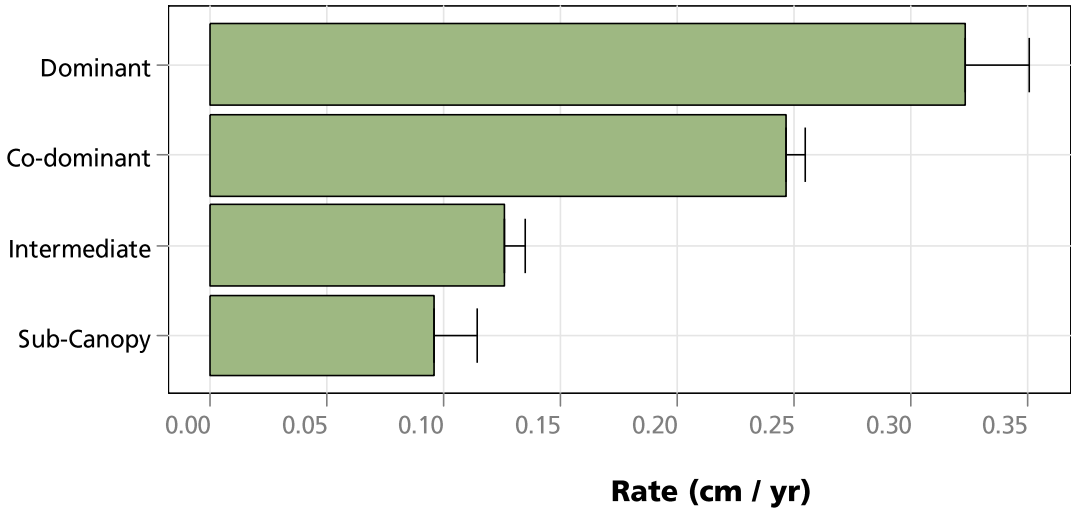


Figure 8. Crown class growth rates of mature trees in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

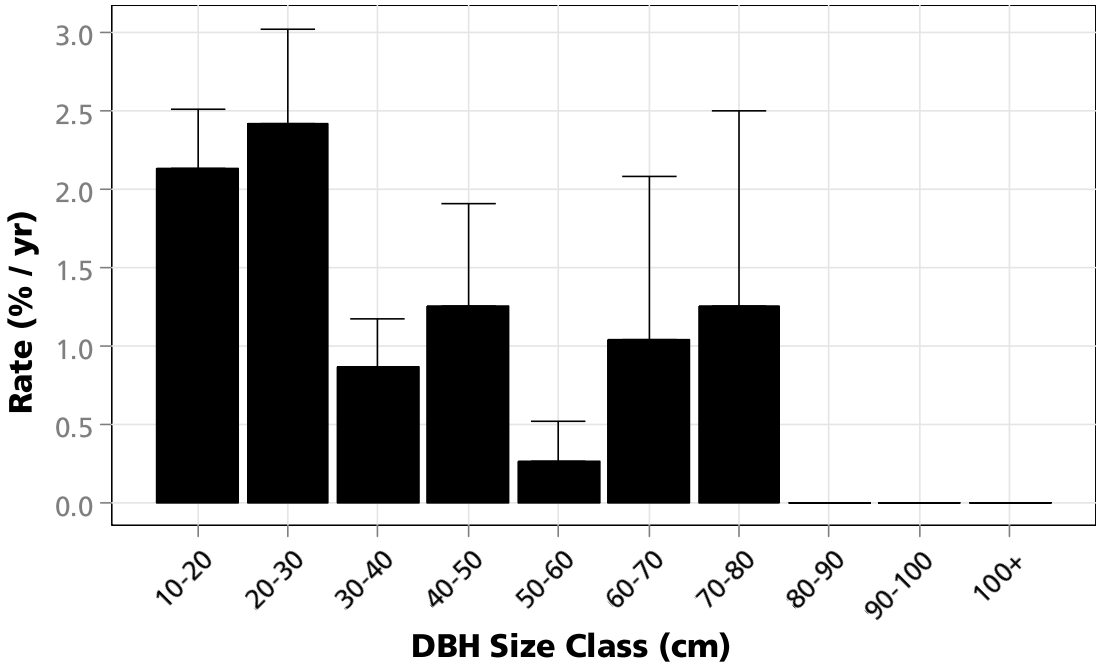


Figure 9. Diameter class mortality rates of mature trees in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

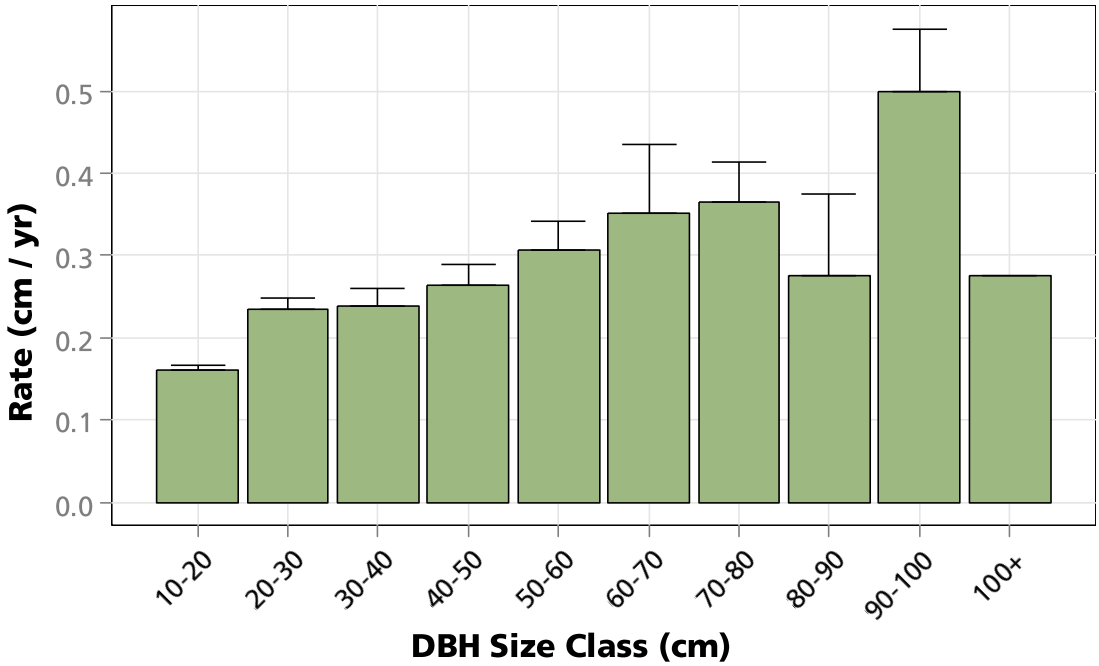


Figure 10. Diameter class growth rates of trees ≥ 10 cm DBH rates in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

Structural Stage

A range of forest structural stages enhances species diversity by providing multiple habitats within park units. As multiple stressors including global climate change and exotic pest and pathogen outbreaks alter disturbance regimes (Dale et al. 2001), structural stage distributions are likely to shift. This metric assesses the structural stage distribution of forest plots in relation to the expected distribution under natural disturbance regimes. It provides an indicator of altered disturbance regimes, and habitat availability for species dependent on specific structural stages (Tierney et al. 2009).

Structural stage distribution is assessed for each park based on calculations from canopy trees (trees with a DBH ≥ 10 cm that are categorized as belonging to the dominant, co-dominant, or intermediate crown classes based on their relative position in the canopy) in forested plots using methods similar to that of Frelich and Lorimer (1991) but substituting basal area for exposed crown area (Goodell and Faber-Langendoen 2007). The canopy trees are assigned into the following size classes: 10-25.9 cm DBH (pole), 26-45.9 cm DBH (mature), and ≥ 46 cm DBH (large). Plots are then classified as pole stage, mature stage, late-successional stage, or mosaic based on relative basal area of live canopy trees within pole, mature, and large size classes as follows:

Pole stage: ≥ 67% of total plot BA of canopy trees in pole plus mature sizes, with more basal area in pole than mature size.

Mature stage: ≥ 67% of total plot BA of canopy trees in pole plus mature sizes, with more basal area in mature than pole size or ≥ 67% in mature plus large size, with more basal area in mature than large size.

Late-successional stage: ≥ 67% of total plot BA of canopy trees in mature plus large sizes, with more basal area in large than mature size.

Mosaic: Any plot not meeting the above criteria.

Ratings based on expected percentage of late-successional forest stages across the landscape are then assigned according to Frelich and Lorimer (1991) and Lorimer and White (2003) as follows:

Good: At least 25% late-successional structure across the park.

Caution: Less than 25% late-successional structure across the park.

Significant Concern: Less than 25% combined mature and late-successional structure across the park.

For the plots sampled in 2011, the distribution of structural stages in Mid-Atlantic and Northeast Coastal and Barrier network forests is generally classified as "Good", with only Booker T. Washington NM, and the Chancellorsville and Wilderness unit and Fredericksburg unit of Fredericksburg and Spotsylvania NMP rated as "Caution", and the Five Forks unit of Petersburg NB rated as "Significant Concern. Plots at Appomattox Court House NHP showed an improvement from "Caution" in 2007 to "Good" in 2011 (Figure 11).

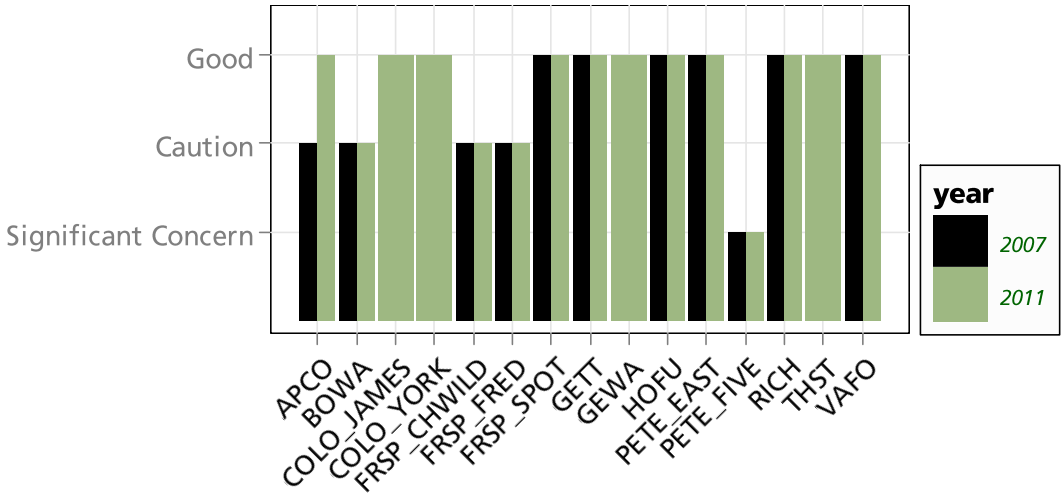


Figure 11. Structural condition of mature trees in the Mid-Atlantic and Northeast Coastal and Barrier network parks for plots sampled in 2007 and 2011.

Canopy Tree Condition

The Mid-Atlantic Network uses a tree condition ecological integrity metric to assess foliage condition in canopy trees (DBH ≥ 10 cm and in a dominant, co-dominant, or intermediate crown class). As the season progresses, most trees develop minor foliage problems (e.g., insect damage, chlorosis, etc.) and this is visible in MIDN plots as they are sampled between August 1 and September 30. More extensive damage, however, can indicate a wide variety of stressors ranging from forest pests and pathogens, to air quality and climatic change impacts. Pests and pathogens in particular pose a significant threat to forest communities, and several, such as beech bark disease (BBD) or hemlock woolly adelgid (HWA), affect individual species. Some pest and pathogen species are considered a high priority due to the severity of their threat, including Asian longhorned beetle (ALB), emerald ash borer (EAB), and sudden oak death (SOD). Other pests are low priority, including BBD, butternut canker (BC), elongate hemlock scale (EHS), and HWA. For this metric, any plot that had a high priority pest was ranked as "Significant Concern", and plots with BC, EHS, or HWA, or a high severity of BBD were ranked as "Caution". Foliar damage (insect damage, chlorosis, etc.) is visually estimated within broad classes (0-1, 1-10, 10-50, 50-90 and 90-100%). The average foliage problem for the plot is calculated. Rankings are assigned to each plot as follows:

Good: Average foliage problem with < 10% for canopy stems in plot, and no HWA, BC, EHS, ALB, EAB or SOD, and an average BBD severity ≤ 2 among all canopy beech stems in plot.

Caution: Average foliage problem with 10-50 % for canopy stems or species (species with at least two stems) in plot, or evidence of HWA, EHS or BC, or an average BBD severity > 2 among all canopy beech stems in plot.

Significant Concern: Average foliage problem with > 50% of canopy stems or species (species with at least two stems) in plot, or evidence of ALB, EAB, or SOD among any stems in the plot.

Table 6. Canopy tree condition in forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Park	# of Plots in a Good Condition	# of Plots in a Caution Condition	# of Plots in a Significant Concern Condition
APCO	4	3	
BOWA	1	1	
COLO_JAMES	2		
COLO_YORK	6	4	
FRSP_CHWILD	4	8	
FRSP_FRED	4	3	
FRSP_SPOT	2	5	
GETT	5	3	
GEWA	1	1	
HOFU	1	3	
PETE_EAST	6	1	
PETE_FIVE	5	1	
RICH	1	4	3
THST		1	1
VAFO	3	3	1

Tree condition metrics were not consistently collected in 2007, therefore the data for 2011 represent the first full tree condition data for the plots (Table 6). About half the plots were classified as having canopy trees in "Good" condition, while 5% were classified as "Significant Concern".

Snags

Standing dead biomass (snags) is an important element of eastern forests, contributing nesting and feeding habitat for birds and other vertebrates (Conner et al. 1979, Rosenberg et al. 1988, Petranka et al. 1994). In addition, snags are an important indicator of the structural age and health of the forest (Keddy and Drummond 1996). The proportion of snags in relation to live standing trees and shrubs with DBH ≥ 10 cm can indicate a higher or a lower mortality than expected for a given community.

The Mid-Atlantic Network considers snags to include all dead standing trees and shrubs ≥ 10 cm DBH (those that are leaning beyond 45° are classified as coarse woody debris). Forests are considered healthy ("Good") if snags constitute 10% or more of the standing trees and shrubs ≥ 10 cm DBH, and, for stems ≥30 cm DBH, snags make up 10% or more of the composition (Nilsson et al. 2002).

Good: At least 10% of all standing trees and shrubs ≥ 10 cm DBH in a park or group of plots are snags and at least 10% of all medium-large (≥ 30 cm DBH) standing trees in a park or group of plots are snags.

Caution: Less than 10% of standing trees and shrubs ≥ 10 cm DBH in a park or group of plots are snags or less than 10% of all medium-large (≥ 30 cm DBH) standing trees in a park or group of plots are snags

Significant Concern: Fewer than five medium-large snags (≥ 30 cm DBH) per hectare, calculated for the park or a group of plots.

Table 7. Snags in forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Plot	# of plots	Mean # of snags/plot	Snags / ha	BA (m^2) / ha	Snags / ha ≥30 cm	% snags	% snags ≥ 30 cm	Rating[1] 2007	Rating[1] 2011
APCO	7	8.29	207.14	5.98	0.00	13.81%	0.00%	SC	SC
BOWA	2	8.00	200.00	7.13	12.50	12.07%	10.00%	C	G
COLO_JAMES	2	0.00	0.00	0.00	0.00	0.00%	0.00%	-	SC
COLO_YORK	10	1.40	35.00	1.77	7.50	6.39%	4.17%	-	C
FRSP_CHWILD	12	4.42	110.42	6.49	10.42	7.76%	5.88%	SC	C
FRSP_FRED	8	6.00	150.00	4.04	0.00	11.51%	0.00%	SC	SC
FRSP_SPOT	7	5.57	139.29	4.49	3.57	8.50%	2.44%	C	SC
GETT	8	8.00	200.00	8.37	9.38	20.56%	7.69%	C	C
GEWA	2	0.50	12.50	0.10	0.00	1.79%	0.00%	-	SC
HOFU	4	1.50	37.50	0.48	0.00	3.03%	0.00%	SC	SC
PETE_EAST	7	8.14	203.57	12.69	21.43	10.34%	11.32%	G	G
PETE_FIVE	6	5.17	129.17	2.50	0.00	8.14%	0.00%	SC	SC
RICH	8	2.75	68.75	2.55	3.13	4.30%	2.17%	SC	SC
THST	2	1.00	25.00	1.26	12.50	6.06%	7.69%	-	C
VAFO	7	3.29	82.14	3.02	3.57	7.83%	2.78%	SC	SC

[1] Rating for 2007 and 2011 as G: Good; C: Caution; SC: Significant Concern.

The rating for snags generally remained constant across the network between 2007 and 2010 (Table 7). Ratings improved in Booker T. Washington NM and Chancellorsville and Wilderness

unit of Fredericksburg and Spotsylvania NMP, while in the Spotsylvania unit of Fredericksburg and Spotsylvania NMP the rating declined.

Tree Saplings

Tree saplings were measured in three 3-m radius microplots and included all tree species with a DBH ≥ 1 cm and < 10 cm and generally represent immature individuals that can become part of the forest canopy. In 2011, saplings were measured in plots established in 2007 and in new plots established in three NCBN parks (Table 8). Tree sapling mortality, recruitment, and growth are presented for vegetation community types and species across the Mid-Atlantic Network (Figure 12 to 15). Figure 16 presents diameter class mortality rates of tree saplings; recruitment is excluded as most recruits generally fall within the smallest size class category.

Table 8. Tree saplings in forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Park	# of plots	Mean # of saplings / plot	Saplings / ha	Mean BA (m^2) / plot	BA (m^2) / ha	Total # of species[1]	Mean # of species / plot[1]
APCO	7	36.0	4,244.1	0.04	4.80	25	9.0
BOWA	2	17.5	2,063.1	0.03	3.71	8	5.5
COLO_JAMES	2	10.0	1,178.9	0.02	2.41	2	1.0
COLO_YORK	10	6.9	813.5	0.02	2.06	12	2.8
FRSP_CHWILD	12	10.9	1,287.0	0.02	2.23	17	4.0
FRSP_FRED	8	7.7	909.5	0.01	1.50	9	3.3
FRSP_SPOT	7	8.0	943.1	0.01	1.54	9	3.4
GETT	8	10.3	1,208.4	0.01	1.59	14	2.9
GEWA	2	5.5	648.4	0.02	2.53	4	2.0
HOFU	4	4.3	501.0	0.01	1.51	4	1.0
PETE_EAST	7	3.9	454.7	0.01	1.30	10	2.3
PETE_FIVE	6	23.0	2,711.5	0.04	5.04	14	6.5
RICH	8	8.8	1,031.6	0.02	1.90	10	2.4
THST	2	3.5	412.6	0.01	0.77	3	2.0
VAFO	7	2.1	252.6	0.01	0.78	8	1.4

[1] Species richness of tree saplings only includes saplings identified to species.

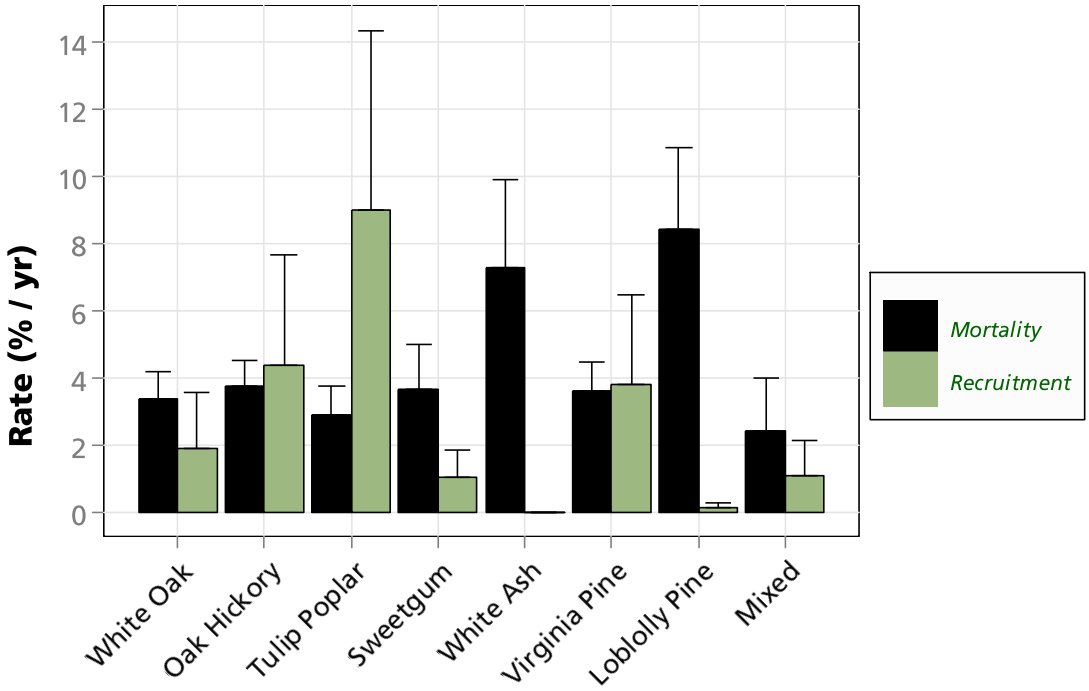


Figure 12. Tree sapling mortality and recruitment rates in different community types in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

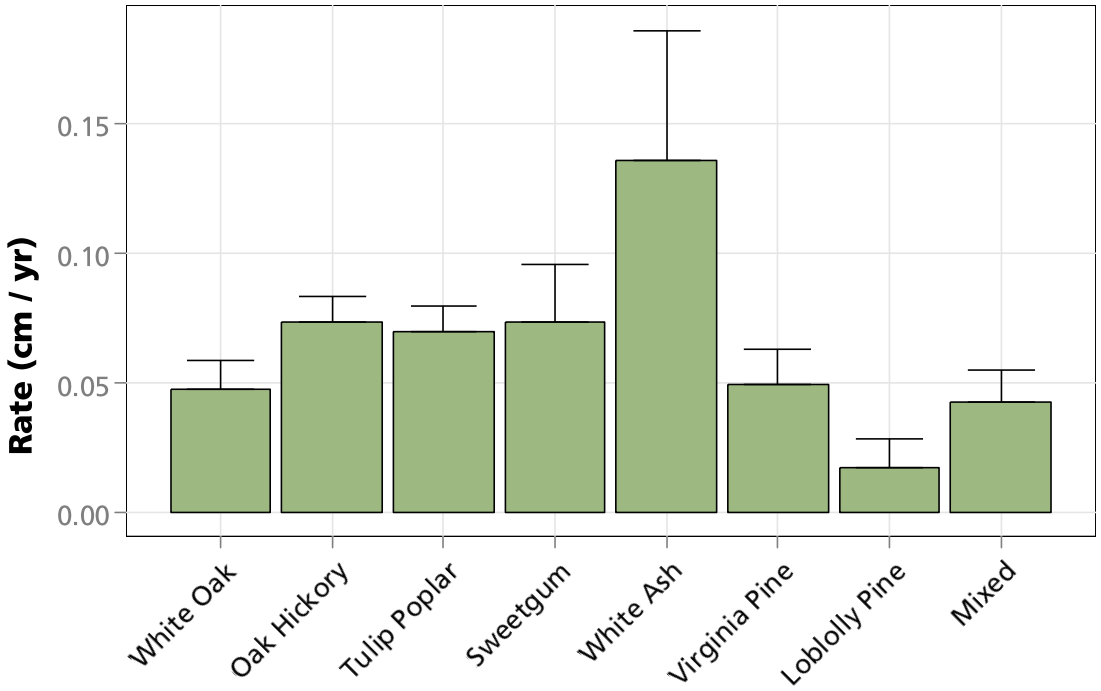


Figure 13. Tree sapling growth rates in different community types in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

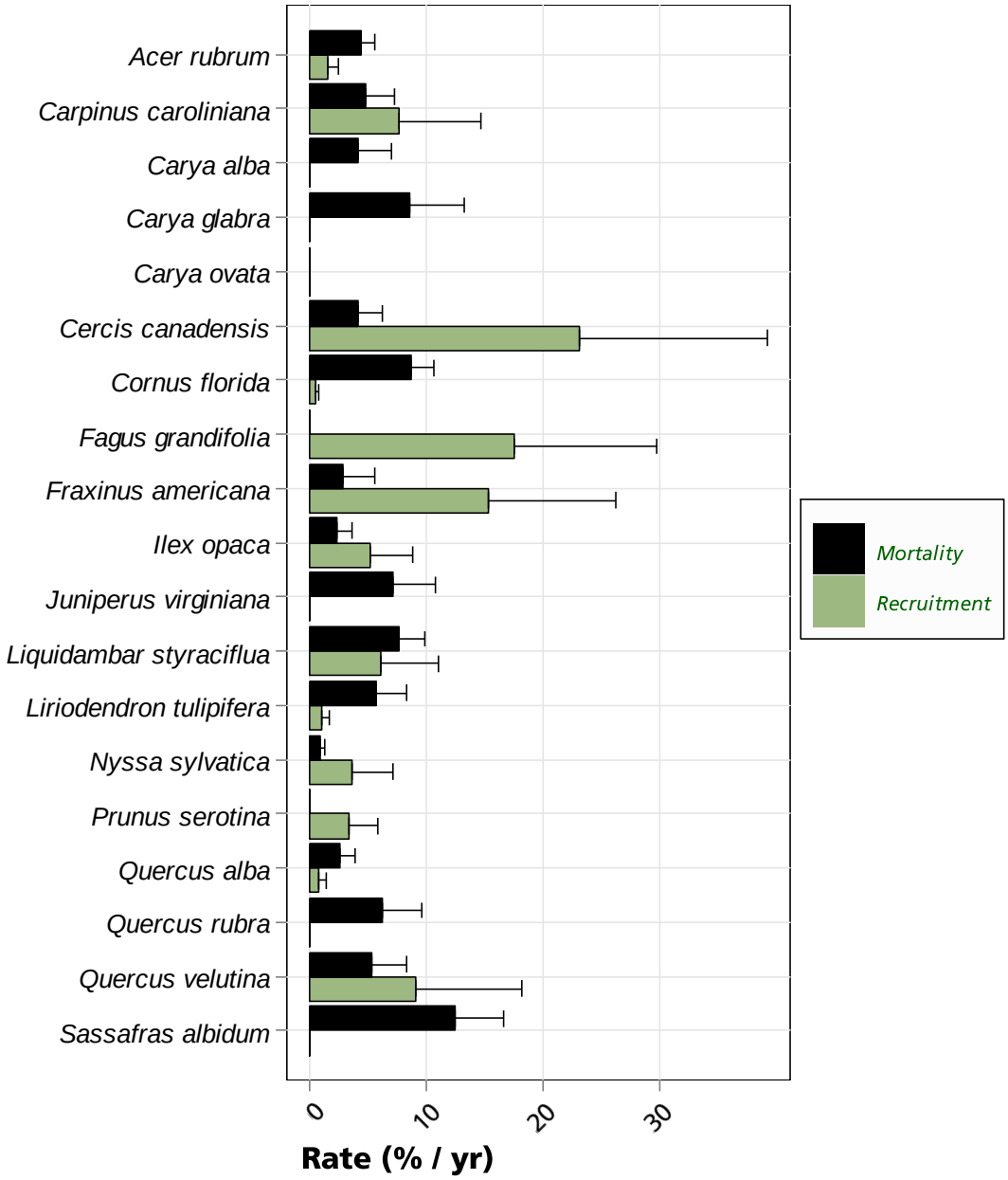


Figure 14. Species mortality and recruitment rates of tree saplings in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

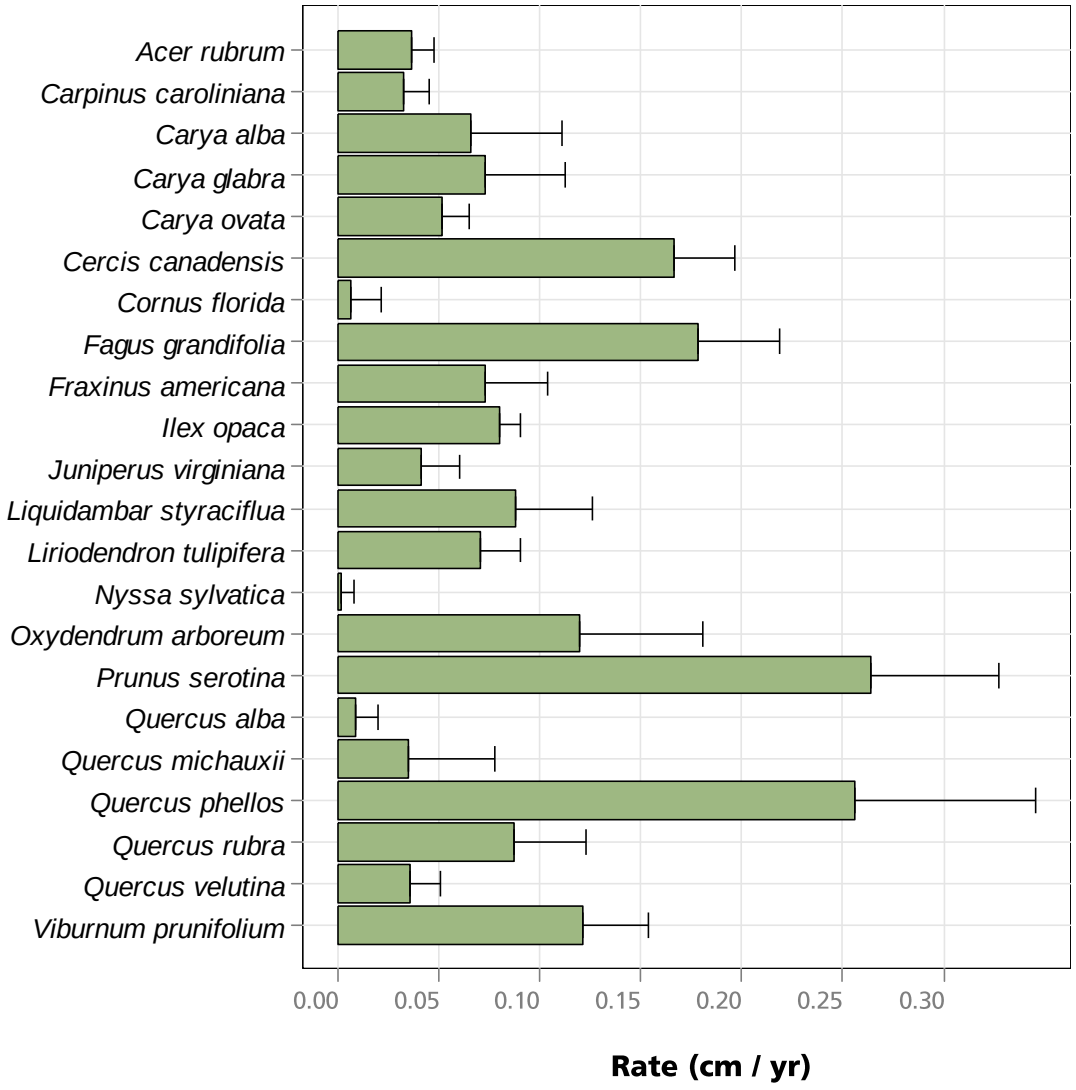


Figure 15. Species growth rates of tree saplings in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

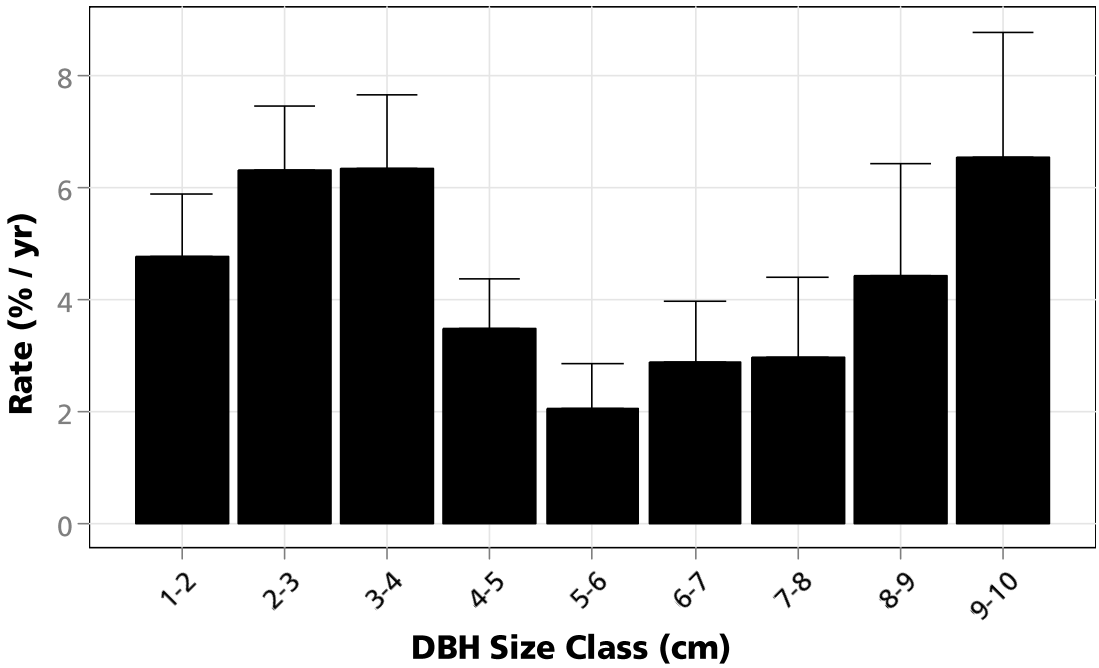


Figure 16. Diameter class mortality rates of tree saplings in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

Tree Seedlings

Forest regeneration in the Mid-Atlantic and Northeast Coastal and Barrier networks is primarily affected by deer browse as is seen across the region (Rooney and Waller 2003, Randall and Walters 2011). Impacts on forest regeneration occur at densities as low as 8.5 deer per km^2 or about 22 per mi^2 (Augustine and DeCalesta 2003). However, a dense understory growth of invasive exotic species can also suppress seedling regeneration and alter natural succession (Meiners 2007, Flory and Clay 2010).

Stocking rates established by McWilliams et al. (2005) for Pennsylvania are used throughout the Mid-Atlantic Network. Tree seedlings ≥ 15 cm in height and less than 1 cm in DBH are identified, counted, and assigned to a height class category in twelve 1-m^2 quadrats. A score is applied that is weighted according to the height class – e.g. one seedling that is >1.5 m in height is equivalent to 50 seedlings that are 0.15 to 0.3 m in height (Table 9). In Valley Forge NHP, an additional height class category (0.5-1.5 m) was included due to the low density of seedlings as a result of high deer browse pressure. Exotic tree species and species that do not reach the canopy are excluded from the seedling index score. In areas with low deer densities, the forest is considered adequately stocked (i.e. having sustainable regeneration) if there is an average weighted score or stocking index of 24 or more seedlings per twelve 1-m^2 quadrats, or about 2 or more seedlings per 1-m^2. In high deer density areas, an average stocking index of 8 or more seedlings per 1-m^2 is required. Since deer densities are generally considered to be high throughout the Mid-Atlantic region, we consider regeneration to be “Good” if the stocking index

is above 8 seedlings per m^2 averaged across all plots, “Caution” if less than or equal to 8 but greater than 2 per m^2, and “Significant Concern” if stocking index is below or equal to 2 per m^2. It is important to note that this is a conservative ranking as in areas with low deer densities a stocking index above 2 per m^2 would be considered “Good”.

Another metric that can be used is to evaluate regeneration is to determine the proportion of plots meeting minimum average weighted scores (>2 per m^2 in areas with low deer densities and >8 per m^2 in areas with high deer densities); if 70% of plots meet the appropriate criterion, then regeneration is deemed to be adequate. Again, the criterion we use is >8 per m^2.

Table 9. Height class categories for enumeration of seedlings and the associated weighted score to estimate stocking index (modified from McWilliams et al. 2005).

Seedling height class	Weighted score
0.05 – 0.15 m[1]	1
0.15 – 0.3 m	**1**
0.3 – 1 m	2
1 – 1.5 m	20
>1.5	50

[1] Only in Valley Forge NHP due to the high density of deer in the park.

Figure 17 shows the average weighted seedling score per m^2 per plot in each of the parks as compared to the mean for the Mid-Atlantic Network. The two dashed lines show the lower limits for adequate stocking established for the high and low deer densities. Each bar shows the 95% confidence limits of the scores; any value within that limit is not significantly different from the mean (i.e. the difference is due to chance). The graph shows that Appomattox Court House NHP and Gettysburg NMP have the highest seedling regeneration, with means that have increased significantly over the past four years and are now classified in the “Good” level. Booker T. Washington NM and Five Forks unit of Petersburg NB also showed an increase, but continue to be classified in the "Caution" category. All units in Fredericksburg and Spotsylvania NMP, Hopewell Furnace NHS, Eastern Front of Petersburg NB, and Richmond NBP showed declines in seedling scores over the past four years. Regeneration also varied across community types (Figure 18).

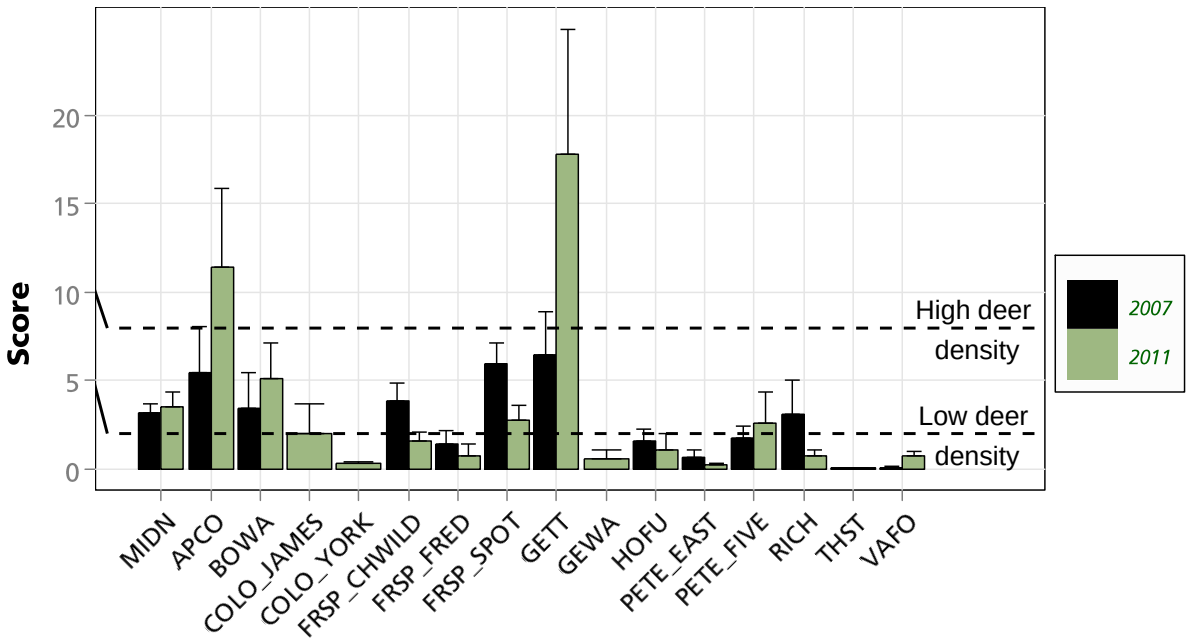


Figure 17. Canopy tree species regeneration (average weighted seedling score per 1 m^2 per plot) across Mid-Atlantic and Northeast Coastal and Barrier network parks for plots established in 2007 and remeasured in 2011. Exotic tree species and species that do not reach the canopy are excluded from the seedling index score. Bars show the 95% confidence interval.

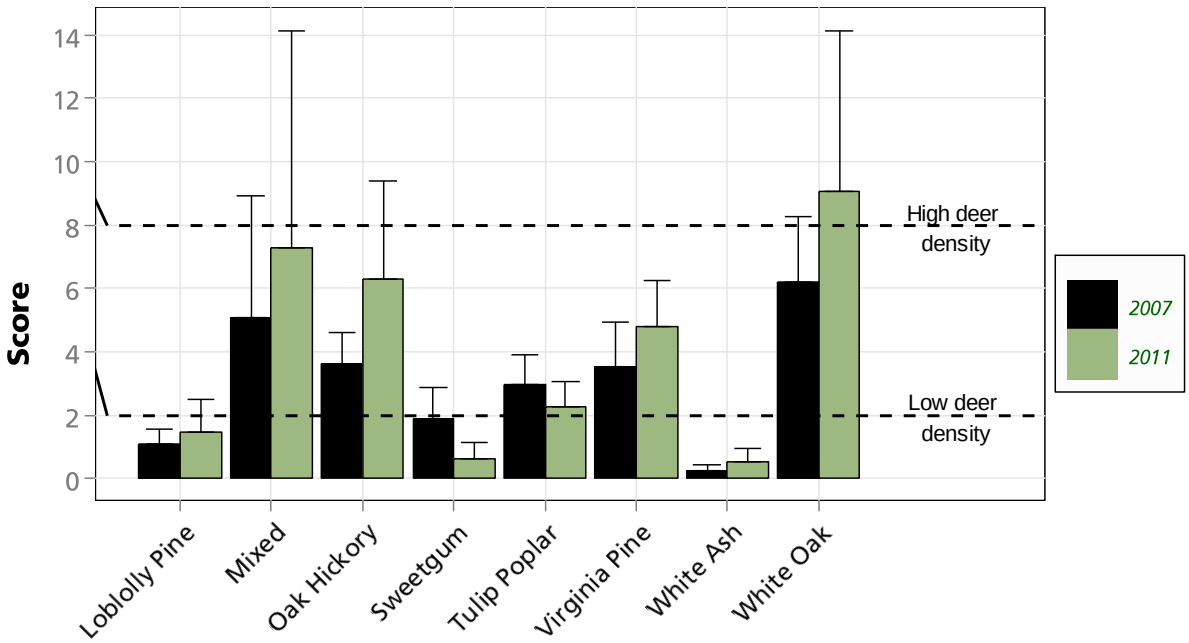


Figure 18. Canopy tree species regeneration (average weighted seedling score per 1 m^2 per plot) across different community types in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

Vine Indicator Species

Vines are common throughout the Mid-Atlantic and Northeast Coastal and Barrier networks. Vines can indicate disturbance and may result in increased tree mortality (Mohan et al. 2006). Table 10 shows the vine species documented in the two networks, while Table 11 summarizes vine occurrence across the networks in 2011.

Table 10. Vine indicator species frequency (number of plots) in forest vegetation monitoring plot quadrats sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Species	APCO	BOWA	COLO_JAMES	COLO_YORK	FRSP_CHWILD	FRSP_FRED	FRSP_SPOT	GETT	GEWA	HOFU	PETE_EAST	PETE_FIVE	RICH	THST	VAFO
Campsis radicans			1	1					1			1	3		
Celastrus orbiculatus[1]										3					3
Hedera helix[1]				2											
Lonicera japonica[1]	5	2		7		1	1	7	2		2	1	6	2	2
Parthenocissus quinquefolia	6	2	2	4	3	2	3	7	1	3	3	3	4	2	5
Smilax spp.	1	1	1	3		1	1		1	2	1				
Smilax glauca	6	2		5	8	5	1			1	3	4	4		
Smilax rotundifolia	5	2	2	5	7	4	3	2	2	1	3	2	7	2	
Toxicodendron radicans	3	2	2	5	1	1		4	2	3	3		2		4
Vitis spp.	6	2		5	3	2	2	5	2	2	5	6	4	1	3
Total species/taxa	7	7	5	9	5	7	6	5	7	7	7	6	7	4	5

[1] Invasive exotic species.

Table 11. Summary of indicator vines in forest vegetation monitoring plot sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Park	# of plots	# species in trees in plot[1]	# species in quadrats[1]	# trees with vines in plot	Mean # of trees per plot with vines	# tree species in plot with vines
APCO	7	2	7	7	1.00	6
BOWA	2	3	7	4	2.00	2
COLO_JAMES	2	2	5	4	2.00	3
COLO_YORK	10	3	9	12	1.20	7
FRSP_CHWILD	12	1	5	2	0.17	2
FRSP_FRED	8	1	7	3	0.43	1
FRSP_SPOT	0	0	0	0	0.00	0
GETT	8	2	5	8	1.00	6
GEWA	2	4	7	13	6.50	3
HOFU	4	3	7	6	1.50	4
PETE_EAST	7	6	7	24	3.43	5
PETE_FIVE	6	1	6	1	0.17	1
RICH	8	6	7	61	7.62	11
THST	2	1	4	1	0.50	1
VAFO	7	5	5	26	3.71	9

[1] Species richness only includes vine indicator taxa.

Invasive Exotic Indicator Species

A list of 29 invasive exotic indicator species and taxa is targeted for monitoring by the Mid-Atlantic Network. The cover of these exotic indicators is recorded in each of the 12 quadrats, and additional species of indicator exotics present in the plot are noted. Table 12 summarizes exotic indicator species sampled in 2011 by park, while Table 13 summarizes species data. The change in mean percent cover of invasive exotic indicator species (Figure 19) and their occurrence in different community types (Figure 20) between 2007 and 2011 in Mid-Atlantic Network parks are illustrated. More extensive analysis of invasive exotic indicator data will be conducted once more plots have been remeasured.

Table 12. Summary of invasive exotic indicator species and taxa in forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Park	# of plots	# plots with exotics[1]	% quadrats with exotics	Mean # quadrats / plot with exotics	Total # exotic species[2]	Mean # exotic species[2]
APCO	7	5 (0)	26.19%	3.14	2 (0)	1.00 (0.00)
BOWA	2	2 (0)	87.50%	10.5	3 (0)	2.00 (0.50)
COLO_JAMES	2	0 (1)	0.00%	0.00	0 (1)	0.00 (0.50)
COLO_YORK	10	8 (1)	40.00%	4.80	4 (0)	1.60 (0.40)
FRSP_CHWILD	12	1 (1)	0.69%	0.08	1 (1)	0.08 (0.08)
FRSP_FRED	8	1 (0)	6.25%	0.86	1 (0)	0.12 (0.00)
FRSP_SPOT	7	1 (1)	8.33%	1.00	1 (1)	0.14 (0.14)
GETT	8	8 (0)	87.50%	10.5	8 (0)	3.50 (0.75)
GEWA	2	2 (0)	54.17%	6.50	2 (1)	1.50 (0.50)
HOFU	4	3 (0)	70.83%	8.50	5 (1)	3.00 (0.75)
PETE_EAST	7	5 (1)	38.10%	4.57	3 (2)	1.14 (0.29)
PETE_FIVE	6	1 (0)	1.39%	0.17	1 (0)	0.17 (0.00)
RICH	8	6 (1)	55.43%	6.38	3 (0)	1.5 (0.38)
THST	2	2 (0)	87.50%	10.50	3 (1)	3.00 (0.50)
VAFO	7	7 (0)	79.52%	9.43	10 (2)	3.43 (1.14)

[1] Number of plots with invasive exotic indicator species in quadrats. Values in parentheses are additional number of plots with exotic indicator species recorded only outside the quadrats.
[2] Number of exotic indicator species in quadrats. Values in parentheses are additional exotic indicator species counted only outside the quadrats in the plots.

Table 13. Invasive exotic indicator species and taxa in forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Latin Name	**Common Name**	**# of plots[1]**	**Mean cover class / plot[2]**
Alliaria petiolata	garlic mustard	6 (1)	2-5%
Berberis thunbergii	Japanese barberry	6 (4)	2-5%
Celastrus orbiculatus	oriental bittersweet	6 (1)	0-1%
Duchesnea indica	Indian strawberry	1 (0)	0-1%
Hedera helix	English ivy	2 (1)	0-1%
Ligustrum	ligustrum, privet	4 (5)	0-1%
Lonicera - Exotic	honeysuckle - exotic	3 (0)	0-1%
Lonicera japonica	Japanese honeysuckle	38 (2)	1-2%
Microstegium vimineum	Japanese stiltgrass	33 (6)	10-25%
Polygonum caespitosum	Oriental lady's thumb	8 (4)	0-1%
Rosa multiflora	multiflora rose	10 (5)	0-1%
Rubus phoenicolasius	wine raspberry	7 (3)	2-5%
Total Species:	12		

[1] Number of plots with invasive exotic indicator species in quadrats. Values in parentheses are additional number of plots with exotic indicator exotic species recorded only outside quadrats.
[2] Mean cover class was derived using mid-points of each cover class and averaging across quadrats. Averaged mid-point was then converted back to cover class category.

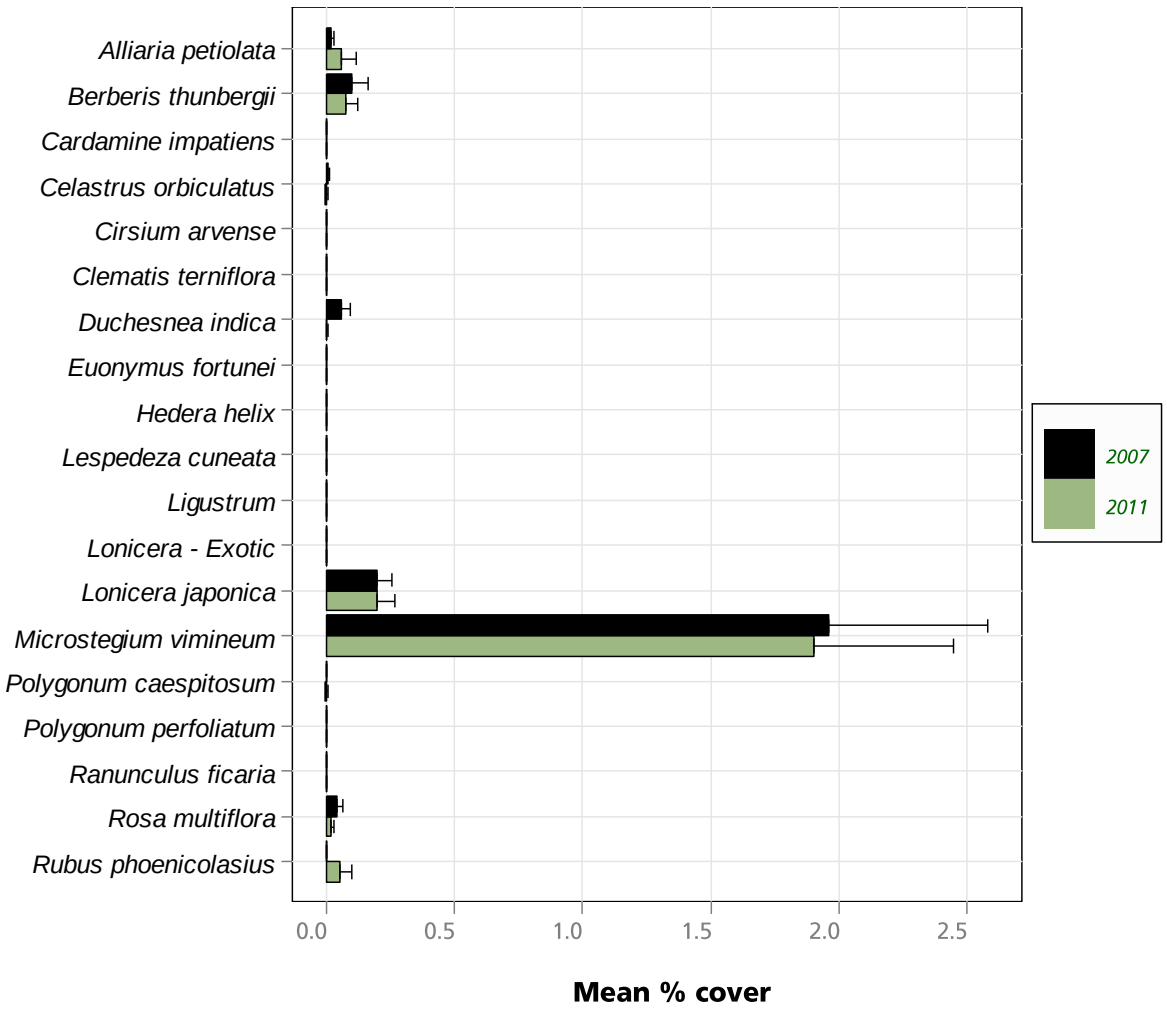


Figure 19. Mean percent cover of invasive exotic indicator species in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

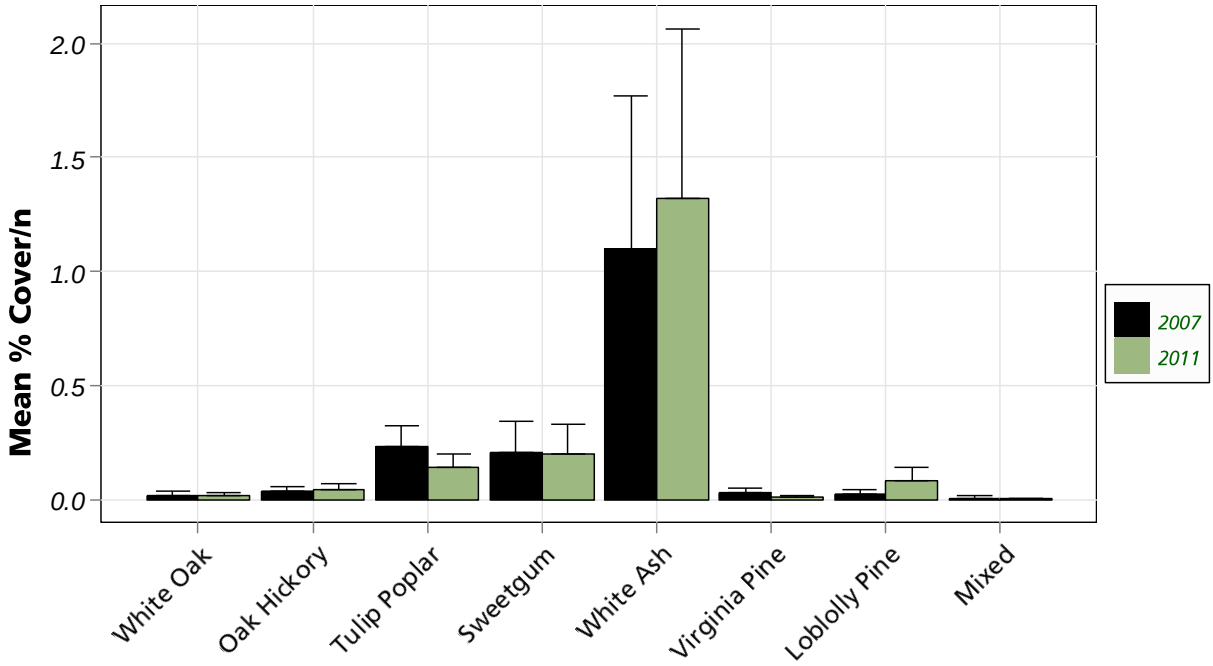


Figure 20. Mean percent cover of invasive exotic indicator species in different community types in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

Deer-Browse Indicator Species

A list of 34 native deer-browse indicator taxa (including vines) is targeted for measurement in the 12 quadrats in each plot, and their presence is also noted if they occur in the plot only but outside the quadrats. Table 14 summarizes the results for deer-brwose indicator species and taxa sampled in 2011 by park, while Table 15 summarizes species data. The change in mean percent cover of deer-browse indicator species (Figure 21) and their occurrence in different community types (Figure 22) between 2007 and 2011 are illustrated. The 2011 deer-browse indicator species data are presented as the mean number and percent cover of deer-avoided and deer-preferred herbaceous (including vines) and shrub indicator species per plot in each park (Table 16). More extensive analysis of deer-browse indicators will be conducted once more plots have been sampled.

Table 14. Deer-browse indicator species and taxa in forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Park	# of plots	Plots with indicator spp.[1]	% quads / plot with indicator spp.	Mean # quads / plot with indicator spp.	Total # indicator spp.[2]	Mean # indicator spp. / plot[2]
APCO	7	7 (0)	88.10%	10.57	15 (2)	8.14 (2.14)
BOWA	2	2 (0)	100.00%	12.00	17 (3)	13.00 (1.50)
COLO_JAMES	2	2 (0)	100.00%	12.00	7 (1)	5.50 (1.00)
COLO_YORK	10	10 (0)	48.33%	5.80	12 (2)	4.50 (2.10)
FRSP_CHWILD	12	12 (0)	88.89%	10.67	16 (5)	5.42 (1.92)
FRSP_FRED	8	8 (0)	68.75%	9.43	12 (1)	4.75 (1.62)
FRSP_SPOT	7	7 (0)	60.71%	7.29	13 (6)	4.14 (3.57)
GETT	8	8 (0)	86.46%	10.38	12 (3)	5.38 (1.88)
GEWA	2	2 (0)	79.17%	9.50	12 (0)	8.00 (2.00)
HOFU	4	4 (0)	89.58%	10.75	14 (4)	6.00 (2.00)
PETE_EAST	7	7 (0)	69.05%	8.29	15 (2)	5.57 (2.14)
PETE_FIVE	6	6 (0)	88.89%	10.67	14 (3)	6.17 (2.83)
RICH	8	8 (0)	82.61%	9.50	16 (3)	6.38 (2.50)
THST	2	2 (0)	79.17%	9.50	9 (1)	6.50 (0.50)
VAFO	7	6 (1)	43.37%	5.14	8 (1)	3.43 (0.86)

[1] Number of plots with deer-browse indicator species in quadrats. Values in parentheses are additional number of plots with indicators found in plots only outside quadrats.
[2] Number/Mean of deer-browse indicator species occurring in quadrats. Values in parentheses are additional number/mean of indicators found in plots only outside quadrats.

Table 15. Deer-browse indicator species and taxa in forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Latin Name	Common Name	Plots[1]	Mean % Cover / Plot[2]
Arisaema triphyllum	Indian jack in the pulpit	8 (8)	0-1%
Campsis radicans	trumpet creeper, cow-itch	7 (2)	0-1%
Cyperaceae spp.	sedges	42 (8)	0-1%
Dennstaedtia punctilobula	eastern hayscented fern	1 (1)	5-10%
Eurybia divaricata	white wood aster	1 (2)	0-1%
Ferns (all families)	Ferns	21 (7)	0-1%
Impatiens capensis	jewelweed	1 (0)	0-1%
Maianthemum racemosum	feathery false lily of the valley	12 (8)	0-1%
Medeola virginiana	Indian cucumber	2 (1)	0-1%
Orchid spp.	Orchids	2 (2)	0-1%
Parthenocissus quinquefolia	Virginia creeper	50 (12)	0-1%
Poaceae spp.	grasses	45 (15)	0-1%
Polygonatum biflorum	Smooth Solomon's seal	8 (7)	0-1%
Polygonatum pubescens	hairy Solomon's seal	1 (0)	0-1%
Polystichum acrostichoides	Christmas fern	8 (14)	0-1%
Rubus spp.	blackberry	25 (6)	0-1%
Sanguinaria canadensis	bloodroot	2 (0)	0-1%
Smilax spp.	Common greenbriar	12 (3)	0-1%
Smilax glauca	cat greenbrier	39 (15)	0-1%
Smilax rotundifolia	roundleaf greenbrier	47 (14)	0-1%
Thelypteris noveboracensis	New York fern	5 (6)	2-5%
Toxicodendron radicans	eastern poison ivy	32 (18)	0-1%
Uvularia perfoliata	perfoliate bellwort	5 (3)	0-1%
Uvularia sessilifolia	sessileleaf bellwort	7 (3)	0-1%
Vaccinium spp.[3]	blueberries	41 (6)	2-5%
Vaccinium corymbosum	highbush blueberry	14 (4)	2-5%
Vaccinium stamineum	deerberry	29 (8)	0-1%
Vitis spp.	grape	48 (14)	0-1%
Total Species:	28		

[1] Number of plots with deer-browse indicators in quadrats. Values in parentheses are additional number of plots with indicators recorded only outside quadrats.
[2] Mean cover class was derived using mid-points of cover class and averaging across quadrats. Averaged mid-point values were then converted back to cover class.
[3] Includes *Gaylussacia* spp.

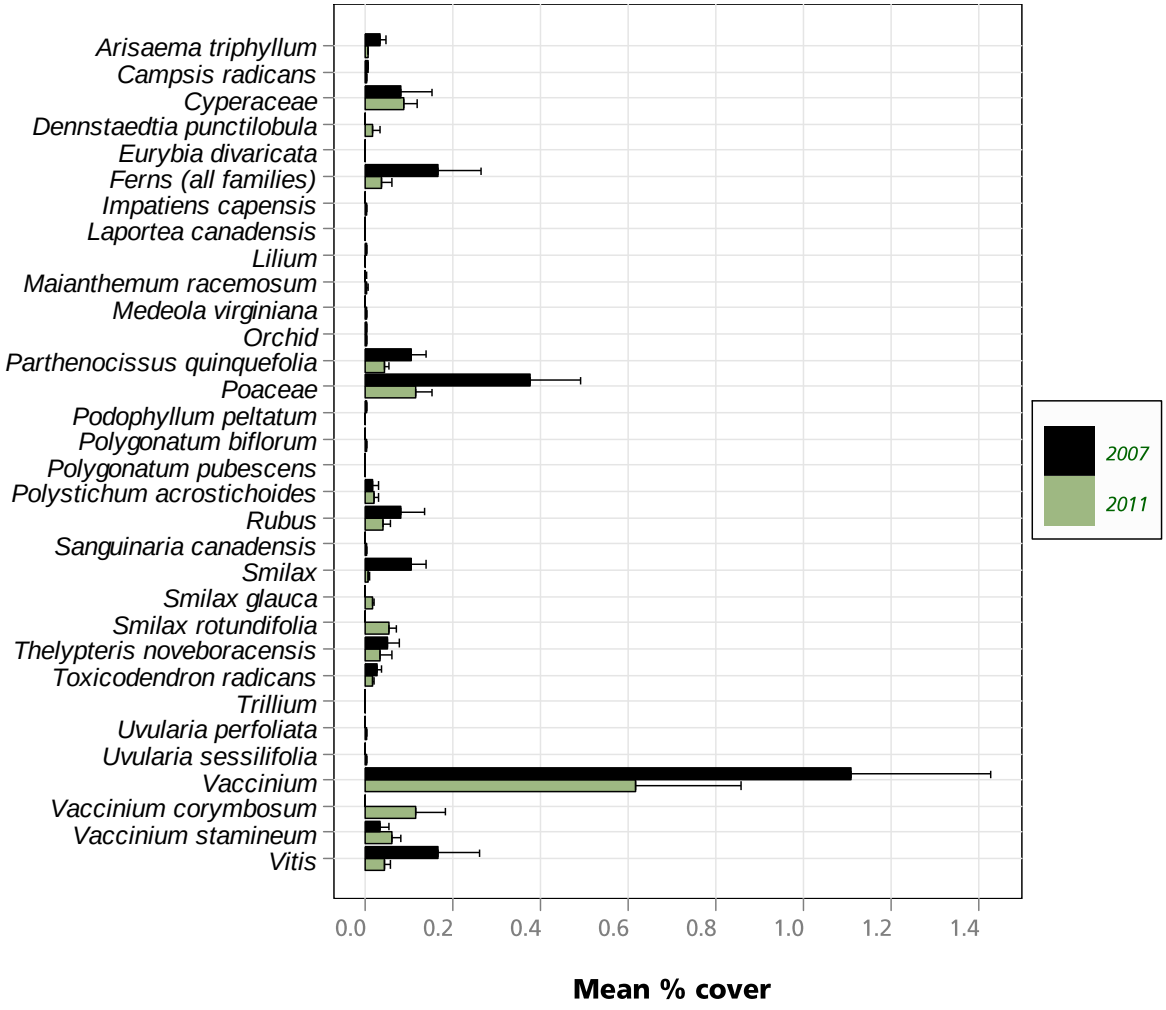


Figure 21. Mean percent cover of deer-browse indicator species in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

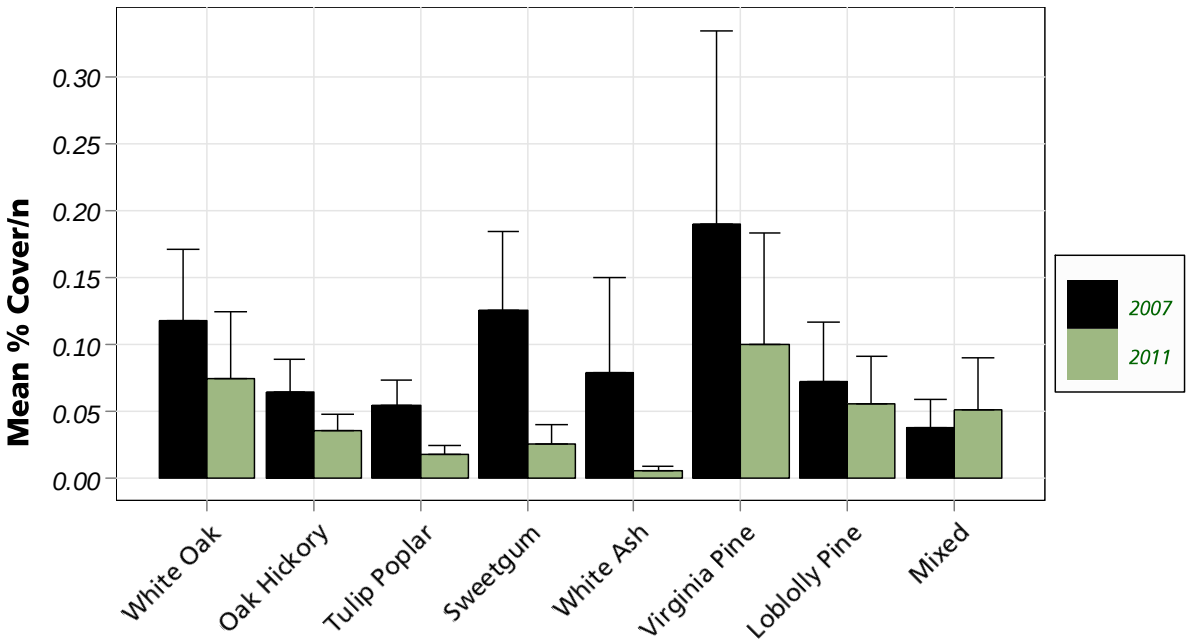


Figure 22. Mean percent cover of deer-browse indicator species in different community types in the Mid-Atlantic Network parks for plots established in 2007 and remeasured in 2011.

Table 16. Deer-browse indicator herbaceous and shrub species and taxa in forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Park	# of plots	Mean # of indicator species / plot				Mean % cover / plot			
		Herbaceous[1]		Shrubs		Herbaceous[1]		Shrubs	
		Avoided	Preferred	Avoided	Preferred	Avoided	Preferred	Avoided	Preferred
APCO	7	2.57	3.86	1.29	0.43	0.03	0.07	0.51	0.03
BOWA	2	5.00	7.00	0.50	0.50	0.35	0.07	0.02	0.06
COLO_JAMES	2	3.50	2.00	0.00	0.00	0.51	0.11	0.00	0.00
COLO_YORK	10	2.50	1.90	0.00	0.10	0.03	0.02	0.00	0.00
FRSP_CHWILD	12	1.00	2.08	2.17	0.17	0.11	0.01	3.73	0.09
FRSP_FRED	7	1.29	1.71	1.71	0.00	0.16	0.02	1.26	0.00
FRSP_SPOT	7	1.29	1.43	1.43	0.00	0.03	0.01	0.11	0.00
GETT	8	3.00	1.50	0.00	0.88	0.22	0.01	0.00	1.27
GEWA	2	4.50	3.00	0.00	0.50	0.75	0.02	0.00	0.17
HOFU	4	2.75	2.00	0.75	0.50	0.12	0.03	1.05	0.22
PETE_EAST	7	2.57	1.86	0.86	0.29	0.07	0.04	2.00	0.01
PETE_FIVE	6	1.00	2.83	2.33	0.00	0.01	0.06	1.90	0.00
RICH	8	3.50	2.50	0.25	0.13	0.28	0.03	0.02	0.01
THST	2	4.00	2.00	0.00	0.50	0.27	0.01	0.00	0.13
VAFO	7	2.43	0.43	0.00	0.57	0.03	0.00	0.00	0.04

[1] Including vine species.

Coarse Woody Debris

Coarse woody debris (CWD) volume is calculated from the transect data (Marshall et al. 2000) and corrected for slope (Van Wagner 1982). Tree volume is calculated for all live mature trees. All calculations are provided in the monitoring protocol SOP and performed using the ecological integrity database (Mitchell 2011). Not all Mid-Atlantic and Northeast Coastal and Barrier networks plots are included in this calculation due to missing or incomplete data (tree heights and slope corrections were not collected in 2007).

Plots are rated based on the following criteria:

Good: CWD volume > 15% of live tree volume.

Caution: CWD volume is 5-15% of live tree volume.

Significant Concern: CWD volume < 5% of live tree volume.

Among plots sampled in 2011, both units at Colonial NHP and Gettysburg NMP had the highest mean volume of CWD (Table 17). Five Forks unit of Petersburg NB, George Washington Birthplace NM, and Hopewell Furnace NHS were the only parks with proportions considered as "Significant Concern", that is, CWD was < 5% of standing live tree volume. The highest ratios of CWD to live trees were found at Appomattox Court House NHP. Differences in how CWD was measured in 2007 and 2011 mean that comparisons between the two years cannot be made.

Table 17. Coarse woody debris in forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Park	# of plots	Mean volume CWD (m^3 / ha)	Mean volume live trees (m^3 / ha)	Mean ratio CWD to live trees / Plot	Rating
APCO	7	36.17	250.83	73.20%	Good
BOWA	2	16.37	292.23	5.51%	Caution
COLO_JAMES	2	70.28	604.27	25.65%	Good
COLO_YORK	10	68.05	580.10	13.86%	Caution
FRSP_CHWILD	12	19.38	385.80	6.12%	Caution
FRSP_FRED	7	13.93	350.80	5.98%	Caution
FRSP_SPOT	7	40.40	483.53	19.83%	Good
GETT	8	68.03	339.01	19.96%	Good
GEWA	2	4.74	576.77	0.52%	Significant Concern
HOFU	4	9.81	576.47	2.02%	Significant Concern
PETE_EAST	7	42.01	583.97	8.69%	Caution
PETE_FIVE	6	5.87	362.38	0.89%	Significant Concern
RICH	8	19.13	434.84	6.19%	Caution
THST	2	48.33	440.77	11.11%	Caution
VAFO	7	29.16	528.49	8.53%	Caution

Soil Chemistry

Ecological integrity metrics are reported for soil chemistry, as they are indicative of the effects of acid deposition on soil nutrients including calcium (Ca), magnesium (Mg), and potassium (K). Leaching can increase the availability of aluminum (Al) which is toxic to forest plants (Driscoll et al. 2001). For Ca:Al ratios as low as 1, there is an estimated 50% risk of adverse impact on growth across a wide range of tree species (Cronan and Grigal 1995). However, we have stopped using the Caution and Significant Concern ratings due to different extractant methods used to analyze our soils which provide actual soil concentrations of Ca:Al, compared to Cronan and Grigal (1995) where soil water concentrations were measured. In the interim, we are only presenting data on sites where Ca:Al ratios are considered to be Good.

Good: Ca:Al ratio > 4.0 in O and A horizons or in upper depth.

In addition, increased nitrogen (N) loading can cause nitrification and reduce plant vigor. Ratios of C:N below 20-25 result in nitrification.

Good: C:N ratio > 25 in O and A horizon or in upper depth.

Caution: C:N ratio from 20-25 in O and A horizon or in upper depth.

Significant Concern: C:N ratio < 20 in O and A horizon or in upper depth.

Soil samples were collected from the O and A horizons at three locations in each plot in 2011. If the horizons were not apparent, a composite sample was collected from the top 10 cm (upper depth). The soils were analyzed for a suite of metrics, but currently we only report on the ratio of Ca to Al as an indicator of acid stress, and the ratio of total C to total N as an indicator of nitrogen status.

Results show that all parks across the networks had at least one metric that was either of "Significant Concern" or "Caution" (Table 18). Acidification is of "Concern" in Fredericksburg and Spotsylvania NMP and Thomas Stone NHS. Nitrification is rated as "Good" only in the Five Forks unit of Petersburg NB and Chancellorsville and Wilderness unit of Fredericksburg and Spotsylvania NMP.

These data need to be interpreted with caution as soil results presented are only for samples taken in 2011. In addition, there is disagreement among soil scientists as to whether these metrics are sufficient for interpreting acid deposition stress on forest soils. Furthermore, different labs use different extraction methods that may overestimate the values beyond those that would normally be available and affect plants. Over the coming years we hope to gain a better understanding and approach to sampling and reporting soil chemistry.

Table 18. Soil chemistry ratings for forest vegetation monitoring plots sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

Unit[1]	Median Ca:Al	Ca:Al Rating	Median C:N	C:N Rating
APCO	171.49	Good	21.13	Caution
BOWA	155.91	Good	16.37	Significant Concern
FRSP_CHWILD	0.24		26.54	Good
FRSP_FRED	0.26		24.99	Caution
FRSP_SPOT	2.12		16.98	Significant Concern
GETT	97.47	Good	17.59	Significant Concern
GEWA	15.82	Good	13.38	Significant Concern
PETE_EAST	1.24		18.00	Significant Concern
PETE_FIVE	1.32		27.37	Good
RICH	1.85		18.65	Significant Concern
THST	0.68		16.31	Significant Concern
VAFO	5.22	Good	21.42	Caution

[1] No soil samples were collected in Colonial NHP. Samples could not be analyzed for some of the Valley Forge NHP, Hopewell Furnace NHS, and Gettysburg NMP plots and these will be collected again in 2012.

Park Resource Briefs

The following pages provide the park specific resource briefs for 2011 forest vegetation monitoring. High resolution versions of each may be downloaded from the MIDN website at http://science.nature.nps.gov/im/units/midn/ProtocolForestVegetation.cfm.

Appomattox Court House National Historical Park

Northeast Region
Inventory & Monitoring Program

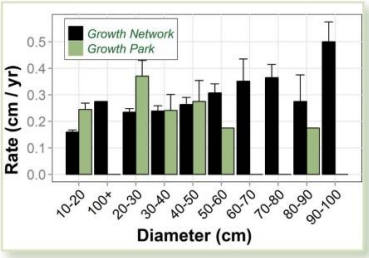
National Park Service
U.S. Department of the Interior

Mid-Atlantic Network **Forest Vegetation Resource Brief**

Appomattox Court House National Historical Park 2011 Status & Trends

In 2011, seven plots established in 2007 at Appomattox Court House NHP (APCO) were revisited. With only one-quarter of the total plots in the park resampled, the following highlights of temporal trends are preliminary.

All trees with a diameter at breast height (DBH) equal to or greater than 10 cm were measured and their condition was assessed. Trees that had died since the last census were noted, while recruited trees, those reaching the minimum DBH of 10 cm, were identified, measured, mapped, marked, and tagged. Most of the tree mortality occurred in the pine communities where the pines had a higher mortality than the network average. This is not uncommon due to many patches of early successional forest in the park that are currently maturing, and illustrated by the high recruitment rates of hardwood species such as white oak (*Quercus alba*). Growth rates were generally higher than observed across the network, especially among the smaller diameter size classes (see figure to left).



Growth rates of mature trees in different diameter size classes at Appomattox Court House NHP.

Three microplots in each plot were sampled for tree saplings and shrubs with diameters greater than 1 cm and less than 10 cm. The trends were similar to those observed among mature trees, with most of the recruitment occurring in the oak-hickory and tulip poplar forests. However, growth rates in oak-hickory community were well below the

Objectives

1. *Determine the status and trends in forest structure, composition, and dynamics of canopy and understory woody species.*
2. *Determine the status and trends in the density and composition of native tree seedlings and selected herbaceous species that are indicators of deer browse.*
3. *Detect and monitor the presence of invasive exotic plants, exotic plant diseases and pathogens, and forest pests.*
4. *Determine the status and trends in forest coarse woody debris and the availability of snags.*
5. *Determine the status and trends in soil Ca:Al and C:N ratios to assess the extent of base cation depletion, change in aluminum availability, and nitrogen saturation impacting MIDN forest soils.*

Importance

The Mid-Atlantic region is primarily a forested ecoregion and all Mid-Atlantic Network parks have forests that form an essential part of the landscape and provide habitat for a diversity of wildlife. Forest structure, composition, and dynamics are important measures of forest condition and health. Changes in these metrics can be indicative of stressors that may result in alterations in the future ecological integrity of forest communities. For example, high tree mortality rates can signal a change in the canopy species; declines in seedling and sapling densities can indicate a reduced capacity of the forest to regenerate; or increases in invasive exotic plants can exclude other herbaceous plants in the forest understory.

Management Applications

- *Provide a measure of forest health and changes over time.*
- *Indicate composition and trends in invasive exotic plants, pests, and pathogens in the park.*
- *Evaluate the impact of and trends in white-tailed deer browse on forest understory communities.*

Long-term Monitoring

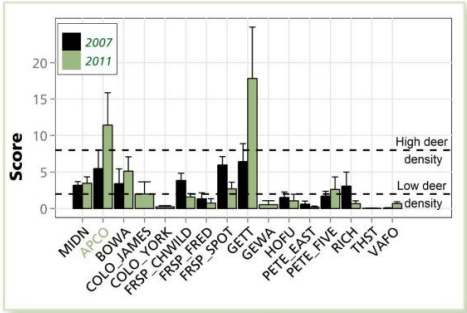
Plot locations were randomly selected from a 250-m sampling grid. Each plot consists of a 20 x 20 m square where all trees and shrubs with a diameter at breast height (dbh) ≥ 10 cm are identified, measured, tagged, marked, and mapped, and their condition is assessed. Trees and shrubs with a dbh ≥ 1 cm are identified, measured, marked, and tagged in each of three microplots. The number and height of tree seedlings and cover of a select group of native and invasive herbaceous indicator plants are recorded in 12 quadrats. Coarse woody debris is measured along three transects. Soil samples are collected from outside each plot. A variety of parameters are measured to describe the overall plot characteristics, including vegetation cover at different strata or layers, evidence of disturbance and deer-browse, slope, and aspect. The plots are revisited every four years to evaluate changes.

2011 Status & Trends...

network average.

Tree seedlings are identified in each of 12 quadrats, and their heights measured. The number and height of seedlings determines whether there is adequate regeneration to sustain the forest canopy. In parks where deer densities are high, a larger number of seedlings are required due to the heavier browse pressure than in parks where deer densities are low. Thus, regeneration is considered as "Good" if it exceeds the high deer density level, and "Significant Concern" when it falls below the low deer density level in any park. Appomattox Court House NHP is one of the few parks regeneration score increased above the level required under heavy deer-browse pressure. Seedling regeneration in the park is therefore considered to be "Good" (see figure below).

Indicator invasive exotic and native species are also monitored in the quadrats.



Mean regeneration scores for the Mid-Atlantic Network and individual parks in 2007 and 2011. Lines indicate minimum score needed to maintain sustainable regeneration under low and high deer densities. Codes refer to the parks monitored (see below or full report at www.nature.nps.gov/im/units/midn).

Compared to the rest of the network, Appomattox Court House NHP had a low average percent cover of exotics in the plots sampled with the most common species being Japanese honeysuckle (*Lonicera japonica*) which showed a significant decrease in cover over the previous four years. However, multiflora rose (*Rosa multiflora*) was detected in plots where it previously did not occur. Among the native indicators, *Vaccinium* species were the most abundant, but showed a decline in cover.

In 2012, field crews will revisit plots established in 2008, adding to the data on forest dynamics and increasing our confidence in the forest health trends.

Photos by James Comiskey (front) and Karen Patterson (below).

A Final Note

It is important to note that the data presented here are preliminary. Only one-quarter of the park's plots have been revisited, and therefore the trends we report are likely to change as we add more data. However, these early results illustrate the analyses and indicators derived from long-term monitoring and their value to park management.

We would like to thank Brian Eick, APCO Natural Resource Manager, for his continued support and input, as well as the field crews that dedicated long, hot summer days to sample the plots across the network.

Lead Scientist
James Comiskey
Jim_Comiskey@nps.gov
Program Manager/Ecologist

Mid-Atlantic Network
120 Chatham Lane
Fredericksburg, VA 22405
www.nature.nps.gov/im/units/midn

Parks monitored: *Appomattox Court House NHP • Booker T. Washington NM • Colonial NHP • Eisenhower NHS • Fredericksburg & Spotsylvania NMP Gettysburg NMP • George Washington Birthplace NM • Hopewell Furnace NHS • Petersburg NB • Richmond NBP • Thomas Stone NHS • Valley Forge NHP*

May 2012

Booker T. Washington National Monument

Northeast Region
Inventory & Monitoring Program

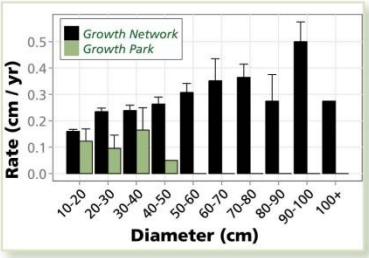
National Park Service
U.S. Department of the Interior

Mid-Atlantic Network **Forest Vegetation Resource Brief**

Booker T. Washington National Monument 2011 Status & Trends

In 2011, two plots established in 2007 at Booker T. Washington NM (BOWA) were revisited. With only one-quarter of the total plots in the park resampled, the following highlights of temporal trends are preliminary.

All trees with a diameter at breast height (DBH) equal to or greater than 10 cm were measured and their condition was assessed. Trees that had died since the last census were noted, while recruited trees, those reaching the minimum DBH of 10 cm, were identified, measured, mapped, marked, and tagged. Most of the tree mortality occurred in the Virginia pine community, though the pine mortality rate was lower than the network average. This is not uncommon due to patches of early successional forest in the park that are currently maturing, and illustrated by the high recruitment rates of early successional hardwood species such as tulip poplar (*Liriodendron tulipifera*). Growth rates were generally lower than observed across the network, especially among the smaller diameter size classes (see figure to left).



Growth rates of mature trees in different diameter size classes at Booker T. Washington NM.

Three microplots in each plot were sampled for tree saplings and shrubs with diameters greater than 1 cm and less than 10 cm. Sapling mortality was only documented in the pine community, but recruitment occurred in both community types. The pine community had substantially higher recruitment

Objectives

1. *Determine the status and trends in forest structure, composition, and dynamics of canopy and understory woody species.*
2. *Determine the status and trends in the density and composition of native tree seedlings and selected herbaceous species that are indicators of deer browse.*
3. *Detect and monitor the presence of invasive exotic plants, exotic plant diseases and pathogens, and forest pests.*
4. *Determine the status and trends in forest coarse woody debris and the availability of snags.*
5. *Determine the status and trends in soil Ca:Al and C:N ratios to assess the extent of base cation depletion, change in aluminum availability, and nitrogen saturation impacting MIDN forest soils.*

Importance

The Mid-Atlantic region is primarily a forested ecoregion and all Mid-Atlantic Network parks have forests that form an essential part of the landscape and provide habitat for a diversity of wildlife. Forest structure, composition, and dynamics are important measures of forest condition and health. Changes in these metrics can be indicative of stressors that may result in alterations in the future ecological integrity of forest communities. For example, high tree mortality rates can signal a change in the canopy species; declines in seedling and sapling densities can indicate a reduced capacity of the forest to regenerate; or increases in invasive exotic plants can exclude other herbaceous plants in the forest understory.

Management Applications

- *Provide a measure of forest health and changes over time.*
- *Indicate composition and trends in invasive exotic plants, pests, and pathogens in the park.*
- *Evaluate the impact of and trends in white-tailed deer browse on forest understory communities.*

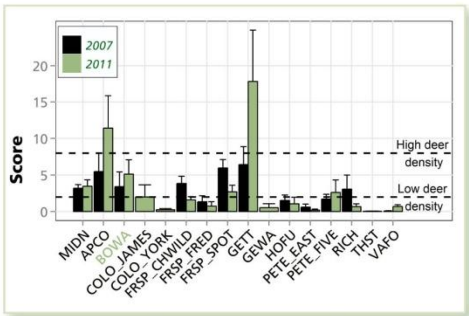
Long-term Monitoring

Plot locations were randomly selected from a 250-m sampling grid. Each plot consists of a 20 x 20 m square where all trees and shrubs with a diameter at breast height (dbh) ≥ 10 cm are identified, measured, tagged, marked, and mapped, and their condition is assessed. Trees and shrubs with a dbh ≥ 1 cm are identified, measured, marked, and tagged in each of three microplots. The number and height of tree seedlings and cover of a select group of native and invasive herbaceous indicator plants are recorded in 12 quadrats. Coarse woody debris is measured along three transects. Soil samples are collected from outside each plot. A variety of parameters are measured to describe the overall plot characteristics, including vegetation cover at different strata or layers, evidence of disturbance and deer-browse, slope, and aspect. The plots are revisited every four years to evaluate changes.

2011 Status & Trends...

rates than those observed across the network. In contrast, growth rates were highest in the tulip poplar community, well above the network average.

Tree seedlings are identified in each of 12 quadrats, and their heights measured. The number and height of seedlings determines whether there is adequate regeneration to sustain the forest canopy. In parks where deer densities are high, a larger number of seedlings are required due to the heavier browse pressure than in parks where deer densities are low. Thus, regeneration is considered as "Good" if it exceeds the high deer density level, and "Significant Concern" when it falls below the low deer density level in any park. Booker T. Washington NM is one of the few network parks where the tree seedling regeneration score increased from 2007 to 2011. However, seedling regeneration in the park is still classified as "Caution" (see figure below).



Mean regeneration scores for the Mid-Atlantic Network and individual parks in 2007 and 2011. Lines indicate minimum score needed to maintain sustainable regeneration under low and high deer densities. Codes refer to the parks monitored (see below or full report at www.nature.nps.gov/im/units/midn).

Indicator invasive exotic and native species are also monitored in the quadrats. Compared to the rest of the network, Booker T. Washington NM had a low average percent cover of exotics in the plots sampled with the most common species being Japanese honeysuckle (*Lonicera japonica*) and Japanese stiltgrass (*Microstegium vimineum*). Among the native indicators, *Cyperaceae* species (sedges) were the most abundant.

In 2012, field crews will revisit plots established in 2008, adding to the data on forest dynamics and increasing our confidence in forest health trends.

Photos by James Comiskey (front) and NPS (below).

A Final Note

It is important to note that the data presented here is preliminary. Only one-quarter of the park's plots have been revisited, and therefore the trends we report are likely to change as we add more data. However, these early results illustrate the analyses and indicators derived from long-term monitoring and their value to park management.

We would like to thank Timbo Sims, BOWA Natural Resource Manager, for his continued support and input, as well as the field crews that dedicated long, hot summer days to sample the plots across the network.

Lead Scientist
James Comiskey
Jim_Comiskey@nps.gov
Program Manager/Ecologist

Mid-Atlantic Network
120 Chatham Lane
Fredericksburg, VA 22405
www.nature.nps.gov/im/units/midn

Parks monitored: *Appomattox Court House NHP • Booker T. Washington NM • Colonial NHP • Eisenhower NHS • Fredericksburg & Spotsylvania NMP Gettysburg NMP • George Washington Birthplace NM • Hopewell Furnace NHS • Petersburg NB • Richmond NBP • Thomas Stone NHS • Valley Forge NHP*

May 2012

Fredericksburg and Spotsylvania National Military Park

Northeast Region
Inventory & Monitoring Program

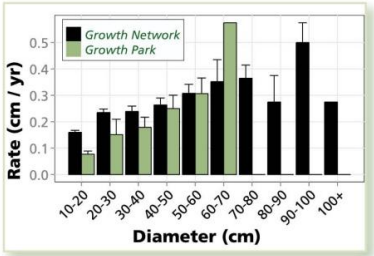
National Park Service
U.S. Department of the Interior

Mid-Atlantic Network **Forest Vegetation Resource Brief**

Fredericksburg and Spotsylvania National Military Park 2011 Status & Trends

In 2011, 12 plots established in 2007 at the Chancellorsville and Wilderness unit (treated as one unit) of Fredericksburg and Spotsylvania NMP (FRSP) were revisited, along with seven plots in each of the Fredericksburg and Spotsylvania units. With only one-quarter of the total plots in the park resampled, the following highlights of temporal trends are preliminary.

All trees with a diameter at breast height (DBH) equal to or greater than 10 cm were measured and their condition was assessed. Trees that had died since the last census were noted, while recruited trees, those reaching the minimum DBH of 10 cm, were identified, measured, mapped, marked, and tagged. The highest tree mortality occurred in the Virginia pine community of the Fredericksburg unit, while the highest recruitment rates occurred in the oak-hickory communities of the Spotsylvania unit. Growth rates were also highest in the pine community of the Fredericksburg unit especially among the mid-sized tree diameter classes (see figure to left).



Growth rates of mature trees in different diameter size classes at Fredericksburg unit of Fredericksburg and Spotsylvania NMP .

Three microplots in each plot were sampled for tree saplings and shrubs with diameters greater than 1 cm and less than 10 cm. Sapling mortality was highest in the oak-hickory communities in the Fredericksburg unit, while recruitment was low. The highest recruitment rates were in the tulip poplar community of the Spotsylvania unit. American beech (*Fagus grandifolia*) growth rates were among the highest in the Fredericksburg and Spotsylvania units, while American holly (*Ilex opaca*) had higher than aver-

Objectives

1. *Determine the status and trends in forest structure, composition, and dynamics of canopy and understory woody species.*
2. *Determine the status and trends in the density and composition of native tree seedlings and selected herbaceous species that are indicators of deer browse.*
3. *Detect and monitor the presence of invasive exotic plants, exotic plant diseases and pathogens, and forest pests.*
4. *Determine the status and trends in forest coarse woody debris and the availability of snags.*

Importance

The Mid-Atlantic region is primarily a forested ecoregion and all Mid-Atlantic Network parks have forests that form an essential part of the landscape and provide habitat for a diversity of wildlife. Forest structure, composition, and dynamics are important measures of forest condition and health. Changes in these metrics can be indicative of stressors that may result in alterations in the future ecological integrity of forest communities. For example, high tree mortality rates can signal a change in the canopy species; declines in seedling and sapling densities can indicate a reduced capacity of the forest to regenerate; or increases in invasive exotic plants can exclude other herbaceous plants in the forest understory.

Management Applications

- *Provide a measure of forest health and changes over time.*
- *Indicate composition and trends in invasive exotic plants, pests, and pathogens in the park.*
- *Evaluate the impact of and trends in white-tailed deer browse on forest understory communities.*

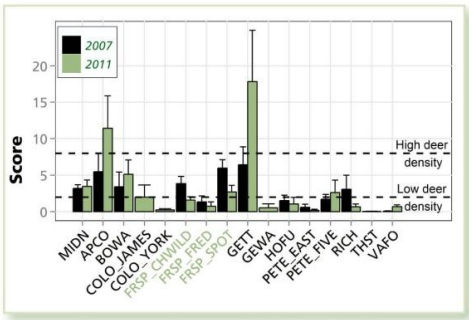
Long-term Monitoring

Plot locations were randomly selected from a 250-m sampling grid. Each plot consists of a 20 x 20 m square where all trees and shrubs with a diameter at breast height (dbh) ≥ 10 cm are identified, measured, tagged, marked, and mapped, and their condition is assessed. Trees and shrubs with a dbh ≥ 1 cm are identified, measured, marked, and tagged in each of three microplots. The number and height of tree seedlings and cover of a select group of native and invasive herbaceous indicator plants are recorded in 12 quadrats. Coarse woody debris (dead trees and large branches) is measured along three transects. A variety of parameters are measured to describe the overall plot characteristics, including vegetation cover at different strata or layers, evidence of disturbance and deer-browse, slope, and aspect. The plots are revisited every four years to evaluate changes.

2011 Status & Trends...

age growth in the Chancellorsville and Wilderness unit.

Tree seedlings are identified in each of 12 quadrats, and their heights measured. The number and height of seedlings determines whether there is adequate regeneration to sustain the forest canopy. In parks where deer densities are high, a larger number of seedlings are required due to the heavier browse pressure than in parks where deer densities are low. Thus, regeneration is considered as "Good" if it exceeds the high deer density level, and "Significant Concern" when it falls below the low deer density level in any park. All three Fredericksburg and Spotsylvania NMP units showed declines in tree seedling regeneration scores between 2007 to 2011. In the Chancellorsville and Wilderness unit the regeneration declined from "Caution" to "Significant Concern" (see figure below). Additional data over the coming years will help us determine if there are potential long-term impacts on the forest communities of the park.



Mean regeneration scores for the Mid-Atlantic Network and individual parks in 2007 and 2011. Lines indicate minimum score needed to maintain sustainable regeneration under low and high deer densities. Codes refer to the parks monitored (see below or full report at www.nature.nps.gov/im/units/midn).

Indicator invasive exotic and native species are also monitored in the quadrats. Compared to the rest of the network, Fredericksburg and Spotsylvania NMP had a low average percent cover of exotics in the plots sampled with the most common species being Japanese honeysuckle (*Lonicera japonica*). Among the native indicators, *Vaccinium* species (blueberries) were the most abundant.

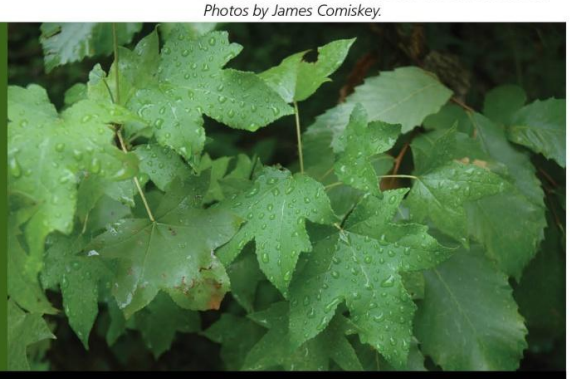
In 2012, field crews will revisit plots established in 2008, adding to the data on forest dynamics and increasing our confidence in forest health trends

Photos by James Comiskey.

A Final Note

It is important to note that the data presented here is preliminary. Only one-quarter of the park's plots have been revisited, and therefore the trends we report are likely to change as we add more data. However, these early results illustrate the analyses and indicators derived from long-term monitoring and their value to park management.

We would like to thank Gregg Kneipp, FRSP Natural Resource Manager, for his continued support and input, as well as the field crews that dedicated long, hot summer days to sample the plots across the network.



Lead Scientist
James Comiskey
Jim_Comiskey@nps.gov
Program Manager/Ecologist

Mid-Atlantic Network
120 Chatham Lane
Fredericksburg, VA 22405
www.nature.nps.gov/im/units/midn

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May 2012

Gettysburg National Military Park

Northeast Region
Inventory & Monitoring Program

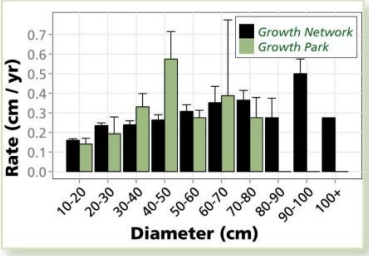
National Park Service
U.S. Department of the Interior

Mid-Atlantic Network **Forest Vegetation Resource Brief**

Gettysburg National Military Park 2011 Status & Trends

In 2011, eight plots established in 2007 at Gettysburg NMP (GETT) were revisited. With only one-quarter of the total plots in the park resampled, the following highlights of temporal trends are preliminary.

All trees with a diameter at breast height (DBH) equal to or greater than 10 cm were measured and their condition was assessed. Trees that had died since the last census were noted, while recruited trees, those reaching the minimum DBH of 10 cm, were identified, measured, mapped, marked, and tagged. Most of the tree mortality occurred in the tulip poplar forest community, which was significantly higher than the network average. This is not uncommon as the successional forests in the park mature. However, recruitment rates were highest in the oak-hickory forest communities, though lower than the network average. In contrast, these two community types had higher tree growth rates than seen across the network, particularly in the mid-size diameter classes (see figure to left).



Growth rates of mature trees in different diameter size classes at Gettysburg NMP.

Three microplots in each plot were sampled for tree saplings and shrubs with diameters greater than 1 cm and less than 10 cm. Sapling mortality was highest in the white ash community, but recruitment was greatest in the oak and tulip poplar communities, at rates higher than the network average. Like-

Objectives

1. *Determine the status and trends in forest structure, composition, and dynamics of canopy and understory woody species.*
2. *Determine the status and trends in the density and composition of native tree seedlings and selected herbaceous species that are indicators of deer browse.*
3. *Detect and monitor the presence of invasive exotic plants, exotic plant diseases and pathogens, and forest pests.*
4. *Determine the status and trends in forest coarse woody debris and the availability of snags.*
5. *Determine the status and trends in soil Ca:Al and C:N ratios to assess the extent of base cation depletion, change in aluminum availability, and nitrogen saturation impacting MIDN forest soils.*

Importance

The Mid-Atlantic region is primarily a forested ecoregion and all Mid-Atlantic Network parks have forests that form an essential part of the landscape and provide habitat for a diversity of wildlife. Forest structure, composition, and dynamics are important measures of forest condition and health. Changes in these metrics can be indicative of stressors that may result in alterations in the future ecological integrity of forest communities. For example, high tree mortality rates can signal a change in the canopy species; declines in seedling and sapling densities can indicate a reduced capacity of the forest to regenerate; or increases in invasive exotic plants can exclude other herbaceous plants in the forest understory.

Management Applications

- *Provide a measure of forest health and changes over time.*
- *Indicate composition and trends in invasive exotic plants, pests, and pathogens in the park.*
- *Evaluate the impact of and trends in white-tailed deer browse on forest understory communities.*

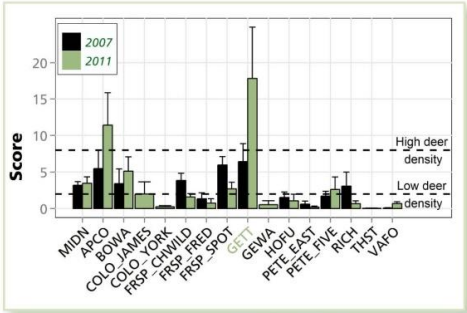
Long-term Monitoring

Plot locations were randomly selected from a 250-m sampling grid. Each plot consists of a 20 x 20 m square where all trees and shrubs with a diameter at breast height (dbh) ≥ 10 cm are identified, measured, tagged, marked, and mapped, and their condition is assessed. Trees and shrubs with a dbh ≥ 1 cm are identified, measured, marked, and tagged in each of three microplots. The number and height of tree seedlings and cover of a select group of native and invasive herbaceous indicator plants are recorded in 12 quadrats. Coarse woody debris is measured along three transects. Soil samples are collected from outside each plot. A variety of parameters are measured to describe the overall plot characteristics, including vegetation cover at different strata or layers, evidence of disturbance and deer-browse, slope, and aspect. The plots are revisited every four years to evaluate changes.

2011 Status & Trends...

wise, growth rates were well above those observed across the network.

Tree seedlings are identified in each of 12 quadrats, and their heights measured. The number and height of seedlings determines whether there is adequate regeneration to sustain the forest canopy. In parks where deer densities are high, a larger number of seedlings are required due to the heavier browse pressure than in parks where deer densities are low. Thus, regeneration is considered as "Good" if it exceeds the high deer density level, and "Significant Concern" when it falls below the low deer density level in any park. Gettysburg NMP is one of the few network parks where the tree seedling regeneration score has not only increased, but has done so to a level above that required under heavy deer-browse pressure. Seedling regeneration in the park is therefore considered to be "Good" (see figure to right).



Mean regeneration scores for the Mid-Atlantic Network and individual parks in 2007 and 2011. Lines indicate minimum score needed to maintain sustainable regeneration under low and high deer densities. Codes refer to the parks monitored (see below or full report at www.nature.nps.gov/im/units/midn).

Indicator invasive exotic and native species are also monitored in the quadrats. Compared to the rest of the network, Gettysburg NMP had a high average percent cover of exotics in the plots sampled with the most common species being Japanese honeysuckle (*Lonicera japonica*), Japanese stiltgrass (*Microstegium vimineum*) and Japanese barberry (*Berberis thunbergii*). Most exotics declined over the previous four years except Japanese honeysuckle. Among the native indicators, *Poaceae* species (grasses) and *Rubus* species (blackberry) were the most abundant.

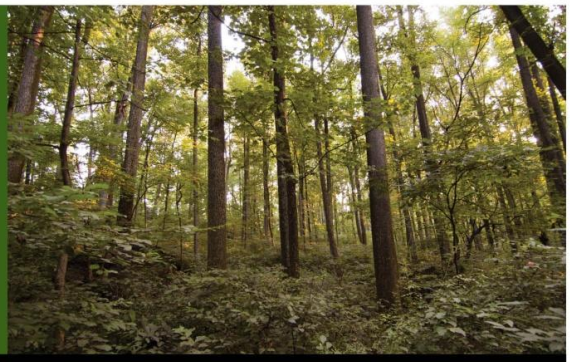
In 2012, field crews will revisit plots established in 2008, adding to the data on forest dynamics and increasing our confidence in forest health trends.

Photos by James Comiskey.

A Final Note

It is important to note that the data presented here is preliminary. Only one-quarter of the park's plots have been revisited, and therefore the trends we report are likely to change as we add more data. However, these early results illustrate the analyses and indicators derived from long-term monitoring and their value to park management.

We would like to thank Sara Koenig, GETT Natural Resource Manager, for her continued support and input, as well as the field crews that dedicated long, hot summer days to sample the plots across the network.



Lead Scientist
James Comiskey
Jim_Comiskey@nps.gov
Program Manager/Ecologist

Mid-Atlantic Network
120 Chatham Lane
Fredericksburg, VA 22405
www.nature.nps.gov/im/units/midn

Parks monitored: *Appomattox Court House NHP • Booker T. Washington NM • Colonial NHP • Eisenhower NHS • Fredericksburg & Spotsylvania NMP Gettysburg NMP • George Washington Birthplace NM • Hopewell Furnace NHS • Petersburg NB • Richmond NBP • Thomas Stone NHS • Valley Forge NHP*

May 2012

Hopewell Furnace National Historic Site

Northeast Region
Inventory & Monitoring Program

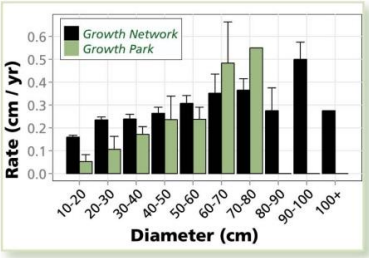
National Park Service
U.S. Department of the Interior

Mid-Atlantic Network **Forest Vegetation Resource Brief**

Hopewell Furnace National Historic Site 2011 Status & Trends

In 2011, four plots established in 2007 at Hopewell Furnace NHS (HOFU) were revisited. With only one-quarter of the total plots in the park resampled, the following highlights of temporal trends are preliminary.

All trees with a diameter at breast height (DBH) equal to or greater than 10 cm were measured and their condition was assessed. Trees that had died since the last census were noted, while recruited trees, those reaching the minimum DBH of 10 cm, were identified, measured, mapped, marked, and tagged. No trees died during this time, and recruitment was primarily in the tulip poplar dominated forest community. This is not uncommon due to patches of early successional forest in the park that are currently maturing, and illustrated by the high growth rate of early successional hardwood species such as tulip poplar (*Liriodendron tulipifera*). Growth rates were generally lower than observed across the network except among trees in the larger diameter size classes (see figure to left).



Growth rates of mature trees in different diameter size classes at Hopewell Furnace NHS.

Three microplots in each plot were sampled for tree saplings and shrubs with diameters greater than 1 cm and less than 10 cm. Sapling mortality was only documented in the tulip poplar community and was below the network average. No sapling recruitment was observed in any plots. Sapling growth rates were

Objectives

1. *Determine the status and trends in forest structure, composition, and dynamics of canopy and understory woody species.*
2. *Determine the status and trends in the density and composition of native tree seedlings and selected herbaceous species that are indicators of deer browse.*
3. *Detect and monitor the presence of invasive exotic plants, exotic plant diseases and pathogens, and forest pests.*
4. *Determine the status and trends in forest coarse woody debris and the availability of snags.*
5. *Determine the status and trends in soil Ca:Al and C:N ratios to assess the extent of base cation depletion, change in aluminum availability, and nitrogen saturation impacting MIDN forest soils.*

Importance

The Mid-Atlantic region is primarily a forested ecoregion and all Mid-Atlantic Network parks have forests that form an essential part of the landscape and provide habitat for a diversity of wildlife. Forest structure, composition, and dynamics are important measures of forest condition and health. Changes in these metrics can be indicative of stressors that may result in alterations in the future ecological integrity of forest communities. For example, high tree mortality rates can signal a change in the canopy species; declines in seedling and sapling densities can indicate a reduced capacity of the forest to regenerate; or increases in invasive exotic plants can exclude other herbaceous plants in the forest understory.

Management Applications

- *Provide a measure of forest health and changes over time.*
- *Indicate composition and trends in invasive exotic plants, pests, and pathogens in the park.*
- *Evaluate the impact of and trends in white-tailed deer browse on forest understory communities.*

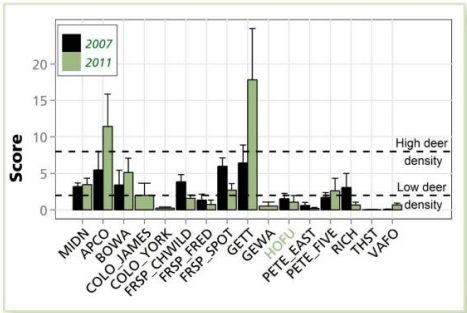
Long-term Monitoring

Plot locations were randomly selected from a 250-m sampling grid. Each plot consists of a 20 x 20 m square where all trees and shrubs with a diameter at breast height (dbh) ≥ 10 cm are identified, measured, tagged, marked, and mapped, and their condition is assessed. Trees and shrubs with a dbh ≥ 1 cm are identified, measured, marked, and tagged in each of three microplots. The number and height of tree seedlings and cover of a select group of native and invasive herbaceous indicator plants are recorded in 12 quadrats. Coarse woody debris is measured along three transects. Soil samples are collected from outside each plot. A variety of parameters are measured to describe the overall plot characteristics, including vegetation cover at different strata or layers, evidence of disturbance and deer-browse, slope, and aspect. The plots are revisited every four years to evaluate changes.

2011 Status & Trends...

generally higher than observed across the network.

Tree seedlings are identified in each of 12 quadrats, and their heights measured. The number and height of seedlings determines whether there is adequate regeneration to sustain the forest canopy. In parks where deer densities are high, a larger number of seedlings are required due to the heavier browse pressure than in parks where deer densities are low. Thus, regeneration is considered as "Good" if it exceeds the high deer density level, and "Significant Concern" when it falls below the low deer density level in any park. At Hopewell Furnace NHS, the tree seedling regeneration score decreased slightly from 2007 to 2011. Seedling regeneration in the park continues to be classified as "Significant Concern" (see figure below). Additional data over the coming years will help us determine if there are potential long-term impacts on the forest communities of the park.



Mean regeneration scores for the Mid-Atlantic Network and individual parks in 2007 and 2011. Lines indicate minimum score needed to maintain sustainable regeneration under low and high deer densities. Codes refer to the parks monitored (see below or full report at www.nature.nps.gov/im/units/midn).

Indicator invasive exotic and native species are also monitored in the quadrats. Compared to the rest of the network, Hopewell Furnace NHS had a moderate percent cover of exotics in the plots sampled. The most common invasive exotic plant species was Japanese stiltgrass (*Microstegium vimineum*) which showed a substantial decrease in cover over the previous four years. Among the native indicators, *Vaccinium* species (blueberries) were the most abundant.

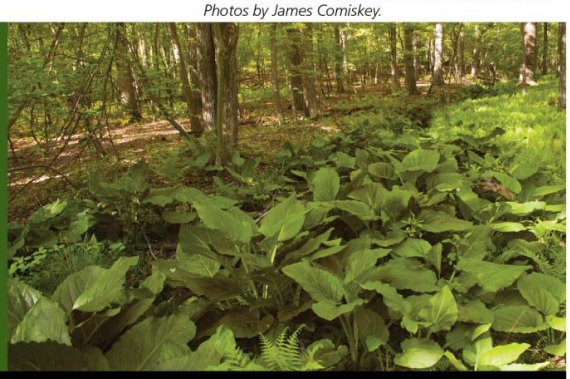
In 2012, field crews will revisit plots established in 2008, adding to the data on forest dynamics and increasing our confidence forest health trends.

Photos by James Comiskey.

A Final Note

It is important to note that the data presented here is preliminary. Only one-quarter of the park's plots have been revisited, and therefore the trends we report are likely to change as we add more data. However, these early results illustrate the analyses and indicators derived from long-term monitoring and their value to park management.

We would like to thank Steven Ambrose, HOFU Natural Resource Manager, for his continued support and input, as well as the field crews that dedicated long, hot summer days to sample the plots across the network.



Lead Scientist
James Comiskey
Jim_Comiskey@nps.gov
Program Manager/Ecologist

Mid-Atlantic Network
120 Chatham Lane
Fredericksburg, VA 22405
www.nature.nps.gov/im/units/midn

Parks monitored: *Appomattox Court House NHP • Booker T. Washington NM • Colonial NHP • Eisenhower NHS • Fredericksburg & Spotsylvania NMP Gettysburg NMP • George Washington Birthplace NM • Hopewell Furnace NHS • Petersburg NB • Richmond NBP • Thomas Stone NHS • Valley Forge NHP*

May 2012

Petersburg National Battlefield

Northeast Region
Inventory & Monitoring Program

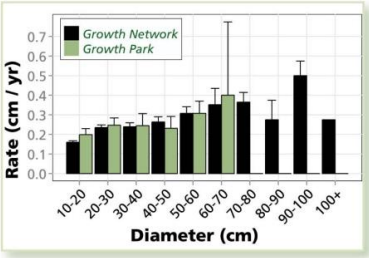
National Park Service
U.S. Department of the Interior

Mid-Atlantic Network **Forest Vegetation Resource Brief**

Petersburg National Battlefield 2011 Status & Trends

In 2011, 13 plots established in 2007 at Petersburg NB (PETE) were revisited, seven in the Eastern Front unit and six in the Five Forks unit. With only one-quarter of the total plots in the park resampled, the following highlights of temporal trends are preliminary.

All trees with a diameter at breast height (DBH) equal to or greater than 10 cm were measured, and their condition was assessed. Trees that had died since the last census were noted, while recruited trees, those reaching the minimum DBH of 10 cm, were identified, measured, mapped, marked, and tagged. Most of the tree mortality and recruitment occurred in the oak-hickory community of the Five Forks unit, at a rate above the network average. Growth rates were generally lower than observed across the network, especially in the tulip poplar community. Larger diameter size classes at the Eastern Front unit had growth rates that were above the network average (see figure to left).



Growth rates of mature trees in different diameter size classes at the Eastern Front unit of Petersburg NB.

Three microplots in each plot were sampled for tree saplings and shrubs with diameters greater than 1 cm and less than 10 cm. Sapling mortality was substantially lower in the loblolly pine communities of Five Forks than across the network, but growth rates of sweetgum (*Liquidambar styraciflua*) saplings at Eastern Front were higher than average for the Mid-Atlantic Network.

Objectives

1. *Determine the status and trends in forest structure, composition, and dynamics of canopy and understory woody species.*
2. *Determine the status and trends in the density and composition of native tree seedlings and selected herbaceous species that are indicators of deer browse.*
3. *Detect and monitor the presence of invasive exotic plants, exotic plant diseases and pathogens, and forest pests.*
4. *Determine the status and trends in forest coarse woody debris and the availability of snags.*
5. *Determine the status and trends in soil Ca:Al and C:N ratios to assess the extent of base cation depletion, change in aluminum availability, and nitrogen saturation impacting MIDN forest soils.*

Importance

The Mid-Atlantic region is primarily a forested ecoregion and all Mid-Atlantic Network parks have forests that form an essential part of the landscape and provide habitat for a diversity of wildlife. Forest structure, composition, and dynamics are important measures of forest condition and health. Changes in these metrics can be indicative of stressors that may result in alterations in the future ecological integrity of forest communities. For example, high tree mortality rates can signal a change in the canopy species; declines in seedling and sapling densities can indicate a reduced capacity of the forest to regenerate; or increases in invasive exotic plants can exclude other herbaceous plants in the forest understory.

Management Applications

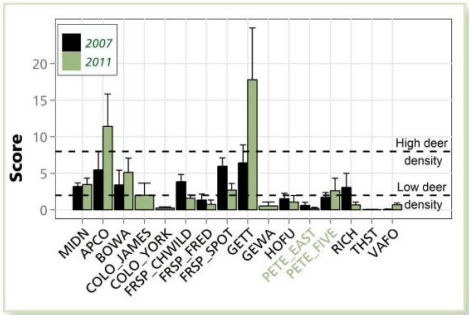
- *Provide a measure of forest health and changes over time.*
- *Indicate composition and trends in invasive exotic plants, pests, and pathogens in the park.*
- *Evaluate the impact of and trends in white-tailed deer browse on forest understory communities.*

Long-term Monitoring

Plot locations were randomly selected from a 250-m sampling grid. Each plot consists of a 20 x 20 m square where all trees and shrubs with a diameter at breast height (dbh) ≥ 10 cm are identified, measured, tagged, marked, and mapped, and their condition is assessed. Trees and shrubs with a dbh ≥ 1 cm are identified, measured, marked, and tagged in each of three microplots. The number and height of tree seedlings and cover of a select group of native and invasive herbaceous indicator plants are recorded in 12 quadrats. Coarse woody debris is measured along three transects. Soil samples are collected from outside each plot. A variety of parameters are measured to describe the overall plot characteristics, including vegetation cover at different strata or layers, evidence of disturbance and deer-browse, slope, and aspect. The plots are revisited every four years to evaluate changes.

2011 Status & Trends...

Tree seedlings are identified in each of 12 quadrats, and their heights measured. The number and height of seedlings determines whether there is adequate regeneration to sustain the forest canopy. In parks where deer densities are high, a larger number of seedlings are required due to the heavier browse pressure than in parks where deer densities are low. Thus, regeneration is considered as "Good" if it exceeds the high deer density level, and "Significant Concern" when it falls below the low deer density level in any park. At the Eastern Front unit, the tree seedling regeneration score decreased from 2007 to 2011, being classified as "Significant Concern". However, at Five Forks the seedling score increased, and the regeneration is now classified as "Caution" in that unit (see figure below). Additional data over the coming years will help us determine if there are potential long-term impacts on the forest communities of the park.



Mean regeneration scores for the Mid-Atlantic Network and individual parks in 2007 and 2011. Lines indicate minimum score needed to maintain sustainable regeneration under low and high deer densities. Codes refer to the parks monitored (see below or full report at www.nature.nps.gov/im/units/midn).

Indicator invasive exotic and native species are also monitored in the quadrats. The Five Forks unit had a very low average percent cover of exotics in the plots sampled, while the Eastern Front plots had a high percent cover of Japanese stiltgrass (*Microstegium vimineum*) that increased since 2007. Among the native indicators, *Vaccinium* species (blueberries) were the most abundant in both units.

In 2012, field crews will revisit plots established in 2008, adding to the data on forest dynamics and increasing our confidence in forest health trends.

Photos by James Comiskey (front) and Gary Flemming (below).

A Final Note

It is important to note that the data presented here is preliminary. Only one-quarter of the park's plots have been revisited, and therefore the trends we report are likely to change as we add more data. However, these early results illustrate the analyses and indicators derived from long-term monitoring and their value to park management.

We would like to thank Tim Blumenschine, PETE Natural Resource Manager, for his continued support and input, as well as the field crews that dedicated long, hot summer days to sample the plots across the network.

Lead Scientist
James Comiskey
Jim_Comiskey@nps.gov
Program Manager/Ecologist

Mid-Atlantic Network
120 Chatham Lane
Fredericksburg, VA 22405
www.nature.nps.gov/im/units/midn

Parks monitored: *Appomattox Court House NHP • Booker T. Washington NM • Colonial NHP • Eisenhower NHS • Fredericksburg & Spotsylvania NMP Gettysburg NMP • George Washington Birthplace NM • Hopewell Furnace NHS • Petersburg NB • Richmond NBP • Thomas Stone NHS • Valley Forge NHP*

March 2012

Richmond National Battlefield Park

Northeast Region
Inventory & Monitoring Program

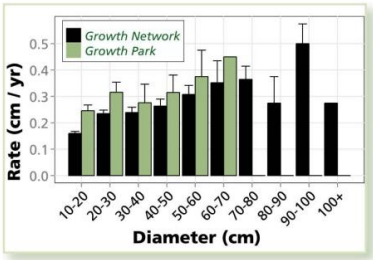
National Park Service
U.S. Department of the Interior

Mid-Atlantic Network **Forest Vegetation Resource Brief**

Richmond National Battlefield Park 2011 Status & Trends

In 2011, eight plots established in 2007 at Richmond NBP (RICH) were revisited. With only one-quarter of the total plots in the park resampled, the following highlights of temporal trends are preliminary.

All trees with a diameter at breast height (DBH) equal to or greater than 10 cm were measured and their condition was assessed. Trees that had died since the last census were noted, while recruited trees, those reaching the minimum DBH of 10 cm, were identified, measured, mapped, marked, and tagged. Most of the tree mortality occurred in the loblolly pine community at a rate significantly higher than the network average. In contrast, most of the recruitment occurred in the tulip poplar and sweetgum community types, though at levels below those observed across the network. The dominant species recruited was American holly (*Ilex opaca*). Growth rates were generally higher than observed across the network, especially for tree of heaven (*Ailanthus altissima*) and loblolly pine (*Pinus taeda*), and among trees in all diameter size classes (see figure to left).



Growth rates of mature trees in different diameter size classes at Richmond NBP.

Three microplots in each plot were sampled for tree saplings and shrubs with diameters greater than 1 cm and less than 10 cm. Sapling mortality was significantly higher in the loblolly forest community, while recruitment was generally lower than the network aver-

Objectives

1. *Determine the status and trends in forest structure, composition, and dynamics of canopy and understory woody species.*
2. *Determine the status and trends in the density and composition of native tree seedlings and selected herbaceous species that are indicators of deer browse.*
3. *Detect and monitor the presence of invasive exotic plants, exotic plant diseases and pathogens, and forest pests.*
4. *Determine the status and trends in forest coarse woody debris and the availability of snags.*
5. *Determine the status and trends in soil Ca:Al and C:N ratios to assess the extent of base cation depletion, change in aluminum availability, and nitrogen saturation impacting MIDN forest soils.*

Importance

The Mid-Atlantic region is primarily a forested ecoregion and all Mid-Atlantic Network parks have forests that form an essential part of the landscape and provide habitat for a diversity of wildlife. Forest structure, composition, and dynamics are important measures of forest condition and health. Changes in these metrics can be indicative of stressors that may result in alterations in the future ecological integrity of forest communities. For example, high tree mortality rates can signal a change in the canopy species; declines in seedling and sapling densities can indicate a reduced capacity of the forest to regenerate; or increases in invasive exotic plants can exclude other herbaceous plants in the forest understory.

Management Applications

- *Provide a measure of forest health and changes over time.*
- *Indicate composition and trends in invasive exotic plants, pests, and pathogens in the park.*
- *Evaluate the impact of and trends in white-tailed deer browse on forest understory communities.*

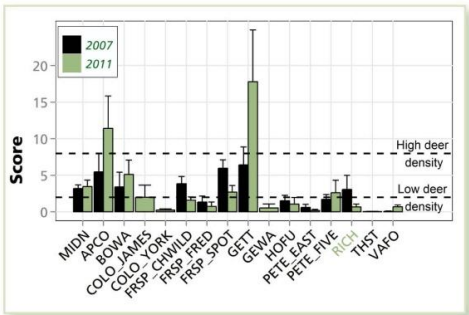
Long-term Monitoring

Plot locations were randomly selected from a 250-m sampling grid. Each plot consists of a 20 x 20 m square where all trees and shrubs with a diameter at breast height (dbh) ≥ 10 cm are identified, measured, tagged, marked, and mapped, and their condition is assessed. Trees and shrubs with a dbh ≥ 1 cm are identified, measured, marked, and tagged in each of three microplots. The number and height of tree seedlings and cover of a select group of native and invasive herbaceous indicator plants are recorded in 12 quadrats. Coarse woody debris is measured along three transects. Soil samples are collected from outside each plot. A variety of parameters are measured to describe the overall plot characteristics, including vegetation cover at different strata or layers, evidence of disturbance and deer-browse, slope, and aspect. The plots are revisited every four years to evaluate changes.

2011 Status & Trends...

age and was dominated by mockernut hickory (*Carya alba*). Likewise, growth rates were generally low compared to those observed across the network.

Tree seedlings are identified in each of 12 quadrats, and their heights measured. The number and height of seedlings determines whether there is adequate regeneration to sustain the forest canopy. In parks where deer densities are high, a larger number of seedlings are required due to the heavier browse pressure than in parks where deer densities are low. Thus, regeneration is considered as "Good" if it exceeds the high deer density level, and "Significant Concern" when it falls below the low deer density level in any park. In Richmond NBP the tree seedling regeneration scores declined from 2007 to 2011, changing the regeneration condition from "Caution" to "Significant Concern" (see figure below). Additional data over the coming years will help us determine if there are potential long-term impacts on the forest communities of the park.



Mean regeneration scores for the Mid-Atlantic Network and individual parks in 2007 and 2011. Lines indicate minimum score needed to maintain sustainable regeneration under low and high deer densities. Codes refer to the parks monitored (see below or full report at www.nature.nps.gov/im/units/midn).

Indicator invasive exotic and native species are also monitored in the quadrats. Compared to the rest of the network, Richmond NBP had a moderate percent cover of exotics in the plots sampled with the most common species being Japanese stiltgrass (*Microstegium vimineum*), which increased over the previous four years, and Japanese honeysuckle (*Lonicera japonica*) which declined in cover. Among the native indicators, percent cover declined since 2007.

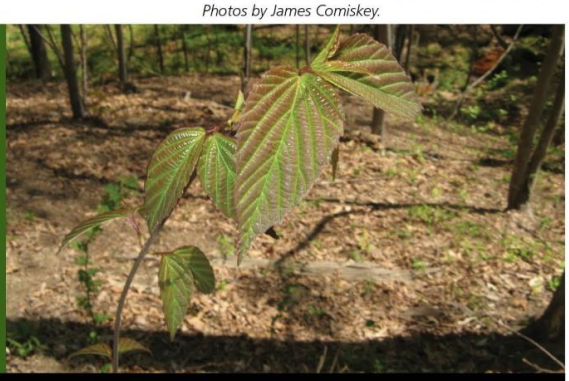
In 2012, field crews will revisit plots established in 2008, adding to the data on forest dynamics.

Photos by James Comiskey.

A Final Note

It is important to note that the data presented here is preliminary. Only one-quarter of the park's plots have been revisited, and therefore the trends we report are likely to change as we add more data. However, these early results illustrate the analyses and indicators derived from long-term monitoring and their value to park management.

We would like to thank Kristen Allen, RICH Natural Resource Manager, for her continued support and input, as well as the field crews that dedicated long, hot summer days to sample the plots across the network.



Lead Scientist
James Comiskey
Jim_Comiskey@nps.gov
Program Manager/Ecologist

Mid-Atlantic Network
120 Chatham Lane
Fredericksburg, VA 22405
www.nature.nps.gov/im/units/midn

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May 2012

Valley Forge National Historical Park

Northeast Region
Inventory & Monitoring Program

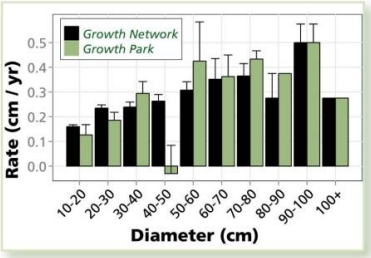
National Park Service
U.S. Department of the Interior

Mid-Atlantic Network **Forest Vegetation Resource Brief**

Valley Forge National Historical Park 2011 Status & Trends

In 2011, seven plots established in 2007 at Valley Forge NHP (VAFO) were revisited. With only one-quarter of the total plots in the park resampled, the following highlights of temporal trends are preliminary.

All trees with a diameter at breast height (DBH) equal to or greater than 10 cm were measured and their condition was assessed. Trees that had died since the last census were noted, while recruited trees, those reaching the minimum DBH of 10 cm, were identified, measured, mapped, marked, and tagged. Most of the tree mortality occurred in the tulip poplar community, at a rate higher than the network average. Recruitment was highest in the white ash dominated community. Growth rates were generally lower than observed across the network, especially in the tulip poplar community and among the smaller diameter size classes (see figure to left).



Growth rates of mature trees in different diameter size classes at Valley Forge NHP.

Three microplots in each plot were sampled for tree saplings and shrubs with diameters greater than 1 cm and less than 10 cm. Sapling mortality was lower than observed across the network, but recruitment was not documented in any community type. However, growth rates among saplings were mostly above average, so we anticipate increased recruitment rates in the future.

Tree seedlings are identified in each of 12 quadrats, and their heights measured.

Objectives

1. *Determine the status and trends in forest structure, composition, and dynamics of canopy and understory woody species.*
2. *Determine the status and trends in the density and composition of native tree seedlings and selected herbaceous species that are indicators of deer browse.*
3. *Detect and monitor the presence of invasive exotic plants, exotic plant diseases and pathogens, and forest pests.*
4. *Determine the status and trends in forest coarse woody debris and the availability of snags.*
5. *Determine the status and trends in soil Ca:Al and C:N ratios to assess the extent of base cation depletion, change in aluminum availability, and nitrogen saturation impacting MIDN forest soils.*

Importance

The Mid-Atlantic region is primarily a forested ecoregion and all Mid-Atlantic Network parks have forests that form an essential part of the landscape and provide habitat for a diversity of wildlife. Forest structure, composition, and dynamics are important measures of forest condition and health. Changes in these metrics can be indicative of stressors that may result in alterations in the future ecological integrity of forest communities. For example, high tree mortality rates can signal a change in the canopy species; declines in seedling and sapling densities can indicate a reduced capacity of the forest to regenerate; or increases in invasive exotic plants can exclude other herbaceous plants in the forest understory.

Management Applications

- *Provide a measure of forest health and changes over time.*
- *Indicate composition and trends in invasive exotic plants, pests, and pathogens in the park.*
- *Evaluate the impact of and trends in white-tailed deer browse on forest understory communities.*

Long-term Monitoring

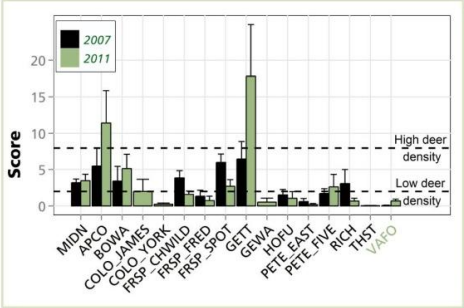
Plot locations were randomly selected from a 250-m sampling grid. Each plot consists of a 20 x 20 m square where all trees and shrubs with a diameter at breast height (dbh) ≥ 10 cm are identified, measured, tagged, marked, and mapped, and their condition is assessed. Trees and shrubs with a dbh ≥ 1 cm are identified, measured, marked, and tagged in each of three microplots. The number and height of tree seedlings and cover of a select group of native and invasive herbaceous indicator plants are recorded in 12 quadrats. Coarse woody debris is measured along three transects. Soil samples are collected from outside each plot. A variety of parameters are measured to describe the overall plot characteristics, including vegetation cover at different strata or layers, evidence of disturbance and deer-browse, slope, and aspect. The plots are revisited every four years to evaluate changes.

2011 Status & Trends...

The number and height of seedlings determines whether there is adequate regeneration to sustain the forest canopy. In parks where deer densities are high, a larger number of seedlings are required due to the heavier browse pressure than in parks where deer densities are low. Thus, regeneration is considered as "Good" if it exceeds the high deer density level, and "Significant Concern" when it falls below the low deer density level in any park. Valley Forge NHP did show a slight increase in the tree seedling regeneration score from 2007 to 2011. However, seedling regeneration in the park is still classified as "Significant Concern" (see figure to right). Continued monitoring will determine whether regeneration is improving across the park.

Indicator invasive exotic and native species are also monitored in the quadrats. Compared to the rest of the network, Valley Forge NHP had a high average percent cover of exotics in the plots sampled with the most common species being Japanese stiltgrass (*Microstegium vimineum*), which showed a decline in cover over the previous four years. However, wine raspberry (*Rubus phoenicolasius*) and garlic mustard (*Alliaria petiolata*) increased in cover. Among the native indicators, Virginia creeper (*Parthenocissus quinquefolia*) was the most abundant.

In 2012, field crews will revisit plots established in 2008, adding to the data on forest dynamics and increasing our confidence in forest health trends.



Mean regeneration scores for the Mid-Atlantic Network and individual parks in 2007 and 2011. Lines indicate minimum score needed to maintain sustainable regeneration under low and high deer densities. Codes refer to the parks monitored (see below or full report at www.nature.nps.gov/im/units/midn).

Photos by James Comiskey.

A Final Note

It is important to note that the data presented here is preliminary. Only one-quarter of the park's plots have been revisited, and therefore the trends we report are likely to change as we add more data. However, these early results illustrate the analyses and indicators derived from long-term monitoring and their value to park management.

We would like to thank Kris Heister, VAFO Natural Resource Manager, for her continued support and input, as well as the field crews that dedicated long, hot summer days to sample the plots across the network.

Lead Scientist
James Comiskey
Jim_Comiskey@nps.gov
Program Manager/Ecologist

Mid-Atlantic Network
120 Chatham Lane
Fredericksburg, VA 22405
www.nature.nps.gov/im/units/midn

Parks monitored: *Appomattox Court House NHP • Booker T. Washington NM • Colonial NHP • Eisenhower NHS • Fredericksburg & Spotsylvania NMP Gettysburg NMP • George Washington Birthplace NM • Hopewell Furnace NHS • Petersburg NB • Richmond NBP • Thomas Stone NHS • Valley Forge NHP*

May 2012

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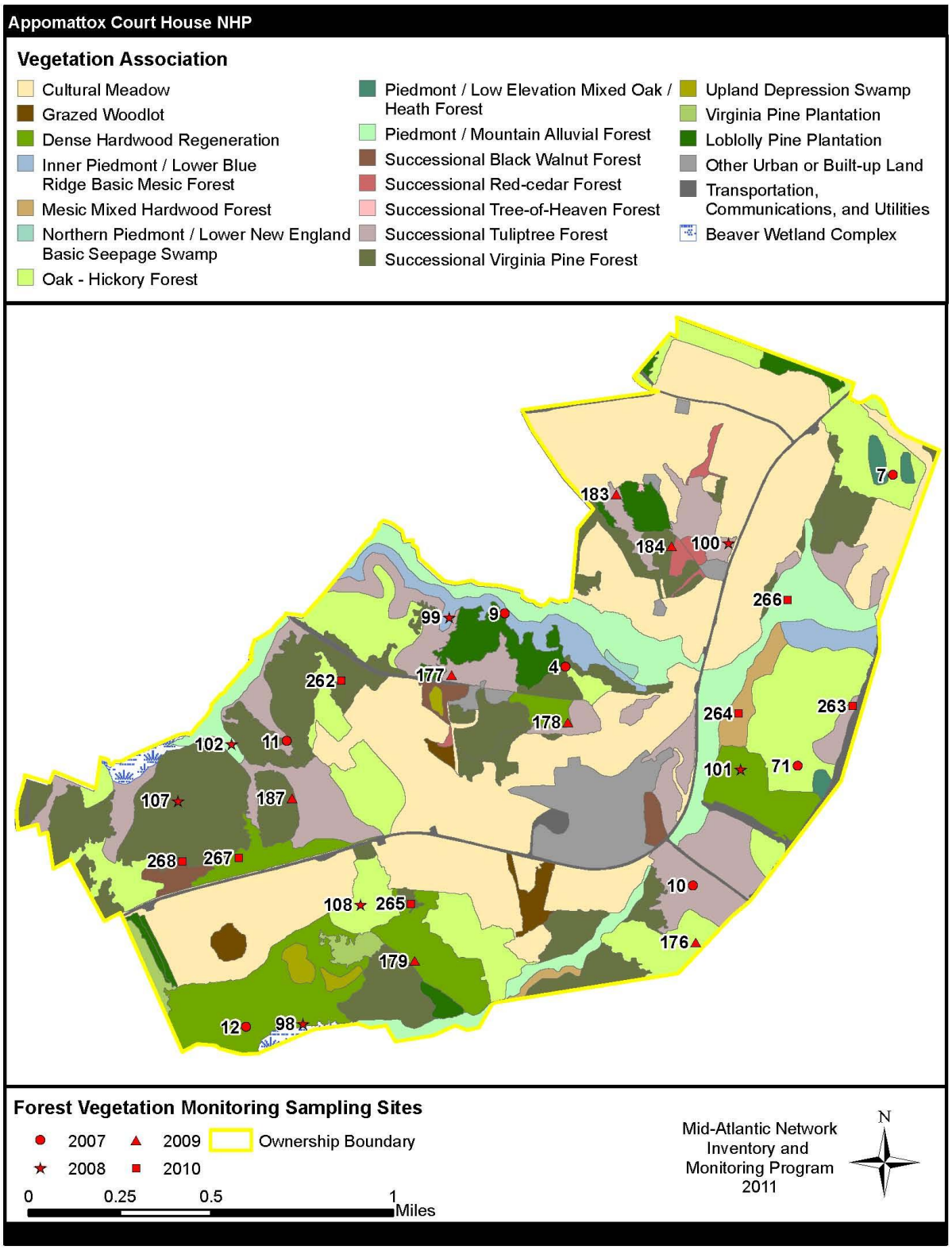
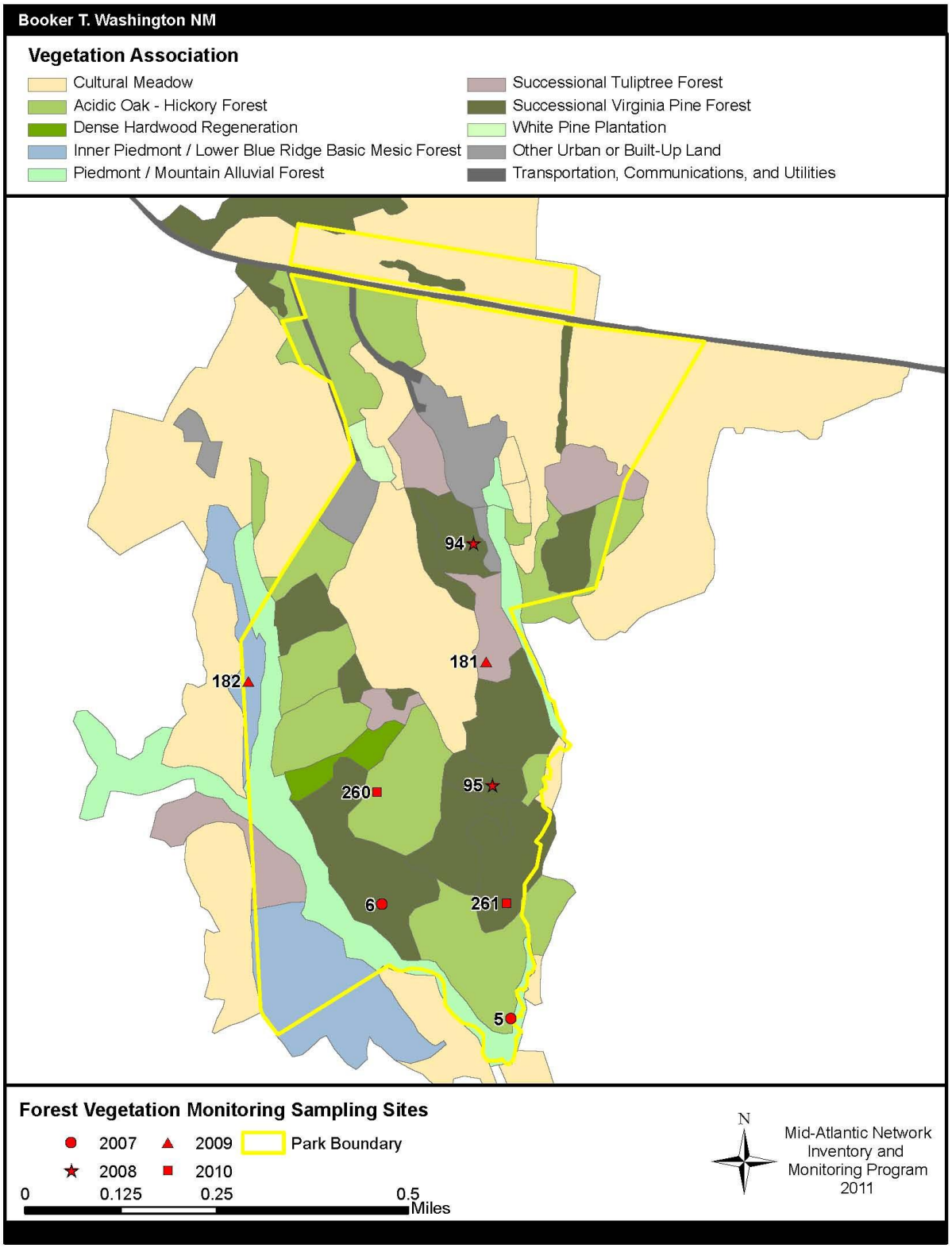
Appendix A. Maps of forest vegetation monitoring plots established between 2007 and 2010 and sampled in 2011 in the Mid-Atlantic and Northeast Coastal and Barrier networks.

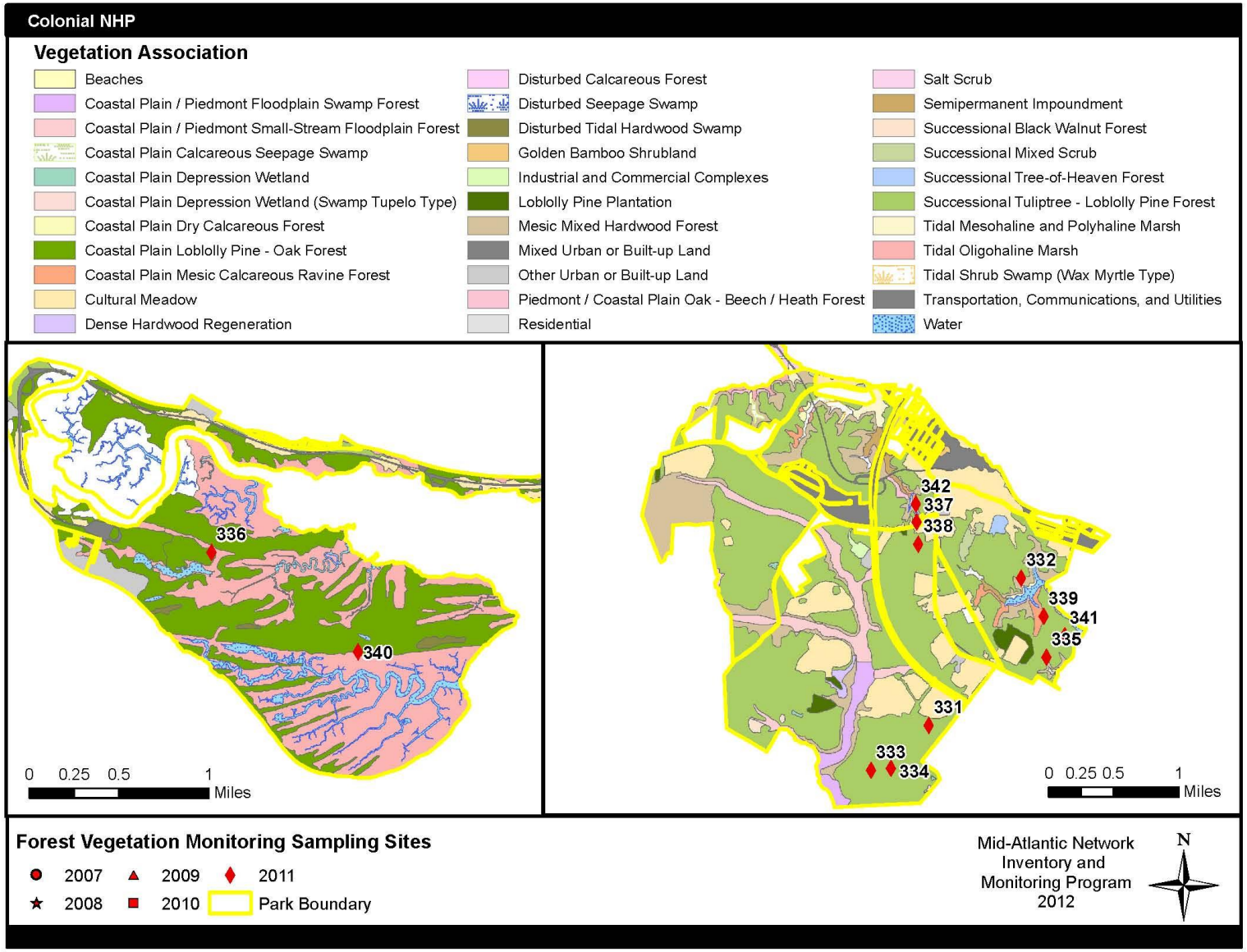
Appendix A1. Forest vegetation monitoring plots established between 2007 and 2010 at Appomattox Court House NHP. Plots measured in 2011 are those established in 2007.



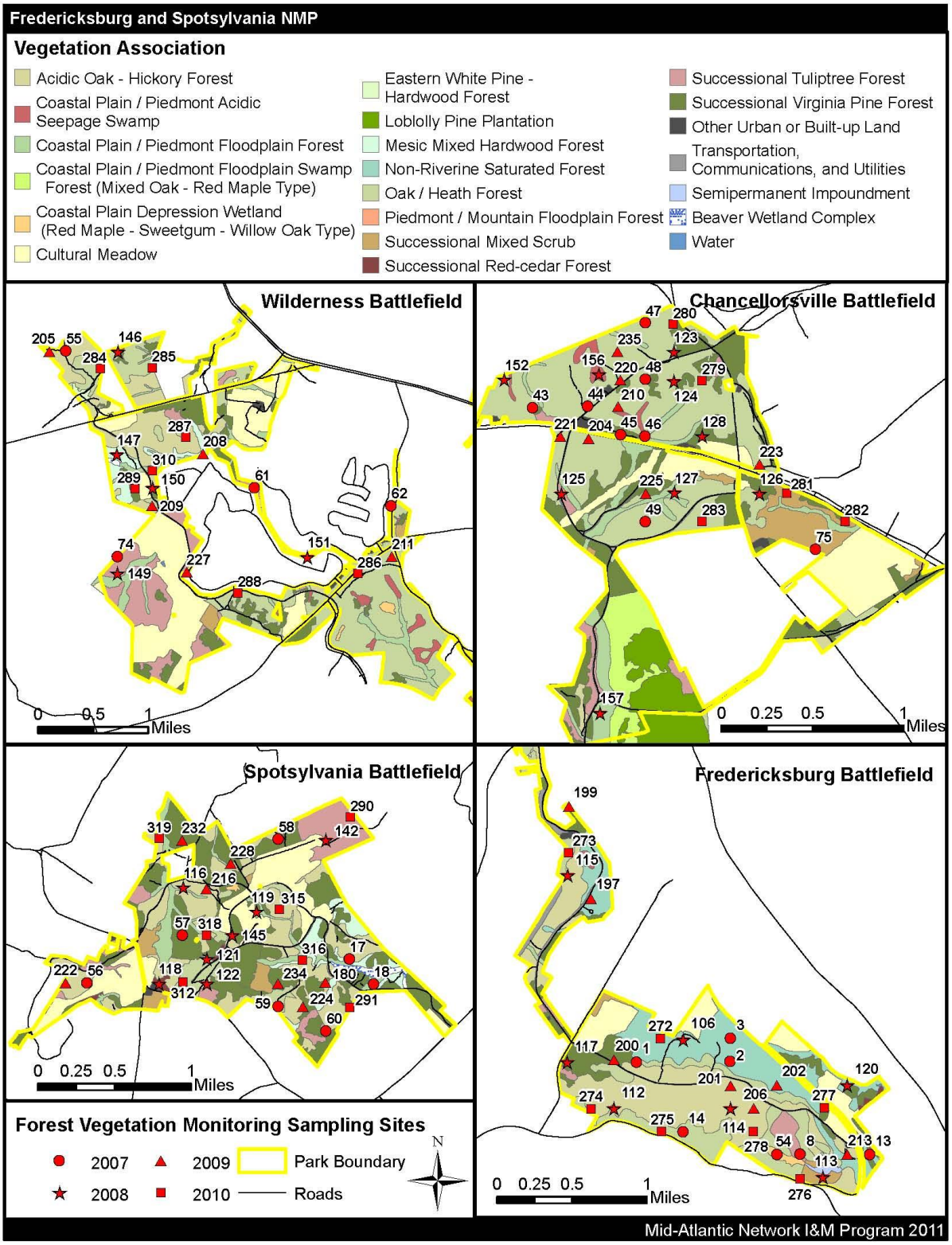
Appendix A2. Forest vegetation monitoring plots established between 2007 and 2010 at Booker T. Washington NM. Plots measured in 2011 are those established in 2007.



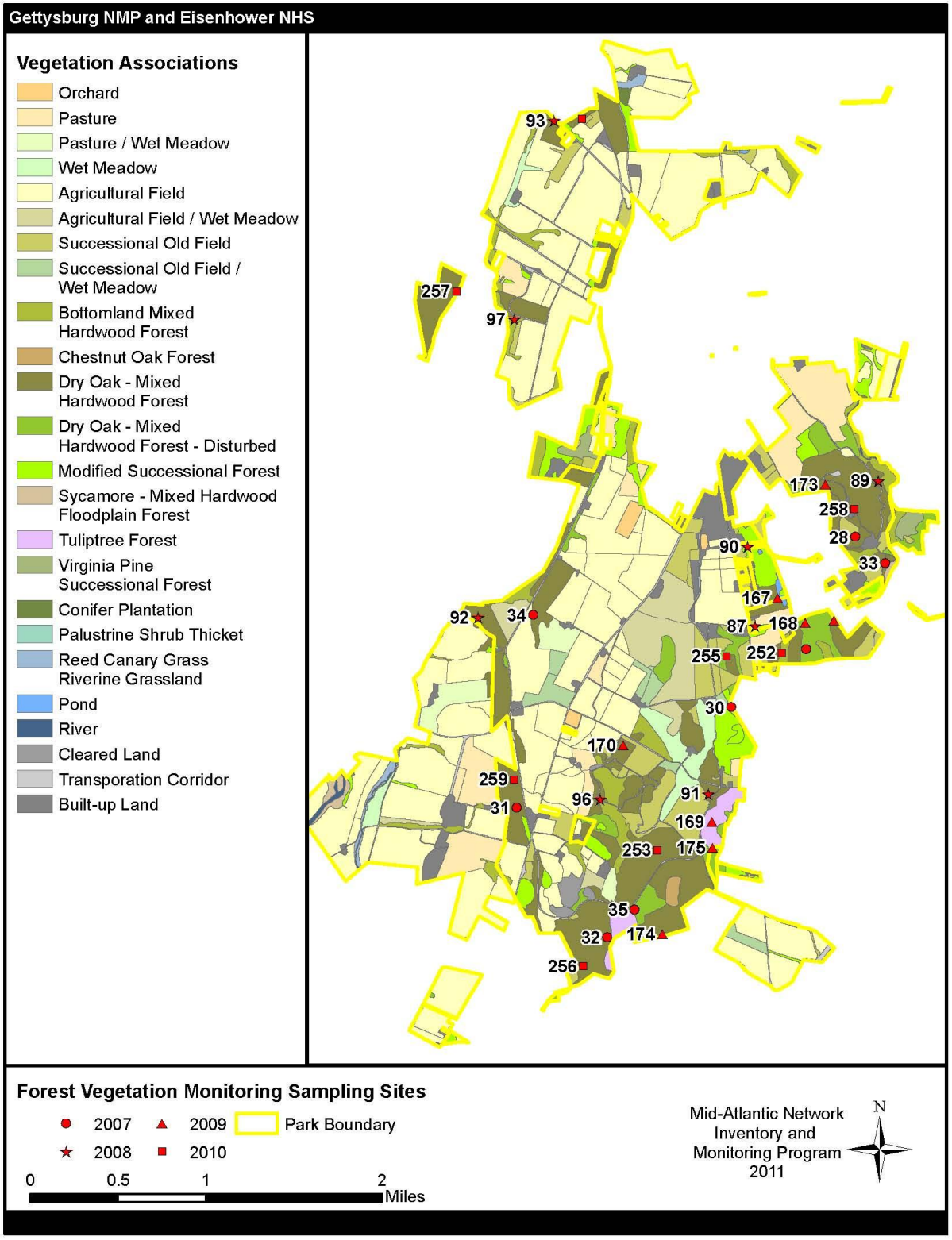
Appendix A3. Forest vegetation monitoring plots established in 2011 at Colonial NHP.



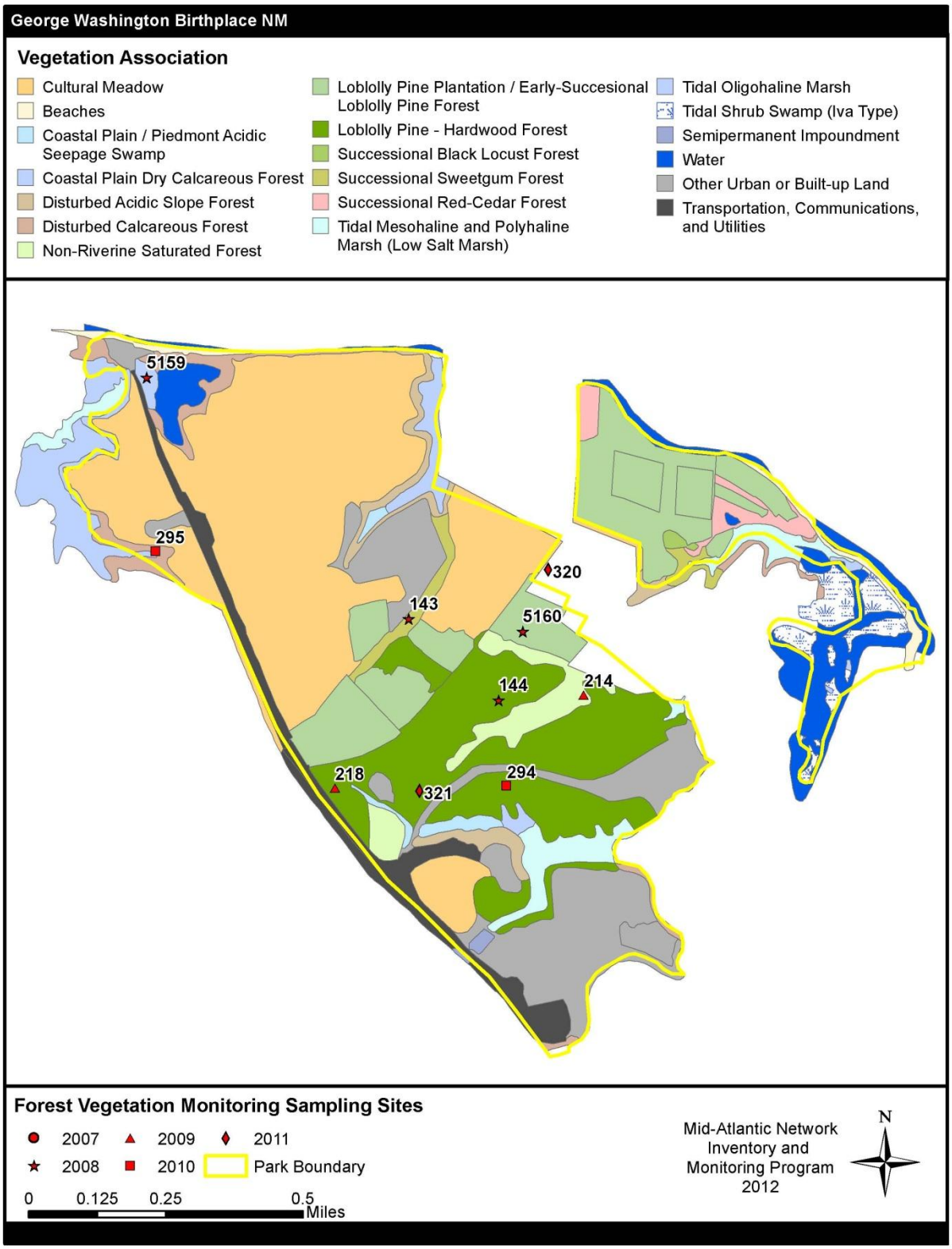
Appendix A4. Forest vegetation monitoring plots established between 2007 and 2010 at Fredericksburg and Spotsylvania NMP. Plots measured in 2011 are those established in 2007.



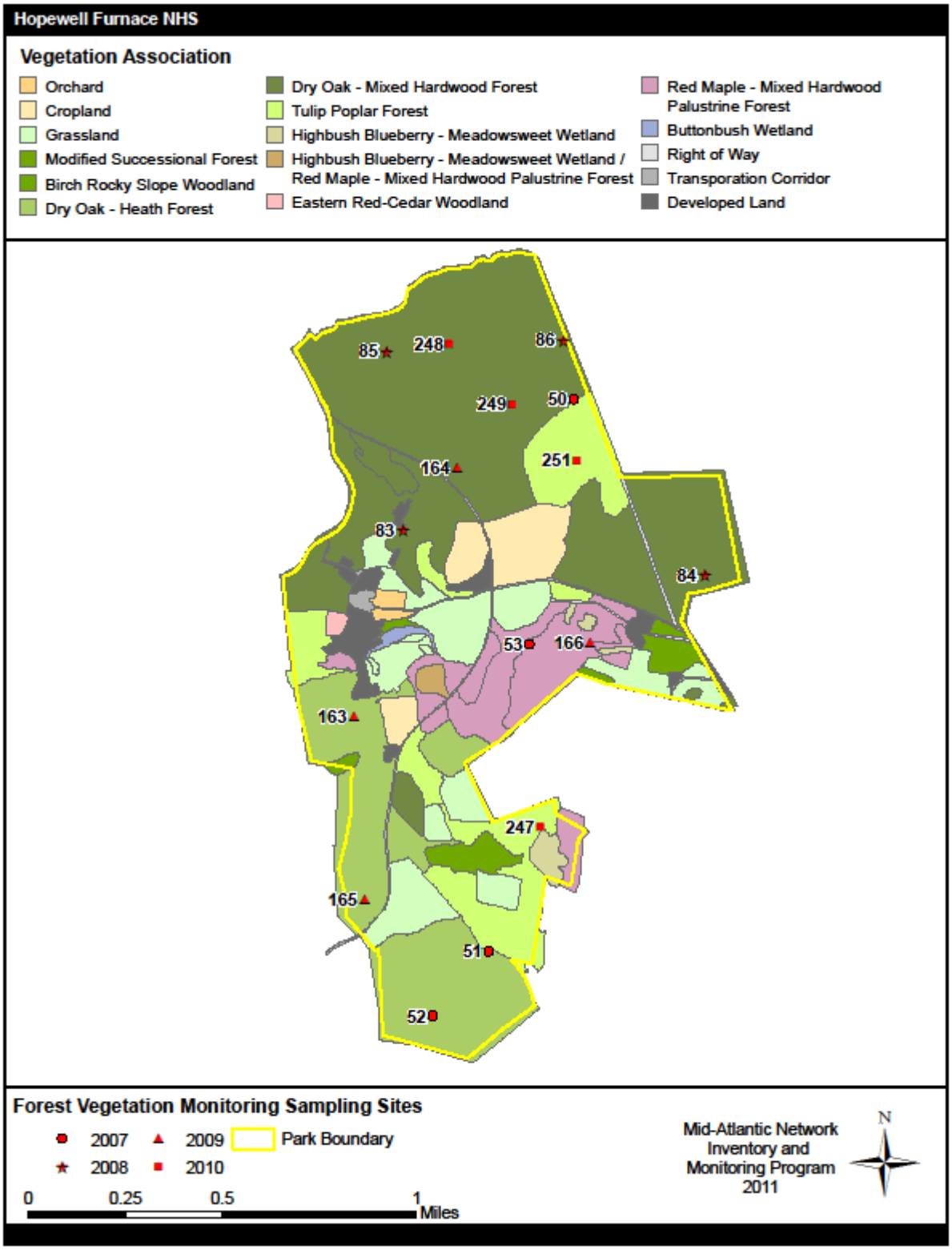
Appendix A5. Forest vegetation monitoring plots established between 2007 and 2010 at Gettysburg NMP. Plots measured in 2011 are those established in 2007.



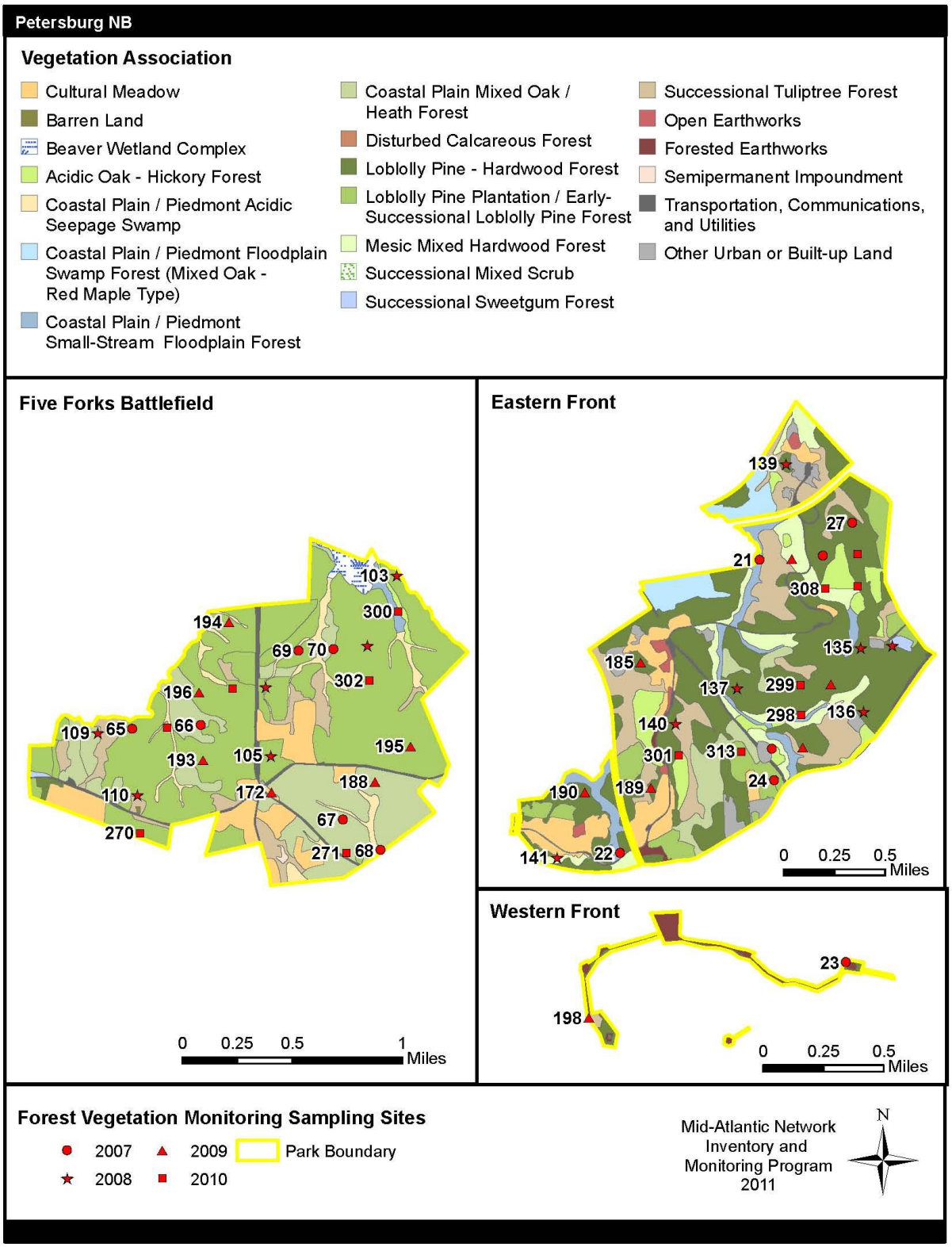
Appendix A6. Forest vegetation monitoring plots established between 2008 and 2011 at George Washington Birthplace NM.



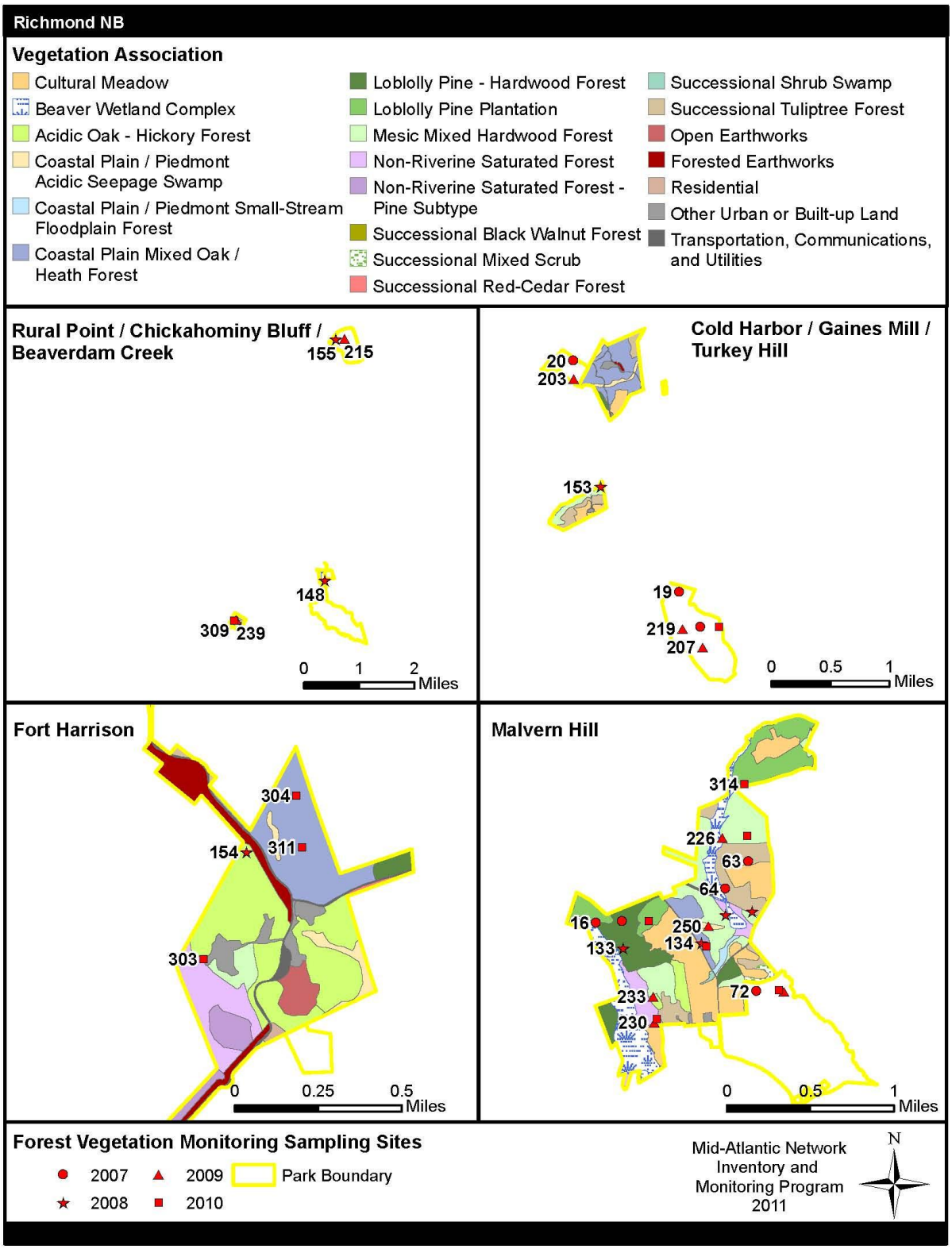
Appendix A7. Forest vegetation monitoring plots established between 2007 and 2010 at Hopewell Furnace NHS. Plots measured in 2011 are those established in 2007.



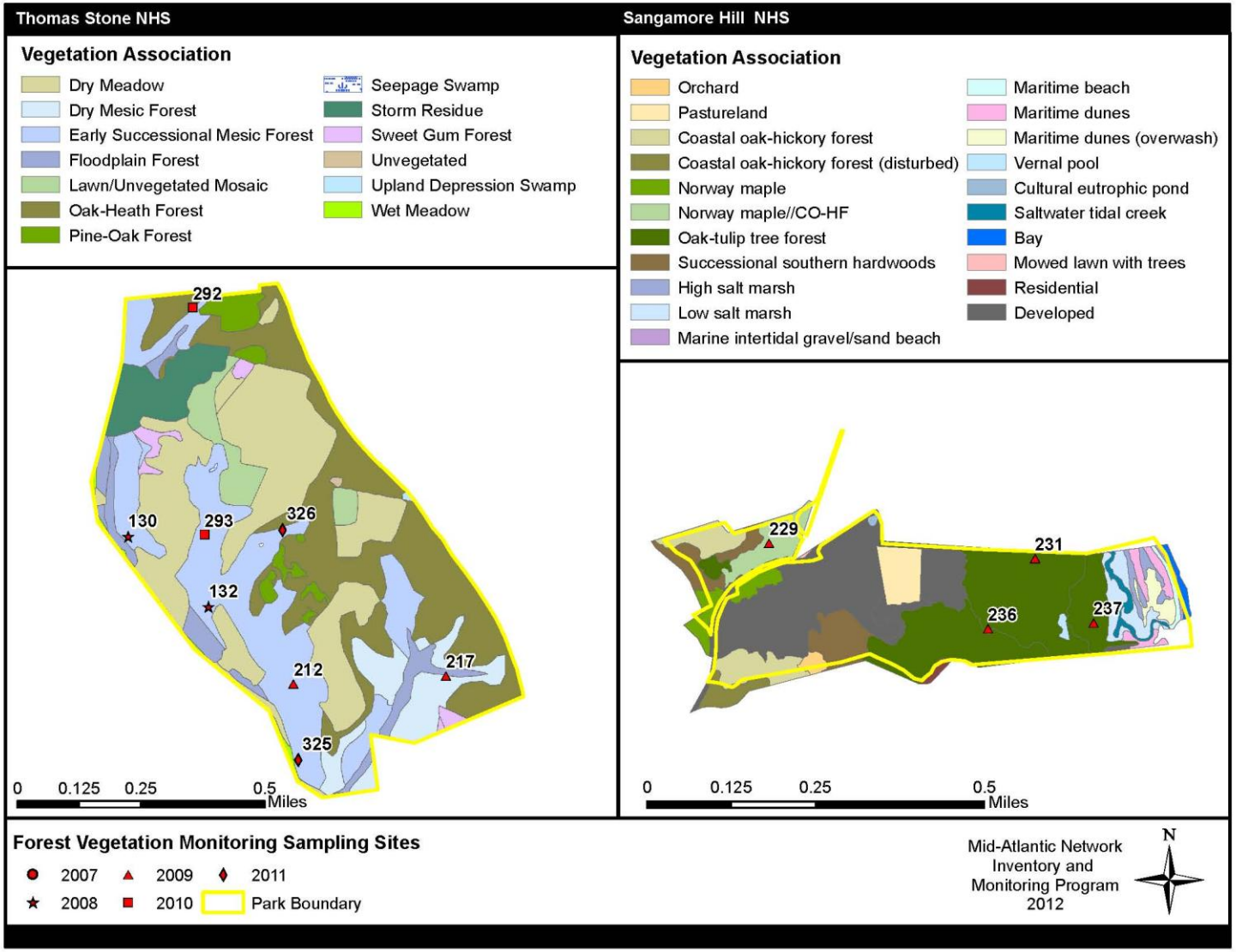
Appendix A8. Forest vegetation monitoring plots established between 2007 and 2010 at Petersburg NB. Plots measured in 2011 are those established in 2007.



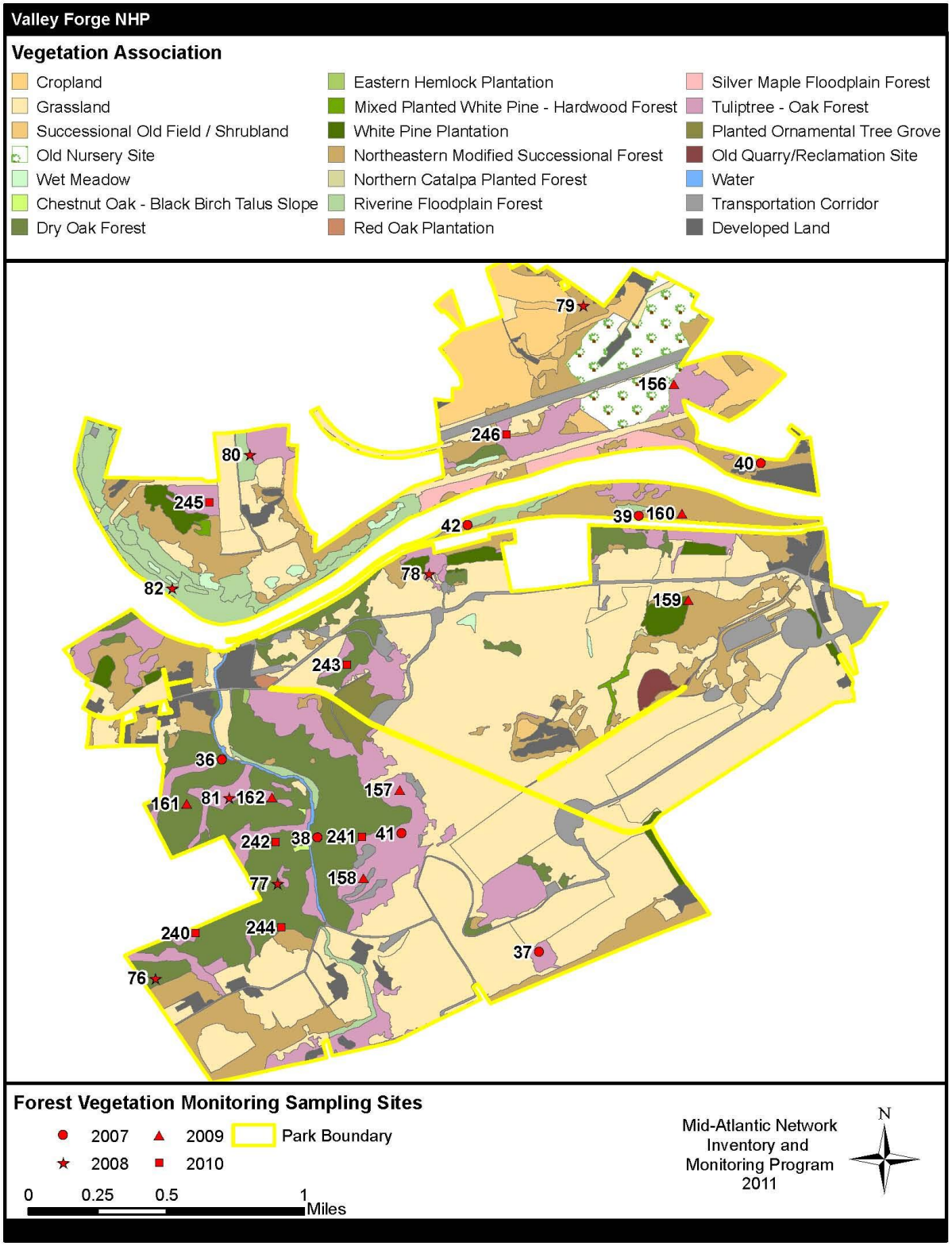
Appendix A9. Forest vegetation monitoring plots established between 2007 and 2010 at Richmond NBP. Plots measured in 2011 are those established in 2007.



Appendix A10. Forest vegetation monitoring plots established between 2008 and 2011 at Thomas Stone NHS and Sagamore Hill NHS.



Appendix A11. Forest vegetation monitoring plots established between 2007 and 2010 at Valley Forge NHP. Plots measured in 2011 are those established in 2007.



Appendix B. List of shrub species sampled in forest vegetation monitoring plots between 2007 and 2011 in Mid-Atlantic and Northeast Coastal and Barrier networks.

Latin Name	Common Name	Measurement Type[1,2]
Alnus serrulata	hazel alder	DRC
Berberis thunbergii [i]	Japanese barberry	Cover
Clethra acuminata	cinnamon clethra, mountain sweetpepperbush	DRC
Clethra alnifolia	summersweet clethra	DRC
Cornus spp.	dogwood	DRC
Cornus rugosa	roundleaf dogwood	DRC
Corylus americana	American hazelnut	DRC
Crataegus spp.	hawthorns	DBH
Elaeagnus umbellata [i]	autumn olive	DRC
Euonymus alata [i]	burning bush	DRC
Hamamelis virginiana	American witchhazel	DRC
Hypericum prolificum	shrubby St. Johnswort	DRC
Kalmia latifolia	mountain laurel	DRC
Ligustrum spp.	ligustrum, privet	DRC
Ligustrum vulgare [i]	European privet	DRC
Lindera benzoin	northern spicebush	DRC
Lonicera spp.	honeysuckle	Cover
Lonicera — Exotic [i]	honeysuckle - exotic	Cover
Lonicera — Native	native - exotic	Cover
Lonicera maackii [i]	Amur honeysuckle, Amur honeysuckle bush	DRC
Prunus spp.	chokecherry	DBH
Prunus virginiana	chokecherry (common)	DBH
Rhododendron	rhododendron	DRC
Ribes spp.	currant	DRC
Rosa multiflora [i]	multiflora rose	Cover
Rubus spp.	blackberry	Cover
Rubus occidentalis	black raspberry	Cover
Rubus phoenicolasius [i]	Japanese wineberry	Cover
Symphoricarpos orbiculatus	Indiancurrant coralberry, coralberry, coralberry	DRC
Vaccinium spp.	blueberries	Cover
Vaccinium corymbosum	highbush blueberry	DRC
Vaccinium stamineum	deerberry	DRC
Viburnum acerifolium	mapleleaf viburnum	DRC
Viburnum dentatum	arrowwood	DRC
Viburnum rufidulum	rusty blackhaw	DRC

[i] Invasive exotic species.

[1] Measurement types are: diameter at breast height (DBH), diameter at root crown (DRC), and percent cover (Cover).

[2] All species with DRC measurement type were changed to cover only in 2011.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 962/114763, June 2012

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Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

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