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Condition of vegetation communities in Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial:

Eastern Rivers and Mountains Network summary report 2007–2009

Natural Resource Data Series NPS/ERMN/NRDS—2010/034

ON THE COVER
Long-term monitoring plot in Johnstown Flood National Memorial.
Photograph by: Tom Saladyga.

Condition of vegetation communities in Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial:

Eastern Rivers and Mountains Network summary report 2007–2009

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Executive Summary

Beginning in 2007, the Eastern Rivers and Mountains Network (ERMN) of the National Park Service (NPS) began monitoring vegetation communities and soil in eight of its nine parks. The objective of this monitoring program is to provide information on the condition of the parks' vegetation and soil, and how this condition is changing through time. Permanent long-term monitoring plots have been established in Allegheny Portage Railroad National Historic Site (ALPO, n=15) and Johnstown Flood National Memorial (JOFL, n=7). Within the permanent plots, data are collected on forest stand structure; tree health, growth, and mortality; tree regeneration; coarse woody debris; shrubs; groundstory diversity; invasive species; and soil. The last panel of plots will be established in 2010, and in 2011 the first panel of plots will be revisited, providing data on how the vegetation is changing through time.

This report summarizes vegetation monitoring data collected between 2007 and 2009 in ALPO and JOFL and presents the condition of the parks' vegetation based on those data. These data provide a snap-shot of the status of the vegetation communities and are compared to expected ranges of variability for eastern forests. The results reported here provide highlights of the available data, but additional measures are being investigated and may be reported in the future.

Vegetation condition highlights within ALPO and JOFL include:

- Forest stands within the parks are predominantly young or middle-aged. Forests in ALPO tend to be older, while stands in JOFL tend to be younger.
- In ALPO, trees that are regenerating (trees of the future) are not the same species as are present in the canopy (present trees). Striped maple (*Acer pensylvanicum*) is strongly dominant in the sapling and seedling layers, which contrasts with the somewhat evenly distributed diversity of species in the forest canopy. If left unmanaged, ALPO's forest canopy will likely be strongly dominated by striped maple in the future.
- If browse pressure is low, most stands in ALPO and JOFL contain sufficient seedlings and saplings to regenerate the canopy; however, under high-browse intensity, only approximately 40% of stands in the two parks contain sufficient tree regeneration.
- Canada mayflower (*Maianthemum canadense*) is the most abundant species that are being monitored as an indicator of deer browse pressure. Changes in the number of plants, their height, and their reproductive status are being monitored and will be reported in the future.
- Only one occurrence of forest pests or pathogens was detected in the monitoring plots, which may indicate that these pests and pathogens are absent or in low abundance within the parks.
- Snag (standing dead trees) densities and the volume of coarse woody debris (fallen logs) in ALPO are typical of values found in other second-growth forests in the Appalachian Mountains. JOFL contains the highest density of snags and the lowest volume of coarse woody debris of any ERMN park. Snags and coarse woody debris provide important habitat for wildlife.

- The composition of the shrub layer is predominantly native species in ALPO and JOFL forests. Exotic invasive shrubs are less common in ALPO and JOFL forests than in other Pennsylvania ERMN parks.
- The diversity and nativity of the forest groundstory is an important component of the overall forest health since the groundstory is the most diverse strata. Between 75–90% of the species and cover in the groundstory are native plants. Given the relatively small size of the two parks, the abundance of nonnative species in the groundstory is relatively low.
- Invasive exotic plant species were observed in 33% of ALPO plots and 71% of JOFL plots. No species from the invasive exotic early detection watch lists were observed in the two parks between 2007 and 2009.

In general, forests in ALPO and JOFL are typical of other second-growth forests in the Appalachian Mountains; however, results from the monitoring data underscore two important points for park managers:

1) **Established and new invasive exotic species are a serious continuing threat to the parks' resources.** It is imperative to reduce the threat to park resources from invasive species through the following actions:

a) Keep the majority of the parks invasive-free by containing the spread from disturbed areas and eliminating isolated occurrences of invasive species;
b) Detect occurrences of new invasive species introduced to the parks;
c) Quickly eliminate or manage new populations of invasive species; and
d) Work with partners to encourage research on and experimental treatments of invasive species within the parks, especially those species that are already well established.

2) **Striped maple will likely be strongly dominant in the future forest canopy in ALPO; however, any striped maple management should be conducted as a targeted pilot study.** The published literature on striped maple treatment focuses on the most effective method to kill striped maple, with little available information on which tree species regenerated after these treatments, or on the effects of the treatments on non-woody understory plants. Therefore, before beginning a management program for striped maple at ALPO, park resource managers should consider potential impacts of herbicide application on non-target plants, especially non-woody species in the understory, and whether deer exclosure fencing would be required to ensure regeneration of desired Allegheny hardwood species. Until further information on the impacts of herbicides on non-target woody species and desired tree regeneration are available, any management of striped maple at ALPO should be conducted as a targeted pilot study, from which more information on these issues can be obtained.

Introduction

In 2007, the Eastern Rivers and Mountains Network (ERMN) of the National Park Service (NPS) began monitoring vegetation communities and soil in eight of its nine parks. This monitoring effort is a component of the ERMN Vital Signs monitoring program (Marshall and Piekielek 2007) as part of the nationwide NPS Inventory and Monitoring Program (Fancy et al. 2009).

Long-term monitoring of vegetation and soils was identified among the highest priority vital signs during the ERMN prioritization process (Marshall and Piekielek 2007). The vital sign process highlighted the importance of plant species diversity and functional plant communities as natural resources critical to the parks. These vegetation communities also serve as an integrated measure of terrestrial ecosystem health by expressing information about climate, soils, and disturbance. Furthermore, vegetation serves as a base for other trophic components such as wildlife.

The ERMN Vegetation and Soil Monitoring Program provides information regarding the condition of the parks' vegetation and soil, and how this condition is changing through time. Data generated by this program contribute to the monitoring of several of the network's vital signs, including: Forest, Woodland, Shrubland, and Riparian Plant Communities; Status and Trends of Invasive/Exotic Plants, Animals, and Diseases; Early Detection of Invasive/Exotic Plants, Animals, and Diseases; and Soil Function and Dynamics.

Numerous ecological and anthropogenic forces affect the parks' vegetation. Ecological factors such as geology, soil nutrient availability, weather, and disturbance patterns directly influence the structure, composition, and dynamics of the vegetation. Some anthropogenic stressors are easily identified, such as visitor overuse or loss and fragmentation of habitat due to development inside and outside of the parks. Many changes in forest vegetation through time are often linked to several interacting ecological and anthropogenic factors. Exotic species, white-tailed deer (*Odocoileus virginianus*), atmospheric acid and nutrient deposition, climate change, altered disturbance regimes, and changes in land use are also important factors affecting the parks' vegetation (Rentch 2006, Perles et al. 2009).

Depending on the successional stage, disturbance history, and site conditions, there are certain parameters within which a terrestrial vegetation ecosystem can be described as "healthy" (Tierney et al. 2009). By measuring taxonomic, structural, and demographic features an assessment can be made as to whether or not the ecosystem's parameters fall within expected or accepted norms and ranges of variability. These measures serve as indicators of ecological integrity that can be explicitly linked to park management.

This report is intended to provide preliminary results to natural resource managers at ALPO and JOFL on the condition of the vegetation communities in the parks, utilizing the first three years' of collected data. These data provide a snap-shot of the status of the vegetation communities and are compared to expected ranges of variability for eastern forests. In the future, when the monitoring plots have been revisited, data will be available on how the vegetation is changing through time and these results will also be presented.

Methods

Although a brief overview of the vegetation and soil monitoring methods is provided here, a detailed rationale of the sampling design and methods, in addition to Standard Operating Procedures, are provided in the Vegetation and Soil Monitoring Protocol (Perles et al. 2009). The protocol was based on the U.S. Forest Service (USFS) Forest Inventory and Analysis (FIA) program (USFS 2007) and the vegetation monitoring protocols of four other Inventory and Monitoring programs in the eastern United States (Sanders et al. 2006, Schmit et al. 2006, Tierney and Faber-Langendoen 2007, Comisky et al. 2009). Adopting widely used protocols facilitates comparisons of ERMN data with other NPS networks and regional data sets.

Site Selection

Vegetation and soil are monitored at permanent plots, since the use of permanent plots increases power to detect trends through time. For each park, a regular grid of potential plot locations was overlain on the park. Potential plot locations were 250 meters apart for ALPO and 100 meters apart for JOFL. Sampling locations were selected from the regular grid using a generalized random-tessellation stratified (GRTS) design (McDonald 2004, Stevens and Olsen 2004). The three main advantages to a GRTS design are: 1) the GRTS design is spatially balanced, wherein there is generally uniform dispersion of sampling sites over the area of interest; 2) the GRTS design allows for flexible sample size, such that sites can be added to or excluded from the sampling plan without compromising the integrity of the overall design; and 3) the GRTS method is a probabilistic sampling design, whereby sampling points are randomly chosen from among those in a systematic grid, eliminating site selection bias, and allowing inference to the entire sampling frame (Stevens and Olsen 2004).

Plots are sampled on a four-year panel design in which one panel containing one-fourth of a park's total plots is sampled each year. On the fifth year, the first panel is re-sampled. Sampling began in ALPO and JOFL in 2007. Over the past three summers, a total of 15 plots have been sampled in ALPO (Figure 1) and seven plots have been sampled in JOFL (Figure 2). Sampling took place in May and September in 2007 and in July in 2008 and 2009.

Field Methods

At each plot, the ERMN monitors a suite of vegetation and soil variables. The plot design includes several embedded sampling units (Figure 3). Tree, stand, and site measurements are collected within fixed-area, circular plots, 15 m in radius. Tree regeneration and shrub measurements are collected on four 2-m radius circular microplots embedded within each plot. Data on coarse woody debris are collected using line intersect sampling (Van Wagner 1964) along six 15-m transects. Data on understory plant composition and the diversity of understory species are monitored using twelve 1-m^2 quadrats set along the six transects. A photograph of the plot is taken from the plot's southern edge to document change in vegetation structure through time. Three soil samples are collected from sampling frames located adjacent to the plot's northern edge.

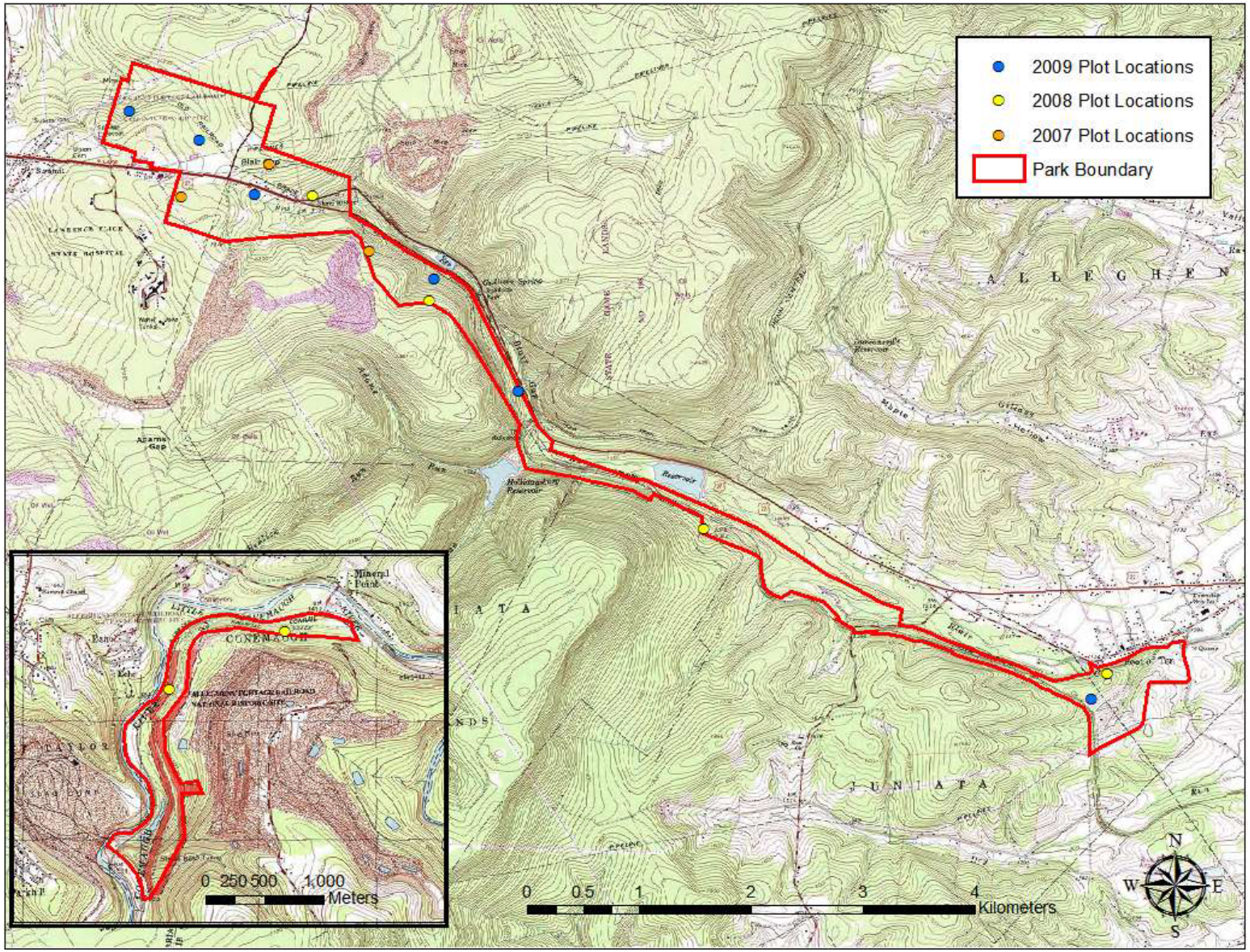

Figure 1. Location of vegetation and soil monitoring plots (2007–2009) in Allegheny Portage Railroad National Historic Site.

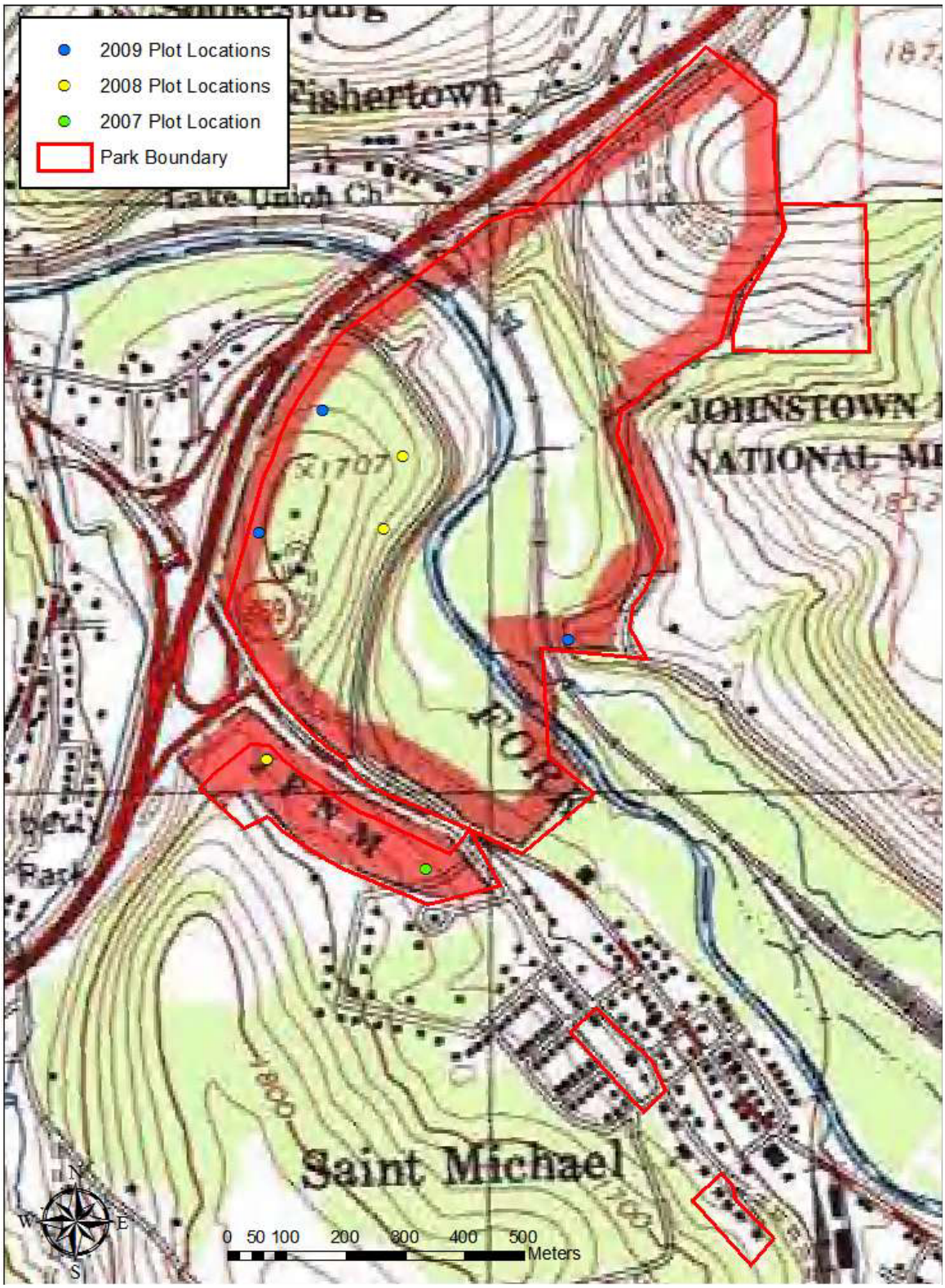

Figure 2. Location of vegetation and soil monitoring plots (2007–2009) in Johnstown Flood National Memorial.

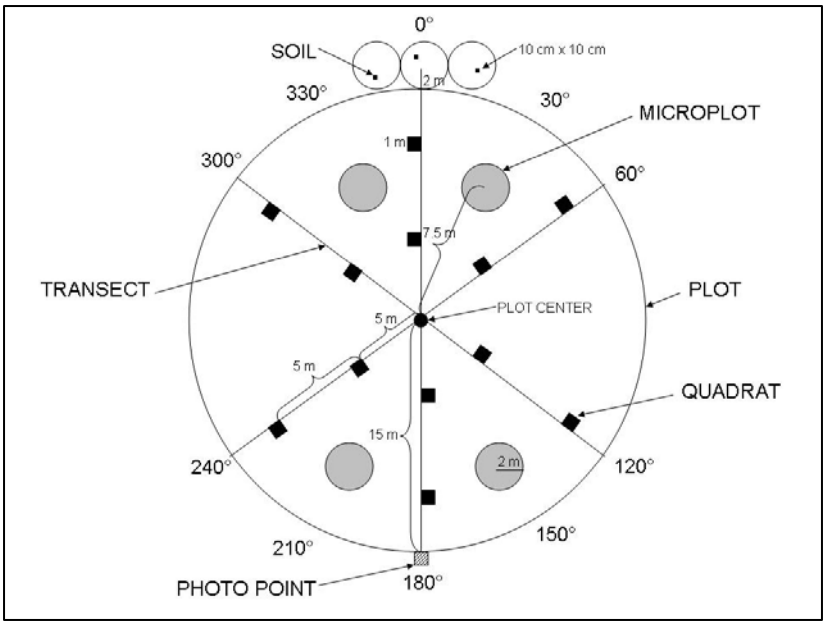

Figure 3. Plot design for Eastern Rivers and Mountains Network Vegetation Monitoring protocol. Tree, stand, and site measurements are collected within the plot. Tree regeneration and shrub measurements are collected in the microplots. Data on coarse woody debris are collected along the transects. Data on understory plant composition and the diversity of understory species are collected in the quadrats. A photograph of the plot is taken from the plot's southern edge. Three soil samples are collected from sampling frames located adjacent to the plot's northern edge.

Data Analysis

This report summarizes the vegetation monitoring data collected between 2007 and 2009 in ALPO and JOFL and presents the condition of the parks' vegetation based on those data. These data provide a snap-shot of the status of the vegetation communities and are compared to expected ranges of variability for eastern forests.

The results reported here are highlights of the available data, but additional measures are being investigated and may be reported in the future. Furthermore, as plots are revisited through time and additional data are collected, we will report how the conditions discussed below are changing through time.

Results

Stand Structure and Succession

The parks' vegetation monitored by this project is primarily forest, though the forest stands vary greatly in age and land use history. A wide variety of non-forested vegetation types also exist in the parks. Monitoring the successional stage of the vegetation plots provides a picture of the shifting mosaic of stand structures within the parks. Based on the monitoring plot data, forest stands within the parks are predominantly young or middle-aged (Table 1). Forests in ALPO tend to be older, while stands in JOFL tend to be younger.

For each plot, the quadratic mean diameter (QMD) of the plot was calculated. The quadratic mean diameter is the "average" diameter for the plot; specifically, the diameter of a hypothetical tree with its basal area equal to the plot's average basal area of live trees (Curtis and Marshall 2000). The plots are then classified into non-forested, pole, mature, and late-successional categories based on the following classification (adapted from Frelich and Lorimer 1991): non-forested = no trees in the plot; pole = 10 cm≤QMD>26 cm; mature = 26 cm≤QMD>46 cm; late-successional = QMD≥46 cm dbh. Table 1 shows the percentage of plots that fall into these categories.

Table 1. Distribution of plots in stand structural classes from monitoring plots visited between 2007 and 2009 in Alletheny Portage Railroad National Historic Site (ALPO) and Johnstown Flood National Memorial (JOFL).

	ALPO (n=15)		JOFL (n=7)	
Stand structural class	**Number of plots**	**Percent of total plots**	**Number of plots**	**Percent of total plots**
Non-forested	0	0%	0	0%
Pole	5	33%	4	57%
Mature	10	67%	3	42%
Late-successional	0	0%	0	0%

Forest Composition and Structure

The relative proportion of species among different strata of a forest stand provides information on the current and future composition of the forest. For this analysis, the relative density by species for trees, saplings, and seedlings were calculated for each park. These data provide an illustration of how the species composition shifts among the canopy, sapling, and seedling layers of the forest (Figures 4 and 5).

In ALPO (Figure 4), red maple (*Acer rubrum*) and black cherry (*Prunus serotina*) comprise a large proportion of the relative density in all three forest strata. However, striped maple (*Acer pensylvanicum*) is strongly dominant in the sapling and seedling layers. This abundance of striped maple in the understory contrasts with the somewhat evenly distributed diversity of species in the forest canopy. Other forests in northern Pennsylvania, notably the Allegheny National Forest, have observed similar distributions of striped maple. If left unmanaged, ALPO's forest canopy will likely be strongly dominated by striped maple in the future.

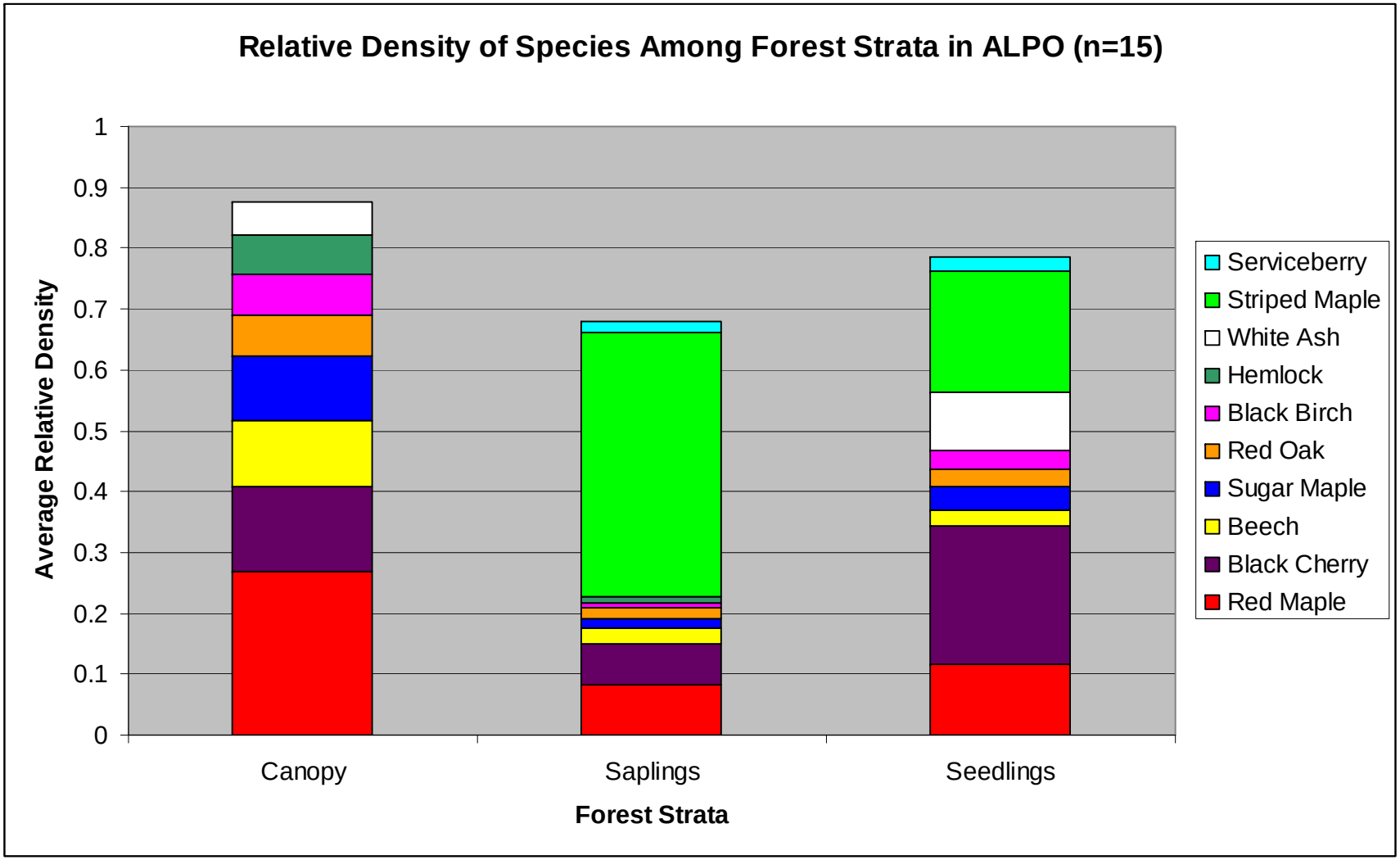

Figure 4. The average relative density of select species for canopy trees, saplings, and seedlings in Allegheny Portage Railroad National Historic Site (ALPO; n=15).

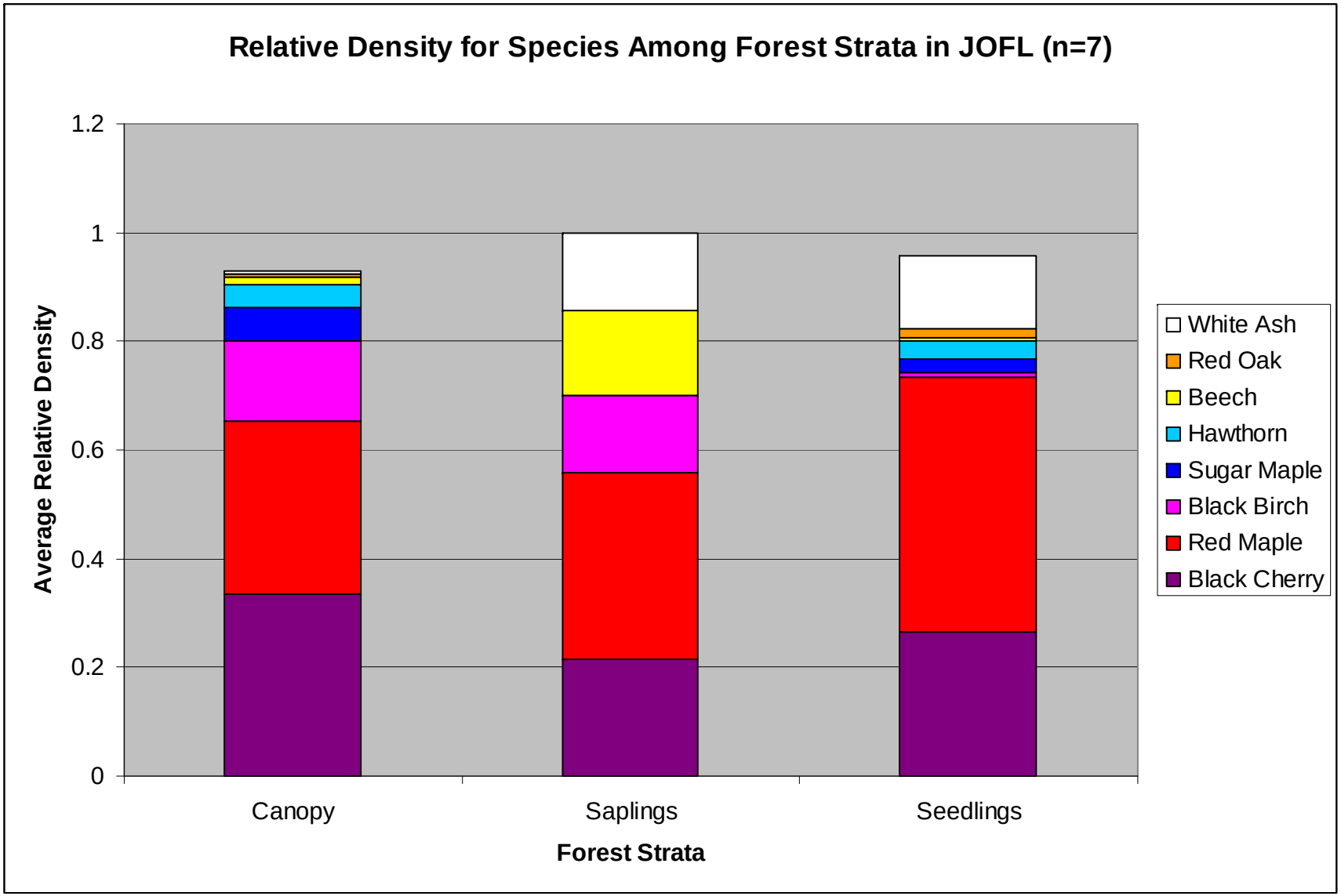

Figure 5. The average relative density of select species for canopy trees, saplings, and seedlings in Johnstown Flood National Memorial (JOFL; n=7).

The distribution of species among forest strata in JOFL (Figure 5) is somewhat uniform. Red maple and black cherry are strongly dominant in all three strata. Black birch (*Betula lenta*), white ash (*Fraxinus americana*), and American beech (*Fagus grandifolia*) exhibit an uneven distribution among the layers; however, future forest composition will likely be similar to current forest composition for the foreseeable future.

Forest Regeneration

One approach to assessing forest regeneration quantifies whether current seedling quantities are sufficient to restock a forest stand's canopy trees. McWilliams et al. (2005) developed an index for hardwood stands in Pennsylvania that assigns point values to seedlings by size class and to saplings observed within the 2-m radius circular microplots. McWilliams et al. (2005) suggested that the standard guideline for acceptable regeneration is an index value of 25 per microplot in areas with low deer densities. In areas where high deer densities are likely to impact tree regeneration, an acceptable index value is 100. A forest plot is considered adequately regenerated if at least 70% of the microplots (three out of four microplots) exceed the stocking index (McWilliams et al. 2001).

Based on the results presented in Table 2, if browse pressure is low, most stands in ALPO and JOFL contain sufficient seedlings and saplings to regenerate the canopy; however, under high browse intensity, only approximately 40% of stands in the two parks contain sufficient tree regeneration. Compared to other ERMN parks, ALPO contains among the highest proportion of plots with sufficient regeneration, while percentage of stocked plots is about average in JOFL. However, much of the regeneration at ALPO is striped maple. When all striped maple seedlings and saplings are removed from this analysis, only 13% of plots are adequately stocked at high browse intensity and 67% of plots are stocked at low browse intensity.

Table 2. Percentage of plots with adequate tree regeneration in Allegheny Portage Railroad National Historic Site (ALPO) and Johnstown Flood National Memorial (JOFL) at two levels of browse intensity.

Browse intensity	ALPO (n=15)	ALPO w/o striped maple (n=15)	JOFL (n=7)
Low browse intensity (Index > 25)	86.7%	66.7%	71.4%
High browse intensity (Index > 100)	40.0%	13.3%	42.8%

Forest Health

Only one occurrence of forest pests or pathogens was detected in the monitoring plots in ALPO and JOFL. Evidence of gypsy moth (*Lymantria dispar*) was observed on one black cherry tree in one plot in JOFL in 2008. This probably indicates that these pests and pathogens are in low abundance within or absent from the parks. Although hemlock woolly adelgid (*Adelges tsugae*) and elongate hemlock scale (*Fiorinia externa*) are known to exist in ALPO, neither species was detected in the monitoring plots. For a complete list of the forest pest and pathogens targeted by this study, see the ERMN Vegetation and Soil Monitoring Protocol (Perles et al. 2009).

The health of each tree in the monitoring plots is measured using standardized assessments of tree vigor and branch dieback (Perles et al. 2009). These measurements were first collected in 2009. As additional data are collected, we will provide vigor estimates for individual tree species in the parks as well as trends in tree vigor.

Snags

Standing dead trees, or snags, are important structural features in forests and provide habitat for cavity-nesting birds and mammals. The density and size of snags are indicative of habitat availability for those species. Summary data on snags in ALPO and JOFL are presented in Table 3. JOFL contains the highest density of snags of any ERMN park; though, in general, the values reported in Table 3 are typical of second-growth forests that are similar age to those in ALPO and JOFL.

In a hemlock - northern hardwood stand in Pennsylvania, standing snags accounted for 14% of the total basal area (6.7 m^2/ha) and 12% of the total stem density (49 snags/ha; Tritton and Siccama 1990). In mesic oak - hickory stands in Connecticut, snags accounted for 5–15% of the total basal area (1.3–3.4 m^2/ha) and 8–19% of the total stem density (47–109 snags/ha; Tritton and Siccama 1990). In hardwood forests in West Virginia, snag densities ranged from 22.4–55.1/ha (Carey 1983). In chestnut oak and oak - hickory stands in southwestern Virginia, snag densities ranged from 62.2–69.2/ha (Rosenberg et al 1998).

Old-growth forests also exhibit variability in snag densities ranging from 10–20 snags/ha in southern Appalachia (Runkle 1998, 2000), to 43 snags/ha in Kentucky (McComb and Muller 1983), and 39–73 snag/ha in northern Michigan and Wisconsin (Goodburn and Lorimer 1998).

Table 3. Summary data on snags in Allegheny Portage Railroad National Historic Site (ALPO) and Johnstown Flood National Memorial (JOFL).

Snags	ALPO (n=15)	JOFL (n=15)
All snags		
Basal area (m^2/ha)	2.8	2.5
Percent of total tree basal area	8.0%	6.9%
Volume (m^3/ha)	14.6	19.8
Percent of total tree volume	5.0%	4.7%
Density (snags/ha)	68.8	93.0
Percent of total tree density	11.8%	12.6%
Number of live trees / snag	7	7
Large snags (DBH > 30 cm)		
Density (large snags/ha)	8.5	8.1
Percent of total large tree density	5.3%	4.1%
Number of live trees / snag	18	18

Coarse Woody Debris

Fallen logs, or coarse woody debris, provide important habitat for microbes, arthropods, amphibians, reptiles, small mammals, and fungi. Among the plots in ALPO (n=15), the average coarse woody debris volume is 24.5 m^3/ha, which is 8.2% of the standing live tree volume on average. Among JOFL plots (n=7), average coarse woody debris volume is 8.9 m^3/ha, or 1.7% of the standing live tree volume on average. JOFL contains substantially less coarse woody debris than the other ERMN parks, while reported values for ALPO are typical of second-growth forests that are of similar age. The volume of coarse woody debris in JOFL may increase in the future when some of the high density of standing snags fall and become coarse woody debris.

Coarse woody debris volume can range from 25 m^3/ha in even-aged northern hardwood stands to 102 m^3/ha in old-growth northern hardwood forest in northern Michigan and Wisconsin (Goodburn and Lorimer 1998). Other published values include 46–132 m^3/ha for mixed oak forests (Harmon et al 1983) and 48 m^3/ha for old-growth forests in eastern Kentucky (Muller and Liu 1991), though the latter study only measured logs >20 cm in diameter.

Shrubs

The composition of the shrub layer is predominantly native species in ALPO and JOFL (Table 4). Spicebush (*Lindera benzoin*) is the most abundant shrub on average in both parks. Other common native species are dewberries and blackberries (*Rubus* spp.) and American witch hazel (*Hamamelis virginiana*). Microplots in ALPO contain 1.25 shrub species on average, while JOFL microplots contain 1.78 shrub species on average. With the exceptions of Morrow's honeysuckle (*Lonicera morrowii*) which is abundant in JOFL, and privet (*Ligustrum* spp.) which is somewhat common in ALPO, the exotic invasive shrubs that are common in other ERMN parks are relatively uncommon in ALPO and JOFL.

Table 4. Average percent cover and number of stems per microplot for the most abundant shrub species in Allegheny Portage Railroad National Historic Site (ALPO) and Johnstown Flood National Memorial (JOFL).

	ALPO (n=15)		JOFL (n=7)	
Shrub species	**Percent cover**	**Stem count**	**Percent cover**	**Stem count**
Spicebush (*Lindera benzoin*)	3.3%	0.3	7.3%	2.9
Morrow's honeysuckle (*Lonicera morrowii*)			5.8%	0.8
Bristly dewberry (*Rubus hispidus*)	2.2%	6.8		
American witch hazel (*Hamamelis virginiana*)	0.9%	1.2	0.1%	0.1
Blackberry (*Rubus* sp.)	0.8%	0.9	1.1%	2.0
Northern dewberry (*Rubus flagellaris*)	0.7%	1.6		
Privet (*Ligustrum* spp.)	0.4%	0.1		
Allegheny blackberry (*Rubus allegheniensis*)	0.3%	0.2	7.5%	6.7
Black chokeberry (*Photinia melanocarpa*)	0.3%	0.7		
Lowbush blueberry (*Vaccinium angustifolium*)	0.2%	0.9		
Elderberry (*Sambucus* sp.)			0.3%	0.2

Groundstory Diversity and Nativity

The groundstory of most vegetation communities is the most diverse strata; thus, diversity and nativity of this vegetation layer is an important component of the overall health of the vegetation community. Given the relatively small size of the two parks, the abundance of nonnative species is relatively low. Table 5 shows several metrics that will be monitored to determine trends in groundstory vegetation diversity and nativity in ALPO and JOFL. Quadrat richness is calculated by counting the number of species observed in each quadrat and averaging the counts across the 12 quadrats within a plot. Plot richness is calculated by counting the number of unique species found among all twelve quadrats. The values shown in Table 5 are averaged across all plots sampled in the park.

Table 5. Average values for several groundstory diversity measures, calculated from monitoring plot data in Allegheny Portage Railroad National Historic Site (ALPO) and Johnstown Flood National Memorial (JOFL).

Diversity measures	ALPO (n=9)	JOFL (n=4)
Plot richness (from all quadrats within a plot)	20.4	26.0
Quadrat richness	5.8	7.4
Percent of total quadrat cover from nonnative species	5.8%	2.3%
Percent of total quadrat cover from native species	82.3%	88.7%
Percent of quadrat richness from nonnative species	6.1%	3.1%
Percent of quadrat richness from native species	76.6%	84.8%

Deer Browse Indicators

Data on numerous herbaceous plant species that are considered sensitive to deer browse are being collected. Canada mayflower (*Maianthemum canadense*) occurred in one-third of the ALPO plots and 56% of the plots in JOFL. With an average quadrat frequency of 35% in ALPO and 65% in JOFL, this species will likely be sufficiently abundant to serve as an indicator in these parks. Canada mayflower is also being considered as a deer browse indicator species in state forest lands in Pennsylvania (Diefenbach and Fritsky 2007). The number of reproducing, non-reproducing, browsed, and non-browsed plants in each quadrat is collected, along with the height of the three tallest plants in each quadrat. We will be looking for changes in these variables through time to gauge the survival and persistence of these species.

Habitat Diversity

Biotic homogenization is the process by which regional biodiversity declines through time due to the addition of widespread exotic species as well as the loss of native species (Olden & Rooney 2006). Homogenization occurs when the variety of different vegetation types within a park become more similar to each other, shifting from specialized unique vegetation communities towards a more generic homogeneous species composition throughout. Biotic homogenization can be caused by many factors, including land use change, climate change, deer browse, soil fertility, and invasive exotic animal and plant species.

Jaccard's similarity index can be used to evaluate biotic homogenization by comparing the similarity between the species composition of any two plots. The average Jaccard's index for the park includes all possible between-plot comparisons and provides a measure of the diversity of

habitats in the park. The average Jaccard's index for ALPO's monitoring plots is 0.204. Among the monitoring plots in JOFL, the average Jaccard's index is 0.236.

Tracking the change in Jaccard's index through time will provide information on the extent and magnitude of biotic homogenization within the park. Through time, an increase in the average Jaccard's index would indicate that the park's vegetation types are becoming less diverse.

Lists of all of the vascular plant taxa observed in monitoring plots between 2007 and 2009 are provided in Appendix A for ALPO and Appendix B for JOFL.

Invasive Exotic Plant Species

Sixteen invasive exotic plant species were observed in the monitoring plots between 2007 and 2009 (Table 6). In ALPO, 67% of the plots were free of invasive plant species, while only 13% of ALPO's plots contained three or more invasive plant species. In JOFL, 28% of the plots were free of invasive plant species and no plots contained three or more invasive plant species. The most commonly observed invasive exotic plant species were Japanese barberry (*Berberis thunbergii*) in four plots, multiflora rose (*Rosa multiflora*) in four plots, sweet vernalgrass (*Anthoxanthum odoratum*) in three plots, and Morrow's honeysuckle (*Lonicera morrowii*) in three plots.

No species from the early detection terrestrial plant and forest pest/pathogen watch lists were observed in ALPO or JOFL between 2007 and 2009. For the full list of species on these watch lists, see the ERMN Invasive Species Early Detection and Rapid Response protocol (Keefer et al. 2009).

Table 6. Invasive exotic plant species observed in monitoring plots in Allegheny Portage Railroad National Historic Site (ALPO) and Johnstown Flood National Memorial (JOFL) between 2007–2009.

Common name	Scientific name	Number of plots in ALPO (n=9)	Number of plots in JOFL (n=4)
Japanese barberry	*Berberis thunbergii*	3	1
sweet vernalgrass	*Anthoxanthum odoratum*	2	1
multiflora rose	*Rosa multiflora*	2	2
Japanese stiltgrass	*Microstegium vimineum*	2	
garlic mustard	*Alliaria petiolata*	2	
Privet	*Ligustrum* sp.	1	
Oriental ladysthumb	*Polygonum caespitosum*	1	
Oriental bittersweet	*Celastrus orbiculatus*	1	
Morrow's honeysuckle	*Lonicera morrowii*	1	2
Fuller's teasel	*Dipsacus fullonum*	1	
dame's rocket	*Hesperis matronalis*	1	
colt's foot	*Tussilago farfara*	1	
Canada thistle	*Cirsium arvense*	1	
Amur honeysuckle	*Lonicera maackii*	1	
Norway maple	*Acer platanoides*		1
giant knotweed	*Polygonum sachalinense*		1

Discussion

This report summarized the vegetation monitoring data collected between 2007 and 2009 in the ALPO and JOFL and presented the condition of the parks' vegetation, as compared to expected ranges of variability for eastern forest systems. In general, forests in ALPO and JOFL are typical of other second-growth forests in the Appalachian Mountains. Results from the monitoring data underscore two important points for park managers: 1) established and new invasive exotic species are a serious continuing threat to the parks' resources; and 2) striped maple will likely be strongly dominant in the future forest canopy of ALPO; however, any striped maple management should be conducted as a carefully controlled pilot study.

Presently, nonnative plant species are in relatively low abundance and distribution with the forests of ALPO and JOFL, especially considering the small size of the parks. Invasive exotic plant species are relatively uncommon in ALPO and are clumped in a few disturbed areas (e.g. Foot-of-Ten). In addition, many key forest pest and pathogens are absent or in low abundance in the parks. These findings are good news for the condition of the parks' forests and suggest that management goals should be focused on maintaining this good condition. These findings underscore the vital importance of the ongoing projects in ALPO and JOFL directed by park managers, external researchers, and the Exotic Pest Management Teams that are addressing invasive exotic species.

Several recent incidents, including the detection of hemlock wooly adelgid and elongate hemlock scale at ALPO, have highlighted how serious the threat of new invasive species is to the parks. Thus, it is imperative to reduce the threat to park resources from invasive species through the following actions:

1) <u>Keep the majority of the parks invasive-free</u> by eliminating invasive exotic plants from areas of the parks in which invasive species are less abundant and containing the spread of these plants from the disturbed areas where they are abundant.

2) <u>Detect occurrences of new invasive species introduced to the parks</u>. Information of the distribution of these species is critical to making strategic decisions for exotic plant and integrated pest management.

3) <u>Quickly eliminate (when possible) or manage new populations of invasive species</u>. This is the most efficient method for managing these species. If left unmanaged, these species will become larger threats to the parks' resources, requiring more resources to mitigate the damages.

4) <u>Work with partners to encourage research on and experimental treatments</u> of invasive species within the parks, especially those species that are already well established.

In ALPO, striped maple (*Acer pensylvanicum*) is disproportionately dominant in the forest understory when compared with the somewhat evenly distributed diversity of species in the forest canopy. This dominance of striped maple in the sapling and seedling layers is most likely a result of previous repeated partial cuttings of the forests along with the preferential browsing of other tree species seedlings by white-tailed deer (Marquis and Brenneman 1981).

Based on this distribution of species among the forest strata in ALPO, the forest canopy will likely be strongly dominated by striped maple in the future. Since striped maple is well adapted to survive under heavy shade, it will likely persist in the understory until gaps form in the forest canopy. Even then, striped maple has been known to occupy forest openings for more than 100 years (Gabriel and Walters 1990). The abundance of striped maple can interfere with the establishment and growth of other species typical of the Allegheny hardwood forest (Horsley and Bjorkbom 1983).

There have been several U.S. Forest Service research projects that examine the most effective ways to manage striped maple, typically using foliar spray and stem injections of herbicides (Horsley and Bjorkbom 1983, Kochenderfer and Kochendefer 2008). The published literature on striped maple treatment focuses on the most effective method to kill striped maple, with little available information on which tree species regenerated after these treatments, or on the effects of the treatments on non-woody understory plants. Therefore, before beginning a management program for striped maple at ALPO, park resource managers should consider potential impacts of herbicide application on non-target plants, especially non-woody species in the understory, and whether deer exclosure fencing would be required to ensure regeneration of typical Allegheny hardwood species (other than striped maple). An ongoing research project at the Allegheny National Forest is investigating these issues; however, no results are available yet from that study. Until further information on the impacts of herbicides on non-target woody species and on desired tree regeneration are available, any management of striped maple at ALPO should be conducted as a targeted pilot study, from which from more information on these issues can be obtained.

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Appendix A. Plants observed in Allegheny Portage Railroad National Historic Site during vegetation monitoring plot sampling, 2007–2009.

Nomenclature follows the Master Plant List in the Vegetation and Soil Monitoring Database (Perles et al 2009), which is based on the USDA PLANTS Database (USDA, NRCS 2007).

Family	Latin name	Common name	Nativity
Aceraceae	*Acer pensylvanicum*	striped maple	N
	Acer rubrum	red maple	N
	Acer saccharum	sugar maple	N
	Acer sp.	maple	N
Anacardiaceae	*Toxicodendron radicans*	eastern poison ivy	N
Aquifoliaceae	*Ilex montana*	mountain holly	N
Araceae	*Arisaema triphyllum*	Jack in the pulpit	N
Asteraceae	*Ageratina altissima*	white snakeroot	N
	Ambrosia trifida	great ragweed	N
	Aster sp.	aster	u
	Bidens sp.	beggarticks	u
	Cirsium altissimum	tall thistle	N
	Cirsium arvense	Canada thistle	E
	Erechtites hieraciifolia	American burnweed	N
	Eurybia divaricata	white wood aster	N
	Euthamia graminifolia	flat-top goldentop	N
	Leucanthemum vulgare	oxeye daisy	E
	Prenanthes sp.	rattlesnakeroot	u
	Solidago gigantea	giant goldenrod	N
	Solidago rugosa	wrinkleleaf goldenrod	N
	Solidago sp.	goldenrod	u
	Symphyotrichum lateriflorum	calico aster	N
	Symphyotrichum prenanthoides	crookedstem aster	N
	Taraxacum sp.	dandelion	u
	Tussilago farfara	coltsfoot	E
Balsaminaceae	*Impatiens capensis*	jewelweed	N
	Impatiens sp.	touch-me-not	u
Berberidaceae	*Berberis thunbergii*	Japanese barberry	E
	Podophyllum peltatum	mayapple	N
Betulaceae	*Betula alleghaniensis*	yellow birch	N
	Betula lenta	sweet birch	N
	Betula sp.	birch	N
	Carpinus caroliniana	American hornbeam	N
	Ostrya virginiana	hophornbeam	N
Boraginaceae	*Hackelia virginiana*	beggarslice	N
Brassicaceae	*Alliaria petiolata*	garlic mustard	E
	Hesperis matronalis	dames rocket	E
Caprifoliaceae	*Lonicera maackii*	Amur honeysuckle	E
	Lonicera morrowii	Morrow's honeysuckle	E
	Sambucus sp.	elderberry	u
	Viburnum dentatum	southern arrowwood	N
Celastraceae	*Celastrus orbiculatus*	Oriental bittersweet	E
Clusiaceae	*Hypericum punctatum*	spotted St. Johnswort	N
Cornaceae	*Cornus alternifolia*	alternateleaf dogwood	N
	Cornus racemosa	gray dogwood	N
	Nyssa sylvatica	blackgum	N
Cyperaceae	*Carex annectens*	yellowfruit sedge	N
	Carex cephaloidea	thinleaf sedge	N

Family	Latin name	Common name	Nativity
Cyperaceae (cont)	*Carex debilis*	white edge sedge	N
	Carex digitalis	slender woodland sedge	N
	Carex gynandra	nodding sedge	N
	Carex laxiculmis	spreading sedge	N
	Carex normalis	greater straw sedge	N
	Carex projecta	necklace sedge	N
	Carex sp.	sedge	u
	Carex stipata	owlfruit sedge	N
	Carex swanii	Swan's sedge	N
	Carex virescens	ribbed sedge	N
	Carex vulpinoidea	fox sedge	N
	Scirpus sp.	bulrush	u
Dennstaedtiaceae	*Dennstaedtia punctilobula*	eastern hayscented fern	N
	Pteridium aquilinum	western brackenfern	N
Dipsacaceae	*Dipsacus fullonum*	Fuller's teasel	E
Dryopteridaceae	*Athyrium filix-femina*	common ladyfern	N
	Cystopteris sp.	bladderfern	u
	Dryopteris carthusiana	spinulose woodfern	N
	Dryopteris intermedia	intermediate woodfern	N
	Dryopteris marginalis	marginal woodfern	N
	Dryopteris sp.	woodfern	u
	Polystichum acrostichoides	Christmas fern	N
Ericaceae	*Gaylussacia baccata*	black huckleberry	N
	Vaccinium angustifolium	lowbush blueberry	N
	Vaccinium pallidum	Blue Ridge blueberry	N
	Vaccinium stamineum	deerberry	N
Euphorbiaceae	*Acalypha rhomboidea*	common threeseed mercury	N
Fabaceae	*Melilotus* sp.	sweetclover	u
	Robinia pseudoacacia	black locust	N
	Trifolium repens	white clover	E
Fagaceae	*Fagus grandifolia*	American beech	N
	Quercus alba	white oak	N
	Quercus prinus	chestnut oak	N
	Quercus rubra	northern red oak	N
	Quercus velutina	black oak	N
Hamamelidaceae	*Hamamelis virginiana*	American witchhazel	N
Juglandaceae	*Carya cordiformis*	bitternut hickory	N
	Carya glabra	pignut hickory	N
	Carya sp.	hickory	N
	Juglans nigra	black walnut	N
Juncaceae	*Juncus effusus*	common rush	N
	Juncus tenuis	poverty rush	N
Lamiaceae	*Clinopodium vulgare*	wild basil	E
	Lamiaceae	mint	u
	Lycopus sp.	waterhorehound	u
	Prunella vulgaris	common selfheal	E
Lauraceae	*Lindera benzoin*	northern spicebush	N
	Sassafras albidum	sassafras	N
Liliaceae	*Erythronium americanum*	dogtooth violet	N
	Lilium sp.	lily	u
	Maianthemum canadense	Canada mayflower	N
	Maianthemum racemosum	feathery false lily of the valley	N
	Medeola virginiana	Indian cucumber	N
	Polygonatum pubescens	hairy Solomon's seal	N
	Prosartes lanuginosa	yellow fairybells	N

Family	Latin name	Common name	Nativity
Liliaceae (cont)	*Trillium* sp.	trillium	u
	Uvularia sessilifolia	sessileleaf bellwort	N
Magnoliaceae	*Liriodendron tulipifera*	tuliptree	N
	Magnolia acuminata	cucumber-tree	N
Oleaceae	*Fraxinus americana*	white ash	N
	Fraxinus sp.	ash	N
	Ligustrum sp.	privet	E
Onagraceae	*Circaea lutetiana*	broadleaf enchanter's nightshade	N
Ophioglossaceae	*Ophioglossum* sp.	adderstongue	u
Osmundaceae	*Osmunda cinnamomea*	cinnamon fern	N
Oxalidaceae	*Oxalis montana*	mountain woodsorrel	N
	Oxalis sp.	woodsorrel	u
	Oxalis stricta	common yellow oxalis	N
Pinaceae	*Picea* sp.	spruce	u
	Tsuga canadensis	eastern hemlock	N
Poaceae	*Agrostis gigantea*	redtop	E
	Agrostis perennans	upland bentgrass	N
	Agrostis sp.	bentgrass	u
	Anthoxanthum odoratum	sweet vernalgrass	E
	Brachyelytrum erectum	bearded shorthusk	N
	Dactylis glomerata	orchardgrass	E
	Danthonia compressa	flattened oatgrass	N
	Danthonia sp.	oatgrass	u
	Danthonia spicata	poverty oatgrass	N
	Dichanthelium clandestinum	deertongue	N
	Elymus repens	quackgrass	E
	Elymus sp.	wildrye	u
	Festuca subverticillata	nodding fescue	N
	Glyceria striata	fowl mannagrass	N
	Leersia oryzoides	rice cutgrass	N
	Leersia virginica	whitegrass	N
	Microstegium vimineum	Japanese stiltgrass	E
	Phalaris arundinacea	reed canarygrass	N
	Poa compressa	Canada bluegrass	E
	Poa nemoralis	wood bluegrass	E
	Poa sp.	bluegrass	u
	Schedonorus pratensis	meadow fescue	E
Polygalaceae	*Polygala paucifolia*	gaywings	N
Polygonaceae	*Polygonum caespitosum*	Oriental ladysthumb	E
	Polygonum hydropiper	marshpepper knotweed	E
	Polygonum sagittatum	arrowleaf tearthumb	N
	Polygonum virginianum	jumpseed	N
	Rumex obtusifolius	bitter dock	E
	Rumex sp.	dock	u
Polypodiaceae	*Polypodium virginianum*	rock polypody	N
Primulaceae	*Trientalis borealis*	starflower	N
Ranunculaceae	*Ranunculus acris*	tall buttercup	E
	Ranunculus recurvatus	blisterwort	N
Rosaceae	*Amelanchier arborea*	common serviceberry	N
	Crataegus sp.	hawthorn	u
	Geum canadense	white avens	N
	Malus coronaria	sweet crabapple	N
	Malus sp.	apple	u
	Photinia melanocarpa	black chokeberry	N
	Potentilla simplex	common cinquefoil	N

Family	Latin name	Common name	Nativity
Rosaceae (cont)	*Prunus serotina*	black cherry	N
	Prunus sp.	plum	u
	Pyrus sp.	pear	E
	Rosa multiflora	multiflora rose	E
	Rubus allegheniensis	Allegheny blackberry	N
	Rubus flagellaris	northern dewberry	N
	Rubus hispidus	bristly dewberry	N
	Rubus idaeus	American red raspberry	N
	Rubus occidentalis	black raspberry	N
	Rubus sp.	blackberry	u
Rubiaceae	*Galium tinctorium*	stiff marsh bedstraw	N
Scrophulariaceae	*Veronica arvensis*	corn speedwell	E
	Veronica officinalis	common gypsyweed	N
Smilacaceae	*Smilax* sp.	greenbrier	u
	Smilax tamnoides	bristly greenbrier	N
Solanaceae	*Solanum dulcamara*	climbing nightshade	E
Thelypteridaceae	*Thelypteris noveboracensis*	New York fern	N
Tiliaceae	*Tilia americana*	American basswood	N
Ulmaceae	*Ulmus* sp.	elm	N
Verbenaceae	*Verbena urticifolia*	white vervain	N
Violaceae	*Viola blanda*	sweet white violet	N
	Viola hastata	halberdleaf yellow violet	N
	Viola rotundifolia	roundleaf yellow violet	N
	Viola sp.	violet	u
Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	N
	Vitis sp.	grape	u

Under the Nativity heading, the codes indicate: N = native to Pennsylvania; E = exotic, not-native to Pennsylvania; and u = unknown, meaning taxa is not specific enough to assign nativity

Appendix B. Plants observed in Johnstown Flood National Memorial during vegetation monitoring plot sampling, 2007–2009.

Nomenclature follows the Master Plant List in the Vegetation and Soil Monitoring Database (Perles et al 2009), which is based on the USDA PLANTS Database (USDA, NRCS 2007).

Family	Latin name	Common name	Nativity
Aceraceae	*Acer pensylvanicum*	striped maple	N
	Acer platanoides	Norway maple	E
	Acer rubrum	red maple	N
	Acer saccharum	sugar maple	N
Aquifoliaceae	*Ilex Montana*	mountain holly	N
Asteraceae	*Achillea millefolium*	common yarrow	E
	Eurybia divaricata	white wood aster	N
	Oclemena acuminata	whorled wood aster	N
	Prenanthes sp.	rattlesnakeroot	u
	Solidago juncea	early goldenrod	N
	Solidago rugosa	wrinkleleaf goldenrod	N
	Solidago sp.	goldenrod	u
	Symphyotrichum lanceolatum	white panicle aster	N
	Taraxacum officinale	common dandelion	E
Balsaminaceae	*Impatiens* sp.	touch-me-not	u
Berberidaceae	*Berberis thunbergii*	Japanese barberry	E
	Podophyllum peltatum	mayapple	N
Betulaceae	*Betula lenta*	sweet birch	N
	Betula sp.	birch	N
Campanulaceae	*Lobelia inflate*	Indian-tobacco	N
Caprifoliaceae	*Diervilla lonicera*	northern bush honeysuckle	N
	Lonicera morrowii	Morrow's honeysuckle	E
	Sambucus sp.	elderberry	u
	Viburnum dentatum	southern arrowwood	N
	Viburnum recognitum	northern arrowwood	N
Clusiaceae	*Hypericum perforatum*	common St. Johnswort	E
Cornaceae	*Cornus alternifolia*	alternateleaf dogwood	N
	Cornus racemosa	gray dogwood	N
Cyperaceae	*Carex blanda*	eastern woodland sedge	N
	Carex debilis	white edge sedge	N
	Carex digitalis	slender woodland sedge	N
	Carex laxiculmis	spreading sedge	N
	Carex projecta	necklace sedge	N
	Carex sp.	sedge	u
	Carex swanii	Swan's sedge	N
Dennstaedtiaceae	*Dennstaedtia punctilobula*	eastern hayscented fern	N
Dryopteridaceae	*Dryopteris intermedia*	intermediate woodfern	N
	Dryopteris marginalis	marginal woodfern	N
Ericaceae	*Gaylussacia baccata*	black huckleberry	N
	Vaccinium myrtilloides	velvetleaf huckleberry	N
Fabaceae	*Robinia pseudoacacia*	black locust	N
Fagaceae	*Fagus grandifolia*	American beech	N
	Quercus alba	white oak	N
	Quercus rubra	northern red oak	N
	Quercus velutina	black oak	N
Hamamelidaceae	*Hamamelis virginiana*	American witchhazel	N
Juglandaceae	*Carya alba*	mockernut hickory	N
	Carya cordiformis	bitternut hickory	N

Family	Latin name	Common name	Nativity
Juglandaceae (cont)	*Carya* sp.	hickory	N
Juncaceae	*Juncus tenuis*	poverty rush	N
	Luzula multiflora	common woodrush	N
Lauraceae	*Lindera benzoin*	northern spicebush	N
	Sassafras albidum	sassafras	N
Liliaceae	*Allium vineale*	wild garlic	E
	Maianthemum canadense	Canada mayflower	N
	Polygonatum biflorum	smooth Solomon's seal	N
	Polygonatum pubescens	hairy Solomon's seal	N
	Prosartes lanuginosa	yellow fairybells	N
	Trillium sp.	trillium	u
	Uvularia sessilifolia	sessileleaf bellwort	N
Lycopodiaceae	*Lycopodium dendroideum*	tree groundpine	N
Magnoliaceae	*Magnolia acuminata*	cucumber-tree	N
Oleaceae	*Fraxinus americana*	white ash	N
Phytolaccaceae	*Phytolacca americana*	American pokeweed	N
Pinaceae	*Pinus* sp.	pine	u
	Pinus strobes	eastern white pine	N
Poaceae	*Anthoxanthum odoratum*	sweet vernalgrass	E
	Brachyelytrum erectum	bearded shorthusk	N
	Danthonia compressa	flattened oatgrass	N
	Danthonia spicata	poverty oatgrass	N
	Dichanthelium acuminatum	tapered rosette grass	N
	Dichanthelium clandestinum	deertongue	N
	Dichanthelium sp.	rosette grass	u
	Glyceria sp.	mannagrass	u
	Milium effusum	American milletgrass	N
	Poa sp.	bluegrass	u
Polygonaceae	*Polygonum sachalinense*	giant knotweed	E
	Rumex acetosella	common sheep sorrel	E
Rosaceae	*Amelanchier arborea*	common serviceberry	N
	Crataegus sp.	hawthorn	u
	Fragaria virginiana	Virginia strawberry	N
	Geum sp.	avens	u
	Malus sp.	apple	u
	Potentilla simplex	common cinquefoil	N
	Prunus avium	sweet cherry	E
	Prunus serotina	black cherry	N
	Prunus sp.	plum	u
	Pyrus sp.	pear	E
	Rosa multiflora	multiflora rose	E
	Rubus allegheniensis	Allegheny blackberry	N
	Rubus occidentalis	black raspberry	N
	Rubus sp.	blackberry	u
Rubiaceae	*Mitchella repens*	partridgeberry	N
Scrophulariaceae	*Veronica officinalis*	common gypsyweed	N
Smilacaceae	*Smilax* sp.	greenbrier	u
	Smilax tamnoides	bristly greenbrier	N
Thelypteridaceae	*Thelypteris noveboracensis*	New York fern	N
Violaceae	*Viola* sp.	violet	u
Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	N
	Vitis sp.	grape	u

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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.

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