

Forest Health Data Summaries for **Fort Necessity National Battlefield (2007 – 2024)**

Background

Forests are crucial resources in Fort Necessity National Battlefield (FONE), providing an important backdrop for interpreting the opening action of the French and Indian War, recreation opportunities for park visitors, habitat for countless animal and plant species, as well as protecting soil stability and stream health. The following forest health summaries are based on data collected in Eastern Rivers and Mountains Inventory and Monitoring Network (ERMN) long-term forest health monitoring plots between 2007 - 2024. There are 20 ERMN forest health monitoring plots in FONE, with each plot sampled on a 4-year cycle. Most plots were visited four times during this reporting period.

Within each forest plot, tree and stand measurements, including an assessment of deer browse impact, are made within fixed-area, circular plots, 15-m in radius. Tree regeneration data are collected in four 2-m radius circular microplots embedded within each plot. Plots are permanently marked and measured at the same location every cycle. For a more detailed description of our methods, refer to the [ERMN forest monitoring protocol](#).

This document provides data summaries and interpretations of trends in tree regeneration, deer browse impacts, forest structure, tree canopy composition, and invasive plants to help inform National Park Service (NPS) staff of forest health condition and trends.

Tree Regeneration and Deer Impacts

An abundant regeneration layer that is composed of tree seedlings and saplings of varying sizes is an important component of a healthy forest. Regeneration debt occurs when forests lack sufficient regeneration, or the species composition in the regeneration layer does not match the canopy. FONE has a forest regeneration status of Probable Failure, meaning that the park is experiencing regeneration failure due to low numbers of seedlings and a mismatch between the species composition of the canopy trees and the tree regeneration ([Miller et al. 2023](#)).

On average, seedling abundance is stable within FONE (Map 1), as the large number of seedlings in the smallest size class mature into taller height categories (Figure 1, Map 2). This is a positive and healthy trend, however, regeneration is not equally abundant throughout the park (Map 5). The regeneration stocking index, which quantifies whether native seedling and sapling densities are sufficient to restock a forest canopy, shows that forests surrounding the Picnic Loop and in the Braddock's Grave unit have sufficient tree regeneration given moderate deer browse pressure. Forests on the Rush life estate and to the north of the Picnic Loop do not contain enough tree regeneration to replace the forest canopy, given the current levels of invasive shrubs and deer browse pressure. If deer populations are reduced and invasive shrubs are treated, then most plots within the park would be sufficiently stocked to replace the forest canopy.

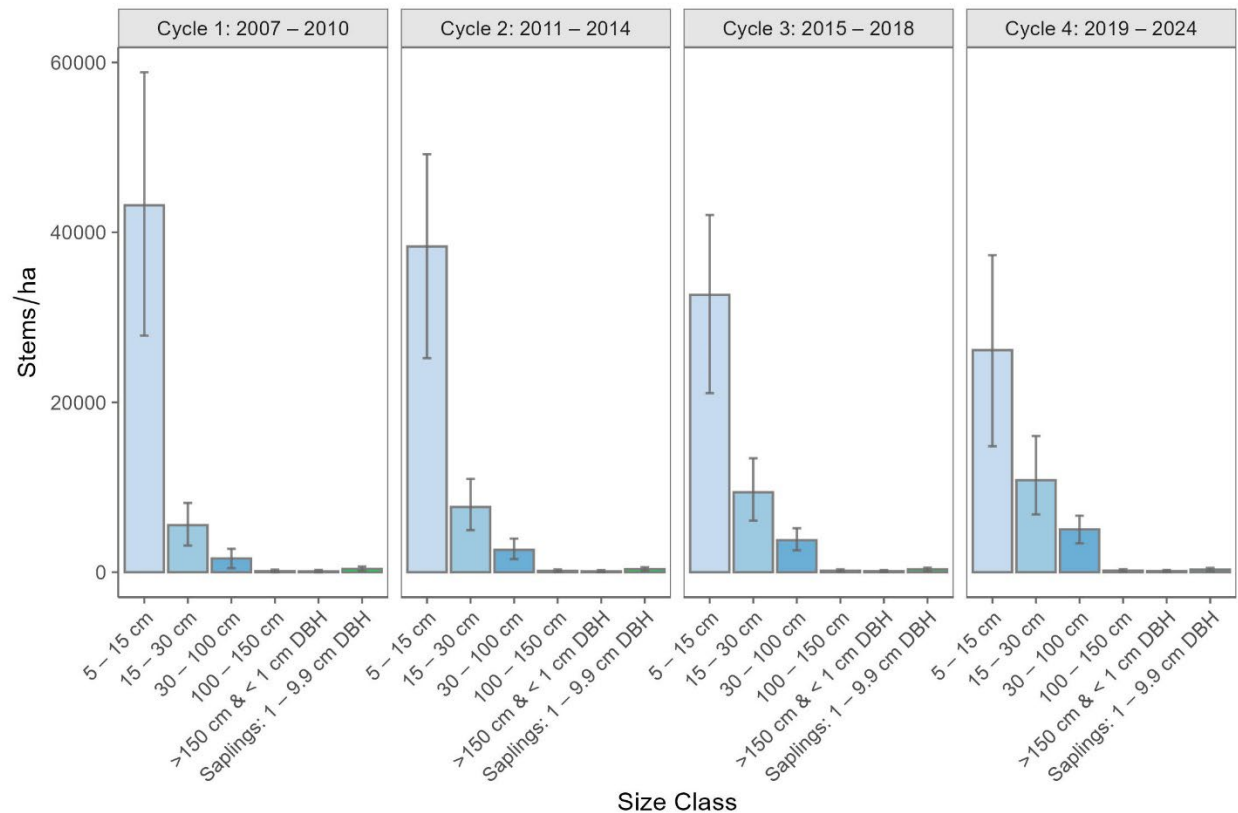


Figure 1. Trends in tree regeneration densities by height class in Fort Necessity National Battlefield, 2007 – 2024. Error bars are 95% bootstrapped confidence intervals to account for non-normal error.

Deer browse impacts are assessed on a scale of 1 – 5, with 1 representing unnaturally low impacts from deer exclusion and 5 representing severe impacts evidenced by a distinct browse line. Impacts of medium (3) or higher typically require management intervention to maintain adequate forest regeneration. In the most recent 4-year survey, deer browse impacts varied across the park (Map 6), with 15% of plots rated as low impacts from deer browse, 35% of plots rated as high deer impacts, and the remaining 50% of plots rated as medium impacts.

The composition of the regeneration layers is also important to long-term forest health. Forests in FONE have a mismatch between the forest canopy and the seedling and sapling layers (compare Maps 3 and 4). Red maple (*Acer rubrum*) is dominant in the regeneration layers, along with hawthorns (*Crataegus* spp.), ash (*Fraxinus* spp.), American beech (*Fagus grandifolia*), black cherry (*Prunus serotina*), and other short-statured native trees that will not reach canopy height, such as serviceberries (*Amelanchier* spp.), musclewood (*Carpinus caroliniana*), and ironwood (*Ostrya virginiana*, Figures 2 and 3). The dominant species in the forest canopy, tuliptree (*Liriodendron tulipifera*) and oaks (*Quercus* spp., Map 4), are uncommon as seedlings and saplings. This mismatch between the canopy and regeneration signals a potential shift in composition in the future forest. Notably, the abundance of ash seedlings peaked during the middle of the monitoring period as ash trees dying from emerald ash borer (*Agrilus planipennis*) infestation produced an abundance of seeds.

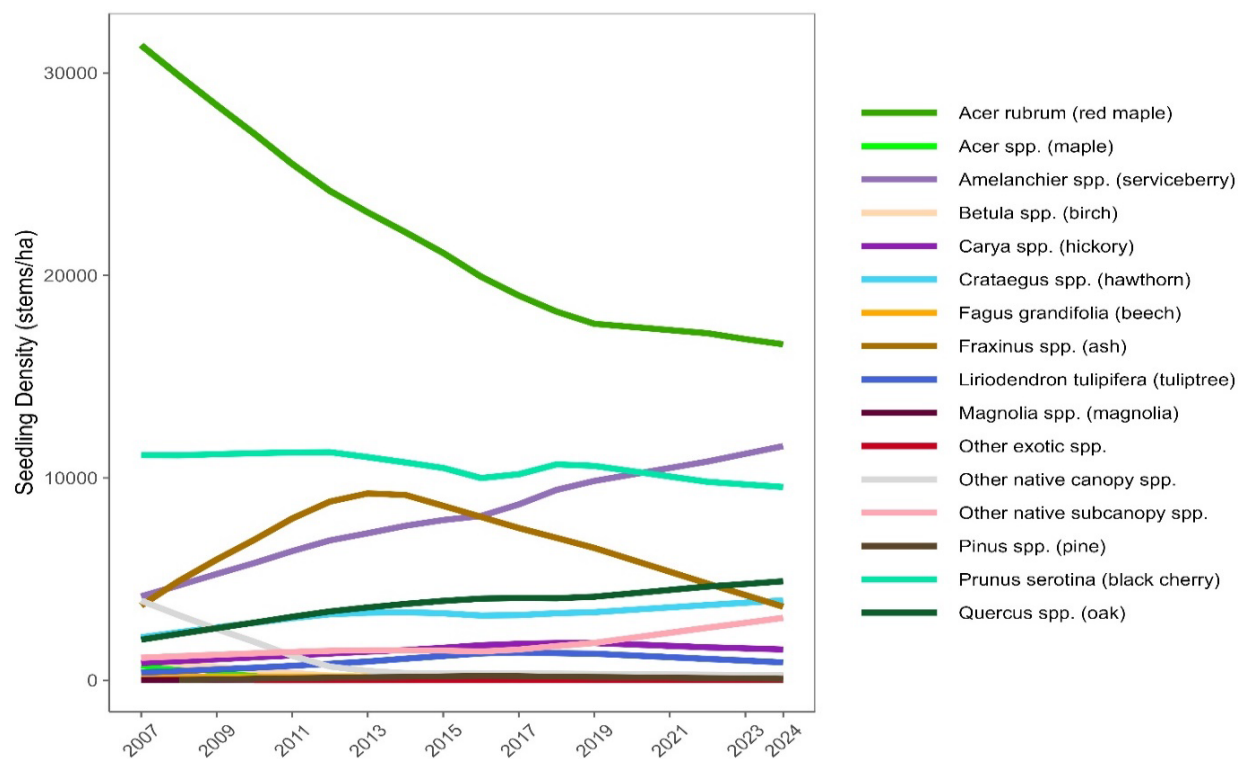


Figure 2. Trends in seedling density by species group and sample year in Fort Necessity National Battlefield. Local regression smoothing approximated a linear trend between consecutive sample events per panel.

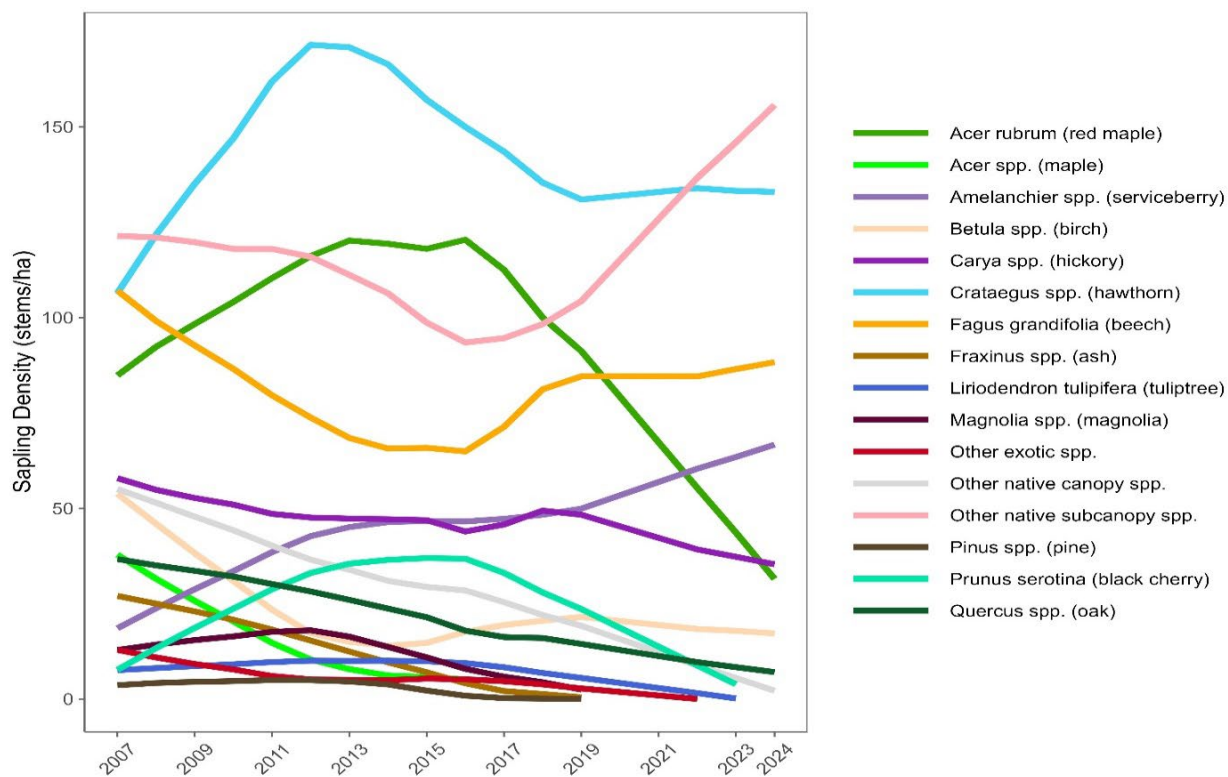


Figure 3. Trends in sapling density by species group and sample year in Fort Necessity National Battlefield. Local regression smoothing approximated a linear trend between consecutive sample events per panel.

Forest Structure and Canopy Composition

Based on tree cores collected near our plots, trees in FONE are primarily 70 to 110 years old, with the oldest cored tree, a white oak (*Quercus alba*), originating nearly 170 years ago. Despite being young to middle-aged, the forests in FONE have more complex older forest structure, such as large live standing trees, than surrounding forests sampled by the US Forest Service ([Miller et al. 2016](#)). Therefore, the protection and management of park forests has importance beyond the boundaries of the park. Canopy cover within monitoring plots is consistently stable in middle-aged forests or increasing in younger forests that have established in abandoned fields (Map 7). The abundance of downed coarse woody debris (Map 10) is another important component of forest structure that provides wildlife habitat and nutrient cycling.

Forest canopies in FONE are dominated by tuliptree, red maple, and oaks, primarily white oak and northern red oak (*Quercus rubra*, Figures 4 and 5, Map 4). Tuliptrees are gaining both in basal area and tree density, while red maples and white oaks show the expected pattern of increasing basal area accompanied by declines in tree density as smaller trees lose out to competition. Notably, mature ash trees (*Fraxinus* spp.) have been nearly eliminated by emerald ash borer during this period. Conifer plantations of native white and red pines (*Pinus strobus* and *P. resinosa*), along with exotic Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), are declining in basal area and tree density as crowded plantations self-thin. Note that the exotic species shown in red on Map 4, as well as Figures 4 and 5, represent Scots pine and Norway spruce, not invasive exotic species. Aside from emerald ash borer's elimination of mature ash trees, no other significant tree pest or pathogen outbreaks were observed in monitoring plots. Spongy moths (*Lymantria dispar*) and hemlock wooly adelgid (*Adelges tsugae*) are known to occur in FONE and may negatively affect the forest in coming years.

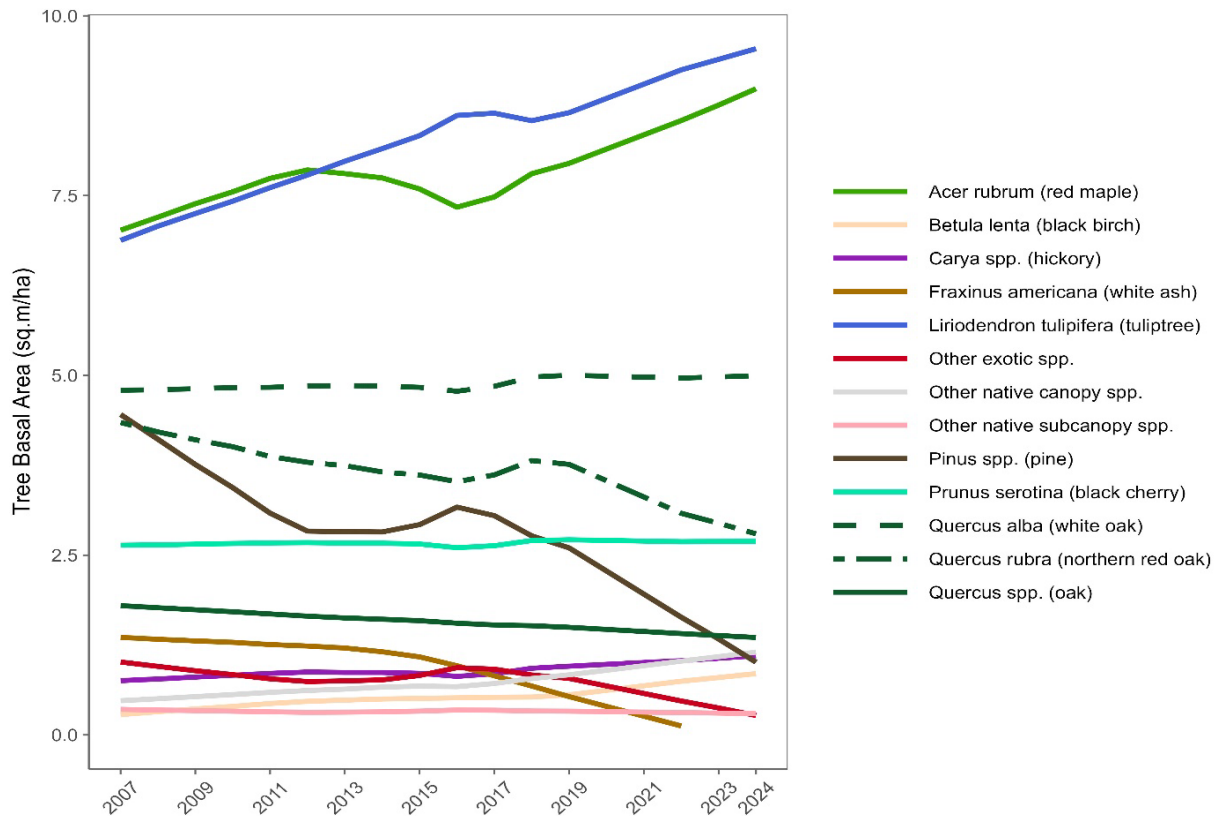


Figure 4. Trends in tree basal area by species group and sample year in Fort Necessity National Battlefield. Local regression smoothing approximated a linear trend between consecutive sample events per panel.

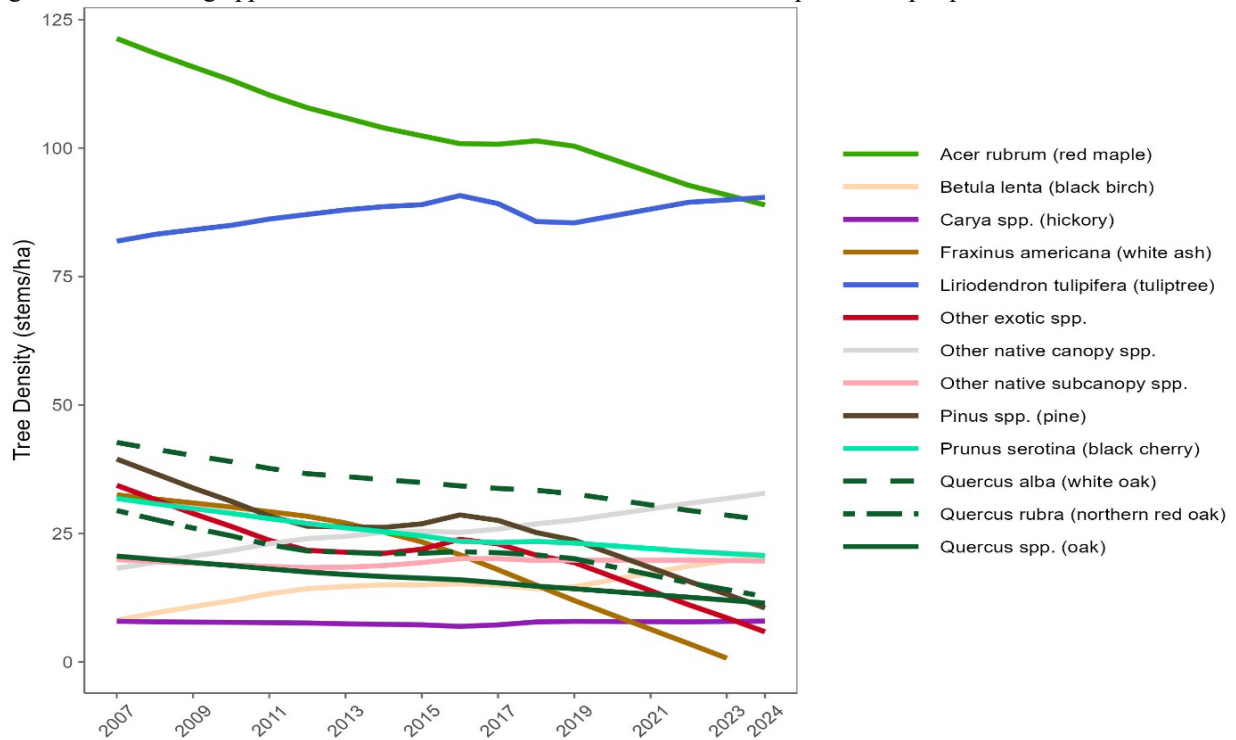


Figure 5. Trends in tree density by species group and sample year in Fort Necessity National Battlefield. Local regression smoothing approximated a linear trend between consecutive sample events per panel.

Invasive Species

Invasive plants can have dramatic impacts on forest health by altering forest structure and diversity, suppressing tree regeneration, altering nutrient cycling and disturbance regimes, and reducing native species diversity. In FONE, invasive plants are not uniform throughout the park (Maps 8 and 9).

Very few to no invasive plants were detected in forest plots in the Picnic Loop area of the Main Unit, as well as the Jumonville Glen and Braddock's Grave units. By contrast, invasive plants are common and increasing in other parts of the Main Unit, especially on the Rush life estate property. Invasive shrubs such as multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), winged burning bush (*Euonymus alatus*), and honeysuckles (*Lonicera* spp.) are the most problematic species, although Japanese stiltgrass (*Microstegium vimineum*) has been spreading in the areas north of the Picnic Loop. The increasing abundance of invasive shrubs in FONE ([Miller et al. 2021](#)) highlights the importance of implementing strategic invasive plant management, especially to protect the high quality forests surrounding the Picnic Loop.

Conclusions

Forests are an important ecological and cultural resource in FONE that provide under-represented and regionally significant forest habitat. However, invasive plants and over abundant deer threaten the ability of park forests to regenerate by suppressing native tree seedlings and sapling necessary to sustain future generations of forest. Managing deer populations to ecologically appropriate levels and continuing strategic investment in invasive plant management will bolster forest resilience and address these forest health concerns.

Author Contributions

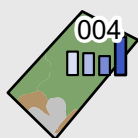
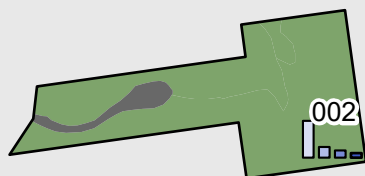
This summary document, completed in December 2025, was written by Stephanie Perles, ERMN Plant Ecologist. Maps and figures were created by Norman Bourg (Regional Biologist), Sara Thiessen (ERMN Forest Crew Member), and Stephanie Perles. This document was adapted from materials developed by staff from the NPS Northeast Temperate and Mid-Atlantic Inventory and Monitoring Networks, including Kate Miller (NETN/MIDN Quantitative Ecologist), Camilla Seirup (former NETN/MIDN Forest Crew Leader), and Jamie Attanasio (NETN/MIDN Forest Crew Member).



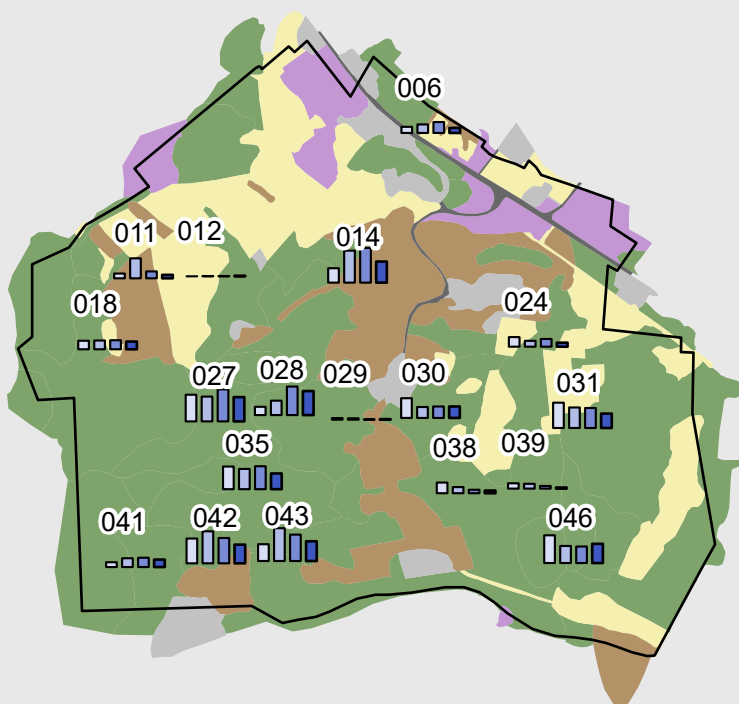
Map 1. Native Canopy-Forming Tree Regeneration by Cycle

Trends in tree regeneration, including seedlings and saplings of native canopy-forming species, observed in forest plots during four monitoring cycles spanning 2007 - 2024. Regeneration stem densities range from 796 to 128,120 per hectare. Reporting Date: 04/16/2025.

Jumonville Glen



Braddock's Grave and
Fort Necessity Battlefield Main Unit



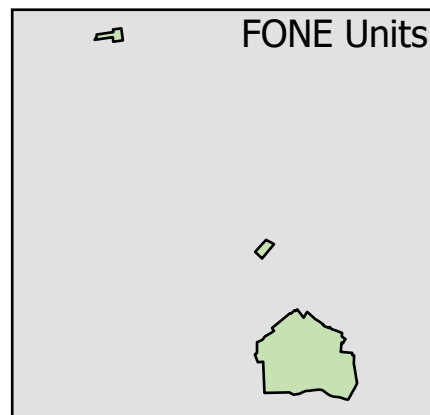
Vegetation types

- Deciduous Forest
- Conifer Plantation
- Open field
- Open wetland
- Developed land
- Transportation corridor
- Park Boundary

Regeneration densities

- Cycle 1: 2007 to 2010
- Cycle 2: 2011 to 2014
- Cycle 3: 2015 to 2018
- Cycle 4: 2019 to 2024

Plot number



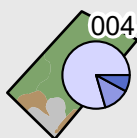
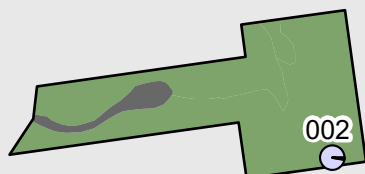
0 500 1,000
Meters



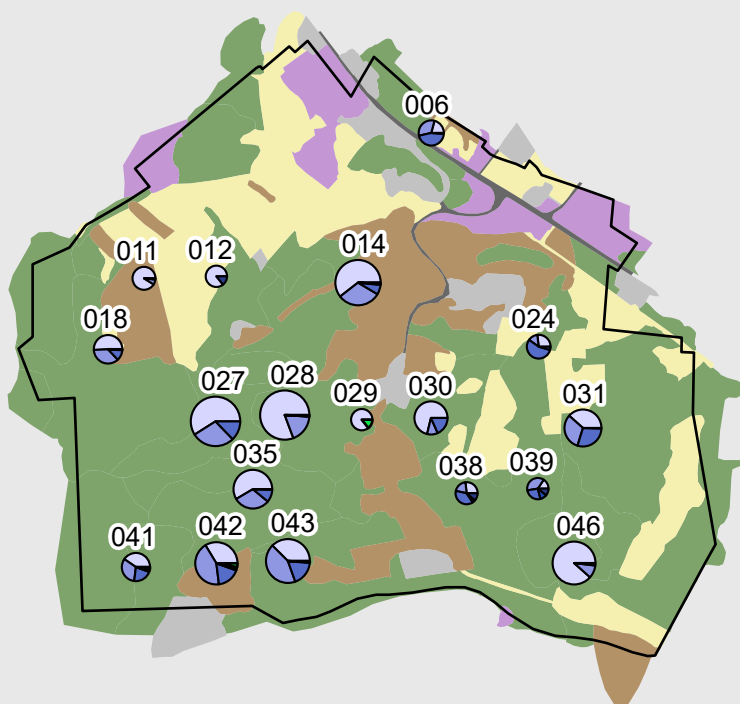
Map 2. Native Canopy-Forming Tree Regeneration by Size Class

Tree regeneration, including seedlings and saplings of native canopy-forming species, by size class observed in forest plots during the last census (2019 - 2024). Pie size is proportional to plot-level regeneration density. Regeneration stem densities range from 1,857 to 128,120 per hectare. Reporting Date: 04/16/2025.

Jumonville Glen



Braddock's Grave and
Fort Necessity Battlefield Main Unit



Vegetation types

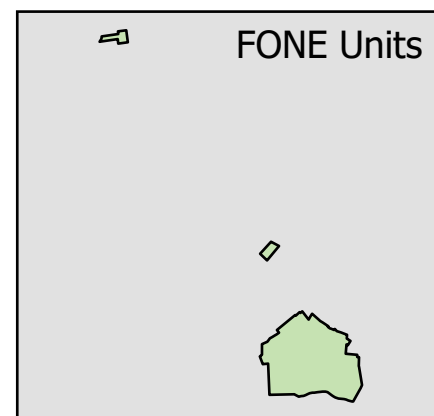
- Deciduous forest
- Open field
- Conifer plantation
- Open wetland
- Developed land
- Transportation corridor

Park boundary

Regeneration densities

- Seedlings 5 to 15 cm
- Seedlings 15 to 30 cm
- Seedlings 30 to 100 cm
- Seedlings 100 to 150 cm
- Seedlings > 150 cm
- Saplings

Plot number



FONE Units



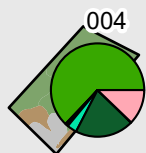
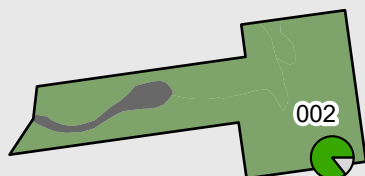
0 500 1,000
Meters



Map 3. Tree Regeneration Composition

Tree regeneration, including seedlings and saplings, by species group observed in forest plots during the last census (2019 - 2024). Pie size is proportional to plot-level regeneration density. Regeneration stem densities range from 1,790 to 141,051 per hectare. Reporting Date: 04/16/2025.

Jumonville Glen



Braddock's Grave and Fort Necessity Battlefield Main Unit

Vegetation types

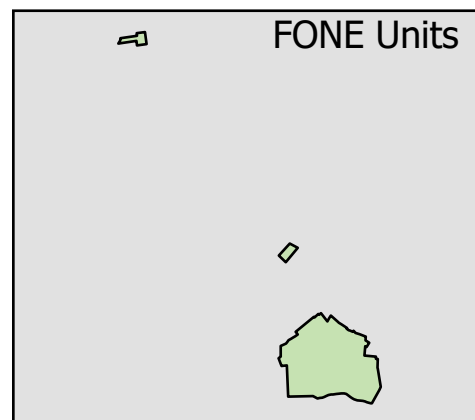
- Deciduous forest
- Open field
- Conifer plantation
- Open wetland
- Developed land
- Transportation corridor

□ Park boundary

Tree Regeneration Composition

- Acer spp. (Maple)
- Betula spp. (Birch)
- Carya spp. (Hickory)
- Fagus grandifolia (Beech)
- Fraxinus spp. (Ash)
- Liriodendron tulipifera (Tulip poplar)
- Magnolia spp. (Magnolia)
- Pinus spp. (Pine)
- Prunus spp. (Cherry)
- Quercus spp. (Oak)
- Ulmus spp. (Elm)
- Other native canopy species
- Other native subcanopy species
- Exotic species

Plot number



N



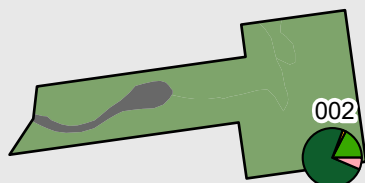
0 500 1,000 Meters



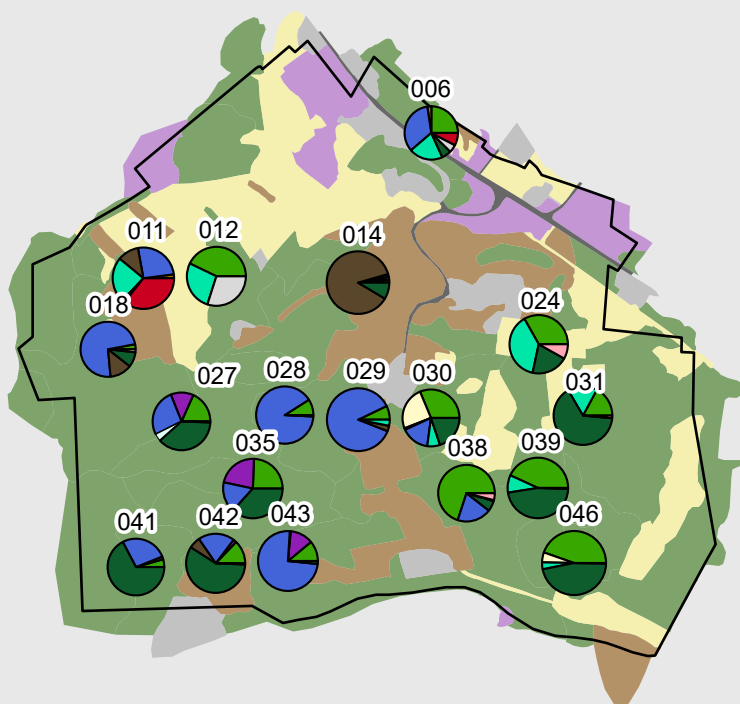
Map 4. Tree Canopy Composition

Tree composition, by species group, observed in forest plots sampled in the most recent census (2019-2024). Pie size is proportional to plot-level tree basal area. Total basal area ranges from 16.8 to 56.3 m²/ha. Reporting Date: 04/16/2025.

Jumonville Glen



Braddock's Grave and Fort Necessity Battlefield Main Unit



Vegetation types

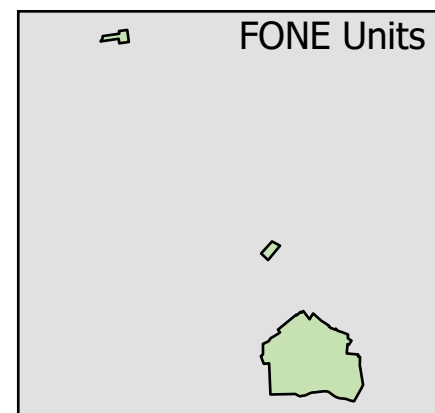
- Deciduous forest
- Open field
- Conifer plantation
- Open wetland
- Developed land
- Transportation corridor

Park boundary

Tree Canopy Composition

- Acer spp. (Maple)
- Betula spp. (Birch)
- Carya spp. (Hickory)
- Fagus grandifolia (Beech)
- Fraxinus spp. (Ash)
- Liriodendron tulipera (Tulip poplar)
- Magnolia spp. (Magnolia)
- Pinus spp. (Pine)
- Prunus spp. (Cherry)
- Quercus spp. (Oak)
- Other native canopy species
- Other native subcanopy species
- Exotic species

Plot number



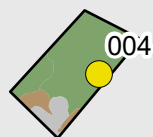
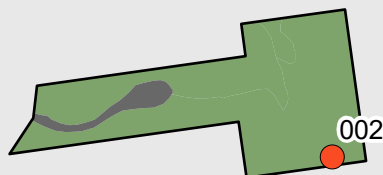
0 500 1,000
Meters



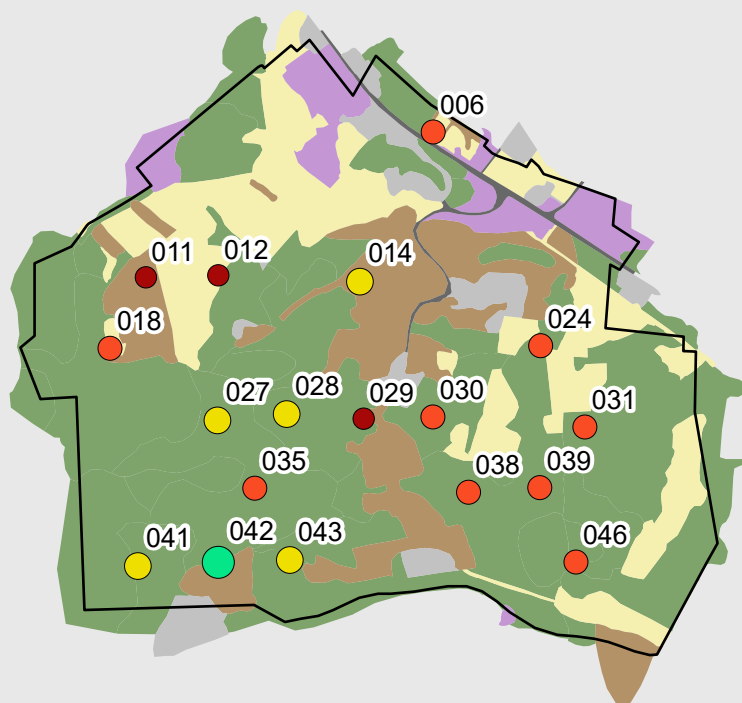
Map 5. Tree Regeneration Stocking Index

Regeneration stocking index for the most recent census (2019-2024) quantifies whether regeneration is sufficient to restock a forest canopy given deer browse impacts. This index is a weighted sum of native canopy-forming tree seedlings and saplings and is reported as a plot-wide average from four microplots. Index values range from 14 to 270. Reporting Date: 04/16/2025

Jumonville Glen



Braddock's Grave and Fort Necessity Battlefield Main Unit



Vegetation types

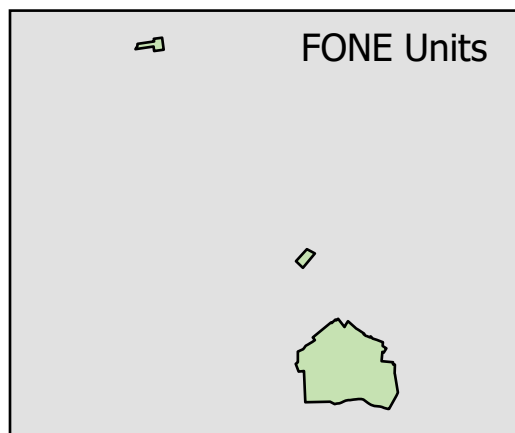
- Deciduous forest
- Open field
- Conifer plantation
- Open wetland
- Developed land
- Transportation corridor

Park boundary

Stocking Index

- < 30: Severely understocked; regeneration is insufficient to replace the forest canopy.
- 30 - 100: Moderately stocked regeneration, sufficient for areas with low deer impacts.
- 100 - 200: Sufficient regeneration to replace forest canopy in areas with moderate (or fewer) deer impacts.
- > 200: Sufficient regeneration to replace forest canopy in areas with high (or fewer) deer impacts.

Plot number



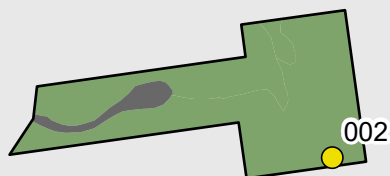
0 500 1,000
Meters



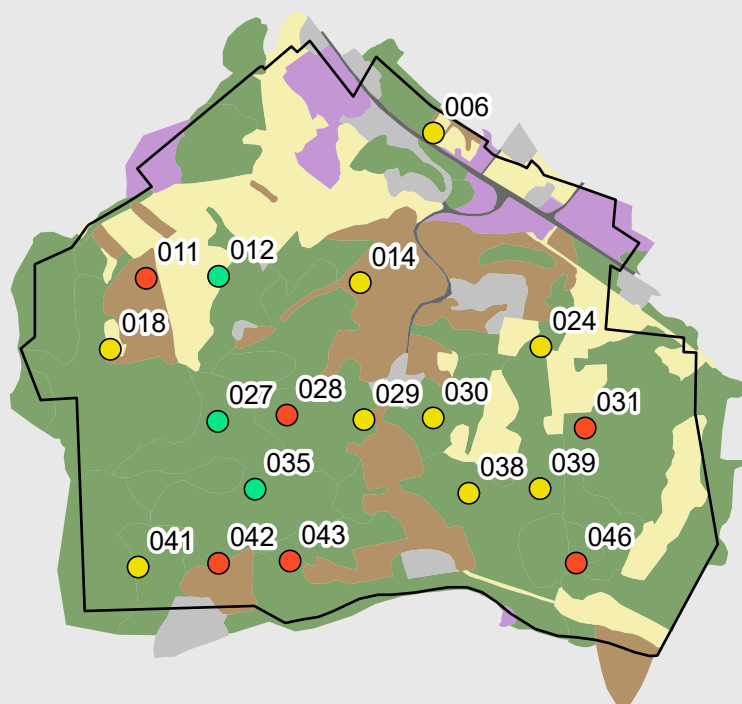
Map 6. Index of Deer Browse Impacts

Index of deer browse impacts observed in forest plots in the most recent census (2019-2024). Deer browse impacts are assessed on a scale of 1-5, with 1 representing no impact and 5 representing severe impacts. Reporting Date: 04/16/2025.

Jumonville Glen



Braddock's Grave and Fort Necessity Battlefield Main Unit



Vegetation types

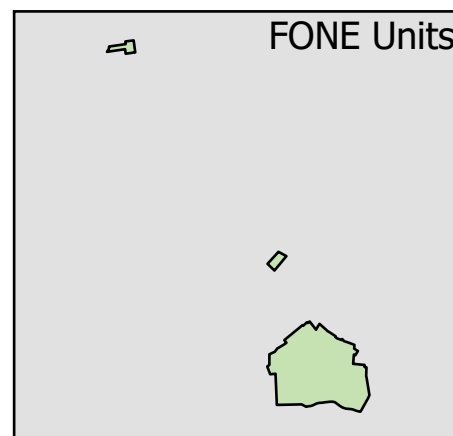
- Deciduous forest
- Open field
- Conifer plantation
- Open wetland
- Developed land
- Transportation corridor

Park boundary

Deer Browse Impact Index

- 2: Low impact: deer-preferred (DP) species abundant and of varying heights.
- 3: Medium impact: DP species present, but mostly under 30 cm tall. DP herbs present but stunted and flowering is uncommon.
- 4: High impact: DP species are rare to absent. Non-preferred and browse-resilient vegetation limited in height by deer browse. DP herbs absent or severely stunted.
- Very low impact and Very high impact not observed

Plot number



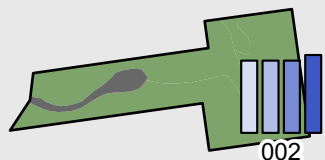
0 500 1,000 Meters



Map 7. % Canopy Cover by Cycle

Trends in tree canopy cover in forest plots from 2007-2024. Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Canopy cover ranges from 37.5% to 96.7%. Reporting Date: 12/15/2025.

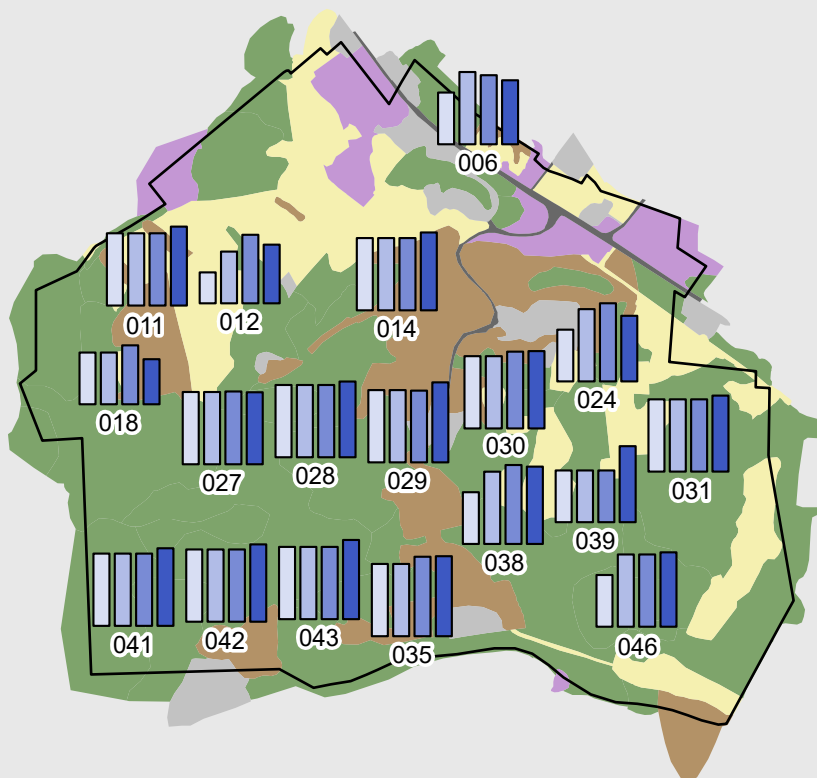
Jumonville Glen



0 225 450
Meters



Braddock's Grave and Fort Necessity Battlefield Main Unit



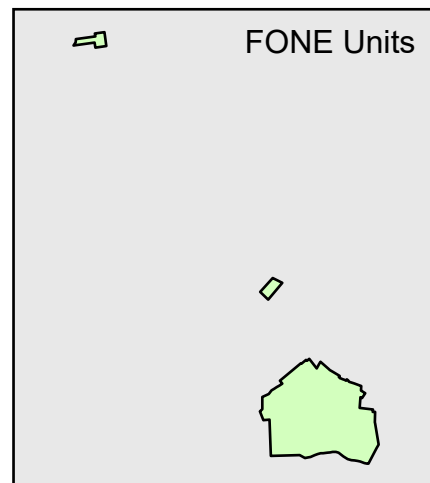
Vegetation types

- Deciduous forest
- Conifer plantation
- Open field
- Open wetland
- Developed land
- Transportation corridor
- Park boundary

Tree canopy cover

- Cycle 1: 2007 to 2010
- Cycle 2: 2011 to 2014
- Cycle 3: 2015 to 2018
- Cycle 4: 2019 to 2024

Plot number



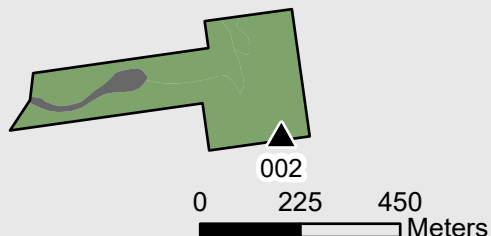
0 500 1,000
Meters



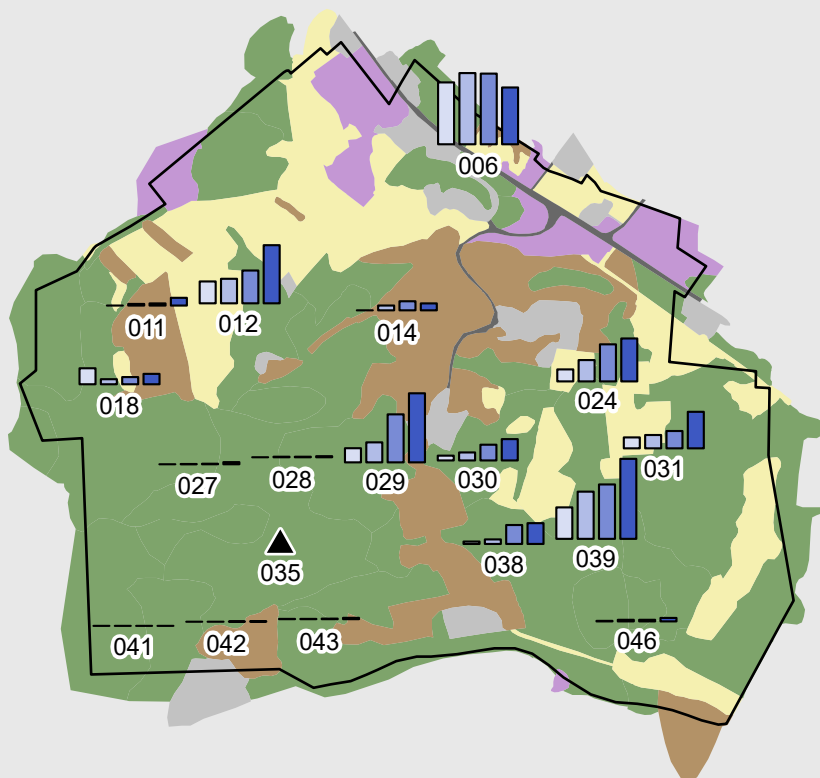
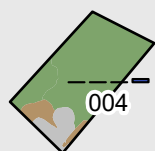
Map 8. Invasive % Cover by Cycle

Trends in percent cover of invasive species observed in quadrats in forest plots sampled from 2007-2024. Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Average invasive cover per plot ranges from 0% to 78.6%. Reporting Date: 12/15/2025.

Jumonville Glen



Braddock's Grave and Fort Necessity Battlefield Main Unit

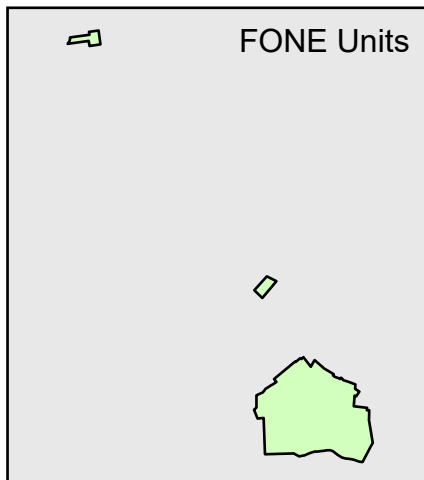


Vegetation types

- Deciduous forest
- Conifer plantation
- Open field
- Open wetland
- Developed land
- Transportation corridor
- Park boundary

Invasive cover

- Cycle 1: 2007 to 2010
- Cycle 2: 2011 to 2014
- Cycle 3: 2015 to 2018
- Cycle 4: 2019 to 2024
- No invasive plants present
- ### Plot number



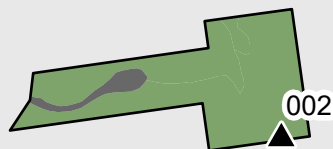
0 500 1,000
Meters



Map 9. Invasive % Cover by Species

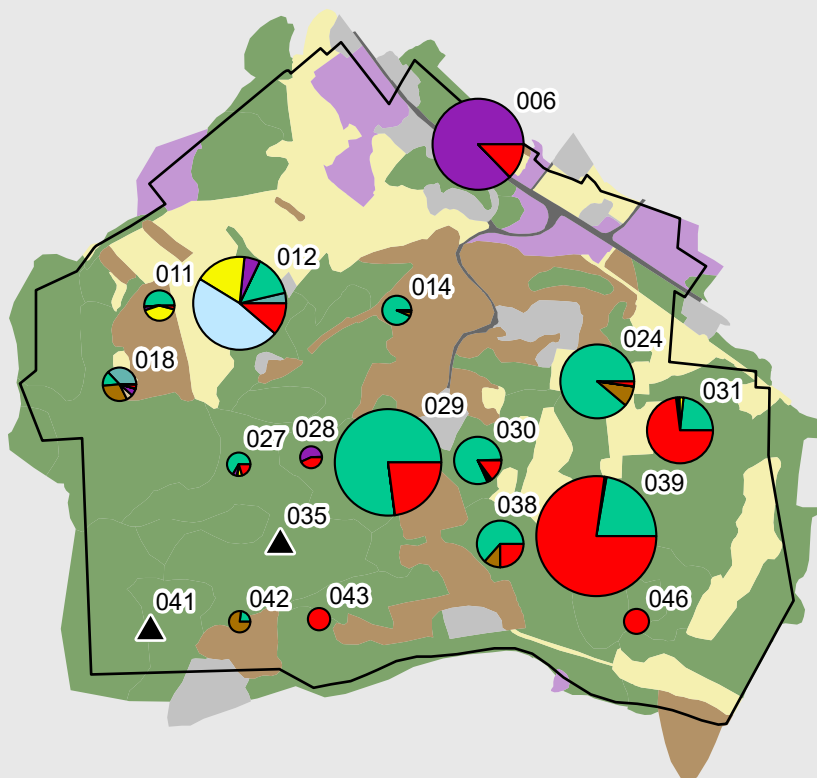
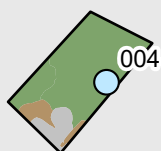
Percent cover of invasive plant species observed in quadrats in forest plots sampled in the most recent census (2019-2024). Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Pie size is proportional to total invasive cover (range: 1% to 157%). Reporting Date: 12/15/2025.

Jumonville Glen



0 225 450
Meters

Braddock's Grave and Fort Necessity Battlefield Main Unit



Vegetation types

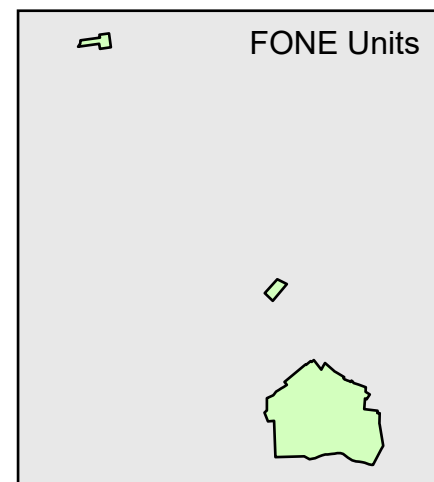
- Deciduous forest
- Conifer plantation
- Open field
- Open wetland
- Developed land
- Transportation corridor
- Park boundary

Invasive species

- Anthoxanthum odoratum (Sweet Vernal Grass)
- Berberis thunbergii (Japanese Barberry)
- Euonymus spp. (Burning-Bush)
- Glechoma hederacea (Creeping Charlie)
- Lonicera exotica (Exotic Honeysuckle)
- Lonicera japonica (Japanese Honeysuckle)
- Microstegium vimineum (Japanese Stiltgrass)
- Persicaria spp. (Smartweeds)
- Prunus avium (Sweet Cherry)
- Rhamnus cathartica (Common Buckthorn)
- Rosa multiflora (Multiflora Rose)
- Securigera varia (Crown Vetch)

▲ No invasive plants present

Plot number



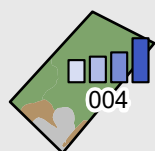
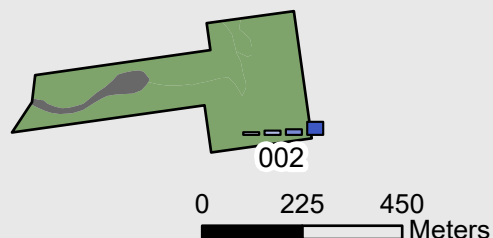
0 500 1,000
Meters



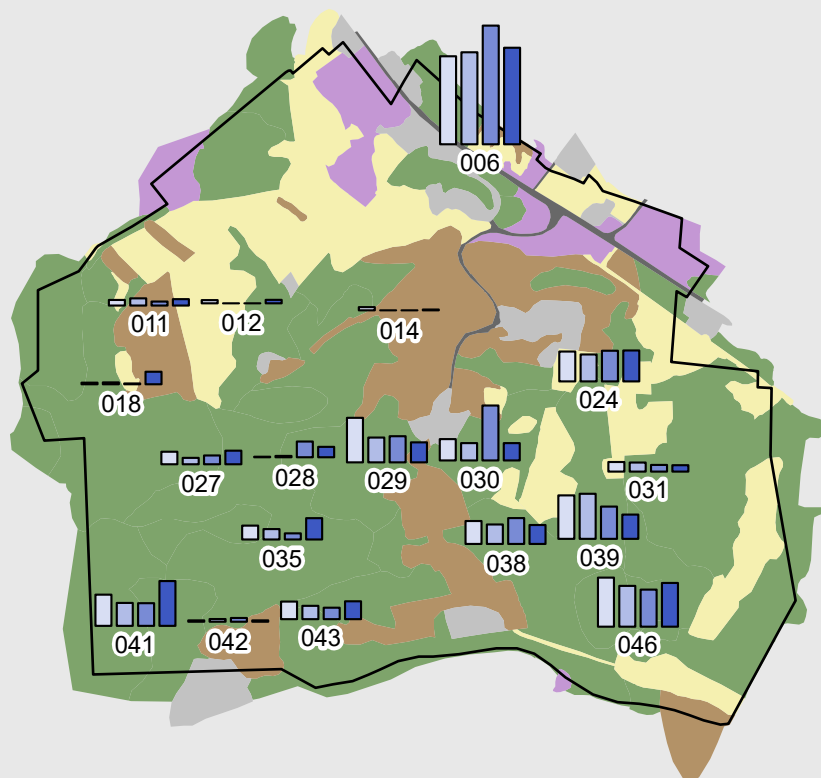
Map 10. Coarse Woody Debris by Cycle

Trends in coarse woody debris (CWD) volume observed in plots sampled from 2007-2024. Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. CWD volume ranges from 0 to 143.6 m³/ha. Reporting Date: 12/15/2025.

Jumonville Glen



Braddock's Grave and Fort Necessity Battlefield Main Unit



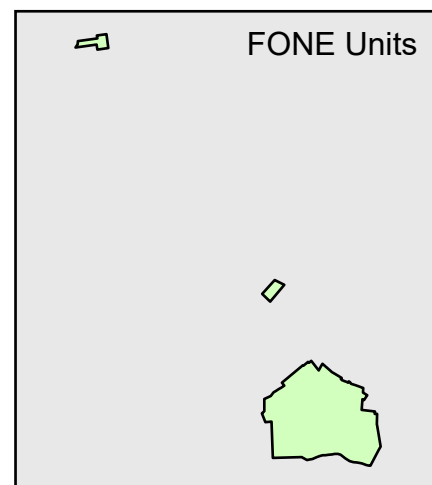
Vegetation types

- Deciduous forest
- Conifer plantation
- Open field
- Open wetland
- Developed land
- Transportation corridor
- Park boundary

Coarse woody debris volume

- Cycle 1: 2007 to 2010
- Cycle 2: 2011 to 2014
- Cycle 3: 2015 to 2018
- Cycle 4: 2019 to 2024

Plot number



0 500 1,000 Meters