

Forest Summaries for Morristown National Historical Park: 2007 – 2024

Background

The following summaries are based on data collected in Northeast Temperate Network (NETN) long-term forest monitoring plots that have been checked for errors, certified, and published at <https://doi.org/10.57830/2306029>. This document summarizes key forest health metrics related to tree regeneration and deer browse impacts, tree composition and condition, and invasive plant abundance and composition to help inform resource management staff of forest issues detected by NETN forest monitoring. For a detailed description of our methods refer to the [NETN forest monitoring protocol](#).

There are 29 NETN forest plots in Morristown National Historical Park (MORR), two of which are located in the large deer enclosure (plots 14 and 25). Note that plot 14 was established to monitor change in the deer enclosure but was not part of the sample design, and therefore not included in park-level summary statistics. Each plot is sampled in an alternating 4-year cycle, with plots 1 – 15 sampled in 2007, 2011, 2015, 2019, and 2024, and plots 16 – 29 sampled in 2009, 2013, 2017 and 2022. Note that the typical 4-year sample design was disrupted in 2020 and 2021 by COVID-19. Therefore, plots 1 – 15 had a 5-year interval between Cycle 4 and Cycle 5, and plots 16 – 29 had a 5-year interval between Cycle 3 and Cycle 4.

Summary of Results

Tree Regeneration and Deer Impacts

An abundant regeneration layer containing tree seedlings and saplings of varying sizes and composed of species found in the canopy is an important component of a healthy forest. When forests lack sufficient regeneration, or the species composition in the regeneration layer does not match the canopy (compositional mismatch), we call this a regeneration debt ([Miller et al. 2023](#)).

Compositional mismatch is problematic when the species in the regeneration layer are invasive, like tree-of-heaven (*Ailanthus altissima*), or suboptimal, like ash (*Fraxinus* spp.) due to its susceptibility to the [emerald ash borer](#) (EAB). Miller et al. (2023) classified regeneration debt status into four categories: Imminent Failure, Probable Failure, Insecure, and Secure. Forests classified as Imminent Failure are experiencing the most severe form of regeneration debt, often a complete lack of regeneration, and are one major disturbance away from forest loss. Forests classified as Probable Failure have insufficient regeneration, both in the seedlings and saplings layers, and what regeneration is present often does not match the canopy composition. Forests classified as Insecure typically have sufficient seedlings but may still lack sufficient sapling density and compositional mismatch is typically present, but less pronounced than Probable Failure. Forests classified as Secure have sufficient seedling and sapling densities and their composition matches the canopy. Only one park's forests in the Northeast Temperate Network were classified as Secure in the most recent census¹.

Forests in MORR are experiencing severe regeneration debt. Based on data from the most recent census (2022 and 2024), the status of regeneration in MORR continues to be rated as Imminent Failure (Figure 1), as reported in Miller et al. (2023). Forest loss has already occurred in areas of the park where Hurricane Sandy caused extensive blowdowns and ash stands have died from EAB. There was no tree regeneration present to replace the forest canopy in these areas, and they have since converted to dense, invasive shrub thickets. Additional forest habitat could be lost after the next major disturbance. While there has been a small increase in seedling density over time averaged

¹ Throughout the report, "most recent census" will be used to describe our most up to date snapshot of the park. This dataset includes the most recent visit to each plot and combines data collected in multiple years. The most recent census may span two 4-year cycles, for instance in 2024, the most recent census includes data from the last year of Cycle 4 (2022) and the first year of Cycle 5 (2024).

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across the park, this has been primarily driven by increases in the plots in and around the large deer enclosure (Map 1; Figure 3A). In the rest of the park, seedling densities are low to absent. Where present, seedlings tend to be restricted in height due to deer browsing and they fail to grow into saplings and subsequently into trees (Map 2; Figure 3). In the most recent census, only 10 out of 29 plots met the target of 0.25 seedlings/m² (~1,000 stems/acre), and only the two plots in the deer enclosure met the target of 0.14 saplings/m² (550 saplings/acre; Table 1). Note that these targets were established as part of a regional regeneration study (Miller et al. 2023) and roughly match the [MORR Vegetation and White-tailed Deer Management Plan](#) targets for seedlings and saplings. The regeneration stocking index², which quantifies whether current seedling and sapling densities are sufficient to restock a forest canopy, remains critically low in MORR, with only one plot outside of the deer enclosure being sufficiently stocked (Map 5; Table 1). High deer impacts³ also continue to be observed throughout MORR, with all but two plots outside the deer enclosure rated high or very high for deer browse impacts in the most recent census (2022 and 2024; Map 6). Browse rates at this level will continue to prevent browse-preferred seedlings from establishing and growing into larger size classes. Interestingly, the number of plots rated Very High for deer browse impacts has declined over time (Figure 2). However, this should not be taken as evidence of a reduction in overall deer browse pressure in the park as the increase in invasive shrub density (Figure 6) may also be influencing patterns of deer movement; some plots are now virtually impenetrable to deer due to the high density of invasive shrubs.

The composition of the regeneration layer in MORR is equally concerning and contributing to the regeneration debt. Beech is the dominant native canopy-forming species regenerating in MORR (Map 3) but is now threatened by the recent introduction of [beech leaf disease](#) (BLD), first detected by MORR park staff in 2019. BLD causes high mortality for seedling and sapling-sized beech and will likely result in declines in beech regeneration over time. As of 2024, beech regeneration is still increasing in the park (Figure 4), but individuals were highly symptomatic and in poor health. Subcanopy species are the next most abundant species regenerating in MORR. Subcanopy species are short-stature trees, such as flowering dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), blackhaw (*Viburnum prunifolium*), and now white ash (*Fraxinus americana*) because of emerald ash borer (EAB), that rarely reach beyond the subcanopy layer of a forest. In contrast, species currently dominant in the canopy, including tulip poplar (*Liriodendron tulipifera*), oak (*Quercus* spp.), and birch (*Betula* spp.), are rare in the regeneration layer (Map 4; Figure 5).

Forest Structure and Composition

MORR forests have considerably more complex older forest structure, such as more large trees and snags and more coarse woody debris, than surrounding unprotected forests ([Miller et al. 2016](#)). Coarse woody debris rates are still fairly low, with only 9 out of 29 plots meeting the target 20-50 m³/ha (285.8-714.6 ft³/acre) threshold (Maps 11 & 12; [Müller and Bütler 2010](#)). Tree cores collected near NETN forest plots in MORR indicate that several stands are quite old, with plots 9, 10, 12, 14, 25, and 26 having trees originating between 1801 and 1867. The canopy layer in MORR is also fairly diverse, with a mix of tulip poplar (*Liriodendron tulipifera*), oak (*Quercus* spp.), beech (*Fagus grandifolia*), black birch (*Betula lenta*), hickory species (*Carya* spp.), maple species (*Acer* spp.), and

²The regeneration stocking index is reported at a 2-m radius scale to maintain consistency with other regional publications. Forests with high deer impacts are considered sufficiently stocked if the stocking index is >100, while forests with medium deer impacts require a stocking index of >50. Stocking index values reported in previous NETN forest summaries included ash species and saplings >2.5 cm DBH, which are no longer included in the stocking index calculation.

³Deer browse impacts (DBI) are assessed on a scale of 1 – 5, with 1 (No Impact) representing unnaturally low impacts from deer exclusion and 5 (Very High) representing severe impacts evidenced by a distinct browse line. Impacts of 3 (Medium) or higher typically require management intervention to maintain adequate forest regeneration. See the Map 6 legend for full description.

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others (Map 4). A diverse canopy promotes high resilience to stressors, pests and diseases, and climate change. Taken together, the long history of protection in MORR has resulted in remarkably old and diverse forests that are otherwise rare in the region, and their continued protection and management is important beyond the boundaries of the park. If the patterns of tree mortality and recruitment we have documented continue, canopy diversity and structure will decline over time and with it a reduction in the value of these forests to park visitors, wildlife, and water quality. Ash (*Fraxinus* spp.) in particular has experienced severe mortality in the most recent census due largely to EAB (Figure 5; Map 13). Many of the most abundant species in the canopy have also experienced elevated mortality since monitoring began in 2007, and mortality rates heavily outweigh recruitment rates. In fact, beech is the only tree species in MORR that has increased in density over time, whereas all other tree species were either stable or declined in density (Figure 5A). Now that BLD is present throughout MORR (Map 8), declines in beech are expected. While overall basal area has continued to increase in MORR over time, gains are almost entirely through incremental stem growth of already established individuals, as there has been very little recruitment of new trees. Tulip poplar, oak, and beech have seen the largest gains in basal area (Figure 5B).

When regeneration failure persists for decades, as has occurred in MORR, declines in the density of small diameter trees are often a signal of impending forest loss. This signal is apparent in MORR, where the density of small trees (i.e., trees < 20 cm diameter at breast height) has declined over time and the shape of the diameter distribution of all species is linear rather than the expected log-linear or exponential curve (Figure 3B; Miller et al. 2023). In fact, forest loss is already underway. When monitoring began in 2007, two plots already had less than 50% canopy cover (Map 7). In the years following, several severe winter storms and Hurricane Sandy have caused extensive canopy openings throughout the Jockey Hollow unit, which have since expanded as ash mortality from EAB began in 2019. As of 2024, almost all the ash found in our plots has died. Now, the number of plots with less than 50% canopy cover has increased to four. These plots (2, 17, 19, and 20) are unlikely to increase their canopy cover without management action as they had little to no observed regeneration in the most recent census and high invasive species cover (Map 9 & 10; Table 2). Ash mortality due to EAB will have the highest impacts in areas with a high density of ash, such as forested wetlands. These areas are sensitive habitat, in particular the montane basic seepage swamp north of the deer enclosure and the riparian areas near Primrose Brook and the Passaic River, and should be a priority for management.

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. Invasive cover continues to be high in MORR, with average cover of invasive species (39%) more than double native species (15%) in the most recent census. Additionally, 90% of plots (26 out of 29) had four or more invasive species in the most recent census (Table 2). The most abundant invasive species in MORR were shrubs, particularly Japanese barberry (*Berberis thunbergii*), multiflora rose (*Rosa multiflora*), and wine raspberry (*Rubus phoenicolasius*; Map 10; Table 3). While invasive shrub cover was already abundant in MORR when monitoring began, invasive shrubs have continued to increase significantly in cover overtime (Figure 6; [Miller et al. 2021](#)). Additionally, Japanese barberry, the most abundant invasive species in MORR (found in 90% of plots), has increased significantly in cover by 3% per cycle (every 4 years) since monitoring began (Miller et al. 2021). Plots with the greatest invasive shrub cover also tend to have low canopy cover and little to no tree regeneration (e.g., 5, 17, 19, and 20), indicating that these invasive shrubs are suppressing regeneration.

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Along with increases in invasive shrub cover, a number of less common invasive woody species increased in plot frequency over time (Table 3), including Asiatic bittersweet (*Celastrus orbiculatus*), burning-bush (*Euonymus alatus*), Christmas berry (*Photinia villosa*), privet (*Ligustrum* spp.), and Siebold's arrowwood (*Viburnum sieboldii*). While these species are all concerning given their demonstrated invasion across eastern forests, the three most abundant shrubs, namely Japanese barberry, multiflora rose, and wine raspberry, pose the greatest threats to forest regeneration and understory diversity in MORR.

In addition to invasive plants, we monitor invasive earthworms in our plots. Impacts from earthworms include reduced leaf-litter and altered soil nutrient cycling, which can negatively impact regeneration and understory herbs and can facilitate invasive species. European nightcrawlers (family: Lumbricidae) have been detected in every plot in MORR. More recently, earthworms from East Asia in the family Megascolecidae have started invading eastern forests. Known as [crazy snake worms](#) (*Amyntas* spp.), these worms can occupy much higher densities and cycle nutrients faster than the European worms, and thus can cause more severe impacts to the understory. We have definitively detected snake worms in three plots (2, 4, and 14), but it is possible that they are present in more plots, as distinguishing between snake worms and European nightcrawlers is easier later in the summer.

Conclusions

The long history of forest protection in MORR has resulted in remarkably old and diverse forests that are otherwise rare in the region but their health and resilience to future disturbance is severely threatened by a combination of stressors. After decades of regeneration failure, much of the forest in MORR is in a state of collapse, with invasive shrub thickets increasingly replacing areas that were once closed canopy forest. Despite small increases in seedling density observed since monitoring began in 2007, most of the gains have been restricted to the area in and around the deer enclosure, the species regenerating are primarily beech (*Fagus grandifolia*), ash (*Fraxinus* spp.), and subcanopy species, and recruitment from saplings to trees is nearly non-existent. The presence of beech leaf disease (BLD) and absence of an effective BLD treatment threatens the long-term persistence of beech, one of the few canopy species regenerating in MORR, and its ability to recruit into the canopy. Regeneration of native, canopy species not devastated by forest pests (e.g. maples, oaks, tulip poplar, etc.) is essential to ensure MORR maintains forest habitat in the future.

We recommend major and sustained management to reduce the deer population and prevent additional invasive shrub thickets from forming in the park. This will encourage a more diverse under- and midstory layer of native trees. In particular, we recommend invasive management efforts focus on stands with a moderate to large component of ash and beech in the canopy. Reducing invasive shrubs to 10-20% cover and maintaining this lower cover for 5-10 years in these areas will hopefully give tree seedlings the time needed to regenerate before invasive shrubs can expand and choke out regeneration. Fencing and/or deer management is also necessary to allow regeneration time to recruit into larger size classes. We strongly encourage park managers and NPS staff to seek ways to reverse the trajectory that MORR's forests are currently on before more forest cover and species are lost.

Resilient Forests Initiative

National parks in the eastern U.S. need active management approaches to restore and sustain their forests over the long term. Parks are faced with sustaining resilient forests amid a changing climate, overabundant deer, novel pests and pathogens, invasive plants, and altered disturbance regimes. The I&M networks of the northeast have launched the [Resilient Forests Initiative](#) to raise awareness of

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threats to forest health and foster collaboration across the region. This initiative promotes and supports management actions in eastern national parks that foster resilient forest ecosystems by:

- Training park staff on tools to address the most pressing threats to their park forests.
- Connecting park managers with resources (funding, agencies, knowledgeable NPS staff) that will enable them to implement resilient forest management.
- Build regional collaboration to gain efficiencies and synergies in addressing threats to forests.

Learn more about the challenges and opportunities facing eastern forests by exploring the [Managing Resilient Forests article series](#).

Author Contributions

This report was produced by Camilla Seirup, NETN Biologist, with code and analyses written and designed by Kate Miller, NETN Quantitative Ecologist.

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