



# Terrestrial Vegetation Monitoring at Kennesaw Mountain National Battlefield Park

## *2021 Data Summary*

Natural Resource Data Series NPS/SECN/NRDS—2023/1388





#### ON THIS PAGE

One of 14 vegetation monitoring plots established on Kennesaw Mountain National Battlefield Park during the summer of 2021 by the Southeast Coast Network (SECN) vegetation field crew. Plots were located across a range of ecological gradients and forest types, including dry to mesic oak- and hickory-dominated forests (pictured above), xeric to subxeric ridge forests dominated by chestnut oak (*Quercus montana*), and granitic flatrock woodlands.

NPS photo / M. Forbes Boyle (SECN Botanist).

#### ON THE COVER

From left, flowers of tall anemone (*Anemone virginiana* var. *virginiana*) and smooth spiderwort (*Tradescantia ohiensis*), two vascular plants common throughout flatrock woodlands of Kennesaw Mountain National Battlefield Park.

NPS photos / M. Forbes Boyle.

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## *2021 Data Summary*

Natural Resource Data Series NPS/SECN/NRDS—2023/1388

M. Forbes Boyle

Southeast Coast Inventory and Monitoring Network  
National Park Service  
Cumberland Island National Seashore  
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Saint Marys, Georgia 31558

October 2023  
U.S. Department of the Interior  
National Park Service  
Natural Resource Stewardship and Science  
Fort Collins, Colorado

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The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible and technically accurate.

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Please cite this publication as:

Boyle, M. F. 2023. Terrestrial vegetation monitoring at Kennesaw Mountain National Battlefield Park: 2021 data summary. Natural Resource Data Series NPS/SECN/NRDS—2023/1388. National Park Service, Fort Collins, Colorado. <https://doi.org/10.36967/2301001>

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## Acknowledgments

The park staff at Kennesaw Mountain National Battlefield Park (KEMO) provided valuable logistical support throughout this monitoring effort. Anthony Winegar (Chief Ranger) was extremely helpful by offering his insight on site access and sampling efficiencies. This project was aided by the many individuals who assisted with fieldwork. Field crew members included Elizabeth Rico (former Southeast Coast Network

[SECN] Biological Technician), Julieanne Montaquila (former SECN SIP Intern), Claire Schmidt (former SECN Coastal Technician), Matt Wood (Appalachian-Piedmont-Coastal Fire Management Zone Fire Ecologist), and Tom Govus (private contractor). Finally, thanks to Mallorie Davis (SECN Biological Technician) for helping create tabular summaries and maps for this report.



Former SECN staff members from left, Claire Schmidt and Julieanne Montaquila at Kennesaw Mountain National Battlefield Park in 2021. NPS photo / M. Forbes Boyle.

# Executive Summary

The Southeast Coast Network (SECN) conducts long-term terrestrial vegetation monitoring as part of the NPS Inventory and Monitoring Program. The vegetation community vital sign is one of the primary-tier resources identified by SECN park managers, and monitoring is conducted at 15 network parks (DeVivo et al. 2008). Monitoring plants and their associated communities over time allows for targeted understanding of ecosystems within the SECN geography, which provides managers information about the degree of change within their parks' natural vegetation.

2021 was the first year of conducting monitoring at Kennesaw Mountain National Battlefield Park (KEMO). Fourteen vegetation plots were established throughout the park from July through August. Data collected in each plot included species richness across multiple spatial scales, species-specific cover and constancy, species-specific woody stem seedling/sapling counts and adult trees (greater than 10 centimeters [3.9 inches {in}]) diameter at breast height (DBH), overall tree health, landform, soil, observed disturbance, and woody biomass (i.e., fuel load) estimates.

This report summarizes the baseline (year 1) terrestrial vegetation data collected at Kennesaw Mountain National Battlefield Park in 2021. Data were stratified across two dominant broadly defined habitats within the park, Piedmont Upland Forests and Shrublands; and Piedmont Open Uplands and Woodlands. Noteworthy findings include:

- 184 vascular plant taxa (species or lower) were observed across 14 vegetation plots, including 27 species not previously documented within the park.
- The most frequently encountered species in each broadly defined habitat included:
  - Piedmont Open Uplands and Woodlands: wafer-ash (*Ptelea trifoliata* var. *mollis*), white fringe-tree (*Chionanthus virginicus*), winged elm (*Ulmus alata*), hog plum (*Prunus umbellata*), Virginia creeper (*Parthenocissus quinquefolia*), and blackseed speargrass (*Piptochaetium avenaceum*).
  - Piedmont Upland Forests and Shrublands: loblolly pine (*Pinus taeda*), tuliptree (*Liriodendron tulipifera* var. *tulipifera*), black cherry (*Prunus serotina* var. *serotina*), muscadine (*Muscadinia rotundifolia* var. *rotundifolia*), Virginia creeper, and cat greenbrier (*Smilax glauca*).
- Fourteen non-native species categorized as invasive by the Georgia Exotic Pest Plant Council (GA-EPPC 2023) were encountered within the park during monitoring. Chinese privet (*Ligustrum sinense*) was the most frequently encountered and abundant invasive plant within the park.
- Two species of special concern listed for Georgia (GADNR 2023) were observed during monitoring and included green, or Missouri, rock cress (*Boechera missouriensis*) and Stone Mountain mint (*Pycnanthemum curvipes*).
- Northern red oak (*Quercus rubra*), winged elm, and eastern redcedar (*Juniperus virginiana*) were the most dominant species within the tree stratum of Piedmont Open Uplands and Woodlands of Kennesaw Mountain National Battlefield Park; loblolly pine, sweetgum (*Liquidambar styraciflua*) and tuliptree were the most dominant species of Piedmont Upland Forests and Shrublands.
- Chinese privet was the most abundant species within the seedling stratum of Piedmont Open Upland and Woodland sites.
- Heavy browsing impacts by white-tailed deer (*Odocoileus virginianus*) were observed within the upland forests of Kennesaw Mountain National Battlefield Park. Long-term monitoring of vegetation structure and composition within the park can be used to determine forest regeneration patterns as they relate to changes in browsing pressure.
- Other threats to native vegetation within the park are (1) the high prevalence of non-native, invasive plant species, and (2) fire suppression within oak-hickory and pine-oak xeric and intermediate forests. Long-term monitoring data will aid in understanding how these threats over time impact the park's forest communities.
- All plots monitored during this sampling are scheduled to be resampled in 2025.

# List of Terms

**Aspect:** The compass direction that a slope faces.

**Basal Area (BA):** The cross-sectional area of woody stems at DBH; used to describe the amount of area occupied by a single or group of stems. BA is expressed in this report as m<sup>2</sup>/ha (square meters per hectare).

**Coarse Woody Debris (CWD):** Downed woody stems on the ground that are either lying prone on the ground, or at least one end of the broken bole of a dead tree is touching the ground at an angle of greater than 45° from vertical. Coarse woody debris includes pieces of wood greater than 8 centimeters (3.1 inch [in]) in diameter (approximately 1,000-hour fuel class).

**Constancy:** The percentage of plots in a given dataset in which a species occurs.

**Cover:** The vertical projection of vegetation from the ground as viewed from above, and in this protocol is estimated as a percentage of area that covers the ground above the ground surface (areal cover).

**Density:** The number of individual woody stems in a given area.

**DBH:** Diameter at breast height of an individual woody stem, or 1.37 meters (4.5 feet [ft]) above the ground surface.

**Duff:** An organic fuel layer that lies below the litter layer and above mineral soil. It is made up of litter material that has decomposed to the point where individual pieces are no longer identifiable. In general, the duff layer is darker than the litter layer.

**Fine Woody Debris (FWD):** Pieces of wood less than 8 centimeters (3.1 in) in diameter. They are either (1) not attached to the woody stem where they once grew and have fallen to the ground, (2) not attached to the stem where they once grew and are supported off the ground by live or dead material, or (3) attached to stems of woody material that are themselves considered “dead” and “down.” Fine woody debris is composed of the following fire size classes: 1-hour fuels (0–0.64 centimeters [0–0.2 in]), 10-hour fuels (0.64–2.54 centimeters [0.2–1 in]), and 100-hour fuels (2.54–8.1 centimeters [1–3.2 in]).

**Global / State Status:** Conservation status assessment ranks developed by NatureServe (2023) and individual state Natural Heritage Programs used to determine the extinction risk of species and ecosystems at the global and state scales. Global codes are as follows:

- G1: Critically imperiled-very high risk of extinction
- G2: Imperiled-high risk of extinction
- G3: Vulnerable-moderate risk of extinction
- G4: Apparently Secure-fairly low risk of extinction
- G5: Secure-very low risk of extinction

**Growth Form:** The shape and physical appearance of a species, reflecting site conditions and genetics. In this report, the following growth forms, following definitions set by USDA (2023a), are used:

- Tree: a perennial, woody plant with a single stem (trunk), normally greater than 4–5 meters (13.1–16.4 ft) in height
- Shrub: a perennial, multi-stemmed woody plant that is usually less than 4–5 meters (13.1–16.4 ft) in height
- Vine: a twining or climbing plant with relatively long stems; can be woody or herbaceous
- Herb/Forb: a plant without significant woody tissue and lacking significant thickening by secondary woody growth
- Graminoid: a grass or grass-like plant; includes grasses (*Poaceae*), sedges (*Cyperaceae*), and rushes (*Juncaceae*).

**Litter:** An organic fuel layer made up of twigs, dead grasses, recently fallen leaves, and pine or other needles where the individual pieces are still identifiable and not altered by decomposition.

**Sapling:** Any live woody stem more than 1.37 meters (4.5 ft) in height but less than 10 centimeters (3.9 in) in diameter at breast height (DBH).

**Seedling:** Any live woody stem with at least two true leaves that are less than 1.37 meters (4.5 ft) tall.

**Slope:** The rise and fall of a land surface.

**Species Richness:** The overall number of species, or group of species, within a defined area.

**Terrain Shape Index (TSI):** A quantitative expression of the geometric shape (ranging from concave to convex) of the land surface. Negative TSI values indicate convex shape, positive values indicate concavity, and values around 0 indicate flat surfaces.

**Tree:** Any woody stem more than 1.37 meters (4.5 ft) in height and greater than or equal to 10 centimeters (3.9 in) in diameter at breast height (DBH). This term is also used to describe a specific growth form (see Growth Form above).

# Introduction

## Overview

Vegetation communities are the primary drivers of a range of ecological processes and integral to the proper function of park ecosystems. Moreover, vegetation communities integrate the biological and physical environment—they serve as the foundation for food webs, provide wildlife habitat for many species, function as a carbon sink, produce oxygen, and cycle nutrients and energy through an ecosystem. Parks within the Southeast Coast Network (SECN) host a diverse assemblage of plants and terrestrial communities. Vegetation communities vary widely. Approximately 180 vegetation associations (i.e., fine-resolution floristic description), as defined by the National Vegetation and Classification Standard, Version 2.0 (FGDC 2008), occur in SECN park units. A diversity of vegetation resources is found in these parks, including dry grassland dunes, maritime oak and pine dominated forests, pyrogenic pine flatwoods, black and brown water floodplain forests, and Piedmont upland forests.

Vegetation communities are dynamic entities whose species composition, abundance, distribution, and structure are influenced by environmental factors and the impacts over time by natural and anthropogenic disturbances. For communities to be considered “natural,” native species must be predominately distributed across the landscape as a consequence of disturbance factors (i.e., stressors) or site condition (i.e., environmental factors, e.g., soil nutrients, landform; Comer et al. 2003). The timing, type, and extent of a disturbance generally evoke a distinguishable response in vegetation across the landscape (Turner et al. 1990; Foster et al. 1998). Natural disturbance processes in SECN parks include those brought about by fire regimes and weather patterns (e.g., hurricanes and drought), while anthropogenic influences include landscape fragmentation, fire suppression, altered hydrology, shifts in seasonal weather patterns, and non-native species introduction.

Determining trends in vegetation communities over time and identifying plant stressors is vital to understanding the ecological health of terrestrial ecosystems within SECN parks. Collectively, this information can be used to guide management actions that sustain a park’s ecological integrity and support plant conservation across a diversity of spatial scales. The Southeast Coast Network collects long-term data on vegetation communities using a protocol largely based on the forest monitoring approaches used by the Cumberland Piedmont Network (White et al. 2011) and Gulf Coast Network (Carlson et al. 2018).

This report provides a summary of data collected during summer 2021 within Kennesaw Mountain National Battlefield Park (KEMO) as part of the SECN’s terrestrial vegetation monitoring effort. This report is intended to provide KEMO resource managers and partners with (a) baseline information on the composition, abundance, and structure of vegetation across broad habitat types, (b) documentation of observable stressors to park vegetation resources, and (c) a summary of ancillary data associated with terrestrial ecosystems (e.g., soil nutrient status and fuel abundance).

## Monitoring Objectives

The overall objective is to detect meaningful changes in species composition and vegetation structure within natural and semi-natural vegetation communities of SECN parks and determine whether these changes are correlated with trends in key stressors.

The data presented herein are from the first iteration of sampling activities in Kennesaw Mountain National Battlefield Park utilizing the recently published SECN terrestrial vegetation monitoring protocol (Boyle et al. 2019). For this “baseline” status report, 2021 data were synthesized to answer the following questions across broad habitat types within the park:

- How does species richness vary across terrestrial vegetation communities?
- What is the status of composition and abundance among native versus non-native, invasive species?
- What are the most common plants encountered during monitoring, and conversely, were there rare species detected?
- In forests, woodlands, and shrublands, what is the relative frequency of woody seedlings, saplings, and subcanopy or canopy species?
- Do observable stressors appear to impact vegetation communities?
- What is the current condition of soil nutrient chemistry and fuel volume?

# Methods

## Study Area

Kennesaw Mountain National Battlefield Park (KEMO) is an 1,183 hectare [ha] (2,923 acre [ac]) urban park located in Cobb County, Georgia and roughly 32 kilometers [km] (20 miles [mi]) northwest of Atlanta (Figure 1). The park surrounds multiple large private land tracts and is largely surrounded by suburban development from Marietta, Georgia. Kennesaw Mountain National Battlefield Park was established as a national military park in 1935 and represents the only nationally-designated battle site that preserves an 1864 Civil War battleground of the Atlanta Campaign (NPS 2013). The Union army victory of the Atlanta Campaign solidified the re-election of Abraham Lincoln and the future preservation of the country. One of the missions of the park is to protect and preserve the natural features of the battlefield site, thereby providing a critical greenspace within the greater Atlanta metropolitan area. Kennesaw Mountain National Battlefield Park is the second-most visited national battlefield in the United States, drawing close to two million visitors a year (A. Winegar, pers. comm., KEMO, August 4, 2023). It was the first designated Globally Important Bird Area within Georgia, and still serves as a focal area for bird conservation within the southeastern Piedmont (NPS 2013).

The park lies within the Southern Inner Piedmont ecoregion of Georgia. The Southern Inner Piedmont typically has higher elevations and steeper slopes than the rest of the Piedmont, with gneiss and schist rocks yielding nutrient-poor, acidic soil (Griffith et al. 2001). Historically, the land of Kennesaw Mountain Battlefield Park was used for agriculture and, following procurement by the National Park Service, former agriculture land underwent vast erosion control techniques

(e.g., hillside terracing) to stabilize soil (Zomlefer et al. 2010). The distribution and composition of forested habitats within the park are largely determined by these former land-use patterns, as well as by localized edaphic conditions. Like most of the vegetated uplands across the Southern Inner Piedmont ecoregion, the park is dominated by a mixture of early- to mid-successional pine, oak, and mixed hardwood forests (McManamay et al. 2015). There are also forested- and graminoid-dominated wetlands along Noses Creek and other small streams within the park (McManamay et al. 2015). Perhaps the most striking feature of the park is the string of higher elevation peaks that runs north to south in the park's northeastern corner; these include Kennesaw Mountain (550 meters [1808 ft]), Little Kennesaw Mountain (490 meters [1600 ft]), Pigeon Hill (380 meters [1250 ft]) and Cheatham Hill (340 meters [1120 ft]). The upper elevations of Kennesaw and Little Kennesaw Mountains are composed of a mosaic of graminoid-, forb-, and shrub-dominated communities occurring under a stunted canopy of widely spaced trees. These intermixed glades and woodlands of the Piedmont are located on thin, rocky soil adjacent to open rock (i.e., rock outcrops). On Little Kennesaw and Kennesaw Mountain, these thin soils are underlain by a combination of felsic (e.g., granite gneiss) and mafic (e.g., amphibolite) geologic material, yielding a unique combination of vegetation with affinities to both acidic and basic soils (Zomlefer et al. 2010). A very rare mafic shrub glade is located on the southwestern aspect of Kennesaw Mountain; base-loving species in this localized community type include hairy mock orange (*Philadelphus hirsutus*), wafer-ash (*Ptelea trifoliata* var. *mollis*), and white fringe-tree (*Chionanthus virginicus*; Edwards et al. 2013).

# Kennesaw Mountain National Battlefield Site Locations

Southeast Coast Network  
National Park Service  
U.S. Department of the Interior

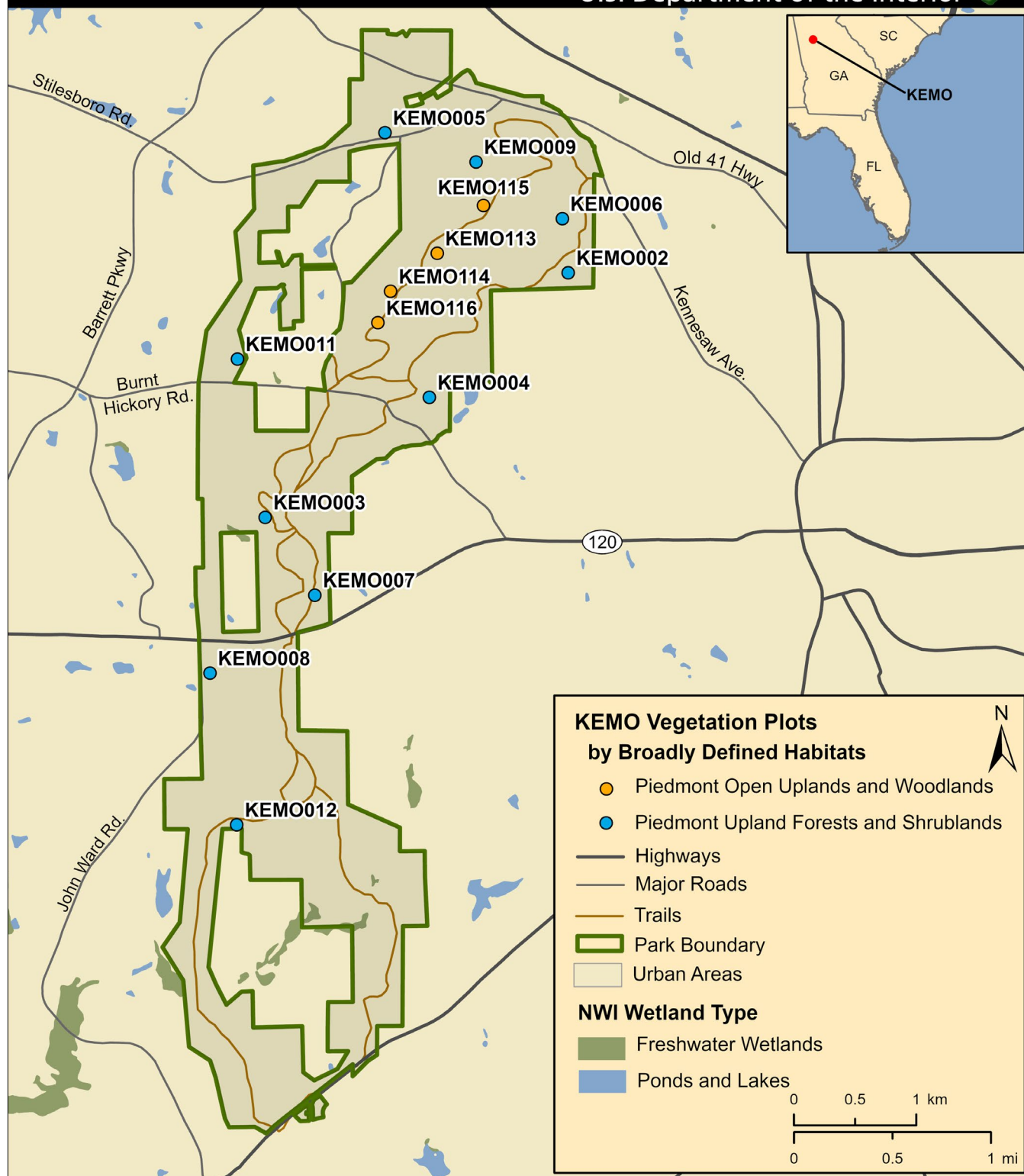


**Figure 1.** Southeast Coast Network terrestrial vegetation monitoring plot locations within Kennesaw Mountain National Battlefield Park.

The most recent floristic survey within the park was conducted in 2006 and reported 538 vascular plant species (Zomlefer et al. 2010), while NPSpecies lists just under 850 species as present within the park (NPS 2023). Of the 538 species listed in Zomlefer et al. (2010), 135 of these are non-native, and 50 of these were considered invasive by the Georgia Exotic Pest Plant Council (GA-EPPC 2023). Invasive species present in the park during the 2006 survey and ranked as either a Category 1 (a serious problem) or Category 2 (a moderate problem) invasive plant in the updated GA-EPPC (2023) report include:

- Mimosa / Silktree (*Albizia julibrissin*; Cat 1)
- Garlic mustard (*Alliaria petiolate*; Cat 1, Alert)
- Small carpetgrass/Joint-head grass (*Arthraxon hispidus*; Cat 1, Alert)
- Bermudagrass (*Cynodon dactylon*; Cat 2)
- Autumn olive (*Elaeagnus umbellata*; Cat 1)
- English ivy (*Hedera helix* var. *helix*; Cat 1)
- Sericea lespedeza (*Lespedeza cuneata*; Cat 1)
- Oxeye daisy (*Leucanthemum vulgare*; Cat 2)
- Chinese privet (*Ligustrum sinense*; Cat 1)
- Japanese honeysuckle (*Lonicera japonica*; Cat 1)
- Amur honeysuckle (*Lonicera maackii*; Cat 2)
- Japanese climbing fern (*Lygodium japonicum*; Cat 1)
- Chinaberrytree (*Melia azedarach*; Cat 1)
- Japanese stiltgrass/Nepalese browntop (*Microstegium vimineum*; Cat 1)
- Marsh dayflower (*Murdannia keisak*; Cat 1)
- Sacred bamboo (*Nandina domestica*; Cat 2)
- European watercress (*Nasturtium officinale*; Cat 2)
- Princess tree (*Paulownia tomentosa*; Cat 1)
- Golden bamboo (*Phyllostachys aurea*; Cat 2)

- Kudzu (*Pueraria montana* var. *lobata*; Cat 1)
- Multiflora rose (*Rosa multiflora*; Cat 1)
- Bigleaf periwinkle (*Vinca major*; Cat 2)
- Common periwinkle (*Vinca minor*; Cat 2)

During the previous floristic survey of the park, there were no federally listed endangered or threatened species, two state protected species (purple milkweed [*Asclepias purpurascens*], status = Rare; glade meadowparsnip [*Thaspium pinnatifidum*], status = Endangered), and one species of special concern (green rockcress [*Boechera missouriensis*]) observed (Zomlefer et al. 2010; GADNR 2023).

## Sampling Design

The Southeast Coast Network monitors vegetation in long-term plots in natural and semi-natural habitats of targeted parks, including Kennesaw Mountain National Battlefield Park. Sample size (i.e., number of plots) is determined by a combination of factors, including (1) priority plots are located in broadly defined habitats that cover more than 30% of the total area of park's natural and semi-natural vegetation (i.e., dominant and co-dominant habitat); (2) the number of priority plots is scaled according to the overall size of dominant/co-dominant mapped polygons, such that the distribution of plots is between 1 and 25 per 100 hectares (247 ac) of these habitat types; (3) the secondary sample target is any broadly defined habitat that covers between 1 and 30% of a park's natural and semi-natural vegetation; (4) each of the secondary sample target habitat types is allotted four plots

Fourteen vegetation plots were established and sampled at Kennesaw Mountain National Battlefield Park from late July through early August 2021 (Figure 1). These plots were in the following broadly defined habitats of the park: Piedmont Open Uplands and Woodlands (4 plots) and Piedmont Upland Forests and Shrublands (10 plots). Plot locations were determined using the generalized random-tessellation stratified (GRTS) sampling methodology, which creates a spatially-balanced array of sample points across an area of interest while maintaining flexibility in a project's sample size (Stevens and Olsen 2004).

## **Nomenclature Standard, Growth Form Determination, and Conservation Status**

Species nomenclature for this report follows the Flora of the Southern and Mid-Atlantic States (Weakley 2020). Every attempt was made to identify all plants to species, variety, or subspecies; when this was not possible, the lowest level of identifiable taxa (e.g., genera, family) was used. Once the final list was determined, each species was cross-referenced with the USDA Plants Database (USDA 2023a) to determine growth form, native status, federal/state noxious status, and to provide a unique common name. When a single taxon linked to multiple growth forms, the lead author subjectively chose a single growth form to link with the taxa. The species list was also cross-referenced with the 782 rare plants in Georgia to determine the state and federal conservation status (e.g.,

Endangered, Threatened, Rarity) of each species (GADNR 2023) and the list of non- native invasive plants in Georgia to determine the degree of invasiveness (GA-EPPC 2023).

## **Sampling Methodology**

The vegetation plot layout for this monitoring effort is based upon the plot design used by the Carolina Vegetation Survey (Peet et al. 1998; Lee et al. 2008) and the Cumberland Piedmont Network (White et al. 2011). The plot array consists of a 20 × 20-meter (65.6 × 65.6-ft) bounded square with multiple nested sampling frames ranging from 1 square meter (10.8 square feet [ft<sup>2</sup>]) to 400 square meters (4,305.5 ft<sup>2</sup>), three 25-meter (82.0-ft) fuel transects that cross both inside and outside the bounded square, and three soil sample frames located adjacent to the bounded square (Figure 2).

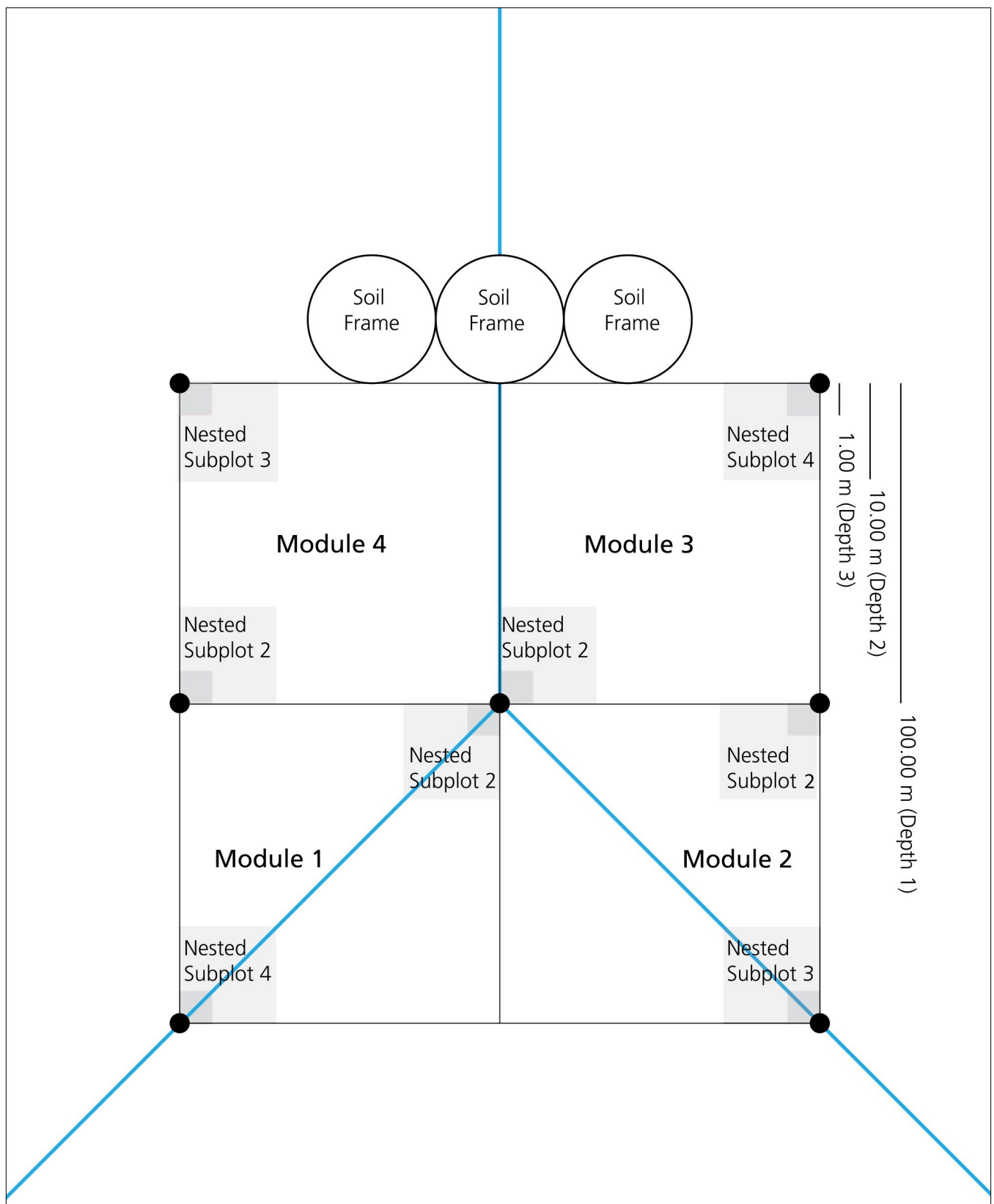


**Figure 2.** The layout of the sampling plot for the Southeast Coast Network, which is a modified version of the standard Level 5 Carolina Vegetation Survey plot. Ideal locations of rebar used as permanent structures to monument the plot are represented by black shaded circles. Blue lines represent locations of the three 25-meter (82-foot) fuel transects.

Vascular plant species presence was determined at three scales within each of the four 100 square meter (1,076.4 ft<sup>2</sup>) modules: the 1 square meter (10.8 ft<sup>2</sup>) nested depth, the 10 square meters (107.6 ft<sup>2</sup>) nested depth, and the full modular depth. The nested depth ‘quadrats’ were located in two of four corners within each module. For each species either rooted in or overhanging a module, an areal cover value was assigned using the cover class codes developed by the Carolina Vegetation Survey (Peet et al. 1998; Table 1).

**Table 1.** Vascular plant cover metrics of the Carolina Vegetation Survey (Peet et al. 1998) and used by the SECN terrestrial vegetation monitoring protocol (Boyle et al. 2019).

| Cover Class | Cover Range (%) | Geometric Mean |
|-------------|-----------------|----------------|
| 1           | 0–0.1           | 0.03           |
| 2           | 0.1–1.0         | 0.32           |
| 3           | 1.0–2.0         | 1.41           |
| 4           | 2.0–5.0         | 3.16           |
| 5           | 5.0–10.0        | 7.07           |
| 6           | 10.0–25.0       | 15.81          |
| 7           | 25.0–50.0       | 35.36          |
| 8           | 50.0–75.0       | 61.24          |
| 9           | 75.0–95.0       | 84.41          |
| 10          | 95.0–100.0      | 97.47          |

Individual woody stem data were also calculated within each module. For each stem greater than or equal to 10 centimeters (3.9 inches [in]; tree) in diameter at 1.4 meters (4.5 ft) linear distance from the ground layer, its species, DBH, and health status was recorded. Within the two 10 square-meter (107.6 ft<sup>2</sup>) nested depth “quadrats” used for detecting overall species presence (see above), each woody stem that reached 1.4 meters (4.5 ft) in linear distance from the ground layer but was less than 10 centimeters (3.9 in) in diameter at this height (sapling) was identified to species and DBH was determined.

Finally, each woody stem less than 1.4 meters (4.5 ft) in linear distance from the ground layer (seedling) was identified to species and a height class was determined: 5–15 centimeters (2–5.9 in); 15–30 centimeters (5.9–11.8 in); 30–50 centimeters (11.8–19.7 in); or 50–137 centimeters (19.7–53.9 in) within the two 1 square meter (10.8 ft<sup>2</sup>) nested depth “quadrats” used for detecting overall species presence (see above).

Surface fuels were assessed at each plot site using the planar transect method for the standard fuel size classes: 1-hour (0–0.6 cm), 10-hour (0.6–2.5 cm), 100-hour (2.5–7.6 cm), and 1000-hour (> 7.6 cm), and duff and litter depths (Brown 1974). Counts of each fuel size class were tallied across three fuel transects, with diameter and decay class recorded for each piece of 1000-hour fuel. These field data were incorporated into equations using constant multipliers defined by Brown (1974)—including quadratic mean diameter, nonhorizontal correction factor, specific gravity, and bulk density—to estimate fuel load weight (units = tons/acre) within each plot.

Additional site characteristics were also measured at each plot. Elements taken from the center of each plot included dominant slope, aspect, and terrain shape; basic hydrological condition; and presence and abundance of disturbance indicators. General canopy conditions were assessed, including canopy closure and average height. Closure was measured from the center of each module using a spherical densiometer, and height was taken from three representative trees within (or just outside) the plot. Soil samples were collected from the upper 10 centimeters (0.3 ft) of mineral soil in three sampling frames located adjacent to each vegetation plot. These samples were combined by plot upon return from the field and dried prior to shipping to a soil testing laboratory for standard nutrient analysis. Each plot was qualitatively assigned to one or two National Vegetation Classification (NVC) vegetation association types that best matched the sample site. Finally, two-dimensional photo points were taken with a point-and-shoot camera at the western and eastern center edge of each plot; a third photo point was made from the plot center using a 360-degree camera.

## Results and Discussion

One hundred and eighty-four vascular plant species were detected during this monitoring effort within Kennesaw Mountain National Battlefield Park (Appendix A), including 27 taxa not detected in previous lists documented in Zomlefer et al. (2010), Heath and Byrne (2014), or NPSpecies (NPS 2023) (Table 2). Fourteen taxa new to the park are also likely new records for Cobb County, Georgia. These include:

- Elliott’s bluestem (*Andropogon gyrans*)
- oval-leaf sedge (*Carex cephalophora*)
- red hickory (*Carya ovalis*)
- climbing dayflower (*Commelina diffusa*)
- bigfruit hawthorn (*Crataegus macrosperma*)
- tapered rosette grass (*Dichanthelium acuminatum*)
- white ash (*Fraxinus biltmoreana*)
- bluntnose bedstraw (*Galium obtusum* var. *filifolium*)
- hairy bedstraw (*Galium pilosum*)
- fragrant bedstraw (*Galium triflorum*)
- St. Andrew’s cross (*Hypericum stragulum*)
- Chinese holly (*Ilex cornuta*)
- Japanese holly (*Ilex crenata*)
- leathery rush (*Juncus coriaceous*)

Two of the species new to the park are listed as invasive by the Georgia Exotic Pest Plant Council (GA-EPPC 2023), Chinese holly and Japanese holly (Table 2).

Native richness ranged from 23 to 56 species per plot, and non-native species comprised between two and 15% of the total richness per plot (Table 3). Native species observed in these plots are common throughout the Piedmont of Georgia, and there were no federally-listed nor state-listed species observed on these plots during monitoring. However, two species of special concern for Georgia were observed and included green, or Missouri, rock cress (*Boechera missouriensis*) and Stone Mountain mint (*Pycnanthemum curvipes*) (GADNR 2023). Fourteen species listed by the GA-EPPC (2023) as invasive were observed in these monitoring plots, including nine ranked as either Category 1 or Category 2 (Appendix A). The frequency of Category 1 and 2 invasive plants in these monitoring plots was very high. Category 1 and 2 species observed (and their frequency) included mimosa (14%), autumn olive (21%), sericea lespedeza (14%), Chinese privet (93%), Japanese honeysuckle (57%), Amur honeysuckle (14%), Japanese stiltgrass (43%), sacred bamboo (7%), and multiflora rose (7%).

Within the Georgia Piedmont, plant species composition and structure patterns within natural vegetation community types are determined by variations in soil and topography, as well as Native American use across the landscape (Edwards et al. 2013). What follows is a synopsis of vegetation and environmental data stratified by each of the broadly defined habitats sampled within the park.

**Table 2.** Vascular plant species, subspecies, or varieties not reported from Zomlefer et al. (2010), Heath and Byrne (2014), or NPSpecies (NPS 2023) but found at Kennesaw Mountain National Battlefield Park in 2021 through this current monitoring effort.

| Scientific Name                                      | Common Name <sup>1</sup>   | Growth Form <sup>1</sup> | Native Status <sup>1</sup> | State Invasive Status <sup>2</sup> | Global Rank <sup>3</sup> | State Rank <sup>3</sup> (Georgia) |
|------------------------------------------------------|----------------------------|--------------------------|----------------------------|------------------------------------|--------------------------|-----------------------------------|
| <i>Acalypha virginica</i>                            | Virginia threeseed mercury | Forb/herb                | Native                     | –                                  | G5                       | SNR                               |
| <i>Aesculus sylvatica</i>                            | painted buckeye            | Tree, Shrub              | Native                     | –                                  | G5                       | S5                                |
| <i>Andropogon gerardi</i>                            | big bluestem               | Graminoid                | Native                     | –                                  | G5                       | S5                                |
| <i>Andropogon gyrans</i>                             | Elliott's bluestem         | Graminoid                | Native                     | –                                  | G5                       | S4                                |
| <i>Bromus pubescens</i>                              | hairy woodland brome       | Graminoid                | Native                     | –                                  | G5                       | S5                                |
| <i>Carex cephalophora</i>                            | oval-leaf sedge            | Graminoid                | Native                     | –                                  | G5                       | S5                                |
| <i>Carya ovalis</i>                                  | red hickory                | Tree                     | Native                     | –                                  | G5                       | S5                                |
| <i>Celtis pumila</i>                                 | dwarf hackberry            | Tree, Shrub              | Native                     | –                                  | G5                       | SNR                               |
| <i>Commelina diffusa</i>                             | climbing dayflower         | Forb/herb                | Native                     | –                                  | G5                       | SNR                               |
| <i>Crataegus macrocarpa</i>                          | bigfruit hawthorn          | Tree, Shrub              | Native                     | –                                  | G5                       | SNR                               |
| <i>Dichanthelium acuminatum</i>                      | tapered rosette grass      | Graminoid                | Native                     | –                                  | G5                       | SNR                               |
| <i>Dichanthelium boscii</i>                          | Bosc's panicgrass          | Graminoid                | Native                     | –                                  | G5                       | SNR                               |
| <i>Elymus villosus</i> var. <i>villosus</i>          | hairy wildrye              | Graminoid                | Native                     | –                                  | G5                       | SNR                               |
| <i>Fraxinus biltmoreana</i>                          | white ash                  | Tree                     | Native                     | –                                  | G5                       | SNR                               |
| <i>Galactia regularis</i>                            | eastern milkpea            | Forb/herb, Vine          | Native                     | –                                  | G5                       | SNR                               |
| <i>Galium obtusum</i> var. <i>filifolium</i>         | bluntleaf bedstraw         | Forb/herb                | Native                     | –                                  | T5                       | SNR                               |
| <i>Galium pilosum</i>                                | hairy bedstraw             | Forb/herb                | Native                     | –                                  | G5                       | SNR                               |
| <i>Galium triflorum</i>                              | fragrant bedstraw          | Vine, Forb/herb          | Native                     | –                                  | G5                       | SNR                               |
| <i>Hypericum stragulum</i>                           | St. Andrew's cross         | Shrub, Subshrub          | Native                     | –                                  | T4                       | SNR                               |
| <i>Ilex cornuta</i>                                  | Chinese holly              | Shrub, Tree              | Non-native                 | Category 4                         | SNR                      | SNR                               |
| <i>Ilex crenata</i>                                  | Japanese holly             | Shrub, Tree              | Non-native                 | Category 4                         | SNR                      | SNR                               |
| <i>Juncus coriaceous</i>                             | leathery rush              | Graminoid                | Native                     | –                                  | G5                       | SNR                               |
| <i>Matelea carolinensis</i>                          | maroon Carolina milkvine   | Vine, Forb/herb          | Native                     | –                                  | G4                       | S4                                |
| <i>Oxalis dillenii</i>                               | slender yellow woodsorrel  | Forb/herb                | Native                     | –                                  | G5                       | S5                                |
| <i>Schizachyrium scoparium</i> var. <i>scoparium</i> | little bluestem            | Graminoid                | Native                     | –                                  | G5                       | SNR                               |
| <i>Viburnum rufidulum</i>                            | rusty blackhaw             | Tree, Shrub              | Native                     | –                                  | G5                       | SNR                               |
| <i>Viola hirsutula</i>                               | southern woodland violet   | Forb/herb                | Native                     | –                                  | G4                       | S4                                |

<sup>1</sup> Information obtained from the PLANTS database (USDA 2023a)

<sup>2</sup> Information obtained from the Georgia Exotic Pest Plant Council (GA-EPPC 2023)

<sup>3</sup> Conservation Status (G4, T4, or S4: Apparently Secure; G5, T5, or S5: Secure; SNR: Not Yet Accessed) obtained from NatureServe Explorer 2.0 (NatureServe 2023)

**Table 3.** Vascular plant species richness across multiple spatial scales on Southeast Coast Network vegetation plots within Kennesaw Mountain National Battlefield Park. The data are summarized by total number of native versus non-native species/plot, and by vegetative growth forms (T: tree, S: shrub, V: vine, H: herbs/forbs, G: graminoids). Growth form information was obtained from the USDA Plants Database (USDA 2023a).

| Broadly Defined Habitat                | Plot               | Native <sup>1</sup> | Non-native <sup>1</sup> | Unknown <sup>1</sup> | T <sup>1</sup> | S <sup>1</sup> | V <sup>1</sup> | H <sup>1</sup> | G <sup>1</sup> | T <sup>2</sup> | S <sup>2</sup> | V <sup>2</sup> | H <sup>2</sup> | G <sup>2</sup> | T <sup>3</sup> | S <sup>3</sup> | V <sup>3</sup> | H <sup>3</sup> | G <sup>3</sup> | T <sup>4</sup> | S <sup>4</sup> | V <sup>4</sup> | H <sup>4</sup> | G <sup>4</sup> |
|----------------------------------------|--------------------|---------------------|-------------------------|----------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Piedmont Upland Forests and Shrublands | KEMO002            | 41.0                | 3.0                     | 0.0                  | 21.0           | 2.0            | 4.0            | 10.0           | 7.0            | 12.50          | 0.75           | 3.00           | 3.75           | 4.75           | 5.00           | 0.38           | 1.50           | 0.88           | 0.88           | 2.00           | 0.13           | 0.50           | 0.25           | 0.13           |
|                                        | KEMO003            | 52.0                | 4.0                     | 0.0                  | 19.0           | 2.0            | 9.0            | 19.0           | 7.0            | 11.50          | 1.25           | 6.00           | 6.50           | 3.00           | 5.88           | 0.88           | 4.38           | 2.25           | 1.13           | 3.63           | 0.38           | 3.25           | 0.63           | 0.13           |
|                                        | KEMO004            | 23.0                | 4.0                     | 0.0                  | 15.0           | 2.0            | 7.0            | 2.0            | 1.0            | 9.50           | 1.00           | 6.00           | 0.75           | 0.25           | 5.50           | 0.25           | 3.75           | 0.25           | 0.13           | 2.63           | 0.00           | 2.00           | 0.00           | 0.00           |
|                                        | KEMO005            | 33.0                | 5.0                     | 0.0                  | 16.0           | 3.0            | 7.0            | 9.0            | 3.0            | 8.75           | 0.75           | 5.75           | 4.25           | 1.00           | 4.88           | 0.25           | 4.13           | 2.00           | 0.50           | 2.50           | 0.00           | 2.50           | 1.00           | 0.25           |
|                                        | KEMO006            | 24.0                | 3.0                     | 0.0                  | 16.0           | 1.0            | 8.0            | 2.0            | 0.0            | 9.00           | 0.25           | 5.00           | 0.50           | 0.00           | 4.00           | 0.00           | 3.25           | 0.25           | 0.00           | 2.00           | 0.00           | 2.38           | 0.00           | 0.00           |
|                                        | KEMO007            | 25.0                | 2.0                     | 0.0                  | 15.0           | 0.0            | 5.0            | 4.0            | 3.0            | 8.50           | 0.00           | 4.25           | 1.50           | 0.75           | 3.38           | 0.00           | 2.75           | 0.50           | 0.13           | 1.63           | 0.00           | 1.63           | 0.00           | 0.00           |
|                                        | KEMO008            | 30.0                | 4.0                     | 1.0                  | 15.0           | 1.0            | 7.0            | 5.0            | 7.0            | 10.25          | 0.25           | 5.50           | 2.00           | 3.50           | 6.25           | 0.13           | 4.13           | 0.63           | 1.25           | 3.00           | 0.00           | 2.25           | 0.13           | 0.50           |
|                                        | KEMO009            | 34.0                | 1.0                     | 0.0                  | 15.0           | 1.0            | 7.0            | 10.0           | 2.0            | 10.00          | 0.25           | 4.75           | 4.25           | 1.00           | 4.38           | 0.00           | 2.38           | 1.25           | 0.25           | 0.88           | 0.00           | 0.63           | 0.00           | 0.00           |
|                                        | KEMO011            | 29.0                | 4.0                     | 0.0                  | 14.0           | 3.0            | 6.0            | 9.0            | 1.0            | 11.00          | 1.00           | 5.50           | 5.25           | 0.50           | 5.88           | 0.25           | 3.25           | 2.00           | 0.00           | 3.38           | 0.00           | 2.25           | 1.13           | 0.00           |
|                                        | KEMO012            | 50.0                | 4.0                     | 0.0                  | 18.0           | 3.0            | 9.0            | 17.0           | 7.0            | 11.00          | 1.75           | 6.50           | 10.00          | 2.75           | 5.50           | 1.13           | 5.00           | 4.38           | 0.63           | 3.25           | 0.25           | 3.88           | 1.25           | 0.00           |
|                                        | average            | 34.1                | 3.4                     | 0.1                  | 16.4           | 1.8            | 6.9            | 8.7            | 3.8            | 10.20          | 0.73           | 5.23           | 3.88           | 1.75           | 5.06           | 0.33           | 3.45           | 1.44           | 0.49           | 2.49           | 0.08           | 2.13           | 0.44           | 0.10           |
|                                        | standard deviation | 10.4                | 1.2                     | 0.3                  | 2.2            | 1.0            | 1.6            | 5.8            | 2.9            | 1.30           | 0.55           | 1.02           | 2.92           | 1.62           | 0.92           | 0.38           | 1.04           | 1.28           | 0.47           | 0.87           | 0.13           | 1.04           | 0.51           | 0.16           |
| Piedmont Open Uplands and Woodlands    | KEMO113            | 54.0                | 4.0                     | 0.0                  | 16.0           | 1.0            | 8.0            | 18.0           | 15.0           | 8.50           | 0.25           | 4.25           | 8.75           | 8.25           | 4.50           | 0.13           | 1.75           | 4.25           | 4.63           | 1.75           | 0.00           | 0.75           | 1.88           | 2.88           |
|                                        | KEMO114            | 54.0                | 1.0                     | 0.0                  | 14.0           | 2.0            | 4.0            | 25.0           | 10.0           | 8.75           | 0.50           | 2.50           | 14.75          | 8.00           | 3.00           | 0.00           | 0.88           | 6.75           | 4.38           | 1.13           | 0.00           | 0.25           | 2.88           | 2.50           |
|                                        | KEMO115            | 56.0                | 7.0                     | 0.0                  | 19.0           | 2.0            | 6.0            | 23.0           | 13.0           | 11.25          | 0.75           | 3.25           | 14.25          | 7.25           | 5.13           | 0.25           | 2.13           | 6.38           | 3.63           | 1.88           | 0.00           | 0.63           | 3.38           | 1.13           |
|                                        | KEMO116            | 42.0                | 1.0                     | 1.0                  | 12.0           | 0.0            | 5.0            | 17.0           | 10.0           | 6.75           | 0.00           | 2.00           | 9.00           | 5.75           | 3.25           | 0.00           | 1.00           | 4.13           | 2.75           | 1.38           | 0.00           | 0.63           | 1.25           | 1.38           |
|                                        | average            | 51.5                | 3.3                     | 0.3                  | 15.3           | 1.3            | 5.8            | 20.8           | 12.0           | 8.81           | 0.38           | 3.00           | 11.69          | 7.31           | 3.97           | 0.09           | 1.44           | 5.38           | 3.84           | 1.53           | 0.00           | 0.56           | 2.34           | 1.97           |
|                                        | standard deviation | 6.4                 | 2.9                     | 0.5                  | 3.0            | 1.0            | 1.7            | 3.9            | 2.4            | 1.85           | 0.32           | 0.98           | 3.26           | 1.13           | 1.01           | 0.12           | 0.60           | 1.38           | 0.84           | 0.34           | 0.00           | 0.22           | 0.96           | 0.85           |

<sup>1</sup> Total species richness at the full plot (400 square meters [4,305.6 ft<sup>2</sup>]) depth

<sup>2</sup> Mean species richness at the modular (100 square meters [1,076.3 ft<sup>2</sup>]) depth

<sup>3</sup> Mean species richness at the nested 10 square meters (107.6 ft<sup>2</sup>) depth

<sup>4</sup> Mean species richness at the nested 1 square meter (10.8 ft<sup>2</sup>) depth

## Piedmont Open Uplands and Woodlands

Naturally vegetated uplands within the Piedmont of the southeastern United States that are not characterized by a closed canopy forested structure can include prairies and savannas dominated by herbaceous plants, open canopy woodlands with widely spaced trees, and glades on shallow soils within a matrix of patchy rock outcrops. Although these natural communities can occur across a broad soil fertility gradient (from mafic to acidic), they all share a few common features including: (1) they are often positioned on middle to upper slopes and ridgetops; (2) soils are typically thin, rocky, and easy to dry out (although prairie soils can be deeper and more mesic); and (3) both anthropogenic and natural (e.g., lightning-caused) fire has historically promoted their degree of “openness” (Edwards et al. 2013).

At Kennesaw Mountain Natural Battlefield Park, open uplands are found on upper slopes and ridges of the higher elevation zones within the northeast corner of the park (see Study Area

for more details; Figure 3). Several vegetation associations corresponding with this broadly defined habitat type were sampled within the park during monitoring, including (descriptions from NatureServe 2023):

- Granitic Flatrock Pine Border Woodland (CEGL003993; 2 plots): Woodlands occurring over granitic bedrock and bordering open flatrocks; the sparse tree canopy is often co-dominated by eastern red-cedar and winged elm (*Ulmus alata*) (Global Status: G3—Vulnerable; State [GA] Status: No Status Rank)
- Piedmont Mafic Xeric Oak Forest (CEGL004416; 2 plots): Oak-hickory forests occurring over amphibolite or other volcanic substrates surrounding herbaceous glades; the stunted canopy and subcanopy of these communities contain a mixture of oak and hickory species, as well as species of more mafic affinities (e.g., wafer-ash). (Global Status: G2—Imperiled; State [GA] Status: No Status Rank)



**Figure 3.** Four Piedmont Open Upland and Woodland plots were established during monitoring on Kennesaw Mountain National Battlefield Park in July and August 2021. Many contained a unique mix of species with affinities to both mafic and acidic substrates. NPS photo / SECN staff.

### ***Species Diversity and Abundance***

Native species richness ranged from 42 to 56 (mean = 51.5) within vegetation plots of this broadly defined habitat type in Kennesaw Mountain National Battlefield Park (Table 3). Herbaceous vegetation represented the most diverse growth forms across all spatial scales within plots of this habitat (Table 3). Non-native species were frequent, with one or more species observed in each plot (Table 3). Seven of the 14 invasive plants found within the park during monitoring were encountered in these Piedmont Open Upland and Woodland plots. Invasive species that occurred in 50% or more of these plots included Chinese privet, Japanese honeysuckle, and sericea lespedeza (Appendix B, Table B-1). Native vascular plants observed in these plots are either fairly common across the southeastern Piedmont or common in open upland glade habitat of the ecoregion. As expected, based on the unique geology of the high elevations of Kennesaw Mountain National Battlefield Park, a mixture of acidic and mafic species were encountered in these plots. The two state rare species observed within the park during monitoring—Missouri rock cress and Stone Mountain mint—were found exclusively in plots of this broadly defined habitat. One hundred seven vascular plant species were found collectively within these four plots, and 64 of these were only found in this broadly defined habitat (Appendix B, Table B-1). A complete species list, along with constancy and average cover per species, is in Appendix B, Table B-1. Species with high constancy in this habitat are listed below, by growth form (constancy values in parentheses):

#### **Trees**

- Wafer-ash (100%)
- White fringe-tree (100%)
- Winged elm (100%)
- Hog plum (*Prunus umbellata*; 100%)
- Chinese privet (75%)

#### **Vines**

- Virginia creeper (*Parthenocissus quinquefolia*; 100%)

#### **Herbs/Forbs/Graminoids**

- Blackseed speargrass (*Piptochaetium avenaceum*; 100%)
- Nodding fescue (*Festuca subverticillata*; 100%)
- Hairy lipfern (*Myriopteris lanosa*; 100%)
- Stone Mountain mint (100%)
- Smooth spiderwort/bluejacket (*Tradescantia ohiensis*; 100%)

#### **Woody Stem Metrics**

Total basal area (BA) of trees ranged from 11.7 to 14.5 m<sup>2</sup>/ha with an overall average of 12.5 m<sup>2</sup>/ha; density of canopy stems ranged from 14 to 21 per plot, with an average of 16.5 (Table 4). Canopy height ranged from nine to 15 meters (average = 11.0), and canopy cover ranged from 54 to 78% (average = 61.4%; Table 4). The most dominant canopy species included northern red oak (*Quercus rubra*; mean BA = 2.77 m<sup>2</sup>/ha, mean density = 75/ha), winged elm (mean BA = 2.20 m<sup>2</sup>/ha, mean density = 100/ha), eastern red-cedar (mean BA = 2.02 m<sup>2</sup>/ha, mean density = 44/ha), chestnut oak (*Quercus montana*; mean BA = 1.95 m<sup>2</sup>/ha, mean density = 38/ha), and pignut hickory (*Carya glabra*; mean BA 1.58 m<sup>2</sup>/ha, mean density = 63/ha) (Appendix B, Table B-2). Sapling density at the 80-meter square scale ranged from 22 to 39 stems, with an average of 27.5, while seedling density at the 8-meter square scale ranged from 14 to 27 stems, with an average of 23.3 across all plots (Table 4). Dominant sapling species included white fringe-tree, rusty blackhaw (*Viburnum rufidulum*), sand hickory (*Carya pallida*), Chinese privet, and pignut hickory; dominant seedlings Chinese privet, Virginia creeper, wafer-ash, winged elm, and pignut hickory (Appendix B, Table B-2).

**Table 4.** Woody stem abundance and canopy metrics on Southeast Coast Network vegetation plots located in Kennesaw Mountain National Battlefield Park [m—meters; ha—hectares].

| Broadly Defined Habitat                | Plot               | Tree Basal Area (m <sup>2</sup> /ha) | Tree Density (400 m <sup>2</sup> ) | Sapling Basal Area (m <sup>2</sup> /ha) | Sapling Density (80 m <sup>2</sup> ) | Seedling Density (8 m <sup>2</sup> ) | Mean Canopy Cover (%) | Mean Height (m) |
|----------------------------------------|--------------------|--------------------------------------|------------------------------------|-----------------------------------------|--------------------------------------|--------------------------------------|-----------------------|-----------------|
| Piedmont Upland Forests and Shrublands | KEMO002            | 21.6                                 | 13.0                               | 8.0                                     | 5.0                                  | 34.0                                 | 83.8                  | 29.3            |
|                                        | KEMO003            | 35.7                                 | 14.0                               | 24.4                                    | 15.0                                 | 98.0                                 | 82.3                  | 43.0            |
|                                        | KEMO004            | 46.4                                 | 22.0                               | 11.3                                    | 5.0                                  | 49.0                                 | 77.1                  | 34.0            |
|                                        | KEMO005            | 10.7                                 | 7.0                                | 29.2                                    | 10.0                                 | 203.0                                | 77.6                  | 39.0            |
|                                        | KEMO006            | 43.0                                 | 21.0                               | 17.1                                    | 9.0                                  | 108.0                                | 75.5                  | 47.0            |
|                                        | KEMO007            | 34.9                                 | 14.0                               | 6.3                                     | 6.0                                  | 68.0                                 | 70.5                  | 36.0            |
|                                        | KEMO008            | 24.5                                 | 37.0                               | 30.0                                    | 21.0                                 | 225.0                                | 78.8                  | 31.0            |
|                                        | KEMO009            | 40.0                                 | 13.0                               | 2.7                                     | 5.0                                  | 13.0                                 | 83.8                  | 33.0            |
|                                        | KEMO011            | 28.0                                 | 12.0                               | 7.7                                     | 4.0                                  | 137.0                                | 70.1                  | 44.0            |
|                                        | KEMO012            | 45.2                                 | 8.0                                | 7.5                                     | 14.0                                 | 113.0                                | 65.8                  | 38.0            |
|                                        | average            | 33.0                                 | 16.1                               | 14.4                                    | 9.4                                  | 104.8                                | 76.5                  | 37.4            |
|                                        | standard deviation | 11.6                                 | 8.7                                | 10.1                                    | 5.6                                  | 69.2                                 | 6.1                   | 5.9             |
| Piedmont Open Uplands and Woodlands    | KEMO113            | 14.5                                 | 17.0                               | 10.1                                    | 24.0                                 | 27.0                                 | 78.4                  | 15.0            |
|                                        | KEMO114            | 11.8                                 | 21.0                               | 14.7                                    | 22.0                                 | 14.0                                 | 53.8                  | 9.0             |
|                                        | KEMO115            | 12.0                                 | 14.0                               | 63.4                                    | 39.0                                 | 27.0                                 | 58.1                  | 10.0            |
|                                        | KEMO116            | 11.7                                 | 14.0                               | 14.1                                    | 25.0                                 | 25.0                                 | 55.3                  | 10.0            |
|                                        | average            | 12.5                                 | 16.5                               | 25.6                                    | 27.5                                 | 23.3                                 | 61.4                  | 11.0            |
|                                        | standard deviation | 1.2                                  | 2.9                                | 21.9                                    | 6.7                                  | 5.4                                  | 10.0                  | 2.3             |

Based on stem count (density) alone, oaks (northern red, chestnut, and post [*Quercus stellata*]) and winged elm comprised over 50% of the relative abundance among species within the tree stratum, while hickories comprised 17% (Figure 4). The sapling stratum was dominated by wafer-ash, while the seedling stratum was dominated by Chinese privet and wafer-ash (Figure 4).

Most of the measured trees in these monitoring plots were living (88%) and just over 50% were categorized with healthy vigor (Figure 5). Of the nine trees that were dead within these plots, five were hickories. Due to edaphic factors which can promote extreme drought conditions and prevent root expansion because of the density of rock outcrops, these mortality rates are not unexpected, nor are the high rates of declining vigor and increased dieback (Table 5). Many plants growing in xeric soil conditions utilize adaptations that prevent water loss, such as leaf curling—a feature that may mimic dieback. Finally, there were 11 stems of tree-sized white ash measured within these plots; two of which were dead and half of the living trees exhibited declining vigor and die back.

As of this writing, emerald ash borer (*Agrilus planipennis*) has expanded its range to many northern Georgia counties, including Cobb (USDA 2023b). The emerald ash borer is a wood-boring pest of ash (*Fraxinus* sp.) native to Asia. Since its discovery in the U.S. in the early 2000s, the insect has been responsible for the death of tens of millions of ash trees in the eastern and midwestern parts of the country. At this time, it is not certain whether the declining health of ash within Kennesaw Mountain National Battlefield Park is due to emerald ash borer, edaphic factors that are responsible for natural mortality and decline, or other factors.

Forests within this broad habitat of the park were characterized by an uneven-age structure, with multiple size-classes of woody stems present across the canopy and subcanopy. Half the trees measured in these plots were directly below the canopy (~intermediate crown class), while about one-third of the trees made up the forest canopy (~co-dominant crown class), and 12% were completely overtopped (Figure 5).

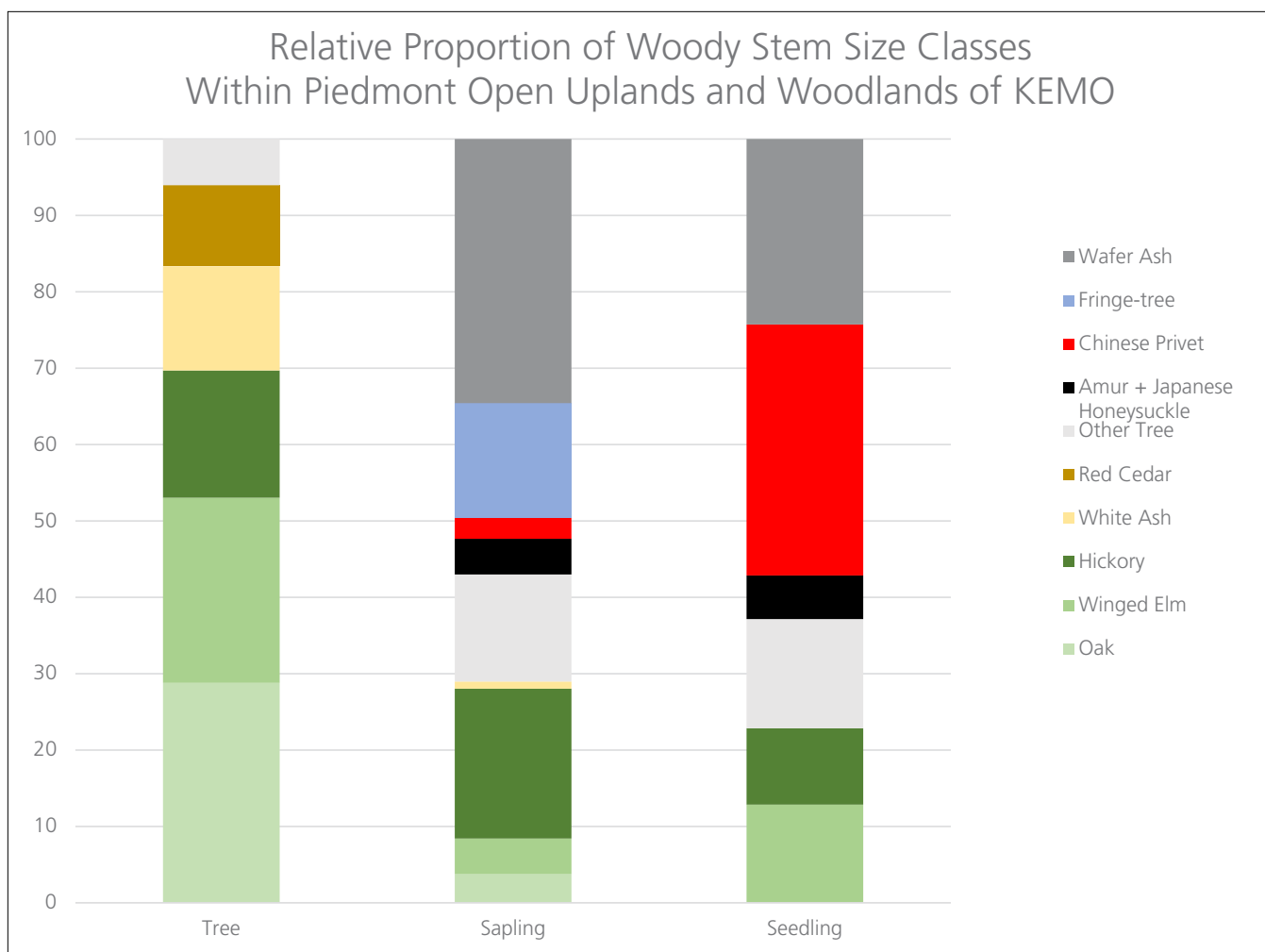


**Figure 4.** Relative proportion of species groups across three woody stem strata—trees, saplings, and seedlings— within Piedmont Open Upland and Woodland monitoring plots of Kennesaw Mountain National Battlefield Park.

# Health Condition of Trees Observed in Piedmont Open Uplands and Woodlands of KEMO

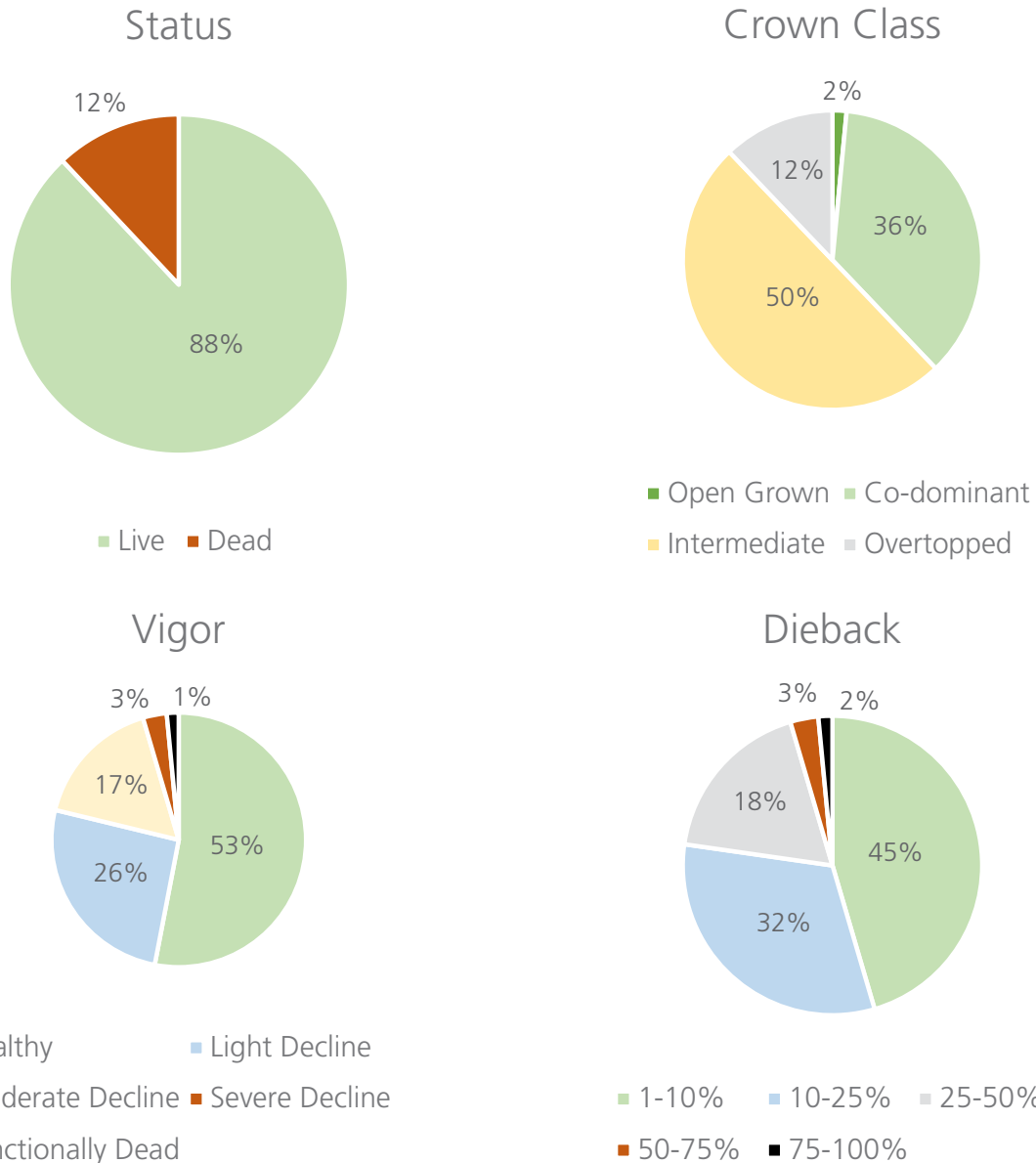


**Figure 5.** Health status of woody stems greater than or equal to 10 centimeters (3.9 in) DBH (“trees”) measured on Piedmont Open Upland and Woodland monitoring plots of Kennesaw Mountain National Battlefield Park.

**Table 5.** Disturbance observations and abundance (%cover) measured on vegetation monitoring plots of Kennesaw Mountain National Battlefield Park.

| Broadly Defined Habitat                | Plot    | Heavy Deer Browse | Heavy Trash/Social Trail | Historical Agriculture |
|----------------------------------------|---------|-------------------|--------------------------|------------------------|
| Piedmont Upland Forests and Shrublands | KEMO002 | –                 | –                        | –                      |
|                                        | KEMO003 | 100               | –                        | –                      |
|                                        | KEMO004 | 100               | –                        | –                      |
|                                        | KEMO005 | –                 | –                        | 40                     |
|                                        | KEMO006 | –                 | –                        | –                      |
|                                        | KEMO007 | –                 | –                        | –                      |
|                                        | KEMO008 | 80                | –                        | 100                    |
|                                        | KEMO009 | 100               | –                        | –                      |
|                                        | KEMO011 | 100               | –                        | 50                     |
|                                        | KEMO012 | –                 | –                        | –                      |
|                                        | KEMO113 | –                 | 20                       | –                      |
|                                        | KEMO114 | –                 | –                        | –                      |
| Piedmont Open Uplands and Woodlands    | KEMO115 | –                 | 10                       | –                      |
|                                        | KEMO116 | –                 | –                        | –                      |

### *Disturbance and Threats*

The most obvious anthropogenic disturbance to this broad habitat type based on observations from these plots was related to human encroachment. Two of the four plots were overrun with trash or were intermixed with social trails (Table 5). These types of disturbances are often found in adjacent granite outcrop communities across Georgia (Murdy and Carter 2000). Human impact trampling can erode these already thin soils, further minimizing the available substrate area where plants can grow.

As noted above, Open Upland and Woodland sites within Kennesaw Mountain National Battlefield Park were frequently dominated by non-native, invasive plant species (e.g., Chinese privet). Human trampling of native vegetation and the creation of social trails can intensify pathways for further invasion of these undesirable species. For more information about invasive plants within the park, see the “Disturbance and Threats”

section under the “Piedmont Upland Forests and Shrublands” description below.

### *Geomorphology and Soil*

Plots of Piedmont Open Uplands and Woodlands within Kennesaw Mountain National Battlefield Park were located on upper slopes of Kennesaw and Little Kennesaw Mountains. Slopes of these sites ranged from 17 to 26.5°; two plots were located on northern-facing aspects (KEMO114 and KEMO115) and two plots were located on southern-facing aspects (KEMO113 and KEMO116; Table 6). Nutrient analysis of soil samples collected from these plots indicated pH ranges from 4.7 to 5.4 (strongly to moderately acidic; Table 7). However, there were probably localized bands of substrate (e.g., amphibolite) responsible for creating more mafic conditions in other zones within the plot—hence the combination of acidic and mafic vegetation within these sites.

**Table 6.** Local landform and hydrologic condition from vegetation monitoring plots at Kennesaw Mountain National Battlefield Park.

| <b>Broadly Defined Habitat</b>         | <b>Plot</b> | <b>Slope (°)</b> | <b>Aspect (°)</b> | <b>TSI<sup>1</sup> (°)</b> | <b>Landform Type</b> | <b>Water Source</b> | <b>Submerged (%)</b> |
|----------------------------------------|-------------|------------------|-------------------|----------------------------|----------------------|---------------------|----------------------|
| Piedmont Upland Forests and Shrublands | KEMO002     | 8.5              | 45                | -0.250                     | side slope           | None                | 0                    |
|                                        | KEMO003     | 11.5             | 135               | -1.125                     | side slope           | None                | 0                    |
|                                        | KEMO004     | 3.0              | 315               | 0.000                      | side slope           | None                | 0                    |
|                                        | KEMO005     | 4.5              | 0                 | 1.250                      | side slope           | None                | 0                    |
|                                        | KEMO006     | 8.0              | 225               | 1.500                      | side slope           | None                | 0                    |
|                                        | KEMO007     | 5.5              | 45                | -2.125                     | side slope           | None                | 0                    |
|                                        | KEMO008     | 6.0              | 135               | 2.625                      | gap/saddle           | None                | 0                    |
|                                        | KEMO009     | 12.0             | 315               | 2.000                      | slope bench          | None                | 0                    |
|                                        | KEMO011     | 4.0              | 0                 | 1.625                      | gap/saddle           | None                | 0                    |
|                                        | KEMO012     | 12.0             | 0                 | -1.625                     | side slope           | None                | 0                    |
|                                        | KEMO113     | 20.5             | 135               | -0.625                     | side slope           | None                | 0                    |
|                                        | KEMO114     | 26.5             | 315               | -0.500                     | side slope           | None                | 0                    |
| Piedmont Open Uplands and Woodlands    | KEMO115     | 23.0             | 315               | 0.750                      | side slope           | None                | 0                    |
|                                        | KEMO116     | 17.0             | 225               | 0.500                      | side slope           | None                | 0                    |

<sup>1</sup> Terrain Shape Index: the larger the value, the higher degree of microsite concavity; the lower the value, the higher degree of microsite convexity; "0" values indicate a completely flat shape.

**Table 7.** Soil nutrient status from vegetation monitoring plots at Kennesaw Mountain National Battlefield Park. The Mehlich III method was used to obtain volume of exchangeable cations and extractable minor elements within soil samples. Methods to obtain other soil chemistry metrics (e.g., total exchange capacity [TEC], pH, and organic matter content [OM]) can be found at [Brookside Laboratories, Inc](#) (BL 2023).

| Broadly Defined Habitat                      | Plot               | TEC<br>(ME/100g) | pH<br>H <sup>2</sup> O 1:1 | OM (%) | P <sup>1</sup> | Ca <sup>1</sup> | Mg <sup>1</sup> | K <sup>1</sup> | Na <sup>1</sup> | B <sup>1</sup> | Fe <sup>1</sup> | Mn <sup>1</sup> | Cu <sup>1</sup> | Zn <sup>1</sup> | Al <sup>1</sup> |
|----------------------------------------------|--------------------|------------------|----------------------------|--------|----------------|-----------------|-----------------|----------------|-----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Piedmont Upland<br>Forests and<br>Shrublands | KEMO002            | 4.65             | 4.80                       | 4.44   | 15.00          | 273.00          | 61.00           | 40.00          | 8.00            | 0.46           | 147.00          | 127.00          | 0.88            | 1.81            | 841.00          |
|                                              | KEMO003            | 11.01            | 4.90                       | 5.53   | 10.00          | 779.00          | 104.00          | 83.00          | 6.00            | 0.43           | 93.00           | 129.00          | 1.05            | 2.44            | 979.00          |
|                                              | KEMO004            | 6.25             | 4.40                       | 6.90   | 18.00          | 307.00          | 56.00           | 42.00          | 9.00            | 0.10           | 116.00          | 126.00          | 1.28            | 2.25            | 916.00          |
|                                              | KEMO005            | 5.12             | 5.10                       | 6.45   | 39.00          | 375.00          | 58.00           | 82.00          | 8.00            | 0.28           | 163.00          | 198.00          | 3.61            | 7.19            | 1,102.00        |
|                                              | KEMO006            | 4.78             | 4.50                       | 3.29   | 18.00          | 254.00          | 42.00           | 39.00          | 7.00            | 0.10           | 117.00          | 55.00           | 0.53            | 3.88            | 739.00          |
|                                              | KEMO007            | 10.05            | 4.30                       | 12.53  | 17.00          | 473.00          | 81.00           | 61.00          | 9.00            | 0.10           | 162.00          | 12.00           | 0.72            | 2.22            | 695.00          |
|                                              | KEMO008            | 3.13             | 4.40                       | 2.75   | 7.00           | 135.00          | 37.00           | 26.00          | 6.00            | 0.10           | 147.00          | 14.00           | 0.57            | 1.15            | 689.00          |
|                                              | KEMO009            | 5.72             | 4.80                       | 3.57   | 10.00          | 321.00          | 90.00           | 33.00          | 7.00            | 0.10           | 172.00          | 141.00          | 0.96            | 3.11            | 726.00          |
|                                              | KEMO011            | 4.86             | 5.00                       | 6.87   | 10.00          | 310.00          | 66.00           | 69.00          | 8.00            | 0.22           | 105.00          | 207.00          | 1.39            | 1.48            | 1,138.00        |
|                                              | KEMO012            | 11.59            | 6.20                       | 8.89   | 9.00           | 1453.00         | 249.00          | 89.00          | 7.00            | 0.64           | 83.00           | 303.00          | 2.22            | 2.88            | 647.00          |
|                                              | average            | 6.72             | 4.84                       | 6.12   | 15.30          | 468.00          | 84.40           | 56.40          | 7.50            | 0.25           | 130.50          | 131.20          | 1.32            | 2.84            | 847.20          |
|                                              | standard deviation | 3.01             | 0.55                       | 2.96   | 9.26           | 386.27          | 61.42           | 23.23          | 1.08            | 0.20           | 31.66           | 90.44           | 0.94            | 1.72            | 178.36          |
| Piedmont Open<br>Uplands and<br>Woodlands    | KEMO113            | 7.59             | 5.10                       | 4.93   | 24.00          | 638.00          | 59.00           | 50.00          | 10.00           | 0.24           | 100.00          | 81.00           | 0.60            | 2.75            | 1,166.00        |
|                                              | KEMO114            | 8.59             | 4.90                       | 5.00   | 26.00          | 617.00          | 65.00           | 80.00          | 16.00           | 0.10           | 102.00          | 76.00           | 0.50            | 3.40            | 979.00          |
|                                              | KEMO115            | 11.05            | 4.70                       | 5.69   | 56.00          | 656.00          | 114.00          | 99.00          | 11.00           | 0.21           | 136.00          | 102.00          | 1.13            | 2.09            | 1,316.00        |
|                                              | KEMO116            | 14.81            | 5.40                       | 6.75   | 19.00          | 1588.00         | 98.00           | 58.00          | 9.00            | 0.38           | 109.00          | 98.00           | 0.77            | 9.65            | 1,135.00        |
|                                              | average            | 10.51            | 5.03                       | 5.59   | 31.25          | 874.75          | 84.00           | 71.75          | 11.50           | 0.23           | 111.75          | 89.25           | 0.75            | 4.47            | 1,149.00        |
|                                              | standard deviation | 3.21             | 0.30                       | 0.84   | 16.76          | 475.77          | 26.34           | 22.16          | 3.11            | 0.12           | 16.62           | 12.69           | 0.28            | 3.49            | 138.17          |

<sup>1</sup>Anions (P: Phosphorous); Exchangeable Cations (Ca: Calcium, Mg: Magnesium, K: Potassium, Na: Sodium); Extractable Minors (B: Boron, Fe: Iron, Mn: Manganese, Cu: Copper, Zn: Zinc, Al: Aluminum). Data reported in parts per million (ppm).

## Piedmont Upland Forests and Shrublands

Piedmont Upland Forests and Shrublands of Kennesaw Mountain National Battlefield Park include early- to mid-successional mixed hardwood and pine forests located on dry slopes or ridge tops and more mesic forests located on lower slopes adjacent to alluvial habitats (McManamay 2015) (Figure 6). The canopy and subcanopy of these forests within the park are dominated by loblolly pine (*Pinus taeda*), tuliptree (*Liriodendron tulipifera* var. *tulipifera*), oaks, and hickories (McManamay 2015). Species composition and structure within these forests can be highly variable, and are largely dependent on soil moisture, available soil nutrients, and former land use. Mesophytic forests typically develop along lower slope positions, flatter topography, northeastern aspects, and where soil depths are higher. These forests are dominated by a diversity of hardwood species. Xeric forests are found on upper slopes and ridgetops where sunlight exposure and edaphic factors contribute to drier, often droughty, conditions. The canopy of these forests is often dominated by dry-site oaks (e.g., chestnut oak) and, when fire is frequent, shortleaf pine (*Pinus echinata*). The most commonly occurring natural upland Piedmont forest of Georgia are oak-hickory forests that occur on intermediate, submesic, or subxeric soils; these are the matrix forests that occur between the driest ridgetops and most mesic lower slopes (Edwards et al. 2013).

The Piedmont Upland Forest and Shrubland habitat type is the most dominant habitat within Kennesaw Mountain National Battlefield Park, occupying about 88% of the coverage of all natural vegetation types (McManamay 2015). Vegetation

associations sampled within the park that belong to this habitat type include (descriptions from NatureServe 2023):

- Piedmont Loblolly Pine – Oak Forest (CEGL004232; 2 plots): Semi-natural forests dominated by a mixture of loblolly pine and various oaks and other hardwoods; these forests develop on former timberland where loblolly pine was planted or abandoned agriculture fields and are abundant across the southern Piedmont and adjacent interior Coastal Plain of the United States. (Global Status: No Status Rank; State [GA] Status: No Status Rank)
- Ruderal Loblolly Pine / Sweetgum – Red Maple Forest (CEGL006011; 2 plots): Early- to mid-successional forests that develop on former sites utilized for agriculture or timber, that are typically dominated by loblolly pine; hardwoods could also co-dominate, such as sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), and a host of oaks and hickories. (Global Status: No Status Rank; State [GA] Status: No Status Rank)
- Piedmont Dry-Mesic Basic Oak – Hickory Forest (CEGL007232; 1 plot): Dry-mesic forests that develop on base-rich, well-drained soils of the Piedmont and typically associated with amphibolite and other mafic rocks; the canopy is often dominated by white oak (*Quercus alba*), often in a combination with other oaks and hickories; chalk maple (*Acer leucoderme*) is often an important understory component, and overall species diversity can be high when sites are not overgrazed by deer. (Global Status: G3—Vulnerable; State [GA] Status: No Status Rank)



**Figure 6.** Ten plots within Piedmont Uplands Forest and Shrubland habitat of Kennesaw Mountain National Battlefield Park were sampled. Plots were often co-dominated by a canopy of loblolly pine (*Pinus taeda*, left) or a mixture of oaks (*Quercus* sp.) and hickories (*Carya* sp., right). NPS photo / SECN staff.

- Subxeric Ridgetop Chestnut Oak Forest (CEGL008431; 3 plots): Forests of subxeric high slopes and ridges of the Cumberland Plateau, southern Ridge and Valley, Southern Blue Ridge, and Piedmont of the Carolinas and Georgia; these forests develop over rocky, shallow soils; the closed canopy is often dominated by chestnut oak, and occasionally co-dominated by scarlet oak (*Quercus coccinea*); the herbaceous layer is often sparse, or absent. (Global Status: G4—Apparently Secure; State [GA] Status: No Status Rank)
- Piedmont Dry-Mesic Acidic Oak – Hickory Forest (CEGL008475; 2 plots): Forests located on submesic to subxeric uplands with acidic, fairly nutrient poor soils and located throughout the Piedmont of the Southeastern U.S.; the canopies can be closed to somewhat open, and are dominated by a mixture of oaks and hickories; in disturbed stands, these forests can also be co-dominated by pines (e.g., loblolly pine), tuliptree, sweetgum, and red maple; these forests can be species rich, particularly in areas where deer populations are effectively controlled. (Global Status: G4—Apparently Secure; State [GA] Status: No Status Rank)

### ***Species Diversity and Abundance***

Native species richness ranged from 23 to 52 (mean = 34.1) within vegetation plots of this broadly defined habitat type, and all plots had at least one non-native species present (Table 3). Tree species exhibited the highest richness across all spatial scales within these plots, while vine richness was high in smaller nested depths (e.g., 10 m<sup>2</sup> and 1 m<sup>2</sup>; Table 3). Overall species richness was highest in KEMO003—classified as a Piedmont Dry-Mesic Basic Oak – Hickory Forest association. All 14 invasive plants found within the park during this monitoring effort were encountered in Piedmont Upland Forest and Shrubland plots, although not all species were observed in all 10 plots. Category 1 invasive plants that had high frequency of occurrence included Chinese privet (100% of the plots), Japanese honeysuckle (70%), and Japanese stiltgrass (60%; Appendix B, Table B-1). Native vascular plants observed in these plots are fairly common across the Southeastern Coastal Plain, and there were no state nor federally listed rare plants encountered. One-hundred twenty vascular plant species were found collectively within these 10 plots, and 77 of these were only found in this broadly defined habitat (Appendix B, Table B-1). A complete species list, along with constancy and average cover per species, is in Appendix B, Table B-1. Species with high constancy in this habitat are listed below, by growth form (constancy values in parentheses):

### **Trees**

- Loblolly pine (100%)
- Tuliptree (100%)
- Black cherry (100%)
- Chinese privet (100%)
- Sweetgum (90%)
- Common persimmon (*Diospyros virginiana*; 90%)
- Pignut hickory (80%)
- Flowering dogwood (*Benthamidia florida*; 80%)
- Winged elm (80%)

### **Vines**

- Muscadine (*Muscadinia rotundifolia* var. *rotundifolia*; 100%)
- Virginia creeper (100%)
- Eastern poison ivy (*Toxicodendron radicans* var. *radicans*; 100%)
- Cat greenbrier (*Smilax glauca*; 100%)
- Roundleaf greenbrier (*Smilax rotundifolia*; 80%)

### **Herbs/Forbs/Graminoids**

- Bursting-heart (*Euonymus americanus*; 80%)
- Variable panicgrass (*Dichanthelium commutatum*; 70%)

### ***Woody Stem Metrics***

Total basal area (BA) of trees ranged from 10.7 to 46.4 m<sup>2</sup>/ha with an overall average of 33.0 m<sup>2</sup>/ha; density of canopy stems ranged from seven to 37 per plot, with an average of 16.1 (Table 4). Canopy height ranged from 29 to 47 meters (average = 37.4), and canopy cover ranged from 66 to 84% (average = 76.5%; Table 4). The most dominant canopy species included loblolly pine (mean BA = 10.86 m<sup>2</sup>/ha, mean density = 78/ha), sweetgum (mean BA = 4.72 m<sup>2</sup>/ha, mean density = 125/ha), and tuliptree (mean BA = 4.53 m<sup>2</sup>/ha, mean density = 30/ha) (Appendix B, Table B-2). Sapling density at the 80-meter square scale was highly variable and ranged from four to 21 stems, with an average of 9.4, while seedling density at the 8-meter square scale ranged from 13 to 225 stems, with an average of 104.8 across all plots (Table 4). The most dominant

sapling species within these plots was Chinese privet; dominant seedlings included muscadine, sweetgum, loblolly pine, and Virginia creeper (Appendix B, Table B-2).

Based on stem count (density) alone, sweetgum and loblolly pine comprised about 50% of the relative abundance among species within the tree stratum; oaks constituted 18% of the relative abundance and hickories constituted 11% (Figure 7). The sapling stratum was heavily dominated by Chinese privet (28% of the relative abundance), while 40% of the abundance was composed of a mixture of species, including American holly (*Ilex opaca*), American beech (*Fagus grandifolia* var. *caroliniana*), white fringe-tree, and others (Figure 7). Sweetgum, loblolly pine, and woody vines dominated the seedling stratum (Figure 7).

Most of the measured trees in these monitoring plots were living (89%) and the majority were categorized with healthy vigor and minimal dieback (Figure 8). Of the 181 trees that were measured within these 10 plots, 20 were dead, and no single species represented a significant percentage of those that were dead. Forests within this broad habitat of the park were characterized by an uneven-age structure, with multiple size-classes of woody stems present across the canopy and subcanopy. About one-third of the trees measured in these plots made up the forest canopy (dominant or co-dominant), while 24% were of intermediate height class, and 48% were completely overtopped (Figure 8).

### ***Disturbance and Threats***

The most frequently encountered observable disturbance within these plots was related to impacts from heavy browse by white-tailed deer (*Odocoileus virginianus*; Table 5). Half the plots monitored had some form of impact from deer browse. Increases in white-tailed deer populations in the eastern United States are due to removal and loss of natural predators and land-use changes, and have had major impacts on the understory vegetation within eastern forested ecosystems. Research has documented the reduction of tree regeneration (e.g., seedlings, saplings) in forest stands of areas with high deer density (Boerner and Brinkman 1996; Russell et al. 2007). Long-term forest monitoring plots established by other National Park Service Inventory and Monitoring Networks in

the eastern United States have also documented the impact of abundant white-tailed deer populations on tree regeneration patterns and ground cover condition (Miller and McGill 2019; Schmit et al. 2020). The population density estimate of white-tailed deer from Cobb County, Georgia from 2001 to 2005 by the Quality Deer Management Association (QDMA) was between 30 to 40 deer per square mile (11.5 to 15.5 per square kilometer; Walters et al. 2016), which is higher than the threshold (> 8.5 square kilometer) proposed by Russell et al. (2001) for significant reduction in tree regeneration. Long-term monitoring of vegetation structure and composition within Kennesaw Mountain National Battlefield Park can be used to determine forest regeneration patterns as they relate to changes in browsing pressure.

Long-term monitoring will also provide a clearer picture of how non-native vegetation are impacting forest regeneration and the stability of native ground cover. The impacts of invasive species on native ecosystems and biodiversity are well-documented, and increased rates of habitat alteration and climate change are providing more opportunities for invasion (Vitousek et al. 1996; Chornesky and Randall 2003). Factors that facilitate pathways for invasion, such as increased density of roadways, land clearings, and urbanization (McNab and Loftis 2002; Christen and Matlack 2006) are a present and increasing reality for the landscape of Kennesaw Mountain National Battlefield Park. The historical legacy from agriculture can also be a factor that leads to the establishment and spread of invasive plants (Kuhman et al. 2011). Management efforts that target reduction of certain non-native species can lead to increased abundances of undesirable native species, other non-native species, or the targeted non-native species (see Royo and Carson 2006), which may have consequences on forest regeneration and ground cover diversity. It is difficult to predict how species will respond to both local-scale management efforts and landscape-scale changes (e.g., climate change). However, data from vegetation monitoring plots which track trends over time of non-native and native species abundance and forest regeneration patterns with regards to specific non-native control efforts can provide keen insight to park managers on the condition of their forest vegetation resources.

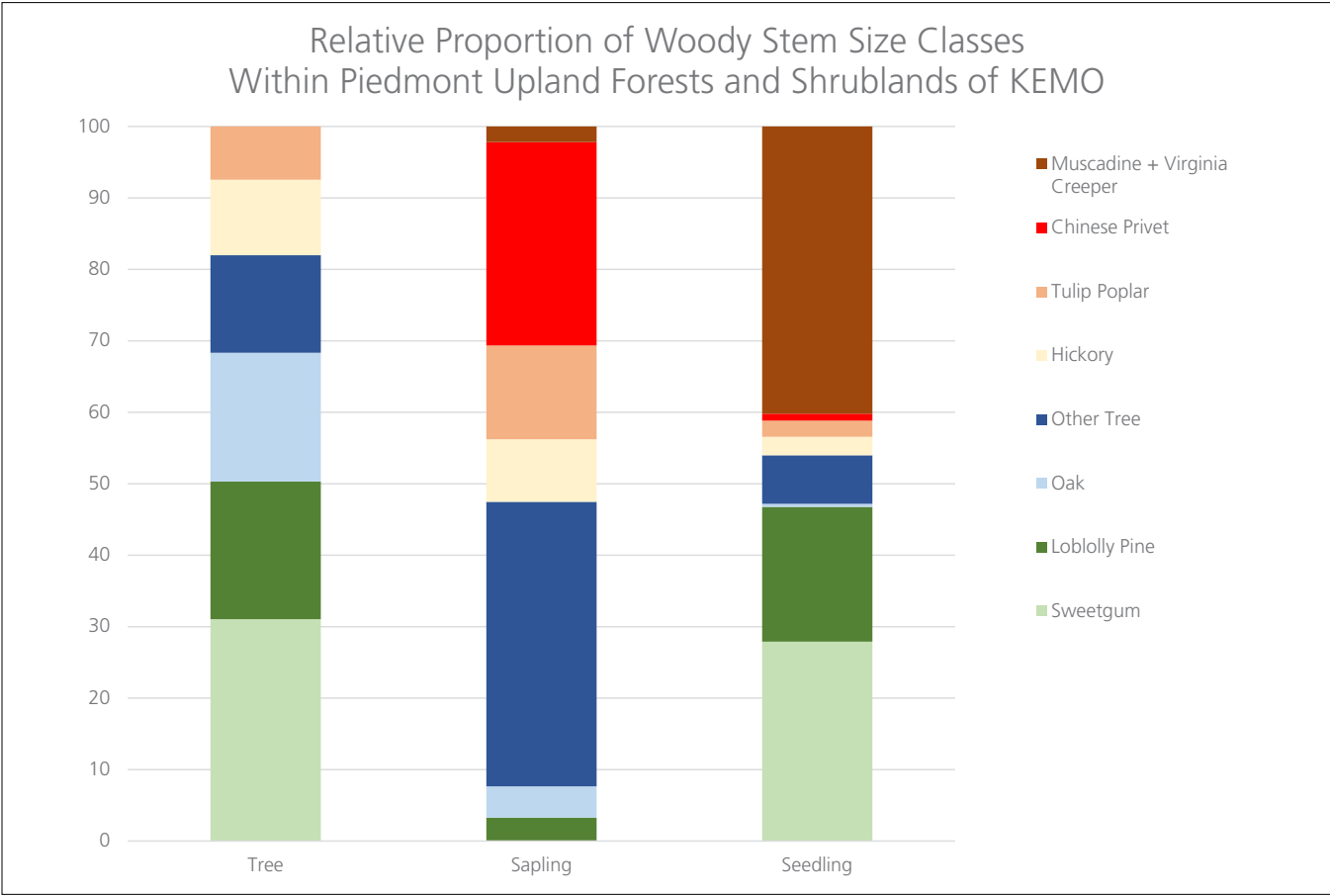


**Figure 7.** Relative proportion of species groups across three woody stem strata—trees, saplings, and seedlings— within Piedmont Upland Forest and Shrubland monitoring plots of Kennesaw Mountain National Battlefield Park.

# Health Condition of Trees Observed in Piedmont Upland Forests and Shrublands of KEMO

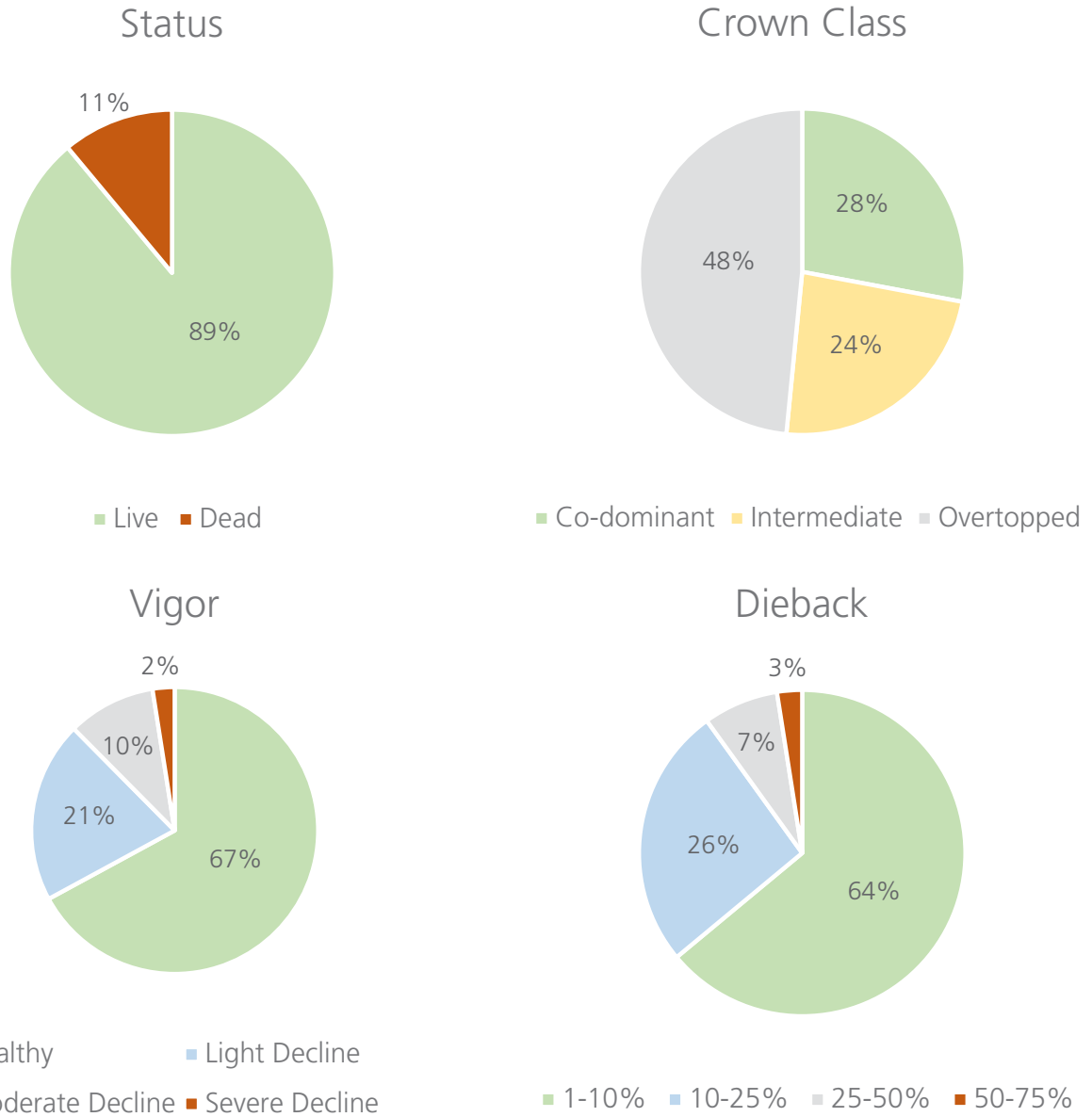


**Figure 8.** Health status of woody stems greater than or equal to 10 centimeters (3.9 in) DBH ("trees") measured on Piedmont Upland Forest and Shrubland monitoring plots of Kennesaw Mountain National Battlefield Park.

Another threat to upland vegetation communities within the Piedmont of Georgia is related to the exclusion of fire—a natural ecosystem-shaping disturbance event. In the Piedmont, fire has been critical in the creation of montane longleaf pine woodlands, xeric pine and pine-oak woodlands, and Piedmont prairies; furthermore, fire promoted oaks and pines on sites of intermediate moisture regime (Edwards et al. 2013). Prior to European settlement, the Piedmont of Georgia was dominated by tree species that either required fire for regeneration or were tolerant of fire (Cowell 1995). Although natural fire compartments were likely smaller in the Piedmont than in the neighboring Coastal Plain where there were large distances between natural fire breaks (e.g. floodplains), fires ignited both naturally (e.g., lightning) and by Native Americans still impacted the landscape, creating a mosaic patchwork of forested systems composed of fire-adapted and fire-intolerant (i.e., mesophytic) species. Fire exclusion over the past century has resulted in the decline in quality and extent of pine-oak woodlands and oak-hickory forests within Georgia's Piedmont (Edwards et al. 2013). Use of fire as a tool to restore these sites is often challenging due to the proximity of roads, houses, shopping centers, and other urban features. Fire events raise public concern about air quality, reduced visibility on highways (e.g., smoke management), and structure damage. These challenges are very apparent at Kennesaw Mountain National Battlefield Park. Historically, the park's drier ridgetops and gentle slopes undoubtedly supported fire-adapted ecosystems. Without fire, or other fire surrogate treatments, these forests likely will become dominated by a higher frequency of mesophytic, fire-intolerant hardwoods (e.g., red maple, tuliptree, sweetgum).

### ***Geomorphology and Soil***

Plots located within Piedmont Upland Forests and Shrublands of Kennesaw Mountain National Battlefield Park occurred across a wide range of slopes, aspects, and terrain shapes (Table 6). The soils collected from these plots were acidic (average pH = 4.8) and had low cation content (Total Exchange Capacity [TEC] = 6.72; Table 7).

### **Fuel Load Estimates**

Fuel loads ranged from 7.5 to 26.1 tons/acre (1.7 to 5.9 kg/m<sup>2</sup>) within vegetation plots of Kennesaw Mountain National Battlefield Park (Figure 9). There was high variability between fuel loads among vegetation plots in the park. Variation in fuel loads among sites is typical and related to differences in live and dead vegetation structure, disturbance history, hydrology, and edaphic conditions. Coarse woody debris (1000-hour fuels), duff, and litter contributed to most of the fuel loads within both Piedmont Open Upland and Woodland plots and in Piedmont Upland Forest and Shrubland plots (Figure 9).

# Kennesaw Mountain National Battlefield Site Locations

Southeast Coast Network  
National Park Service  
U.S. Department of the Interior

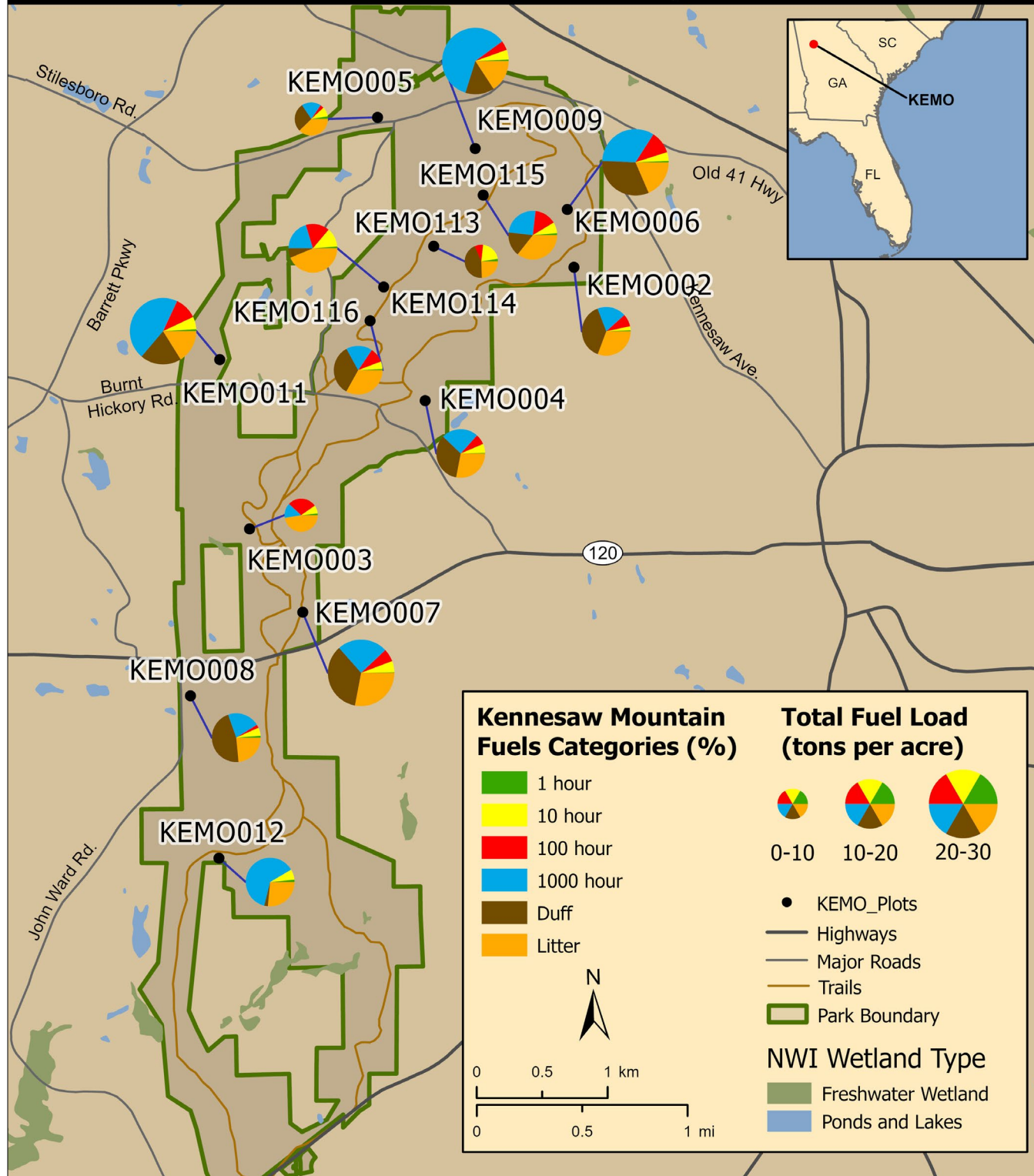


**Figure 9.** Fuel load estimates from vegetation monitoring plots located at Kennesaw Mountain National Battlefield Park.

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## **Appendix A. Vascular Plants Observed During the 2021 Southeast Coast Network Terrestrial Vegetation Monitoring Effort at Kennesaw Mountain National Battlefield Park**

**Table A-1.** Vascular plant species present in 14 vegetation monitoring plots within Kennesaw Mountain National Battlefield Park, July–August 2021.

| Order <sup>1</sup> | Family <sup>1</sup> | Scientific Name                                     | Common Name <sup>1</sup>   | Native Status <sup>1</sup> | Growth Form <sup>1</sup> | State Invasive Status <sup>2</sup> | Georgia Rare-Protected Status <sup>3</sup> |
|--------------------|---------------------|-----------------------------------------------------|----------------------------|----------------------------|--------------------------|------------------------------------|--------------------------------------------|
| Euphorbiales       | Euphorbiaceae       | <i>Acalypha rhomboidea</i>                          | common threeseed mercury   | Native                     | Forb/herb                | –                                  | –                                          |
| Euphorbiales       | Euphorbiaceae       | <i>Acalypha virginica</i>                           | Virginia threeseed mercury | Native                     | Forb/herb                | –                                  | –                                          |
| Sapindales         | Aceraceae           | <i>Acer rubrum</i>                                  | red maple                  | Native                     | Tree                     | –                                  | –                                          |
| Sapindales         | Hippocastanaceae    | <i>Aesculus sylvatica</i>                           | painted buckeye            | Native                     | Tree, Shrub              | –                                  | –                                          |
| Rosales            | Rosaceae            | <i>Agrimonia rostellata</i>                         | beaked agrimony            | Native                     | Forb/herb                | –                                  | –                                          |
| Fabales            | Fabaceae            | <i>Albizia julibrissin</i>                          | silk tree                  | Non-native                 | Shrub, Tree              | Category 1                         | –                                          |
| Asterales          | Asteraceae          | <i>Ambrosia artemisiifolia</i>                      | annual ragweed             | Native                     | Forb/herb                | –                                  | –                                          |
| Fabales            | Fabaceae            | <i>Amorpha fruticosa</i>                            | false indigo bush          | Native                     | Shrub                    | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Andropogon gerardi</i>                           | big bluestem               | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Andropogon gyrans</i>                            | Elliott's bluestem         | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Andropogon ternarius</i>                         | splitbeard bluestem        | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Andropogon virginicus</i> var. <i>virginicus</i> | broomsedge                 | Native                     | Graminoid                | –                                  | –                                          |
| Ranunculales       | Ranunculaceae       | <i>Anemone virginiana</i> var. <i>virginiana</i>    | tall thimbleweed           | Native                     | Forb/herb                | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Antennaria plantaginifolia</i>                   | woman's tobacco            | Native                     | Forb/herb                | –                                  | –                                          |
| Gentianales        | Apocynaceae         | <i>Apocynum cannabinum</i>                          | Indian hemp                | Native                     | Forb/herb                | –                                  | –                                          |
| Arales             | Araceae             | <i>Arisaema pusillum</i>                            | Jack in the pulpit         | Native                     | Forb/herb                | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Arnoglossum atriplicifolium</i>                  | pale Indian plantain       | Native                     | Forb/herb                | –                                  | –                                          |
| Magnoliales        | Annonaceae          | <i>Asimina parviflora</i>                           | smallflower pawpaw         | Native                     | Tree, Shrub              | –                                  | –                                          |
| Polypodiales       | Aspleniaceae        | <i>Asplenium platyneuron</i>                        | ebony spleenwort           | Native                     | Forb/herb                | –                                  | –                                          |
| Cornales           | Cornaceae           | <i>Benthamidia florida</i>                          | flowering dogwood          | Native                     | Tree, Shrub              | –                                  | –                                          |
| Scrophulariales    | Bignoniaceae        | <i>Bignonia capreolata</i>                          | crossvine                  | Native                     | Vine                     | –                                  | –                                          |
| Capparales         | Brassicaceae        | <i>Boechera missouriensis</i>                       | green rockcress            | Native                     | Forb/herb                | –                                  | S2                                         |
| Ophioglossales     | Ophioglossaceae     | <i>Botrypus virginianus</i>                         | rattlesnake fern           | Native                     | Forb/herb                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Brachyelytrum erectum</i>                        | bearded shorthusk          | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Bromus pubescens</i>                             | hairy woodland brome       | Native                     | Graminoid                | –                                  | –                                          |
| Laurales           | Calycanthaceae      | <i>Calycanthus floridus</i>                         | eastern sweetshrub         | Native                     | Shrub                    | –                                  | –                                          |
| Scrophulariales    | Bignoniaceae        | <i>Campsis radicans</i>                             | trumpet creeper            | Native                     | Vine                     | –                                  | –                                          |
| Cyperales          | Cyperaceae          | <i>Carex</i>                                        | sedge                      | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Cyperaceae          | <i>Carex cephalophora</i>                           | oval-leaf sedge            | Native                     | Graminoid                | –                                  | –                                          |

<sup>1</sup> Information obtained from the PLANTS database (USDA 2023a)<sup>2</sup> Information obtained from the Georgia Exotic Pest Plant Council (GAEPPC 2023)<sup>3</sup> Information obtained from the Georgia Department of Natural Resources (GADNR 2023)

**Table A-1 (continued).** Vascular plant species present in 14 vegetation monitoring plots within Kennesaw Mountain National Battlefield Park, July–August 2021.

| Order <sup>1</sup> | Family <sup>1</sup> | Scientific Name                                        | Common Name <sup>1</sup> | Native Status <sup>1</sup> | Growth Form <sup>1</sup> | State Invasive Status <sup>2</sup> | Georgia Rare-Protected Status <sup>3</sup> |
|--------------------|---------------------|--------------------------------------------------------|--------------------------|----------------------------|--------------------------|------------------------------------|--------------------------------------------|
| Cyperales          | Cyperaceae          | <i>Carex digitalis</i>                                 | slender woodland sedge   | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Cyperaceae          | <i>Carex nigromarginata</i>                            | black edge sedge         | Native                     | Graminoid                | –                                  | –                                          |
| Fagales            | Betulaceae          | <i>Carpinus caroliniana</i>                            | American hornbeam        | Native                     | Shrub, Tree              | –                                  | –                                          |
| Juglandales        | Juglandaceae        | <i>Carya glabra</i>                                    | pignut hickory           | Native                     | Tree                     | –                                  | –                                          |
| Juglandales        | Juglandaceae        | <i>Carya ovalis</i>                                    | red hickory              | Native                     | Tree                     | –                                  | –                                          |
| Juglandales        | Juglandaceae        | <i>Carya pallida</i>                                   | sand hickory             | Native                     | Tree                     | –                                  | –                                          |
| Juglandales        | Juglandaceae        | <i>Carya tomentosa</i>                                 | mockernut hickory        | Native                     | Tree                     | –                                  | –                                          |
| Fagales            | Fagaceae            | <i>Castanea dentata</i>                                | American chestnut        | Native                     | Tree                     | –                                  | –                                          |
| Urticales          | Ulmaceae            | <i>Celtis laevigata</i>                                | sugarberry               | Native                     | Tree, Shrub              | –                                  | –                                          |
| Urticales          | Ulmaceae            | <i>Celtis occidentalis</i>                             | common hackberry         | Native                     | Tree, Shrub              | –                                  | –                                          |
| Urticales          | Ulmaceae            | <i>Celtis pumila</i>                                   | dwarf hackberry          | Native                     | Tree, Shrub              | –                                  | –                                          |
| Fabales            | Fabaceae            | <i>Centrosema virginianum</i>                          | spurred butterfly pea    | Native                     | Vine, Forb/herb          | –                                  | –                                          |
| Fabales            | Fabaceae            | <i>Cercis canadensis</i>                               | eastern redbud           | Native                     | Tree, Shrub              | –                                  | –                                          |
| Ericales           | Pyrolaceae          | <i>Chimaphila maculata</i>                             | striped prince's pine    | Native                     | Subshrub                 | –                                  | –                                          |
| Scrophulariales    | Oleaceae            | <i>Chionanthus virginicus</i>                          | white fringetree         | Native                     | Tree, Shrub              | –                                  | –                                          |
| Fabales            | Fabaceae            | <i>Clitoria mariana</i> var. <i>mariana</i>            | Atlantic pigeonwings     | Native                     | Vine, Forb/herb          | –                                  | –                                          |
| Ranunculales       | Menispermaceae      | <i>Cocculus carolinus</i>                              | Carolina coralbead       | Native                     | Vine                     | –                                  | –                                          |
| Commelinales       | Commelinaceae       | <i>Commelina diffusa</i>                               | climbing dayflower       | Native                     | Forb/herb                | –                                  | –                                          |
| Rosales            | Rosaceae            | <i>Crataegus macrosperma</i>                           | bigfruit hawthorn        | Native                     | Tree, Shrub              | –                                  | –                                          |
| Euphorbiales       | Euphorbiaceae       | <i>Croton willdenowii</i>                              | Michaux's croton         | Native                     | Forb/herb                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Danthonia spicata</i>                               | poverty oatgrass         | Native                     | Graminoid                | –                                  | –                                          |
| Fabales            | Fabaceae            | <i>Desmodium rotundifolium</i>                         | prostrate ticktrefoil    | Native                     | Forb/herb                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Dichanthelium</i>                                   | rosette grass            | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Dichanthelium acuminatum</i>                        | tapered rosette grass    | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Dichanthelium boscii</i>                            | Bosc's panicgrass        | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Dichanthelium commutatum</i>                        | variable panicgrass      | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Dichanthelium depauperatum</i>                      | starved panicgrass       | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Dichanthelium dichotomum</i> var. <i>dichotomum</i> | cypress panicgrass       | Native                     | Graminoid                | –                                  | –                                          |

<sup>1</sup> Information obtained from the PLANTS database (USDA 2023a)<sup>2</sup> Information obtained from the Georgia Exotic Pest Plant Council (GAEPPC 2023)<sup>3</sup> Information obtained from the Georgia Department of Natural Resources (GADNR 2023)

**Table A-1 (continued).** Vascular plant species present in 14 vegetation monitoring plots within Kennesaw Mountain National Battlefield Park, July–August 2021.

| Order <sup>1</sup> | Family <sup>1</sup> | Scientific Name                                           | Common Name <sup>1</sup>   | Native Status <sup>1</sup> | Growth Form <sup>1</sup> | State Invasive Status <sup>2</sup> | Georgia Rare-Protected Status <sup>3</sup> |
|--------------------|---------------------|-----------------------------------------------------------|----------------------------|----------------------------|--------------------------|------------------------------------|--------------------------------------------|
| Cyperales          | Poaceae             | <i>Dichanthelium sphaerocarpon</i>                        | roundseed panicgrass       | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Digitaria sanguinalis</i>                              | hairy crabgrass            | Non-native                 | Graminoid                | –                                  | –                                          |
| Liliales           | Dioscoreaceae       | <i>Dioscorea villosa</i>                                  | wild yam                   | Native                     | Forb/herb, Vine          | –                                  | –                                          |
| Ebenales           | Ebenaceae           | <i>Diospyros virginiana</i>                               | common persimmon           | Native                     | Tree                     | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Eclipta prostrata</i>                                  | false daisy                | Native                     | Forb/herb                | –                                  | –                                          |
| Rhamnales          | Elaeagnaceae        | <i>Elaeagnus umbellata</i>                                | autumn olive               | Non-native                 | Shrub                    | Category 1                         | –                                          |
| Cyperales          | Poaceae             | <i>Elymus villosus</i> var. <i>villosus</i>               | hairy wildrye              | Native                     | Graminoid                | –                                  | –                                          |
| Aristolochiales    | Aristolochiaceae    | <i>Endodeca serpentaria</i>                               | Virginia snakeroot         | Native                     | Forb/herb                | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Erechtites hieraciifolius</i>                          | American burnweed          | Native                     | Forb/herb                | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Erigeron philadelphicus</i> var. <i>philadelphicus</i> | Philadelphia fleabane      | Native                     | Forb/herb                | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Erigeron strigosus</i> var. <i>strigosus</i>           | prairie fleabane           | Native                     | Forb/herb                | –                                  | –                                          |
| Celastrales        | Celastraceae        | <i>Euonymus americanus</i>                                | bursting-heart             | Native                     | Forb/herb, Subshrub      | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Eupatorium capillifolium</i>                           | dogfennel                  | Native                     | Forb/herb                | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Eupatorium serotinum</i>                               | lateflowering thoroughwort | Native                     | Forb/herb                | –                                  | –                                          |
| Euphorbiales       | Euphorbiaceae       | <i>Euphorbia pubentissima</i>                             | false flowering spurge     | Native                     | Forb/herb                | –                                  | –                                          |
| Fagales            | Fagaceae            | <i>Fagus grandifolia</i> var. <i>caroliniana</i>          | American beech             | Native                     | Tree                     | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Festuca octoflora</i>                                  | sixweeks fescue            | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Festuca subverticillata</i>                            | nodding fescue             | Native                     | Graminoid                | –                                  | –                                          |
| Scrophulariales    | Oleaceae            | <i>Fraxinus biltmoreana</i>                               | white ash                  | Native                     | Tree                     | –                                  | –                                          |
| Fabales            | Fabaceae            | <i>Galactia regularis</i>                                 | eastern milkpea            | Native                     | Forb/herb, Vine          | –                                  | –                                          |
| Rubiales           | Rubiaceae           | <i>Galium circaezans</i>                                  | licorice bedstraw          | Native                     | Forb/herb                | –                                  | –                                          |
| Rubiales           | Rubiaceae           | <i>Galium obtusum</i> var. <i>filifolium</i>              | bluntleaf bedstraw         | Native                     | Forb/herb                | –                                  | –                                          |
| Rubiales           | Rubiaceae           | <i>Galium pilosum</i>                                     | hairy bedstraw             | Native                     | Forb/herb                | –                                  | –                                          |
| Rubiales           | Rubiaceae           | <i>Galium triflorum</i>                                   | fragrant bedstraw          | Native                     | Vine, Forb/herb          | –                                  | –                                          |
| Orchidales         | Orchidaceae         | <i>Goodyera pubescens</i>                                 | downy rattlesnake plantain | Native                     | Forb/herb                | –                                  | –                                          |
| Rosales            | Saxifragaceae       | <i>Heuchera americana</i>                                 | American alumroot          | Native                     | Forb/herb                | –                                  | –                                          |
| Aristolochiales    | Aristolochiaceae    | <i>Hexastylis arifolia</i>                                | littlebrownjug             | Native                     | Forb/herb                | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Hieracium gronovii</i>                                 | queendevil                 | Native                     | Forb/herb                | –                                  | –                                          |
| Rubiales           | Rubiaceae           | <i>Houstonia purpurea</i>                                 | Venus' pride               | Native                     | Forb/herb                | –                                  | –                                          |

<sup>1</sup> Information obtained from the PLANTS database (USDA 2023a)<sup>2</sup> Information obtained from the Georgia Exotic Pest Plant Council (GAEPPC 2023)<sup>3</sup> Information obtained from the Georgia Department of Natural Resources (GADNR 2023)

**Table A-1 (continued).** Vascular plant species present in 14 vegetation monitoring plots within Kennesaw Mountain National Battlefield Park, July–August 2021.

| Order <sup>1</sup> | Family <sup>1</sup> | Scientific Name                                       | Common Name <sup>1</sup> | Native Status <sup>1</sup> | Growth Form <sup>1</sup> | State Invasive Status <sup>2</sup> | Georgia Rare-Protected Status <sup>3</sup> |
|--------------------|---------------------|-------------------------------------------------------|--------------------------|----------------------------|--------------------------|------------------------------------|--------------------------------------------|
| Rosales            | Hydrangeaceae       | <i>Hydrangea barbara</i>                              | woodvamp                 | Native                     | Vine                     | –                                  | –                                          |
| Fabales            | Fabaceae            | <i>Hylodesmum nudiflorum</i>                          | nakedflower ticktrefoil  | Native                     | Forb/herb                | –                                  | –                                          |
| Theales            | Clusiaceae          | <i>Hypericum stragulum</i>                            | St. Andrew's cross       | Native                     | Shrub, Subshrub          | –                                  | –                                          |
| Celastrales        | Aquifoliaceae       | <i>Ilex cornuta</i>                                   | Chinese holly            | Non-native                 | Shrub, Tree              | Category 4                         | –                                          |
| Celastrales        | Aquifoliaceae       | <i>Ilex crenata</i>                                   | Japanese holly           | Non-native                 | Shrub, Tree              | Category 4                         | –                                          |
| Celastrales        | Aquifoliaceae       | <i>Ilex opaca</i>                                     | American holly           | Native                     | Tree, Shrub              | –                                  | –                                          |
| Liliales           | Iridaceae           | <i>Iris domestica</i>                                 | blackberry lily          | Non-native                 | Forb/herb                | –                                  | –                                          |
| Juglandales        | Juglandaceae        | <i>Juglans nigra</i>                                  | black walnut             | Native                     | Tree                     | –                                  | –                                          |
| Juncales           | Juncaceae           | <i>Juncus coriaceus</i>                               | leathery rush            | Native                     | Graminoid                | –                                  | –                                          |
| Juncales           | Juncaceae           | <i>Juncus tenuis</i>                                  | poverty rush             | Native                     | Graminoid                | –                                  | –                                          |
| Pinales            | Cupressaceae        | <i>Juniperus virginiana</i>                           | eastern redcedar         | Native                     | Tree                     | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Krigia virginica</i>                               | Virginia dwarfdandelion  | Native                     | Forb/herb                | –                                  | –                                          |
| Fabales            | Fabaceae            | <i>Lespedeza cuneata</i>                              | sericea lespedeza        | Non-native                 | Subshrub, Forb/herb      | Category 1                         | –                                          |
| Scrophulariales    | Oleaceae            | <i>Ligustrum sinense</i>                              | Chinese privet           | Non-native                 | Tree, Shrub              | Category 1                         | –                                          |
| Laurales           | Lauraceae           | <i>Lindera benzoin</i>                                | northern spicebush       | Native                     | Tree, Shrub              | –                                  | –                                          |
| Hamamelidales      | Hamamelidaceae      | <i>Liquidambar styraciflua</i>                        | sweetgum                 | Native                     | Tree                     | –                                  | –                                          |
| Magnoliales        | Magnoliaceae        | <i>Liriodendron tulipifera</i> var. <i>tulipifera</i> | tuliptree                | Native                     | Tree                     | –                                  | –                                          |
| Dipsacales         | Caprifoliaceae      | <i>Lonicera japonica</i>                              | Japanese honeysuckle     | Non-native                 | Vine                     | Category 1                         | –                                          |
| Dipsacales         | Caprifoliaceae      | <i>Lonicera maackii</i>                               | Amur honeysuckle         | Non-native                 | Shrub                    | Category 2                         | –                                          |
| Ranunculales       | Berberidaceae       | <i>Mahonia bealei</i>                                 | Beale's barberry         | Non-native                 | Shrub                    | Category 3                         | –                                          |
| Rosales            | Rosaceae            | <i>Malus angustifolia</i>                             | southern crab apple      | Native                     | Tree, Shrub              | –                                  | –                                          |
| Gentianales        | Asclepiadaceae      | <i>Matelea carolinensis</i>                           | maroon Carolina milkvine | Native                     | Vine, Forb/herb          | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Melica mutica</i>                                  | twoflower melicgrass     | Native                     | Graminoid                | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Microstegium vimineum</i>                          | Nepalese browntop        | Non-native                 | Graminoid                | Category 1                         | –                                          |
| Rubiales           | Rubiaceae           | <i>Mitchella repens</i>                               | partridgeberry           | Native                     | Subshrub, Forb/herb      | –                                  | –                                          |
| Lamiales           | Lamiaceae           | <i>Monarda fistulosa</i> var. <i>mollis</i>           | wild bergamot            | Native                     | Subshrub, Forb/herb      | –                                  | –                                          |
| Urticales          | Moraceae            | <i>Morus rubra</i>                                    | red mulberry             | Native                     | Tree                     | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Muhlenbergia schreberi</i>                         | nimblewill               | Native                     | Graminoid                | –                                  | –                                          |

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**Table A-1 (continued).** Vascular plant species present in 14 vegetation monitoring plots within Kennesaw Mountain National Battlefield Park, July–August 2021.

| Order <sup>1</sup> | Family <sup>1</sup> | Scientific Name                                         | Common Name <sup>1</sup>  | Native Status <sup>1</sup> | Growth Form <sup>1</sup> | State Invasive Status <sup>2</sup> | Georgia Rare-Protected Status <sup>3</sup> |
|--------------------|---------------------|---------------------------------------------------------|---------------------------|----------------------------|--------------------------|------------------------------------|--------------------------------------------|
| Rhamnales          | Vitaceae            | <i>Muscadinia rotundifolia</i> var. <i>rotundifolia</i> | muscadine                 | Native                     | Vine                     | –                                  | –                                          |
| Polypodiales       | Pteridaceae         | <i>Myriopteris lanosa</i>                               | hairy lipfern             | Native                     | Forb/herb                | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Nabalus altissimus</i>                               | tall rattlesnakeroot      | Native                     | Forb/herb                | –                                  | –                                          |
| Ranunculales       | Berberidaceae       | <i>Nandina domestica</i>                                | sacred bamboo             | Non-native                 | Shrub                    | Category 2                         | –                                          |
| Cornales           | Cornaceae           | <i>Nyssa sylvatica</i>                                  | blackgum                  | Native                     | Tree                     | –                                  | –                                          |
| Caryophyllales     | Cactaceae           | <i>Opuntia mesacantha</i> ssp. <i>mesacantha</i>        | devil's-tongue            | Native                     | Shrub                    | –                                  | –                                          |
| Geraniales         | Oxalidaceae         | <i>Oxalis dillenii</i>                                  | slender yellow woodsorrel | Native                     | Forb/herb                | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Packera anonyma</i>                                  | Small's ragwort           | Native                     | Forb/herb                | –                                  | –                                          |
| Rhamnales          | Vitaceae            | <i>Parthenocissus quinquefolia</i>                      | Virginia creeper          | Native                     | Vine                     | –                                  | –                                          |
| Violales           | Passifloraceae      | <i>Passiflora lutea</i>                                 | yellow passionflower      | Native                     | Forb/herb, Vine          | –                                  | –                                          |
| Rosales            | Hydrangeaceae       | <i>Philadelphus hirsutus</i>                            | hairy mock orange         | Native                     | Shrub                    | –                                  | –                                          |
| Pinales            | Pinaceae            | <i>Pinus taeda</i>                                      | loblolly pine             | Native                     | Tree                     | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Piptochaetium avenaceum</i>                          | blackseed speargrass      | Native                     | Graminoid                | –                                  | –                                          |
| Polypodiales       | Polypodiaceae       | <i>Pleopeltis michauxiana</i>                           | resurrection fern         | Native                     | Forb/herb                | –                                  | –                                          |
| Liliales           | Liliaceae           | <i>Polygonatum biflorum</i> var. <i>biflorum</i>        | smooth Solomon's seal     | Native                     | Forb/herb                | –                                  | –                                          |
| Polypodiales       | Dryopteridaceae     | <i>Polystichum acrostichoides</i>                       | Christmas fern            | Native                     | Forb/herb                | –                                  | –                                          |
| Rosales            | Rosaceae            | <i>Prunus serotina</i> var. <i>serotina</i>             | black cherry              | Native                     | Shrub, Tree              | –                                  | –                                          |
| Rosales            | Rosaceae            | <i>Prunus umbellata</i>                                 | hog plum                  | Native                     | Tree, Shrub              | –                                  | –                                          |
| Sapindales         | Rutaceae            | <i>Ptelea trifoliata</i> var. <i>mollis</i>             | wafer-ash                 | Native                     | Shrub, Tree              | –                                  | –                                          |
| Lamiales           | Lamiaceae           | <i>Pycnanthemum curvipes</i>                            | stone mountainmint        | Native                     | Forb/herb                | –                                  | S2                                         |
| Fagales            | Fagaceae            | <i>Quercus alba</i>                                     | white oak                 | Native                     | Tree                     | –                                  | –                                          |
| Fagales            | Fagaceae            | <i>Quercus falcata</i>                                  | southern red oak          | Native                     | Tree                     | –                                  | –                                          |
| Fagales            | Fagaceae            | <i>Quercus marilandica</i> var. <i>marilandica</i>      | blackjack oak             | Native                     | Tree                     | –                                  | –                                          |
| Fagales            | Fagaceae            | <i>Quercus montana</i>                                  | chestnut oak              | Native                     | Tree                     | –                                  | –                                          |
| Fagales            | Fagaceae            | <i>Quercus nigra</i>                                    | water oak                 | Native                     | Tree                     | –                                  | –                                          |
| Fagales            | Fagaceae            | <i>Quercus phellos</i>                                  | willow oak                | Native                     | Tree                     | –                                  | –                                          |
| Fagales            | Fagaceae            | <i>Quercus rubra</i>                                    | northern red oak          | Native                     | Tree                     | –                                  | –                                          |
| Fagales            | Fagaceae            | <i>Quercus stellata</i>                                 | post oak                  | Native                     | Tree                     | –                                  | –                                          |

<sup>1</sup> Information obtained from the PLANTS database (USDA 2023a)<sup>2</sup> Information obtained from the Georgia Exotic Pest Plant Council (GAEPPC 2023)<sup>3</sup> Information obtained from the Georgia Department of Natural Resources (GADNR 2023)

**Table A-1 (continued).** Vascular plant species present in 14 vegetation monitoring plots within Kennesaw Mountain National Battlefield Park, July–August 2021.

| Order <sup>1</sup> | Family <sup>1</sup> | Scientific Name                                      | Common Name <sup>1</sup>  | Native Status <sup>1</sup> | Growth Form <sup>1</sup>  | State Invasive Status <sup>2</sup> | Georgia Rare-Protected Status <sup>3</sup> |
|--------------------|---------------------|------------------------------------------------------|---------------------------|----------------------------|---------------------------|------------------------------------|--------------------------------------------|
| Fagales            | Fagaceae            | <i>Quercus velutina</i>                              | black oak                 | Native                     | Tree                      | –                                  | –                                          |
| Ericales           | Ericaceae           | <i>Rhododendron canescens</i>                        | mountain azalea           | Native                     | Shrub                     | –                                  | –                                          |
| Sapindales         | Anacardiaceae       | <i>Rhus copallinum</i>                               | winged sumac              | Native                     | Tree, Shrub               | –                                  | –                                          |
| Rosales            | Rosaceae            | <i>Rosa multiflora</i>                               | multiflora rose           | Non-native                 | Subshrub, Vine            | Category 1                         | –                                          |
| Rosales            | Rosaceae            | <i>Rubus bifrons</i>                                 | Himalayan berry           | Non-native                 | Subshrub                  | Category 3                         | –                                          |
| Rosales            | Rosaceae            | <i>Rubus pensilvanicus</i>                           | sawtooth blackberry       | Native                     | Subshrub                  | –                                  | –                                          |
| Rosales            | Rosaceae            | <i>Rubus trivialis</i>                               | southern dewberry         | Native                     | Subshrub                  | –                                  | –                                          |
| Scrophulariales    | Acanthaceae         | <i>Ruellia caroliniensis</i>                         | Carolina wild petunia     | Native                     | Forb/herb                 | –                                  | –                                          |
| Dipsacales         | Caprifoliaceae      | <i>Sambucus canadensis</i>                           | American black elderberry | Native                     | Shrub, Tree               | –                                  | –                                          |
| Papaverales        | Papaveraceae        | <i>Sanguinaria canadensis</i>                        | bloodroot                 | Native                     | Forb/herb                 | –                                  | –                                          |
| Apiales            | Apiaceae            | <i>Sanicula canadensis</i> var. <i>canadensis</i>    | Canadian blacksnakeroot   | Native                     | Forb/herb                 | –                                  | –                                          |
| Laurales           | Lauraceae           | <i>Sassafras albidum</i>                             | sassafras                 | Native                     | Tree, Shrub               | –                                  | –                                          |
| Ophioglossales     | Ophioglossaceae     | <i>Sceptridium dissectum</i>                         | cutleaf grapefern         | Native                     | Forb/herb                 | –                                  | –                                          |
| Cyperales          | Poaceae             | <i>Schizachyrium scoparium</i> var. <i>scoparium</i> | little bluestem           | Native                     | Graminoid                 | –                                  | –                                          |
| Cyperales          | Cyperaceae          | <i>Scleria</i>                                       | nutrush                   | Unknown                    | Graminoid                 | –                                  | –                                          |
| Cyperales          | Cyperaceae          | <i>Scleria triglomerata</i>                          | whip nutrush              | Native                     | Graminoid                 | –                                  | –                                          |
| Lamiales           | Scrophulariaceae    | <i>Scrophulariaceae</i>                              | Figwort Family            | Unknown                    | Forb/herb                 | –                                  | –                                          |
| Liliales           | Smilacaceae         | <i>Smilax bona-nox</i> var. <i>bona-nox</i>          | saw greenbrier            | Native                     | Shrub, Vine               | –                                  | –                                          |
| Liliales           | Smilacaceae         | <i>Smilax glauca</i>                                 | cat greenbrier            | Native                     | Shrub, Vine               | –                                  | –                                          |
| Liliales           | Smilacaceae         | <i>Smilax rotundifolia</i>                           | roundleaf greenbrier      | Native                     | Vine, Shrub               | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Solidago</i>                                      | goldenrod                 | Native                     | Forb/herb                 | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Symphyotrichum patens</i> var. <i>patens</i>      | late purple aster         | Native                     | Forb/herb                 | –                                  | –                                          |
| Ranunculales       | Ranunculaceae       | <i>Thalictrum thalictroides</i>                      | rue anemone               | Native                     | Forb/herb                 | –                                  | –                                          |
| Orchidales         | Orchidaceae         | <i>Tipularia discolor</i>                            | crippled crane fly        | Native                     | Forb/herb                 | –                                  | –                                          |
| Sapindales         | Anacardiaceae       | <i>Toxicodendron radicans</i> var. <i>radicans</i>   | eastern poison ivy        | Native                     | Forb/herb, Vine, Subshrub | –                                  | –                                          |
| Commelinales       | Commelinaceae       | <i>Tradescantia ohiensis</i>                         | bluejacket                | Native                     | Forb/herb                 | –                                  | –                                          |
| Euphorbiales       | Euphorbiaceae       | <i>Tragia urticifolia</i>                            | nettleleaf noseburn       | Native                     | Vine, Forb/herb           | –                                  | –                                          |
| Liliales           | Liliaceae           | <i>Trillium catesbaei</i>                            | bashful wakerobin         | Native                     | Forb/herb                 | –                                  | –                                          |

<sup>1</sup> Information obtained from the PLANTS database (USDA 2023a)<sup>2</sup> Information obtained from the Georgia Exotic Pest Plant Council (GAEPPC 2023)<sup>3</sup> Information obtained from the Georgia Department of Natural Resources (GADNR 2023)

**Table A-1 (continued).** Vascular plant species present in 14 vegetation monitoring plots within Kennesaw Mountain National Battlefield Park, July–August 2021.

| Order <sup>1</sup> | Family <sup>1</sup> | Scientific Name                              | Common Name <sup>1</sup>  | Native Status <sup>1</sup> | Growth Form <sup>1</sup> | State Invasive Status <sup>2</sup> | Georgia Rare-Protected Status <sup>3</sup> |
|--------------------|---------------------|----------------------------------------------|---------------------------|----------------------------|--------------------------|------------------------------------|--------------------------------------------|
| Urticales          | Ulmaceae            | <i>Ulmus alata</i>                           | winged elm                | Native                     | Tree                     | –                                  | –                                          |
| Urticales          | Ulmaceae            | <i>Ulmus americana</i> var. <i>americana</i> | American elm              | Native                     | Tree                     | –                                  | –                                          |
| Liliales           | Liliaceae           | <i>Uvularia sessilifolia</i>                 | sessileleaf bellwort      | Native                     | Forb/herb                | –                                  | –                                          |
| Ericales           | Ericaceae           | <i>Vaccinium arboreum</i>                    | farkleberry               | Native                     | Tree, Shrub              | –                                  | –                                          |
| Ericales           | Ericaceae           | <i>Vaccinium stamineum</i>                   | deerberry                 | Native                     | Shrub                    | –                                  | –                                          |
| Scrophulariales    | Scrophulariaceae    | <i>Verbascum thapsus</i> ssp. <i>thapsus</i> | common mullein            | Non-native                 | Forb/herb                | Category 4                         | –                                          |
| Dipsacales         | Caprifoliaceae      | <i>Viburnum rufidulum</i>                    | rusty blackhaw            | Native                     | Tree, Shrub              | –                                  | –                                          |
| Violales           | Violaceae           | <i>Viola hirsutula</i>                       | southern woodland violet  | Native                     | Forb/herb                | –                                  | –                                          |
| Violales           | Violaceae           | <i>Viola palmata</i>                         | common blue violet        | Native                     | Forb/herb                | –                                  | –                                          |
| Violales           | Violaceae           | <i>Viola sororia</i>                         | common blue violet        | Native                     | Forb/herb                | –                                  | –                                          |
| Violales           | Violaceae           | <i>Viola tripartita</i>                      | threepart violet          | Native                     | Forb/herb                | –                                  | –                                          |
| Violales           | Violaceae           | <i>Vitis baileyana</i>                       | graybark grape            | Native                     | Forb/herb                | –                                  | –                                          |
| Polypodiales       | Dryopteridaceae     | <i>Woodsia obtusa</i> ssp. <i>obtusa</i>     | bluntlobe cliff fern      | Native                     | Forb/herb                | –                                  | –                                          |
| Asterales          | Asteraceae          | <i>Youngia japonica</i>                      | Oriental false hawksbeard | Non-native                 | Forb/herb                | –                                  | –                                          |

<sup>1</sup> Information obtained from the PLANTS database (USDA 2023a)<sup>2</sup> Information obtained from the Georgia Exotic Pest Plant Council (GAEPCC 2023)<sup>3</sup> Information obtained from the Georgia Department of Natural Resources (GADNR 2023)

## Appendix B. Species Diversity, Abundance, and Woody Stem Metrics Summarized by Broadly Defined Habitats at Kennesaw Mountain National Battlefield Park

**Table B-1.** Constancy and average cover class for all vascular plant species observed in 14 Southeast Coast Network vegetation monitoring plots. Broad Habitat Type Codes are as follows: POUW = Piedmont Open Uplands and Woodlands (four plots) and PUFS = Piedmont Upland Forests and Shrublands (10 plots). Cover classes are as follows: 1: 0–0.1%, 2: 0.1–1%, 3: 1–2%, 4: 2–5%, 5: 5–10%, 6: 10–25%, 7: 25–50%, 8: 50–75%, 9: 75–95%, 10: 95–100%.

| Species                                             | POUW<br>Constancy | POUW<br>Cover | PUFS<br>Constancy | PUFS<br>Cover |
|-----------------------------------------------------|-------------------|---------------|-------------------|---------------|
| <i>Acalypha rhomboidea</i>                          | –                 | –             | 10                | 1             |
| <i>Acalypha virginica</i>                           | 100               | 2             | –                 | –             |
| <i>Acer rubrum</i>                                  | –                 | –             | 70                | 4             |
| <i>Aesculus sylvatica</i>                           | –                 | –             | 20                | 4             |
| <i>Agrimonia rostellata</i>                         | –                 | –             | 10                | 1             |
| <i>Albizia julibrissin</i>                          | –                 | –             | 20                | 2             |
| <i>Ambrosia artemisiifolia</i>                      | 25                | 1             | –                 | –             |
| <i>Amorpha fruticosa</i>                            | –                 | –             | 10                | 1             |
| <i>Andropogon gerardi</i>                           | 50                | 2             | –                 | –             |
| <i>Andropogon gyrans</i>                            | 25                | 2             | –                 | –             |
| <i>Andropogon ternarius</i>                         | 25                | 2             | –                 | –             |
| <i>Andropogon virginicus</i> var. <i>virginicus</i> | 100               | 2             | –                 | –             |
| <i>Anemone virginiana</i> var. <i>virginiana</i>    | 25                | 1             | –                 | –             |
| <i>Antennaria plantaginifolia</i>                   | 50                | 2             | –                 | –             |
| <i>Apocynum cannabinum</i>                          | 25                | 3             | –                 | –             |
| <i>Arisaema pusillum</i>                            | –                 | –             | 20                | 2             |
| <i>Arnoglossum atriplicifolium</i>                  | –                 | –             | 20                | 1             |
| <i>Asimina parviflora</i>                           | –                 | –             | 10                | 1             |
| <i>Asplenium platyneuron</i>                        | 100               | 2             | 30                | 2             |
| <i>Benthamidia florida</i>                          | –                 | –             | 80                | 4             |
| <i>Bignonia capreolata</i>                          | 50                | 2             | 10                | 1             |
| <i>Boechera missouriensis</i>                       | 25                | 1             | –                 | –             |
| <i>Botrypus virginianus</i>                         | –                 | –             | 30                | 2             |
| <i>Brachyelytrum erectum</i>                        | –                 | –             | 10                | 2             |
| <i>Bromus pubescens</i>                             | 25                | 1             | –                 | –             |
| <i>Calycanthus floridus</i>                         | –                 | –             | 20                | 1             |
| <i>Campsis radicans</i>                             | –                 | –             | 20                | 1             |
| <i>Carex</i>                                        | –                 | –             | 10                | 1             |
| <i>Carex cephalophora</i>                           | 25                | 2             | –                 | –             |
| <i>Carex digitalis</i>                              | –                 | –             | 10                | 1             |
| <i>Carex nigromarginata</i>                         | 25                | 1             | 60                | 2             |
| <i>Carpinus caroliniana</i>                         | –                 | –             | 10                | 2             |
| <i>Carya glabra</i>                                 | 75                | 6             | 80                | 5             |
| <i>Carya ovalis</i>                                 | 50                | 4             | 70                | 6             |
| <i>Carya pallida</i>                                | 75                | 4             | 50                | 3             |
| <i>Carya tomentosa</i>                              | –                 | –             | 70                | 5             |
| <i>Castanea dentata</i>                             | –                 | –             | 10                | 3             |

**Table B-1 (continued).** Constancy and average cover class for all vascular plant species observed in 14 Southeast Coast Network vegetation monitoring plots. Broad Habitat Type Codes are as follows: POUW = Piedmont Open Uplands and Woodlands (four plots) and PUF5 = Piedmont Upland Forests and Shrublands (10 plots). Cover classes are as follows: 1: 0–0.1%, 2: 0.1–1%, 3: 1–2%, 4: 2–5%, 5: 5–10%, 6: 10–25%, 7: 25–50%, 8: 50–75%, 9: 75–95%, 10: 95–100%.

| Species                                                   | POUW<br>Constancy | POUW<br>Cover | PUF5<br>Constancy | PUF5<br>Cover |
|-----------------------------------------------------------|-------------------|---------------|-------------------|---------------|
| <i>Celtis laevigata</i>                                   | –                 | –             | 10                | 1             |
| <i>Celtis occidentalis</i>                                | –                 | –             | 10                | 2             |
| <i>Celtis pumila</i>                                      | 75                | 4             | 30                | 1             |
| <i>Centrosema virginianum</i>                             | 25                | 2             | –                 | –             |
| <i>Cercis canadensis</i>                                  | –                 | –             | 10                | 7             |
| <i>Chimaphila maculata</i>                                | –                 | –             | 30                | 2             |
| <i>Chionanthus virginicus</i>                             | 100               | 5             | –                 | –             |
| <i>Clitoria mariana</i> var. <i>mariana</i>               | 50                | 1             | 10                | 1             |
| <i>Cocculus carolinus</i>                                 | 25                | 1             | –                 | –             |
| <i>Commelina diffusa</i>                                  | 25                | 1             | –                 | –             |
| <i>Crataegus macrosperma</i>                              | 25                | 5             | –                 | –             |
| <i>Croton willdenowii</i>                                 | 75                | 2             | –                 | –             |
| <i>Danthonia spicata</i>                                  | 75                | 2             | 10                | 2             |
| <i>Desmodium rotundifolium</i>                            | –                 | –             | 10                | 2             |
| <i>Dichanthelium</i>                                      | –                 | –             | 10                | 1             |
| <i>Dichanthelium acuminatum</i>                           | 50                | 2             | –                 | –             |
| <i>Dichanthelium boscii</i>                               | 75                | 2             | 50                | 2             |
| <i>Dichanthelium commutatum</i>                           | 75                | 2             | 70                | 2             |
| <i>Dichanthelium depauperatum</i>                         | 75                | 2             | –                 | –             |
| <i>Dichanthelium dichotomum</i> var. <i>dichotomum</i>    | 25                | 2             | 20                | 2             |
| <i>Dichanthelium sphaerocarpon</i>                        | 25                | 2             | –                 | –             |
| <i>Digitaria sanguinalis</i>                              | 25                | 1             | –                 | –             |
| <i>Dioscorea villosa</i>                                  | –                 | –             | 10                | 1             |
| <i>Diospyros virginiana</i>                               | 75                | 2             | 90                | 4             |
| <i>Eclipta prostrata</i>                                  | 25                | 2             | –                 | –             |
| <i>Elaeagnus umbellata</i>                                | –                 | –             | 30                | 2             |
| <i>Elymus villosus</i> var. <i>villosus</i>               | 25                | 1             | –                 | –             |
| <i>Endodeca serpentaria</i>                               | 25                | 1             | 60                | 2             |
| <i>Erechtites hieraciifolius</i>                          | 50                | 2             | 30                | 2             |
| <i>Erigeron philadelphicus</i> var. <i>philadelphicus</i> | 25                | 1             | –                 | –             |
| <i>Erigeron strigosus</i> var. <i>strigosus</i>           | 50                | 3             | –                 | –             |
| <i>Euonymus americanus</i>                                | –                 | –             | 80                | 2             |
| <i>Eupatorium capillifolium</i>                           | 25                | 2             | –                 | –             |
| <i>Eupatorium serotinum</i>                               | 50                | 2             | –                 | –             |
| <i>Euphorbia pubentissima</i>                             | 25                | 1             | –                 | –             |
| <i>Fagus grandifolia</i> var. <i>caroliniana</i>          | –                 | –             | 40                | 5             |
| <i>Festuca octoflora</i>                                  | 25                | 1             | –                 | –             |
| <i>Festuca subverticillata</i>                            | 100               | 4             | –                 | –             |
| <i>Fraxinus biltmoreana</i>                               | 75                | 5             | 10                | 6             |
| <i>Galactia regularis</i>                                 | 50                | 2             | –                 | –             |
| <i>Galium circaezans</i>                                  | –                 | –             | 60                | 2             |

**Table B-1 (continued).** Constancy and average cover class for all vascular plant species observed in 14 Southeast Coast Network vegetation monitoring plots. Broad Habitat Type Codes are as follows: POUW = Piedmont Open Uplands and Woodlands (four plots) and PUF5 = Piedmont Upland Forests and Shrublands (10 plots). Cover classes are as follows: 1: 0–0.1%, 2: 0.1–1%, 3: 1–2%, 4: 2–5%, 5: 5–10%, 6: 10–25%, 7: 25–50%, 8: 50–75%, 9: 75–95%, 10: 95–100%.

| Species                                                 | POUW<br>Constancy | POUW<br>Cover | PUF5<br>Constancy | PUF5<br>Cover |
|---------------------------------------------------------|-------------------|---------------|-------------------|---------------|
| <i>Galium obtusum</i> var. <i>filifolium</i>            | –                 | –             | 20                | 2             |
| <i>Galium pilosum</i>                                   | 75                | 1             | –                 | –             |
| <i>Galium triflorum</i>                                 | –                 | –             | 10                | 1             |
| <i>Goodyera pubescens</i>                               | –                 | –             | 20                | 1             |
| <i>Heuchera americana</i>                               | 50                | 1             | 10                | 1             |
| <i>Hexastylis arifolia</i>                              | –                 | –             | 30                | 2             |
| <i>Hieracium gronovii</i>                               | 25                | 2             | –                 | –             |
| <i>Houstonia purpurea</i>                               | 100               | 2             | –                 | –             |
| <i>Hydrangea barbara</i>                                | –                 | –             | 20                | 2             |
| <i>Hylodesmum nudiflorum</i>                            | –                 | –             | 10                | 1             |
| <i>Hypericum stragulum</i>                              | 25                | 1             | 10                | 1             |
| <i>Ilex cornuta</i>                                     | –                 | –             | 10                | 1             |
| <i>Ilex crenata</i>                                     | 25                | 2             | –                 | –             |
| <i>Ilex opaca</i>                                       | –                 | –             | 30                | 1             |
| <i>Iris domestica</i>                                   | 25                | 1             | –                 | –             |
| <i>Juglans nigra</i>                                    | 25                | 4             | –                 | –             |
| <i>Juncus coriaceus</i>                                 | –                 | –             | 10                | 1             |
| <i>Juncus tenuis</i>                                    | 25                | 1             | –                 | –             |
| <i>Juniperus virginiana</i>                             | 75                | 6             | –                 | –             |
| <i>Krigia virginica</i>                                 | 25                | 1             | –                 | –             |
| <i>Lespedeza cuneata</i>                                | 50                | 1             | –                 | –             |
| <i>Ligustrum sinense</i>                                | 75                | 4             | 100               | 2             |
| <i>Lindera benzoin</i>                                  | –                 | –             | 20                | 5             |
| <i>Liquidambar styraciflua</i>                          | 25                | 1             | 90                | 7             |
| <i>Liriodendron tulipifera</i> var. <i>tulipifera</i>   | 25                | 2             | 100               | 5             |
| <i>Lonicera japonica</i>                                | 50                | 2             | 70                | 2             |
| <i>Lonicera maackii</i>                                 | 25                | 3             | 10                | 2             |
| <i>Mahonia bealei</i>                                   | –                 | –             | 20                | 2             |
| <i>Malus angustifolia</i>                               | 25                | 3             | –                 | –             |
| <i>Matelea carolinensis</i>                             | –                 | –             | 20                | 1             |
| <i>Melica mutica</i>                                    | 75                | 2             | 10                | 1             |
| <i>Microstegium vimineum</i>                            | –                 | –             | 60                | 2             |
| <i>Mitchella repens</i>                                 | –                 | –             | 20                | 2             |
| <i>Monarda fistulosa</i> var. <i>mollis</i>             | –                 | –             | 10                | 1             |
| <i>Morus rubra</i>                                      | –                 | –             | 30                | 3             |
| <i>Muhlenbergia schreberi</i>                           | 50                | 2             | 10                | 1             |
| <i>Muscadinia rotundifolia</i> var. <i>rotundifolia</i> | 50                | 2             | 100               | 6             |
| <i>Myriopteris lanosa</i>                               | 100               | 4             | –                 | –             |
| <i>Nabalus altissimus</i>                               | –                 | –             | 10                | 2             |
| <i>Nandina domestica</i>                                | –                 | –             | 10                | 1             |
| <i>Nyssa sylvatica</i>                                  | –                 | –             | 40                | 4             |
| <i>Opuntia mesacantha</i> ssp. <i>mesacantha</i>        | 75                | 2             | –                 | –             |

**Table B-1 (continued).** Constancy and average cover class for all vascular plant species observed in 14 Southeast Coast Network vegetation monitoring plots. Broad Habitat Type Codes are as follows: POUW = Piedmont Open Uplands and Woodlands (four plots) and PUF5 = Piedmont Upland Forests and Shrublands (10 plots). Cover classes are as follows: 1: 0–0.1%, 2: 0.1–1%, 3: 1–2%, 4: 2–5%, 5: 5–10%, 6: 10–25%, 7: 25–50%, 8: 50–75%, 9: 75–95%, 10: 95–100%.

| Species                                              | POUW<br>Constancy | POUW<br>Cover | PUF5<br>Constancy | PUF5<br>Cover |
|------------------------------------------------------|-------------------|---------------|-------------------|---------------|
| <i>Oxalis dillenii</i>                               | 100               | 2             | –                 | –             |
| <i>Packera anonyma</i>                               | 100               | 2             | 10                | 2             |
| <i>Parthenocissus quinquefolia</i>                   | 100               | 2             | 100               | 2             |
| <i>Passiflora lutea</i>                              | 50                | 2             | 20                | 1             |
| <i>Philadelphus hirsutus</i>                         | 75                | 2             | –                 | –             |
| <i>Pinus taeda</i>                                   | 75                | 2             | 100               | 6             |
| <i>Piptochaetium avenaceum</i>                       | 100               | 7             | 20                | 2             |
| <i>Pleopeltis michauxiana</i>                        | 25                | 1             | –                 | –             |
| <i>Polygonatum biflorum</i> var. <i>biflorum</i>     | –                 | –             | 30                | 1             |
| <i>Polystichum acrostichoides</i>                    | –                 | –             | 30                | 2             |
| <i>Prunus serotina</i> var. <i>serotina</i>          | –                 | –             | 100               | 3             |
| <i>Prunus umbellata</i>                              | 100               | 3             | –                 | –             |
| <i>Ptelea trifoliata</i> var. <i>mollis</i>          | 100               | 6             | –                 | –             |
| <i>Pycnanthemum curvipes</i>                         | 100               | 4             | –                 | –             |
| <i>Quercus alba</i>                                  | 50                | 1             | 30                | 6             |
| <i>Quercus falcata</i>                               | –                 | –             | 30                | 6             |
| <i>Quercus marilandica</i> var. <i>marilandica</i>   | 25                | 2             | –                 | –             |
| <i>Quercus montana</i>                               | 75                | 5             | 30                | 7             |
| <i>Quercus nigra</i>                                 | –                 | –             | 30                | 2             |
| <i>Quercus phellos</i>                               | –                 | –             | 40                | 1             |
| <i>Quercus rubra</i>                                 | 75                | 6             | 30                | 4             |
| <i>Quercus stellata</i>                              | 25                | 5             | –                 | –             |
| <i>Quercus velutina</i>                              | –                 | –             | 50                | 6             |
| <i>Rhododendron canescens</i>                        | –                 | –             | 10                | 2             |
| <i>Rhus copallinum</i>                               | 25                | 2             | –                 | –             |
| <i>Rosa multiflora</i>                               | –                 | –             | 10                | 1             |
| <i>Rubus bifrons</i>                                 | 25                | 2             | –                 | –             |
| <i>Rubus pensilvanicus</i>                           | –                 | –             | 10                | 1             |
| <i>Rubus trivialis</i>                               | –                 | –             | 10                | 2             |
| <i>Ruellia caroliniensis</i>                         | –                 | –             | 10                | 2             |
| <i>Sambucus canadensis</i>                           | –                 | –             | 10                | 1             |
| <i>Sanguinaria canadensis</i>                        | –                 | –             | 10                | 2             |
| <i>Sanicula canadensis</i> var. <i>canadensis</i>    | –                 | –             | 30                | 2             |
| <i>Sassafras albidum</i>                             | –                 | –             | 30                | 2             |
| <i>Sceptridium dissectum</i>                         | –                 | –             | 10                | 1             |
| <i>Schizachyrium scoparium</i> var. <i>scoparium</i> | 100               | 3             | –                 | –             |
| <i>Scleria</i>                                       | –                 | –             | 10                | 1             |
| <i>Scleria triglomerata</i>                          | –                 | –             | 10                | 1             |
| <i>Scrophulariaceae</i>                              | 25                | 2             | –                 | –             |
| <i>Smilax bona-nox</i> var. <i>bona-nox</i>          | 75                | 2             | 50                | 2             |
| <i>Smilax glauca</i>                                 | 25                | 1             | 100               | 2             |
| <i>Smilax rotundifolia</i>                           | 50                | 2             | 80                | 2             |

**Table B-1 (continued).** Constancy and average cover class for all vascular plant species observed in 14 Southeast Coast Network vegetation monitoring plots. Broad Habitat Type Codes are as follows: POUW = Piedmont Open Uplands and Woodlands (four plots) and PUF5 = Piedmont Upland Forests and Shrublands (10 plots). Cover classes are as follows: 1: 0–0.1%, 2: 0.1–1%, 3: 1–2%, 4: 2–5%, 5: 5–10%, 6: 10–25%, 7: 25–50%, 8: 50–75%, 9: 75–95%, 10: 95–100%.

| Species                                            | POUW<br>Constancy | POUW<br>Cover | PUF5<br>Constancy | PUF5<br>Cover |
|----------------------------------------------------|-------------------|---------------|-------------------|---------------|
| <i>Solidago</i>                                    | 25                | 1             | –                 | –             |
| <i>Symphytotrichum patens</i> var. <i>patens</i>   | 50                | 2             | –                 | –             |
| <i>Thalictrum thalictroides</i>                    | –                 | –             | 20                | 1             |
| <i>Tipularia discolor</i>                          | –                 | –             | 30                | 2             |
| <i>Toxicodendron radicans</i> var. <i>radicans</i> | 50                | 1             | 100               | 2             |
| <i>Tradescantia ohiensis</i>                       | 100               | 4             | –                 | –             |
| <i>Tragia urticifolia</i>                          | 50                | 2             | –                 | –             |
| <i>Trillium catesbaei</i>                          | –                 | –             | 10                | 1             |
| <i>Ulmus alata</i>                                 | 100               | 5             | 80                | 3             |
| <i>Ulmus americana</i> var. <i>americana</i>       | –                 | –             | 10                | 5             |
| <i>Uvularia sessilifolia</i>                       | 25                | 1             | 30                | 1             |
| <i>Vaccinium arboreum</i>                          | 50                | 3             | 10                | 1             |
| <i>Vaccinium stamineum</i>                         | –                 | –             | 10                | 2             |
| <i>Verbascum thapsus</i> ssp. <i>thapsus</i>       | 25                | 2             | –                 | –             |
| <i>Viburnum rufidulum</i>                          | 25                | 4             | 20                | 1             |
| <i>Viola hirsutula</i>                             | –                 | –             | 20                | 2             |
| <i>Viola palmata</i>                               | –                 | –             | 10                | 2             |
| <i>Viola sororia</i>                               | 50                | 2             | 30                | 2             |
| <i>Viola tripartita</i>                            | –                 | –             | 10                | 1             |
| <i>Vitis baileyana</i>                             | –                 | –             | 10                | 4             |
| <i>Woodsia obtusa</i> ssp. <i>obtusa</i>           | 25                | 2             | –                 | –             |
| <i>Youngia japonica</i>                            | 25                | 2             | –                 | –             |

**Table B-2.** Basal area (BA, m<sup>2</sup>/ha) and density (Den, count/ha) of woody vascular plant species observed in 14 Southeast Coast Network vegetation monitoring plots. Broad Habitat Type Codes are as follows: POUW = Piedmont Open Uplands and Woodlands (four plots) and PUFS = Piedmont Upland Forests and Shrublands (10 plots).

| Species                                                 | POUW<br>Tree<br>BA | POUW<br>Tree<br>DEN | POUW<br>Sapling<br>BA | POUW<br>Sapling<br>Den | POUW<br>Seedling<br>Den | PUFS<br>Tree<br>BA | PUFS<br>Tree<br>DEN | PUFS<br>Sapling<br>BA | PUFS<br>Sapling<br>Den | PUFS<br>Seedling<br>Den |
|---------------------------------------------------------|--------------------|---------------------|-----------------------|------------------------|-------------------------|--------------------|---------------------|-----------------------|------------------------|-------------------------|
| <i>Acer rubrum</i>                                      | –                  | –                   | –                     | –                      | –                       | 0.26               | 8                   | 0.33                  | 300                    | 750                     |
| <i>Aesculus sylvatica</i>                               | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.02                  | 100                    | 125                     |
| <i>Albizia julibrissin</i>                              | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.00                  | 0                      | 250                     |
| <i>Benthamidia florida</i>                              | –                  | –                   | –                     | –                      | –                       | 0.09               | 8                   | 0.11                  | 100                    | 125                     |
| <i>Campsis radicans</i>                                 | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.00                  | 0                      | 125                     |
| <i>Carpinus caroliniana</i>                             | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.11                  | 100                    | 0                       |
| <i>Carya glabra</i>                                     | 1.58               | 63                  | 2.15                  | 3250                   | 2188                    | 0.50               | 10                  | 0.02                  | 100                    | 1000                    |
| <i>Carya ovalis</i>                                     | –                  | –                   | 0.12                  | 500                    | 0                       | 1.38               | 25                  | 0.77                  | 400                    | 1875                    |
| <i>Carya pallida</i>                                    | 0.31               | 6                   | 2.67                  | 1500                   | 0                       | 0.05               | 3                   | 0.44                  | 100                    | 125                     |
| <i>Carya tomentosa</i>                                  | –                  | –                   | –                     | –                      | –                       | 0.74               | 5                   | 0.22                  | 200                    | 0                       |
| <i>Celtis pumila</i>                                    | 0.06               | 6                   | 0.06                  | 250                    | 938                     | –                  | –                   | 0.00                  | 0                      | 125                     |
| <i>Cercis canadensis</i>                                | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 1.44                  | 400                    | 2750                    |
| <i>Chionanthus virginicus</i>                           | –                  | –                   | 4.78                  | 4000                   | 0                       | –                  | –                   | 0.16                  | 500                    | –                       |
| <i>Crataegus macrosperma</i>                            | –                  | –                   | 0.06                  | 250                    | 0                       | –                  | –                   | 1.10                  | 400                    | –                       |
| <i>Diospyros virginiana</i>                             | –                  | –                   | 0.28                  | 250                    | 938                     | –                  | –                   | 0.02                  | 100                    | 1500                    |
| <i>Fagus grandifolia</i> var. <i>caroliniana</i>        | –                  | –                   | –                     | –                      | –                       | 0.05               | 3                   | 0.29                  | 500                    | 0                       |
| <i>Fraxinus biltmoreana</i>                             | 0.96               | 56                  | 1.10                  | 250                    | 0                       | 1.38               | 5                   | 0.00                  | 0                      | 0                       |
| <i>Hydrangea barbara</i>                                | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.02                  | 100                    | 0                       |
| <i>Ilex opaca</i>                                       | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.23                  | 700                    | 125                     |
| <i>Juglans nigra</i>                                    | 0.06               | 6                   | –                     | –                      | –                       | –                  | –                   | –                     | –                      | –                       |
| <i>Juniperus virginiana</i>                             | 2.02               | 44                  | –                     | –                      | –                       | –                  | –                   | –                     | –                      | –                       |
| <i>Ligustrum sinense</i>                                | –                  | –                   | 2.27                  | 750                    | 7188                    | –                  | –                   | 4.68                  | 2600                   | 1125                    |
| <i>Lindera benzoin</i>                                  | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.44                  | 100                    | 2125                    |
| <i>Liquidambar styraciflua</i>                          | –                  | –                   | –                     | –                      | –                       | 4.72               | 125                 | 0.00                  | 0                      | 32375                   |
| <i>Liriodendron tulipifera</i> var. <i>tulipifera</i>   | –                  | –                   | 0.00                  | 0                      | 313                     | 4.53               | 30                  | 0.61                  | 1200                   | 2625                    |
| <i>Lonicera japonica</i>                                | –                  | –                   | 0.40                  | 750                    | 1250                    | –                  | –                   | 0.00                  | 0                      | 5000                    |
| <i>Lonicera maackii</i>                                 | –                  | –                   | 0.55                  | 500                    | 0                       | –                  | –                   | 0.11                  | 100                    | –                       |
| <i>Malus angustifolia</i>                               | 0.11               | 13                  | 1.10                  | 250                    | 0                       | –                  | –                   | 0.00                  | 0                      | –                       |
| <i>Muscadinia rotundifolia</i> var. <i>rotundifolia</i> | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.02                  | 100                    | 34375                   |

**Table B-2 (continued).** Basal area (BA, m<sup>2</sup>/ha) and density (Den, count/ha) of woody vascular plant species observed in 14 Southeast Coast Network vegetation monitoring plots. Broad Habitat Type Codes are as follows: POUW = Piedmont Open Uplands and Woodlands (four plots) and PUFS = Piedmont Upland Forests and Shrublands (10 plots).

| Species                                            | POUW<br>Tree<br>BA | POUW<br>Tree<br>DEN | POUW<br>Sapling<br>BA | POUW<br>Sapling<br>Den | POUW<br>Seedling<br>Den | PUFS<br>Tree<br>BA | PUFS<br>Tree<br>DEN | PUFS<br>Sapling<br>BA | PUFS<br>Sapling<br>Den | PUFS<br>Seedling<br>Den |
|----------------------------------------------------|--------------------|---------------------|-----------------------|------------------------|-------------------------|--------------------|---------------------|-----------------------|------------------------|-------------------------|
| <i>Nyssa sylvatica</i>                             | –                  | –                   | –                     | –                      | –                       | 0.34               | 5                   | 1.33                  | 300                    | 250                     |
| <i>Parthenocissus quinquefolia</i>                 | –                  | –                   | 0.07                  | 500                    | 6563                    | –                  | –                   | 0.02                  | 100                    | 12250                   |
| <i>Pinus taeda</i>                                 | –                  | –                   | 0.00                  | 0                      | 625                     | 10.86              | 78                  | 0.99                  | 300                    | 21875                   |
| <i>Prunus serotina</i> var. <i>serotina</i>        | –                  | –                   | –                     | –                      | –                       | 0.20               | 10                  | 0.11                  | 100                    | 1250                    |
| <i>Prunus umbellata</i>                            | –                  | –                   | 1.10                  | 250                    | 0                       | –                  | –                   | 0.00                  | 0                      | –                       |
| <i>Ptelea trifoliata</i> var. <i>mollis</i>        | –                  | –                   | 1.66                  | 9250                   | 5313                    | –                  | –                   | 0.00                  | 0                      | –                       |
| <i>Quercus alba</i>                                | –                  | –                   | –                     | –                      | –                       | 0.99               | 23                  | 0.00                  | 0                      | 0                       |
| <i>Quercus falcata</i>                             | –                  | –                   | –                     | –                      | –                       | 1.10               | 5                   | 0.00                  | 0                      | 375                     |
| <i>Quercus montana</i>                             | 1.95               | 38                  | 0.28                  | 250                    | 0                       | 2.75               | 28                  | 0.66                  | 300                    | 125                     |
| <i>Quercus rubra</i>                               | 2.77               | 75                  | 1.38                  | 500                    | 0                       | 0.97               | 5                   | 0.00                  | 0                      | –                       |
| <i>Quercus stellata</i>                            | 0.47               | 6                   | 0.28                  | 250                    | 0                       | –                  | –                   | 0.00                  | 0                      | –                       |
| <i>Quercus velutina</i>                            | –                  | –                   | –                     | –                      | –                       | 1.75               | 13                  | 0.11                  | 100                    | 0                       |
| <i>Smilax bona-nox</i> var. <i>bona-nox</i>        | –                  | –                   | 0.00                  | 0                      | 313                     | –                  | –                   | 0.00                  | 0                      | 500                     |
| <i>Smilax glauca</i>                               | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.00                  | 0                      | 3500                    |
| <i>Smilax rotundifolia</i>                         | –                  | –                   | 0.00                  | 0                      | 313                     | –                  | –                   | 0.00                  | 0                      | 1000                    |
| <i>Toxicodendron radicans</i> var. <i>radicans</i> | –                  | –                   | 0.00                  | 250                    | 0                       | –                  | –                   | 0.00                  | 0                      | 2375                    |
| <i>Ulmus alata</i>                                 | 2.20               | 100                 | 1.99                  | 1250                   | 2813                    | 0.24               | 13                  | 0.08                  | 38                     | 750                     |
| <i>Ulmus americana</i> var. <i>americana</i>       | –                  | –                   | –                     | –                      | –                       | 0.09               | 5                   | –                     | –                      | –                       |
| <i>Vaccinium arboreum</i>                          | –                  | –                   | 0.40                  | 1000                   | 313                     | –                  | –                   | –                     | –                      | –                       |
| <i>Vaccinium stamineum</i>                         | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.00                  | 0                      | 125                     |
| <i>Viburnum rufidulum</i>                          | –                  | –                   | 2.88                  | 1500                   | 0                       | –                  | –                   | 0.00                  | 0                      | 125                     |
| <i>Vitis baileyana</i>                             | –                  | –                   | –                     | –                      | –                       | –                  | –                   | 0.01                  | 13                     | 0                       |



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.

**National Park Service**  
**U.S. Department of the Interior**



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**Natural Resource Stewardship and Science**

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