



Terrestrial Vegetation Monitoring in Southeast Coast Network Parks

Protocol Implementation Plan

Natural Resource Report NPS/SECN/NRR—2019/1930



ON THE COVER

Vegetation of the Southeast Coast Network. Clockwise from upper left: common stargrass (*Hypoxis hirsuta*), establishing a vegetation monitoring plot on Canaveral National Seashore, jack-in-the-pulpit (*Arisaema triphyllum*), arrowhead (*Sagittaria latifolia* var. *latifolia*), and sea rocket (*Cakile edentula*).

NPS photos

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This report received formal peer review by subject-matter experts who were not directly involved in the development or pilot implementation of the project. Peer review was conducted by highly qualified individuals with subject area technical expertise and was overseen by a peer review manager.

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Executive Summary

The Southeast Coast Network conducts long-term terrestrial vegetation monitoring as part of the nationwide Inventory and Monitoring Program of the National Park Service. Vegetation in parks is monitored as a key vital sign and indicator of overall ecosystem health because changes in vegetation condition reflect effects of stressors such as extreme weather, disease, invasive species, fire, and land use change. Plants also provide the structured habitat and food resources on which other species depend. 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. The Southeast Coast Network adheres to the definition of "natural" vegetation proposed by the National Vegetation Classification System as "vegetation which appears to be unmodified by human activities", which differs from "cultural" vegetation "which is planted or actively maintained by humans such as annual croplands, orchards, and vineyards (Grossman et al. 1998)."

Terrestrial vegetation monitoring takes place within natural vegetation areas of 15 national park units within the Southeast Coast Network. Parks include Canaveral National Seashore (CANA), Cape Hatteras National Seashore (CAHA), Cape Lookout National Seashore (CALO), Chattahoochee River National Recreation Area (CHAT), Congaree National Park (CONG), Cumberland Island National Seashore (CUIS), Fort Frederica National Monument (FOFR), Fort Matanzas National Monument (FOMA), Fort Pulaski National Monument (FOPU), Fort Sumter National Monument (FOSU), Horseshoe Bend National Military Park (HOBE), Kennesaw Mountain National Battlefield Park (KEMO), Moores Creek National Battlefield (MOCR), Ocmulgee Mounds National Historical Park (OCMU), and Timucuan Ecological and Historic Preserve (TIMU). The Southeast Coast Network monitors between nine and seventy-seven randomly located plots within each park. The number of plots depends on several factors, including the total terrestrial area and coverage of broadly defined habitat types within the park or its respective management unit. Monitored habitat types include tidal and nontidal maritime wetlands, alluvial wetlands, nonalluvial wetlands, upland forests, open upland woodlands, and natural to semi natural successional communities. Plots are 20 × 20 meters (65.6 × 65.6 feet [ft]) in size. Data collected in each plot include species richness, species-specific cover and constancy, species-specific woody stem seedling/sapling counts and adult tree (greater than 10 centimeters [3.9 inches (in)]) diameter at breast height (DBH), and site conditions and environmental covariates.

The Southeast Coast Network's approach, rationale, and required resources for terrestrial vegetation monitoring are described in this document, the protocol implementation plan narrative. Ten associated Standard Operating Procedures (SOPs) provide detailed instructions on how to collect, manage, analyze, and disseminate the project's findings. The network's narrative and some SOPs are derived, in large part, from *Vegetation Monitoring Protocol for the Cumberland Piedmont Network, Version 1* (White et al. 2011). Any differences in approach between the two networks is documented throughout this Southeast Coast Network narrative and the SOP documents.

Section 1. Introduction

Background

The vegetation community is defined as the assemblage of all plant species' populations that occur in Southeast Coast Network (SECN) parks. During the initial network scoping process, the vegetation community vital sign was ranked as second in importance of the 65 potential vital signs considered by SECN park managers during the scoping process (DeVivo et al. 2008).

Vegetation monitoring is used extensively by the National Park Service (NPS) as a tool that, when used in conjunction with appropriate management, helps preserve National Park resources “unimpaired for future generations” (National Park Service Organic Act of 1916). Within the National Park Service, there are 32 networks engaged in monitoring activities as part of the national Inventory and Monitoring Division (IMD). The Southeast Coast Network is in the NPS Southeast Region, and serves seventeen national parks with significant cultural and natural resources plus three additional park units. Like the other networks, the Southeast Coast Network monitors the “overall health or condition of park natural resources” through a representative subset of park processes and elements called vital signs (Fancy et al. 2009). Plant community monitoring was identified as one of the twenty-five vital signs within the Southeast Coast Network (DeVivo et al. 2008). This plan outlines how the Southeast Coast Network collects, manages, and reports monitoring data for its terrestrial vegetation vital sign, thus addressing a range of terrestrial attributes across all network parks.

Vegetation in Southeast Coast Network Parks

The Southeast Coast Network includes a total of 20 parks that span multiple ecoregions across the southeast United States (Figure 1, Table 1). The vegetation within the parks is influenced by factors such as latitude, longitude, elevation, geology, topographic position, and distance from the shore. Southeast Coast Network parks are highly diverse, with just under 3,000 known plant species across the network (NPS 2016). Inland parks, such as Chattahoochee River NRA and Kennesaw Mountain NBP, have approximately 1,000 and 850 species, respectively. Coastal parks, such as Cape Hatteras and Canaveral National Seashores, host over 1,200 and 750 species, respectively. Small SECN park units are diverse, with approximately 250 plant species at parks such as Fort Matanzas and Fort Frederica National Monuments. Vegetation communities vary widely across network parks. Approximately 180 vegetation associations (i.e., fine-resolution floristic description), as defined by the *National Vegetation and Classification Standard, Version 2.0* (Federal Geographic Data Committee 2008), occur in SECN park units. A diversity of vegetation resources is found in these parks, including:

- dry grasslands of barrier island dunes occurring adjacent to the shoreline (typically dominated by *Uniola paniculata* and subjected to full force winds and a regular sand supply), or located on higher stabilized surfaces on the inland side of maritime uplands (Figure 2a);
- maritime oak and/or pine-dominated forests and salt-spray maintained shrublands of the Atlantic Coast;

- maritime tidal graminoid-dominated vegetation (typically dominated by either *Sporobolus alterniflorus* on low saline zones of estuarine flats or *Juncus roemerianus* on higher zones of the same flats) or nontidal wetland vegetation: including either forests/shrublands or herbaceous/graminoid-dominated communities occurring on broad flats or within interdunal swales;
- pyrogenic dry scrub and pine flatwoods of Atlantic coastal Florida (Figure 2b);
- blackwater and brownwater floodplain forests of the Southeastern Plains ecoregion, dominated by some combination of *Nyssa biflora*, *Nyssa aquatica*, or *Taxodium distichum* on wet soils or by other hardwoods (e.g., *Celtis laevigata*, *Acer negundo*, *Liquidambar styraciflua*, *Quercus* spp.) on slightly higher geomorphic positions within alluvial zones (Figure 2c);
- early-mid successional Piedmont alluvial forests and shrublands; and
- mid-late successional Piedmont upland forests occurring on mesic (dominated by *Liriodendron tulipifera*), submesic to subxeric (dominated by *Quercus alba* and other hardwoods), or mesic (dominated by a mixture of hardwoods) landforms (Figure 2d).

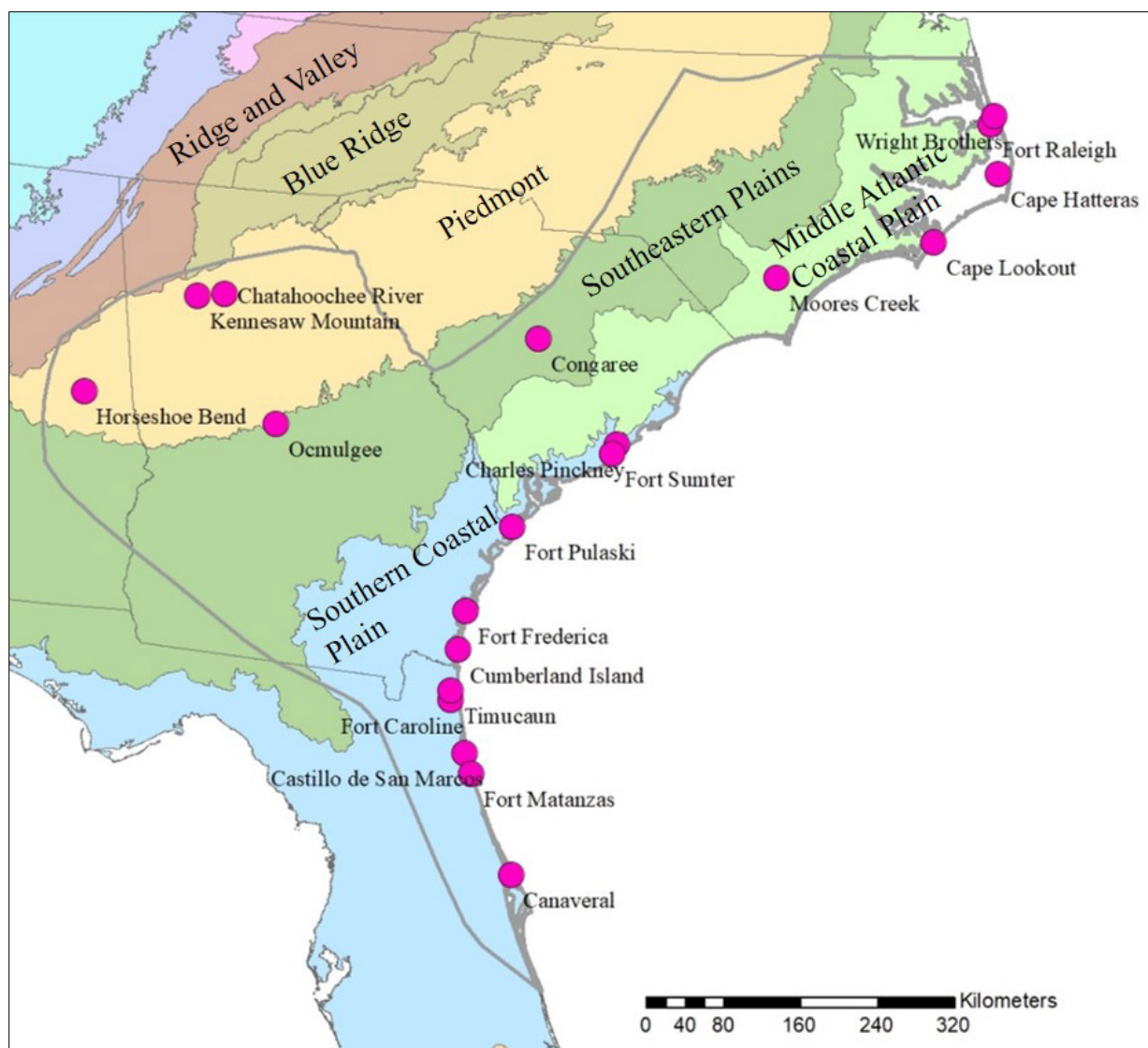


Figure 1. Southeast Coast Network park locations and 2013 EPA Level III Ecoregions of the Continental United States (USEPA 2013, revision of Omernik 1987). The gray line indicates the boundary of the Southeast Coast Network. Pink circles represent the location of the 20 parks in the network.

Table 1. Parks located within the Southeast Coast Network with park unit administration, if different.

Park Code (Admin Unit)	Park Name	Size (acres)	State	Ecoregion	Scheduled
CAHA (CAHA)	Cape Hatteras National Seashore	34,500	NC	Middle Atlantic Coastal Plain	Yes
CALO (CAHA)	Cape Lookout National Seashore	25,000	NC	Middle Atlantic Coastal Plain	Yes
FORA (CAHA)	Fort Raleigh National Historic Site	350	NC	Middle Atlantic Coastal Plain	No
MOCR (CAHA)	Moore's Creek National Battlefield	90	NC	Middle Atlantic Coastal Plain	Yes
WRBR (CAHA)	Wright Brothers National Memorial	420	NC	Middle Atlantic Coastal Plain	No
CHAT	Chattahoochee River National Recreation Area	5,500	GA	Piedmont	Yes
HOBE	Horseshoe Bend National Military Park	2,000	AL	Piedmont	Yes
KEMO	Kennesaw Mountain National Battlefield Park	3,000	GA	Piedmont	Yes
CONG	Congaree National Park	22,000	SC	Southeastern Plains	Yes
CHPI (CONG)	Charles Pinckney National Historic Site	30	SC	Southern Coastal Plain	No
FOSU (CONG)	Fort Sumter National Monument	200	SC	Southern Coastal Plain	Yes
OCMU	Ocmulgee Mounds National Historical Park	700	GA	Southeastern Plains	Yes
CANA	Canaveral National Seashore	58,000	FL	Southern Coastal Plain	Yes
CASA	Castillo de San Marcos National Monument	20	FL	Southern Coastal Plain	No
FOMA (CASA)	Fort Matanzas National Monument	300	FL	Southern Coastal Plain	Yes
CUIS	Cumberland Island National Seashore	20,000	GA	Southern Coastal Plain	Yes
FOFR (CUIS)	Fort Frederica National Monument	250	GA	Southern Coastal Plain	Yes
FOPU	Fort Pulaski National Monument	5,500	GA	Southern Coastal Plain	Yes
TIMU	Timucuan Ecological and Historic Preserve	8,500	FL	Southern Coastal Plain	Yes
FOCA (TIMU)	Fort Caroline National Monument	150	FL	Southern Coastal Plain	No

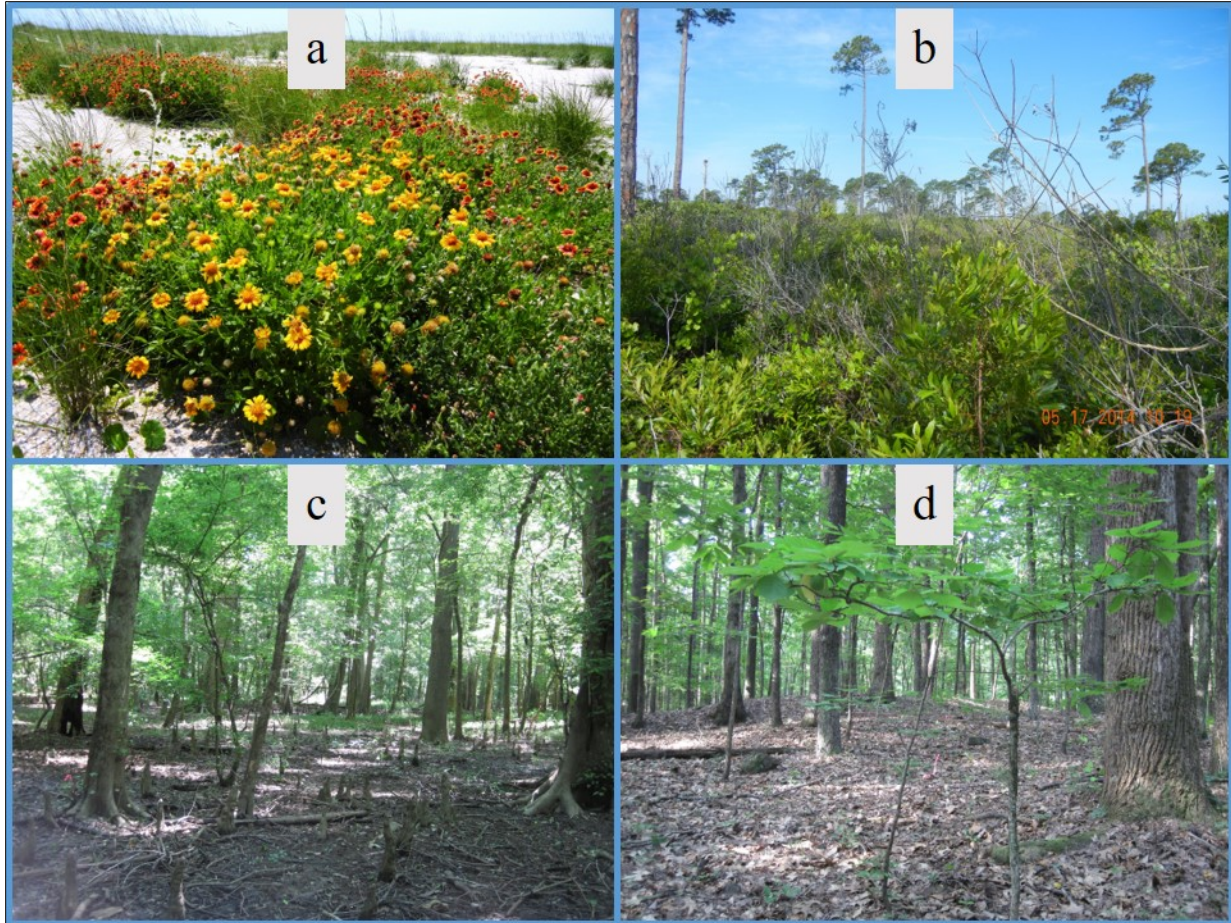


Figure 2. Plant community examples of Southeast Coast Network parks. Upper left (a)—graminoid- and herbaceous-dominated foredune vegetation along the maritime fringe of Cape Lookout National Seashore, North Carolina. Upper right (b)—scrub and sparse pine flatwoods maintained by fire at Canaveral National Seashore, along the Florida coast. Lower left (c)—seasonally flooded riparian forest of Congaree National Park, South Carolina. Lower right (d)—upland oak-dominated submesic forest of Kennesaw Mountain National Battlefield Park, Georgia.

Source Protocol and How It Was Modified

The Southeast Coast Network monitors terrestrial vegetation following a version of the peer-reviewed and approved *Vegetation Monitoring Protocol for the Cumberland Piedmont Network, Version 1* (White et al. 2011), and its 2017 draft revisions (White et al. 2017). All CUPN standard operating procedures (SOPs) were reviewed, modified, and edited as necessary by the Southeast Coast Network to ensure network relevance and integrity. Major changes have been made to the sampling design and analysis, primarily to accommodate the diverse and varied vegetation communities of the Southeast Coast region. A major change has also been made to the personnel size of the first-year sampling effort. Modifications to the CUPN vegetation protocol are listed in Appendix A of this document. This appendix also includes added justification for several of the most substantial changes. Descriptions of specific modifications plus minor procedural modifications are

also provided in each SECN standard operating procedure. Appendix B lists safety and training information.

There are seven major changes made to the CUPN protocol:

1. The Southeast Coast Network sampling frame includes all naturally-vegetated habitats in parks or target units, rather than forests and woodlands only.
2. The sampling design for the Southeast Coast Network consists of plots stratified by broadly defined habitat type, rather than an unstratified design with plots spread evenly throughout an entire park.
3. Sampling occurs across all plots within the same park for a given year within the Southeast Coast Network, rather than a portion of plots in every park each year. Also, all parks regardless of size are sampled once every four years in the Southeast Coast Network, rather than plots across all parks revisited on a five-year schedule.
4. Analysis of vegetation and environmental metrics does not currently link to ecological integrity metrics in the Southeast Coast Network because they have yet to be developed for ecosystems in the South Atlantic Coastal Plain.
5. The Southeast Coast Network uses a single, two-person team to conduct all sampling during the first year of project implementation and two, two-person teams in subsequent years. If resources are available, a three-person team will be utilized.
6. The Cumberland Piedmont Network measures coarse woody debris fuels characteristics in their monitoring plots, while the Southeast Coast Network has chosen to measure additional fuel types, including fine woody debris and duff/litter.
7. The Southeast Coast Network combined six of the CUPN SOPs into three SOPs, and added a network safety SOP that applies to all SECN protocols.

Section 2. Conceptual Framework for Monitoring

The network's general ecosystem model focuses on four broad categories of natural system drivers, five local drivers or agents of change, and the resources and management that occur within SECN parks. System drivers are major external forces that have large-scale influences on natural systems. These drivers can be either natural or anthropogenic and include things such as climate, tidal processes, freshwater and saltwater inputs, and current & historical land use that make up the mosaic of conditions in which SECN parks exist. Local drivers are those processes or disturbances inside or adjacent to SECN parks that potentially alter the condition of resources within park boundaries, and include natural disturbance events, hydrologic modification, dredging and coastal zone management, contaminant inputs, and landscape change (DeVivo 2008).

Vegetated and non-vegetated systems have been classified in most SECN parks through collaborative efforts with the Southeast Regional Office of NatureServe (Durham, North Carolina) and then mapped by the University of Georgia (UGA) Center for Geospatial Research (CGR). Vegetation has been classified and mapped in these parks using the U.S. National Vegetation Classification hierarchy (FGDC 2008; Grossman et al. 1998). Details of the community types can be found in each of the park vegetation classification reports (Table 2). To identify communities that span multiple parks, we have grouped vegetation map units into broadly defined habitat types (Table 3). These types are coarse in scale, but they share key traits with one another across the parks where they occur.

Table 2. Vegetation mapping reports and status for Southeast Coast Network parks.

Park Code	Report Citation	Status
CAHA	McManamay R.H., S. C. Heath, and L. Baron. 2014. Vegetation mapping at Cape Hatteras National Seashore. Natural Resource Report NPS/SECN/NRR—2018/1630	Published
CALO	McManamay, R.H. 2017. Vegetation mapping at Cape Lookout National Seashore. Natural Resource Report NPS/SECN/NRR—2017/1561	Published
CANA	In progress	In progress
CHAT	M. Madden, D. L. Cotten, B. P. Adams, N. K. O'Hare, S. Bernardes, and T. R. Jordan. Vegetation mapping at Chattahoochee River National Recreation Area: photointerpretation key and final vegetation map—Final Report	In review
CONG	Landaal S., A. Weakley, and J. Drake. 1998. Classification of the vegetation of Congaree National Park. USGS-NPS Vegetation Mapping Program.	Published
CUIS	McManamay, R.H. 2017. Vegetation mapping at Cumberland Island National Seashore. Natural Resource Report NPS/SECN/NRR—2017/1511	Published
FOFR	McManamay, R.H., A. C. Curtis, and S. L. Corbett. 2013. Vegetation mapping at Fort Frederica National Monument. Natural Resource Report NPS/FOFR/NRR—2013/684	Published

Table 2 (continued). Vegetation mapping reports and status for Southeast Coast Network parks.

Park Code	Report Citation	Status
FOMA	In progress	In progress
FOPU	McManamay R.H., A.C. Curtis, and S.C. Heath. 2013. Vegetation mapping at Fort Pulaski National Monument. Natural Resource Report NPS/SECN/NRR—2013/718	Published
FOSU	McManamay R.H., A.C. Curtis, and S.L. Corbett. 2012. Vegetation mapping at Fort Sumter National Monument. Natural Resource Data Series NPS/SECN/NRR—2012/320	Published
HOBE	Madden M., B.P. Adams, D.L. Cotten, N.K. O'Hare, S. Bernardes, and T.R. Jordan. Draft. Vegetation mapping for the National Park Service Southeast Coast Inventory and Monitoring Network: Horseshoe Bend National Military Park (HOBE)—Final Report. Natural Resource Report NPS/SECN/NRR—year/xxx	In review
KEMO	McManamay R.H. 2015. Vegetation mapping at Kennesaw Mountain National Battlefield Park. Natural Resource Report NPS/SECN/NRR—2015/1088	Published
MOCR	McManamay R.H., A. C. Curtis, and M. W. Byrne. Vegetation mapping at Moores Creek National Battlefield. 2012. Natural Resource Data Series NPS/SECN/NRDS—2012/319	Published
OCMU	Madden M., D.L. Cotton, B.P. Adams, N.K. O'Hare, S. Bernardes, and T.R. Jordan. Draft. Vegetation mapping at Ocmulgee Mounds National Historical Park: photointerpretation key and draft vegetation map. Natural Resource Report NPS/SECN/NRR—year/xxx	In review
TIMU	In progress	In progress

Table 3A. Habitat types for Southeast Coast Network parks used in the sampling frame. Values represent estimated percent area and are derived from recent vegetation maps.

Physiographic Province	Habitat type	CAHA	CALO	CANA	CHAT	CONG	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU
All	Semi-natural / Successional	3	NA	NA	21	9	< 1	9	NA	NA	NA	61	38	46	8	6
Coastal Plain	Alluvial Wetlands	NA	NA	< 1	NA	82	NA	NA	NA	NA	NA	NA	NA	26	46	NA
	Nonalluvial Wetlands	NA	NA	NA	NA	3	NA	NA	NA	NA	NA	NA	NA	2	NA	NA
	Upland Forests	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA
	Open Uplands and Woodlands	NA	NA	3	NA	< 1	2	NA	NA	NA	NA	NA	NA	NA	NA	< 1
Maritime	Tidal Wetlands NA other	16	9	< 1	NA	NA	2	1	NA	6	NA	NA	NA	NA	NA	6
	Nontidal Wetlands	NA	< 1	6	NA	NA	2	NA	NA	NA	NA	NA	NA	NA	NA	2
	Open Uplands	30	21	< 1	NA	NA	5	NA	16	NA	5	NA	NA	NA	NA	NA
	Upland Forests and Shrublands	1	< 1	2	NA	NA	29	11	47	1	6	NA	NA	NA	NA	13
Piedmont	Alluvial Wetlands	NA	NA	NA	12	NA	NA	NA	NA	NA	NA	4	7	NA	NA	NA
	Nonalluvial Wetlands	NA	NA	NA	< 1	NA	NA	NA	NA	NA	NA	2	< 1	NA	NA	NA
	Upland Forests	NA	NA	NA	32	NA	NA	NA	NA	NA	NA	20	34	NA	18	NA
	Upland Open and Woodlands	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	< 1	NA	NA	NA

Table 3b. Habitat types for Southeast Coast Network parks not used in the sampling frame. Values represent estimated percent area and are derived from recent vegetation maps.

Habitat type	CAHA	CALO	CANA	CHAT	CONG	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU	TIMU
Aquatic / Open Water	< 1	NA	NA	NA	NA	< 1	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tidal Wetlands NA low marsh	13	17	10	NA	NA	24	44	24	65	1	NA	NA	NA	NA	48
Other	37	52	78	34	5	36	36	13	28	88	12	20	26	20	24

Threats to SECN Park Vegetation Resources

Vegetation communities encountered in SECN parks are dynamic entities with frequent changes in composition, cover, and distribution. These changes are caused in part by the vegetation response to natural or anthropogenic environmental stressors. The timing, type, and extent of the disturbance generally evokes a distinguishable response in the species composition, diversity, and structure of the landscape (Turner et al. 1997; Foster et al. 1998). The primary natural disturbance processes in SECN parks are fire and weather (e.g., hurricanes or drought). Anthropogenic disturbances, however, can pose a threat to natural processes, particularly as an additive effect to typical natural disturbances, and have the potential to alter the structure, function, and composition of vegetation communities. The most common anthropogenic disturbances include fire suppression, landscape fragmentation, altered hydrology, artificially high levels of herbivory from deer, and non-native species introduction. By monitoring plant communities, this protocol implementation plan can document the potential impacts of several key stressors that affect park-scale integrity (Table 4). Stressors for parks within the Southeast Coast Network that affect plant community dynamics include expansion of invasive exotic species and forest pests, increased herbivory from deer and other grazers, increased rates of natural and anthropogenic disturbance (e.g., frequency and intensity of coastal zone storms, fire suppression/regime shift, impacts from adjacent land-use and development), and changes in weather patterns and climate. Table 4 provides a list of stressors that affect SECN park's terrestrial vegetation resources and monitoring metrics that can address the impact of those stressors. Vegetation changes are occasionally brought about by multiple interactions among stressors. For example, in SECN's interior parks, Abrams (1998) has suggested that red maple increases and oak decreases are due to some combination of deer over browsing, climate change, and changes in fire regime. These potential interactions will be considered as part of the overall analysis of changes in vegetation over time.

Table 4. Identified stressors affecting terrestrial vegetation resources within Southeast Coast Network parks and potential measures for vital signs monitoring. Information in this table is based on material taken from the vital signs monitoring plans of the Southeast Coast Network (DeVivo 2008), Cumberland Piedmont Network (Leibfreid et al. 2005), and Gulf Coast Network (Segura et al. 2007).

Stressor Category	Issue for the Park	Potential Measures
Invasive Species	Invasive and exotic plant and animal species introduction and their consequent spread is a serious threat to vegetation. These species can displace native plants and change the structure, function and/or composition of vegetation communities. Some native species (e.g., white-tailed deer, loblolly pine) may have artificially high abundances in some parks due to human influence and therefore mimic effects caused by invasive/exotic species.	▪ ¹Invasive species richness, coverage, and frequency. ▪ ¹Change in native species richness/cover with increase in invasive species. ▪ ¹Presence and coverage of grazing/browsing/rooting impact by animals. ▪ ¹Presence of exotic plant pests.
Adjacent Land Use and Development	Urban expansion, residential and commercial land conversion, and road construction are increasing in areas surrounding many SECN parks. Land conversion alters normal hydrologic patterns, disrupts dispersion of plants, and affects natural successional pathways in vegetation communities.	▪ Natural land use / land cover (DeVivo et al. 2018) ▪ Converted land use / land cover (DeVivo et al. 2018) ▪ Discharge, Hydrologic Index Tool metrics, fundamental daily streamflow statistics, and indicators of hydrologic alteration (DeVivo et al. 2018)
Extreme Weather Events	Low-elevation coastal wetlands are vulnerable to storm surges, and even inland systems can be impacted by wind and water disturbance events brought on by ocean-born tropical storms and hurricanes. Plants may be increasingly impacted by these events over time as global climates change and bring about potential shifts in frequency, magnitude, and duration of coastal storms.	▪ ¹Canopy coverage change ▪ ¹Woody stem basal area and seedling/sapling density ▪ ¹Windthrow occurrence ▪ Storm frequency/magnitude (NOAA 2014) ▪ Shoreline displacement/coastal topography (Baron 2018)
Natural Fire Suppression and Fire Application	Some SECN parks have an active prescribed-fire program for vegetation management and restoration, while many park management areas reflect a history of fire suppression. Both activities result in changing vegetation patterns on parks and an increasing need for information about impacted resources.	▪ ¹Changes in native plant species richness, coverage, and frequency ▪ ¹Tree growth, mortality and recruitment ▪ Fire Effects Monitoring program datasets ▪ ¹Fuel load changes

¹Indicates potential measures that have been selected for inclusion in the SECN vegetation monitoring effort. The remaining listed measures are addressed through other monitoring initiatives by NPS or partners.

Table 4 (continued). Identified stressors affecting terrestrial vegetation resources within Southeast Coast Network parks and potential measures for vital signs monitoring. Information in this table is based on material taken from the vital signs monitoring plans of the Southeast Coast Network (DeVivo 2008), Cumberland Piedmont Network (Leibfreid et al. 2005), and Gulf Coast Network (Segura et al. 2007).

Stressor Category	Issue for the Park	Potential Measures
Climate Change	Anticipated long-term climate change is predicted to alter vegetation composition and overall species ranges at SECN parks. Rising sea levels and salt water intrusion into inland/protected sites will impact lower coastal wetlands and flora. Also, changing precipitation and temperature are expected to alter vegetation communities in more xeric areas.	▪ ¹Changes in native plant species richness, coverage, and frequency ▪ ¹Changes in vegetation composition, either from oligohaline and freshwater tolerant to saltwater tolerant species or from upland to wetland tolerant species ▪ ¹Tree growth, mortality and recruitment ▪ Weather station datasets ▪ Sea level using water level stations (NOAA 2018) ▪ Soil chemistry changes
Visitor Use / Other Management Activities	Each park in the Southeast Coast Network has its own goals and their resource management actions can affect vegetation communities. Management activities (e.g., invasive plant removal) may impact certain species, as may visitor impacts.	▪ ¹Changes in native plant species richness, coverage, and frequency ▪ ¹Degree of disturbance from trampling, trail proximity, management action (e.g., mechanical/chemical treatments)

¹Indicates potential measures that have been selected for inclusion in the SECN vegetation monitoring effort. The remaining listed measures are addressed through other monitoring initiatives by NPS or partners.

Section 3. Measurable Objectives

This protocol is being implemented to monitor the status and trends of ecological health for all natural and semi-natural vegetation communities not addressed by other SECN protocols, with the goal of informing management decisions affecting those systems. Ecological health is defined as “the condition of an ecosystem in which processes and functions are adequate to maintain diversity of biotic communities commensurate with those initially found there.” Natural vegetation communities are defined as “types that occur spontaneously without regular management, maintenance, or planting, and that...have a strong component of native species,” while semi-natural vegetation communities are defined as “plant communities where the species composition or structure of the vegetation has been sufficiently altered by anthropogenic disturbance such that no clear natural analogue is known” (Grossman et al. 1998). This monitoring effort does not target areas within SECN parks that are planted, cultivated, and that are managed for those purposes. Non-targeted areas would include building footprints, parking areas, open bodies of water, roads and trails, mowed lawns, and borrow pits.

There is currently one primary monitoring objective for this protocol implementation plan:

Detect meaningful changes in species composition and vegetation structure within natural and semi-natural vegetation communities of SECN parks, excluding those types that are covered by other SECN protocols, and determine whether these changes are correlated with trends in key stressors.

This is the focus of this protocol, which is planned for implementation in 2019. It covers park-wide natural or semi-natural vegetation across 15 parks within the network. This objective has two parts, or sub-objectives:

1. focus sampling effort on the most dominant vegetation communities (broadly defined habitats) on SECN parks.
2. when time allows, increase sampling effort to include other, less dominant vegetation communities (broadly defined habitats) on SECN parks.

A future objective associated with this plan is to “*determine the ecological health of targeted vegetation communities of SECN parks with respect to that community’s reference condition.*” This approach has not yet been developed, but the network hopes to work with partners over the next several years to define ecological integrity metrics of targeted communities of management concern. When metrics have been defined, this will be included as a second primary objective.

These objectives are adapted from the CUPN protocol (White et al. 2011), which is based on a number of monitoring approaches, including the Carolina Vegetation Survey (CVS; Lee et al. 2008), the USDA Forest Service Forest Inventory and Analysis program (USDA 1999), ecological integrity criteria developed by NatureServe and NPS (Faber-Langendoen 2006), and three other inventory and monitoring Programs in the eastern United States (Perles et al. 2007; Sanders et al. 2006; Tierney et al. 2016). The CUPN objectives have been modified to focus on targeted vegetation communities

rather than on forested habitats, and to clarify that “vegetation community measures” mentioned by Cumberland Piedmont Network will include species composition and vegetation structure. We follow the Northeast Temperate Network in defining a statistical target of being able to detect a 40% change in specific metrics of species composition and vegetation structure over 12 years and within a vegetation community (broadly defined habitat), with a power of 80% and chance of false positive of 10% (Tierney et al. 2016, Appendix C).

The vital sign selection process for the Southeast Coast Network highlighted the importance of plant species diversity and functional plant communities with intact disturbance regimes as natural resources critical to the parks (DeVivo et al. 2008). Vegetation communities can serve as an integrated measure of terrestrial ecosystem health by exhibiting changes influenced by alterations in climate, soils, and disturbance patterns. In addition, this protocol implementation plan supports the SECN invasive and exotic plants vital sign by providing information about the prevalence and occurrence of invasive species on parks. This information could help parks understand ecological impacts of these species.

To detect significant changes in species composition and vegetation structure, the Southeast Coast Network has chosen a set of measures that can be monitored at regular intervals and used to report on change over time. Some of these measures relate to key stressors, others relate to specific biotic attributes of the plot, and all can be compared across sampling events to determine whether there is significant change between sampling periods.

Certain measures that have been chosen to address the primary monitoring objective can be combined and used to summarize ecosystem health through an ecological integrity scoring system. By measuring taxonomic, structural, and demographic features, we can look at if the ecosystem’s parameters fall within expected or accepted norms and ranges of variability. To date, however, the metrics and associated thresholds have not been developed for vegetation communities across SECN parks. Over the next several years, the network will work with partners to define metrics and thresholds that will serve as indicators of ecological integrity. These metrics will be easily explained through ratings (i.e., good, fair, or poor) and can be explicitly linked back to park management practices.

Section 4. What's Being Measured and How

The Southeast Coast Network monitors terrestrial vegetation in fixed plots that are resampled once every four years. Plots are selected using a continuous draw of plot centroids across SECN park broad habitat types via the generalized random-tessellation stratified (GRTS) sampling methodology (Stevens and Olsen 2004) to create a spatially-balanced, random set of monitoring sites for each of the SECN parks. Sampling frames were based on broadly defined habitats nested within whole-park polygons (nine of fifteen parks) or targeted management units (six of fifteen parks), with roads, paved surfaces, open lawns, waterbodies, 'low' marsh zones dominated by either *Sporobolus alterniflorus* or *Juncus roemerianus*, and a 14-meter (46 ft) buffer around park boundaries and vegetation polygons excluded in advance. There are three main advantages to a GRTS design. First, the sample points generated by GRTS are spatially balanced, so there is generally uniform dispersion of sampling sites over the area of interest. This ensures that all areas included within the sampling frame are represented. Second, the GRTS design allows for flexible sample size, such that sites can be added to or excluded from the sampling plan, while still maintaining the spatial balance and without compromising the integrity of the overall design. For instance, if "plot #2" is rejected using established decision rules for plot selection, we can simply pick the next number on the list of plots not yet assigned to continue to have a random, spatially balanced sample. This allows potential sites to be rejected if they are determined inappropriate, or additional sites to be added if funding is increased and additional plots are needed to meet our objectives. Finally, the GRTS method eliminates site selection bias, because sampling points are randomly chosen among all possible points within a systematic grid. The GRTS design also offers additional flexibility for post-stratification of plots based on other user-defined criteria, such as vegetation community type or age-class (Stevens and Olsen 2004).

The SECN protocol uses, with a few modifications, the plot layout and field sampling methods that were developed by the Cumberland Piedmont Network (White et al. 2011). Links between monitoring elements, sampling method, and data outputs are provided in Table 5, adapted from the vegetation protocol developed by the Gulf Coast Network (Carlson et al. 2018).

Table 5. Monitoring elements, sampling methods, collected data, and habitat types from which each element will be collected for the SECN Terrestrial Vegetation Monitoring Protocol (table adapted from the GULN vegetation protocol implementation plan, Carlson et al. 2018).

Monitoring Objective	Element	Sampling Method	Data Collected	Habitat Sampled
Objective 1— status and trends	Vascular plant species richness	Count the number of vascular plant species encountered in eight 1 m ² (1 × 1 meter) and eight 10 m ² (3.16 × 3.16 meter) nested subplots, and four 100 m ² (10 × 10 meter) modules. These data can be combined to encompass the full 400 m ² (20 × 20 meter) plot.	The total count of species in a sampling unit is species richness. Data can be summarized as averages across nested subplots, modules, or the 400 m ² plot. There are separate counts of native species and invasive species.	All vegetation types
Objective 1— status and trends	Vascular plant species relative frequency and constancy	Record frequency by documenting species occurrence in four 100 m ² (10 × 10 meter) modules.	For each plot, relative frequency is estimated at one scale per species. At the largest scale, the frequency is the number of 100 m ² modules that contain at least one individual of that species, and then dividing that by the total number of modules (4). Constancy is the frequency of occurrence of a species within a specified group (e.g., broad habitat type) of plots.	All vegetation types
Objective 1— status and trends	Woody stem (tree, ≥10 cm DBH) basal area, density, health condition, mapped location, growth, mortality, and recruitment	Record diameter and health condition (e.g., pest presence) of each live and dead woody stem ≥10 centimeter DBH (1.37 meters above the ground) within each of the four 100 m ² (10 × 10 meter) modules and map their location on gridded datasheets.	Basal area is calculated for each species of tree within the entire plot, from DBH values from individual trees; density is a count of trees/plot, separated by species. The status (e.g., presence of tree pest and disease) for each standing individual tree is ancillary data and will eventually be used to calculate a forest/woodland health condition. Tree growth, mortality and recruitment will be calculated based on repeat sampling data.	All vegetation types

Table 5 (continued). Monitoring elements, sampling methods, collected data, and habitat types from which each element will be collected for the SECN Terrestrial Vegetation Monitoring Protocol (table adapted from the GULN vegetation protocol implementation plan, Carlson et al. 2018).

Monitoring Objective	Element	Sampling Method	Data Collected	Habitat Sampled
Objective 1— status and trends	Woody stem (sapling, ≥ 137 cm tall, < 10 cm DBH) basal area and density; woody stem (seedling, < 137 cm tall) density	Record diameter and species of each sapling in eight 10 m^2 (3.16×3.16 meter) nested subplots; record the height class and species of each seedling in eight 1 m^2 (1×1 meter) nested subplots.	Basal area is calculated for each species of sapling within the 10 m^2 subplots and standardized to the plot area, from DBH values from individual saplings; density is estimated number of saplings or seedlings on the plot, based on the counts of saplings and seedlings standardized to the plot area and separated by species.	All vegetation types
Objective 1— status and trends	Fuel loads of downed woody material	Record the density and decay classes of coarse woody debris, density of fine woody debris and depths of litter, duff, and fuel bed strata across the ground cover of three 25 meter transects.	Density or depth of each downed woody material category (coarse and fine woody debris, litter, duff, fuel bed) is calculated into a fuel load (tons/acre) estimate for the three transects.	Upland types only
Objective 1— status and trends	Threat to Plant Community	Estimate the presence and areal coverage of the following: 1. grazing/rooting impact by animals. 2. exotic plant pests. 3. degree of disturbance from trampling, trail proximity, management action (e.g., mechanical/chemical treatments). 4. fire suppression + fire history	Percent cover is estimated for the entire plot for each threat and disturbance observed within the plot. Fire history data are acquired from the park and regional fire ecologists.	All vegetation types

Table 5 (continued). Monitoring elements, sampling methods, collected data, and habitat types from which each element will be collected for the SECN Terrestrial Vegetation Monitoring Protocol (table adapted from the GULN vegetation protocol implementation plan, Carlson et al. 2018).

Monitoring Objective	Element	Sampling Method	Data Collected	Habitat Sampled
Ancillary Data & Future Objective 2—reference condition comparison	Status of cover class values of vascular species and strata	Estimate percent cover for all species present in each 100 m ² (10 × 10 meter) module, and for each stratum present (tree, shrub, herbaceous) in the full 400 m ² (20 × 20 meter) plot.	Percent cover is estimated for each species and stratum following the Carolina Vegetation Survey cover scale: < 0.1%, 0.1–1, 1–2, 2–5, 5–10, 10–25, 25–50, 50–75, 75–95, 95–100% (Peet et al. 1998). A mean cover class will be reported for each plot.	All vegetation types
Ancillary Data & Future Objective 2—reference condition comparison	Condition of soil nutrient and texture values	Collect soil samples from the top 10 cm of the uppermost soil horizon across three collection points offset from the standard 400 m ² (20 × 20 meter) plot.	Soil nutrient and texture values are determined by laboratory analyses of samples collected in the field.	All vegetation types
Ancillary Data	Vegetation classification	Using classification keys developed for each SECN park, identify the U.S. National Vegetation Classification Standard association(s) for each plot.	Association type(s) for each plot.	All vegetation types
Ancillary Data	Site characteristics	Estimate plot geomorphology (slope, aspect, landform, terrain shape index, topographic position), and percent cover of water on the plot for the entire plot.	1. Slope (degrees) 2. Aspect (compass bearing) 3. Terrain shape index (calculated from 8 slope estimates measured at aspect and 45 degree increments from aspect) 4. Topographic position and landform are qualitative assessments.	All vegetation types

Table 5 (continued). Monitoring elements, sampling methods, collected data, and habitat types from which each element will be collected for the SECN Terrestrial Vegetation Monitoring Protocol (table adapted from the GULN vegetation protocol implementation plan, Carlson et al. 2018).

Monitoring Objective	Element	Sampling Method	Data Collected	Habitat Sampled
Ancillary Data	Photo points	Three digital images are made of each plot, including two horizontally-scaled photos taken from the plot edges and one 360-degree image taken from plot center.	Three digital image files.	All vegetation types
Ancillary Data	Tree Map	All trees sampled within a plot are labeled on gridded paper representing the plot layout.	A graphic illustrating relative location of trees within each plot module.	All vegetation types

Overview of Methods

Preparation and Plot Set-Up

The vegetation monitoring field crew prepares for monitoring activities well in advance of each field season following the steps detailed in SECN SOP 1.4.07 *Field Season Preparation* (Boyle 2018a). All plots within a given park are visited on a single trip or set of consecutive trips for that season, in coordination with park management. On the first visit to each permanent 20 × 20-meter (65.6 × 65.6 ft) plot, the crew uses GPS units and maps to navigate to a pre-selected plot center-point. This point is marked with rebar, and then its location is recorded on-site using a high-accuracy GPS device (e.g., Trimble Geo 7X with sub-meter post processing accuracy for an open canopy). The field crew locates and places the remaining six permanent markers using measuring tapes and a compass. The plot layout is shown in Figure 3. These and related methods are described in SECN SOP 1.4.10 *Site Selection, Plot Establishment, and Return Visits* (Boyle 2018b). Plot establishment data and a plot layout diagram are recorded on *SECN Veg Form 1—Vegetation Plot Establishment* which is included in the Appendices of SOP 1.4.10.

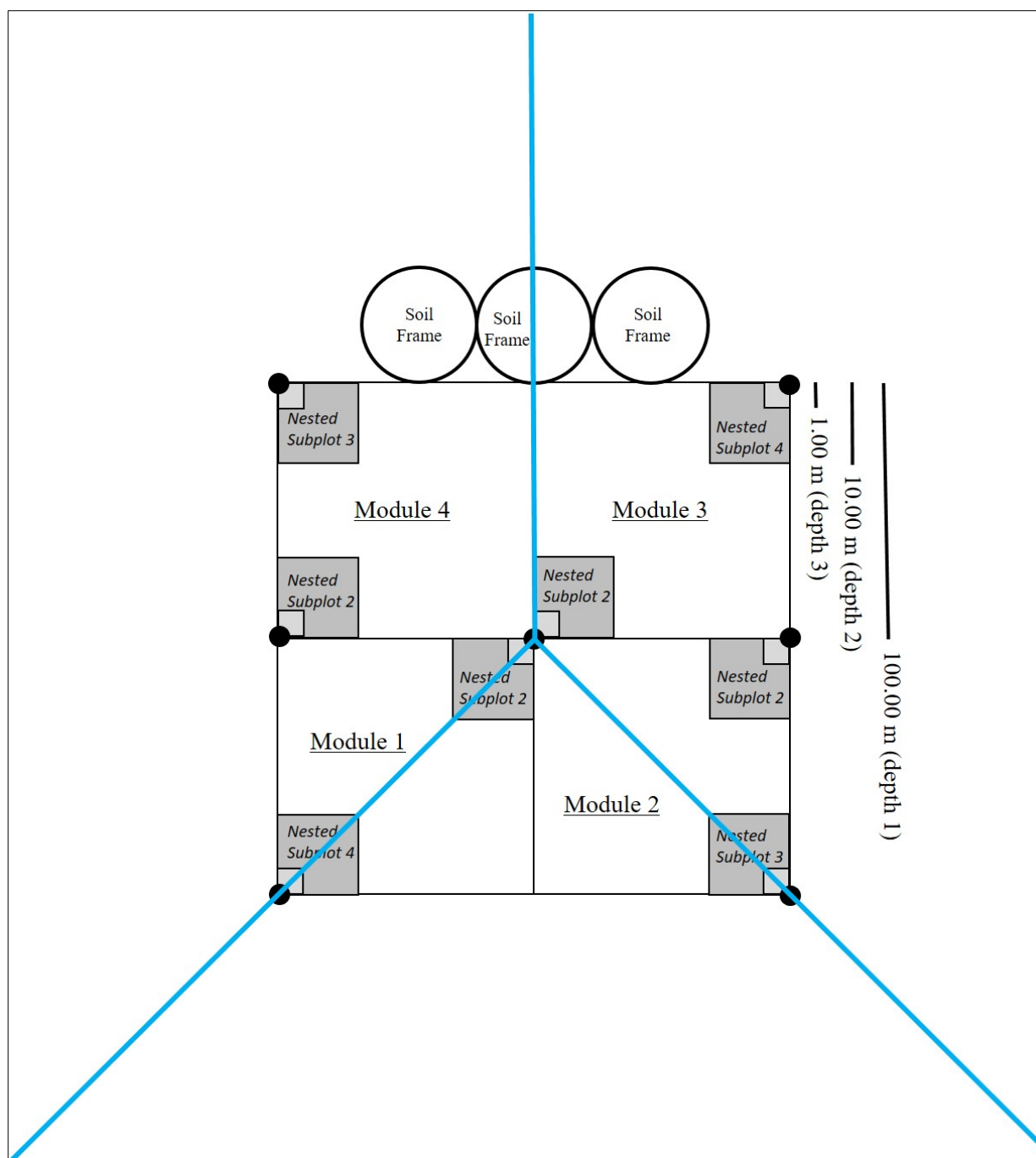


Figure 3. Plot design for long-term vegetation monitoring. The layout of the sampling plot for the Southeast Coast Network, which is a modified version of the standard Level 5 Carolina Vegetation Survey plot. Ideal location of rebar used as permanent structures to monument the plot are black shaded circles. Blue lines represent location of the 3 25-meter fuel transects.

Field Sampling Methods

On every sampling visit to a plot, the field crew completes eight major tasks, including (1) site characteristics, (2) plot photo points, (3) tree measurements and canopy closure estimates, (4) tree

map, (5) taxonomy standard and species diversity and cover measurements, (6) seedling and sapling count, (7) fuel load estimates, and (8) US National Vegetation Classification (US NVC) association identification. Soil samples and certain site characteristic elements (e.g., landform, terrain shape) are only taken during the first sample event directly following plot establishment. Soil macronutrient and relatively stable geomorphology measures from this one-time sample can be used to compare SECN monitoring plots with reference conditions from other vegetation plot databases to begin addressing Objective 2 of this monitoring protocol. If a subset of plots changes dramatically (e.g., burned) or if updated soil data are needed for a park or group of parks, limited repeat soil sampling may be scheduled.

For tasks (1) and (2), the crew records site characteristics such as slope, aspect, basic hydrological condition, terrain shape, and indicators of disturbances to the plot. These methods are described in SOP 1.4.10. The crew takes two photo point photographs for the plot, as described in SOP 1.1.05 *Plot Photo Points* (Boyle 2019c). Site data are recorded on *SECN Veg Form 2—Site Characteristics* (included in SOP 1.4.10) and photo point data are recorded on *SECN Veg Form 3—Plot Photo Points and Canopy Closure Measures* (included in SOP 1.1.05).

For tasks (3) and (4), the crew identifies all woody stems within the 20 × 20-meter plot that are ≥ 10 centimeters (3.9 in) DBH to the highest level of taxonomic accuracy possible. For live trees, they record the DBH and their status, crown class, vigor, dieback, damage, foliage condition, and foliage percent; for dead trees, crews record the DBH, decay class, and estimated height. If available, two trees located within the plot are tagged with an aluminum tree tag to aid in plot relocation efforts. The numbered metal tags are nailed 10 centimeters below the DBH measuring point, which means the tag is placed at 1.27 meters above the ground level. All recorded live or dead trees ≥ 10cm DBH are mapped on a tree diagram—gridded to 1-meter resolution. Finally, a spherical densiometer is used to estimate canopy closure across the plot. SOP 1.4.11—*Tree Measurements* (Boyle 2019d) provides specific details about what data are recorded, as well as instructions for how to deal with forked trees or trees that otherwise require a different DBH measurement. Tree diameter data and plot grids for tree maps are recorded on *SECN Veg Form 4—Tree Measurements* and canopy closure estimates are recorded on *SECN Veg Form 3—Plot Photo Points* (included with SOP 1.4.11).

Tasks (5) and (6) require the development of species lists across nested subplots. The field crew begins by recording the presence of vascular plant species that are rooted within the 1 x 1 meter subplot in corner 2 of module 1 (see Figure 3); next the crew tallies the woody plant seedlings that are between 5 and 137 centimeters (2–54 in) within the subplot. The subplot is then extended to 3.16 × 3.16 m and any vascular plant species that was not located in the 1 × 1 m subplot is recorded; woody plant saplings that are greater than 137 centimeters (53.9 in) in height and less than 10 centimeters (3.9 in) DBH are tallied in this extended subplot. These steps are repeated in corner 4 of module 1. Once these two nested subplots in corners 2 and 4 have been sampled, the remaining area of the module is searched for any new vascular plant species that are either rooted in or overhanging the module. Finally, an areal cover class value is estimated for each species rooted in or overhanging the module. These steps are repeated in module 2 (nested subplots 2 and 3), module 3 (nested subplots 2 and 4), and module 4 (nested subplots 2 and 3). Full instructions are provided in SOP

1.4.14—*Species Diversity and Seedling/Sapling Measurements* (Boyle 2019e). Diversity and species cover data are recorded on *SECN Veg Form 5—Species Diversity* while seedling and sapling measurements are recorded on *SECN Veg Form 6—Seedling/Sapling Measurements* (included with SOP 1.4.14).

For task (7), the field crew records the condition of coarse and fine woody debris, duff depth, litter depth, and fuel bed depth along two 25 m transects that bisect the 20 × 20 m vegetation plot. Full instructions are provided in the SOP 1.4.12—*Fuel Load Measurement* (Boyle et al. 2019a). Data are recorded on *SECN Veg Form 7—Fuel Load Measurements* (included with SOP 1.4.12).

For task (8), the field crew uses dichotomous field keys that have been developed for SECN parks to identify the US NVC vegetation association (or associations) that best match the sampled site. Full instructions are provided in the SOP 1.4.15—*U.S. National Vegetation Classification Identification* (Boyle 2019f). Data are recorded on *SECN Veg Form 8—Vegetation Community Assessment* (included with SOP 1.4.15).

Finally, soil samples are taken once plots are established in three subplots located adjacent to the 20 × 20-meter (65.6 × 65.6 ft) vegetation plot. Upon return from the field, soil samples are oven-dried within 14 days and then shipped to a soil testing laboratory. Details are provided in SOP 1.4.16—*Soil Measurements* (Boyle 2019g). The sampler indicates where soil samples have been taken on the plot using *SECN Veg Form 1—Vegetation Plot Establishment* (included with SOP 1.4.16).

Data Entry and Management

Field data are recorded on paper datasheets. Within two weeks following field work, data are entered into the SECN vegetation database. Data management, quality assurance (QA) and quality control (QC) procedures are explained in the SOP 2.4.05—*Data Management, Quality Assurance and Quality Control I* (Boyle and Capece 2019). See also Section 6, Data Management, Analysis, and Reporting.

Additional Operational Notes

Many SECN parks have indicated strong interest in participating in the terrestrial vegetation sampling event when park staff are available. Such participation will greatly enhance efficiency and shorten overall sampling time. However, as participation is not a park obligation, the SECN sampling schedule is developed annually under the expectation that SECN staff or contractors/collaborators complete all field work on their own.

Section 5. Sampling Design and Monitoring Schedule

The Southeast Coast Network allocates the number of vegetation monitoring plots within each park or unit based on broadly defined habitat type size, with a lower limit of nine plots per unit and an upper limit of 76 plots per unit. The original CUPN vegetation monitoring protocol uses a two-year rotating panel design to sample eight plots per park per year in forested or woodland vegetation only at most of their parks, and a 4-year rotating panel design for the two largest parks. The SECN has chosen to sample in forested and woodland vegetation, as well as other mapped natural and semi-natural vegetation because of the high structural diversity within the Southeastern Coastal Plain geography. In many of the Network's parks, natural shrublands and herbaceous or graminoid-dominated habitats occupy greater spatial coverage than forests and woodlands (see Table 3A). Also, DeVivo et al. (2008) identified all vegetation community types as a primary vital sign to track within the SECN.

The network will sample within its parks every four years, and all plots at a given park are sampled in the same year. This design aligns with the sample size allocation for parks within both the Gulf Coast Network (Carlson et al. 2018) and the Northeast Temperate Network (Tierney et al. 2016). The Gulf Coast Network's protocol implementation plan encompasses a similar variety of habitats as the Southeast Coast Network. Furthermore, parks in the SECN are spread apart in geography (see Figure 1); accessing all 15 parks within a given sample year would not be financially or logistically feasible. Sampling all plots within a year means that for a given park and cycle, different plots will not have differences based on annual variation. This design increases within-cycle similarity across plots, but with the cost of decreasing the between-cycle similarity. Initially this may make it more difficult to detect trends, but it will make it easier to describe vegetation status within a given park and year.

All non-excluded vegetation polygons located within the administrative boundary of a given park, representing broadly defined habitats, are the sampling frame for this protocol. Within five parks, the sampling frame is distributed across distinct park units, based on wide geographical separation of these units--Cape Lookout NS, Canaveral NS, Chattahoochee River NRA, and Timucuan EHP. Within Congaree NP, the sampling frame is distributed across an upland and wetland unit, owing to their clear geomorphologic separation. For a full description of the SECN sample design, including detailed explanations of how sample frames are defined, sample sizes are determined, and plots are spatially allocated, refer to Appendix C in SOP 1.4.10—*Site Selection, Plot Establishment, and Return Visits* (Boyle 2018b).

Sample Size Determination and Power Analysis

Based on sample size allocation using time and cost constraints from the vegetation monitoring projects of the Cumberland Piedmont Network (White et al. 2011) and the Gulf Coast Network (Carlson et al. 2018), the Southeast Coast Network estimates that field crews can target monitoring efforts within 80 to 91 vegetation plots in dominant and co-dominant habitat types and up to 68 additional plots in less dominant habitat types per year. The Southeast Coast Network allocates plots among parks and park-units based on the following factors: (1) the number of plots is scaled according to area coverage of broadly defined habitat types, and (2) the number of plots is scaled

according to park (or park-unit) area. The first factor allows for dominant (greater than 60% total area of sampling frame) and co-dominant (greater than 30% total area of the sampling frame) broadly defined habitat types to have a greater number of plots than habitat types with smaller coverage. Plots that are located within dominant and co-dominant types are the priority sampling target (see Section 3, Measurable Objectives), and represent the minimum sample size during a given year (Table 6). The second factor allows for a greater number of plots within larger parks and park-units. The plot sample size in dominant and co-dominant habitats for the smallest network parks and park-units is five (area between 20–100 hectares) and four (area less than 20 hectares). For the largest parks, the sample size is determined so that 1–2 plots per 100 hectares are distributed among any dominant and co-dominant habitat type. We aimed for between 1 and 25 plots per 100 hectares (247 acres [ac]) for each park and park-unit, which was achieved for all but the smallest park-units in the network (Fort Sumter, Fort Frederica, and Moores Creek) and for the largest park-unit in the network (Congaree-Wetlands) (Table 6).

Table 6. Plot allocation within dominant and co-dominant broad habitat types of parks within the NPS Southeast Coast Network.

Park-Unit	Broadly Defined Habitat	Area¹	Percent²	Sample Size³	Plot / 100 ha
CAHA-Bodie Island	Maritime open upland vegetation	697	64	8	1.1
CAHA-Buxton	Maritime open upland vegetation	672	37	8	1.2
CAHA-Buxton	Tidal wetlands	785	43	8	1.0
CAHA-Hatteras	Maritime open upland vegetation	773	87	8	1.0
CAHA-Ocracoke	Maritime open upland vegetation	761	67	8	1.1
CAHA-Ocracoke	Tidal wetlands	359	31	6	1.7
CALO-Cape Lookout	Maritime open upland vegetation	168	68	6	3.6
CALO-North Core Banks	Maritime open upland vegetation	991	60	10	1.0
CALO-North Core Banks	Tidal wetlands	650	39	8	1.2
CALO-South Core Banks	Maritime open upland vegetation	619	79	8	1.3

¹ Estimated habitat area in hectares

² Estimated habitat percentage across entire sampling frame

³ Total number of plots

Table 6 (continued). Plot allocation within dominant and co-dominant broad habitat types of parks within the NPS Southeast Coast Network.

Park-Unit	Broadly Defined Habitat	Area¹	Percent²	Sample Size³	Plot / 100 ha
CALO-Shackleford Banks	Maritime open upland vegetation	502	86	8	1.6
CANA-Apollo Beach	Maritime nontidal wetlands	420	80	8	1.9
CANA-Oak Hill	Coastal Plain open uplands and woodlands	227	53	8	3.5
CANA-Oak Hill	Maritime nontidal wetlands	167	39	6	3.6
CHAT-Mid	Piedmont upland forests	320	59	6	1.9
CHAT-Mid	Successional forests	185	34	5	2.7
CHAT-North	Piedmont upland forests	260	38	7	2.7
CHAT-North	Successional forests	254	37	7	2.8
CHAT-South	Piedmont upland forests	518	66	8	1.5
CONG-Uplands	Successional forests	583	92	8	1.4
CONG-Wetlands	Coastal Plain alluvial wetlands	7852	94	56	0.7
CUIS	Maritime upland forests and shrublands	4417	72	44	1.0
FOFR	Maritime upland forests and shrublands	20	49	5	25.2
FOFR	Successional forests	18	45	5	27.6
FOMA	Maritime upland forests and shrublands	53	75	5	9.5
FOPU	Tidal wetlands	180	90	8	4.4
FOSU	Maritime open upland vegetation	6	40	4	63.8
FOSU	Maritime upland forests and shrublands	9	57	4	44.9
HOBE	Successional forests	502	69	8	1.6
KEMO	Piedmont upland forests	477	43	8	1.7

¹ Estimated habitat area in hectares

² Estimated habitat percentage across entire sampling frame

³ Total number of plots

Table 6 (continued). Plot allocation within dominant and co-dominant broad habitat types of parks within the NPS Southeast Coast Network.

Park-Unit	Broadly Defined Habitat	Area ¹	Percent ²	Sample Size ³	Plot / 100 ha
KEMO	Successional forests	532	47	8	1.5
MOCR	Coastal Plain alluvial wetlands	16	37	5	31.3
MOCR	Successional forests	25	59	5	19.9
OCMU	Coastal Plain alluvial wetlands	130	63	6	4.6
TIMU-Cedar Point	Maritime upland forests and shrublands	412	97	8	1.9
TIMU-Thomas Creek	Maritime upland forests and shrublands	227	59	8	3.5
TIMU-T Roosevelt	Maritime upland forests and shrublands	157	92	7	4.4
Totals	–	~25,000	–	343	–

¹ Estimated habitat area in hectares

² Estimated habitat percentage across entire sampling frame

³ Total number of plots

Broadly defined habitat types that cover between 1–30% of a park’s or park-unit’s sampling frame are allotted a total of 4 plots per habitat type. These plots represent the secondary sample target of this protocol implementation plan (see Section 3, Measureable Objectives), and are only sampled if time allows during the dedicated field season at a given park. Table 7 summarizes these habitats for each park and park-unit. Habitat types that occupy less than 1% of the sampling frame coverage of a given park or park-unit are allotted a single index plot, and are only sampled if a park-specific need arises. A complete list of scaling rules for sample size determination of both primary and secondary focus vegetation plots is in Appendix C of SOP 1.4.10—*Site Selection, Plot Establishment, and Return Visits* (Boyle 2018b).

The overall sample size of primary and secondary focus plots is greater than 10 for all but one SECN park (Fort Matanzas NM). The Northeast Temperate Network showed that a 10 plot per park sample size met targets for detecting change in several key monitoring metrics and did not perform worse than parks with slightly larger sample sizes (Miller and Mitchell 2014). A preliminary power analysis based on publicly available SECN monitoring data from three sampling events at Cape Lookout NS and Kennesaw Mountain NBP suggest that the 10 plots per park minimum is sufficient for most of the monitoring elements that Objective 1 of this protocol seeks to target. For a full description of the SECN preliminary power analysis, see Appendix C. The current minimum will be reassessed in

subsequent power analyses on a broader geographic scale, once two iterations of data have been collected for all SECN parks included in this protocol.

Table 7. Plot allocation within broad habitat types representing between 1 and 30% coverage of parks within the NPS Southeast Coast Network. For each type within a park-unit, the sample size is 4. These plots represent a secondary focus of this monitoring effort. A total of 200 plots are distributed across these habitat types.

Park-Unit	Broadly Defined Habitat	Area¹	Percent²	Plot / 100 ha
CAHA-Bodie Island	Tidal wetlands	321	29	1.2
CAHA-Bodie Island	Successional forests	73	7	5.5
CAHA-Buxton	Successional forests	215	12	1.9
CAHA-Buxton	Maritime upland forests and shrublands	134	7	3.0
CAHA-Hatteras	Tidal wetlands	97	11	4.1
CAHA-Hatteras	Successional forests	18	2	22.0
CAHA-Ocracoke	Successional forests	21	2	18.8
CALO-Cape Lookout	Tidal wetlands	42	17	9.6
CALO-Cape Lookout	Maritime upland forests and shrublands	26	11	15.3
CALO-Cape Lookout	Maritime nontidal wetlands	10	4	41.0
CALO-Shackleford Banks	Tidal wetlands	80	14	5.0
CALO-South Core Banks	Tidal wetlands	156	20	2.6
CALO-South Core Banks	Maritime upland forests and shrublands	13	2	30.8
CANA-Apollo Beach	Maritime upland forests and shrublands	76	15	5.3
CANA-Apollo Beach	Coastal Plain open uplands and woodlands	13	2	32.0
CANA-Apollo Beach	Invasive vegetation	10	2	40.7
CANA-Oak Hill	Maritime upland forests and shrublands	11	3	35.3
CANA-Oak Hill	Invasive vegetation	10	2	38.4
CANA-Oak Hill	Maritime open upland vegetation	7	2	57.4
CHAT-Mid	Piedmont alluvial wetlands	42	8	9.5
CHAT-North	Piedmont alluvial wetlands	177	26	2.3
CHAT-South	Piedmont alluvial wetlands	139	18	2.9

1 Estimated habitat area in hectares

2 Estimated habitat percentage across entire sampling frame

Table 7 (continued). Plot allocation within broad habitat types representing between 1 and 30% coverage of parks within the NPS Southeast Coast Network. For each type within a park-unit, the sample size is 4. These plots represent a secondary focus of this monitoring effort. A total of 200 plots are distributed across these habitat types.

Park-Unit	Broadly Defined Habitat	Area¹	Percent²	Plot / 100 ha
CHAT-South	Successional forests	125	16	3.2
CONG-Uplands	Coastal Plain open uplands and woodlands	51	8	7.9
CONG-Wetlands	Coastal Plain nonalluvial wetlands	269	3	1.5
CONG-Wetlands	Successional forests	239	3	1.7
CUIS	Tidal wetlands	262	4	1.5
CUIS	Coastal Plain open uplands and woodlands	249	4	1.6
FOFR	Tidal wetlands	2	6	175.5
FOMA	Maritime open upland vegetation	18	25	22.7
FOPU	Maritime upland forests and shrublands	18	9	22.7
FOSU	Invasive vegetation	0	3	950.8
HOBE	Piedmont upland forests	167	23	2.4
HOBE	Piedmont alluvial wetlands	36	5	11.1
HOBE	Piedmont nonalluvial wetlands	13	2	30.4
HOBE	Piedmont open uplands	10	1	38.7
TIMU-T Roosevelt	Maritime upland forests and shrublands	157	92	4.4
KEMO	Piedmont alluvial wetlands	96	9	4.2
KEMO	Piedmont open uplands	12	1	33.1
MOCR	Coastal Plain nonalluvial wetlands	2	4	246.0
OCMU	Piedmont upland forests	52	25	7.8
OCMU	Successional forests	23	11	17.7
OCMU	Coastal Plain upland forests	3	1	135.0
TIMU-Cedar Point	Maritime nontidal wetlands	11	3	36.0
TIMU-T Roosevelt	Coastal Plain alluvial wetlands	7	4	56.8
TIMU-T Roosevelt	Maritime nontidal wetlands	5	3	74.2
TIMU-Thomas Creek	Maritime nontidal wetlands	86	23	4.6

1 Estimated habitat area in hectares

2 Estimated habitat percentage across entire sampling frame

Table 7 (continued). Plot allocation within broad habitat types representing between 1 and 30% coverage of parks within the NPS Southeast Coast Network. For each type within a park-unit, the sample size is 4. These plots represent a secondary focus of this monitoring effort. A total of 200 plots are distributed across these habitat types.

Park-Unit	Broadly Defined Habitat	Area ¹	Percent ²	Plot / 100 ha
TIMU-Thomas Creek	Coastal Plain alluvial wetlands	65	17	6.1
TIMU-Thomas Creek	Tidal wetlands	4	1	101.1
Totals	–	~4,700	–	–

1 Estimated habitat area in hectares

2 Estimated habitat percentage across entire sampling frame

The SECN range of 5–64 plots per park and 80 to 91 plots per year in dominant or co-dominant habitat types, with up to 68 plots in less dominant habitat types each year, is generally consistent with the vegetation monitoring protocol of the Cumberland Piedmont Network (2011), which targeted 112 plots per year. The exception is that the Cumberland Piedmont Network only samples forests and woodlands while the Southeast Coast Network can potentially sample any natural or semi-natural habitat within a park. The Cumberland Piedmont Network initially allocated 16 plots per park for smaller parks and 32 plots per park for larger parks, though these totals were later increased to 20 and 60 respectively (B. Moore, CUPN, personal communication). Like the Cumberland Piedmont Network, the Southeast Coast Network also randomly chooses a portion of plots sampled within a given year (approximately 5% or five plots per year) to be resampled in that same year to monitor data quality and within-year sampling consistency. These quality control resampled plots are determined at the beginning of each field season.

Spatial Allocation

Shapefiles of natural and semi-natural vegetation are obtained from output generated from the most recent vegetation mapping reports in SECN parks (see Table 2). Additionally, vegetation polygons in each park are cross-walked to NatureServe’s Ecological Systems (Comer et al. 2003) and finally to broad habitat categories defined by this report’s lead author (see Table 3). Finally, for several large parks, polygons are concatenated into management units (park-units) that represent areas that are separated by major geographic features (e.g., inlets, large rivers, distance). Cape Hatteras NS, Cape Lookout NS, Canaveral NS, Chattahoochee River NRA, and Timucuan EHP are divided into separate units based on geographic features. One additional park, Congaree NP, is separated into two units based on the clear separation between uplands located on upper terraces of the park’s north end and bottomlands throughout the remainder of the park along the Congaree River floodplain. Unit names are provided in Table 6. The sampling design for vegetation monitoring begins with a continuous draw of plot centroids across SECN park broad habitat types. These polygons represent both the target population and the sampling frame for monitoring, and represent spatial coverage within current administrative boundaries that exclude non-natural features such as roads, buildings, and manicured lawns, as well as open water, and low salt marsh. Low salt marsh habitats are not

targeted for this sampling effort because they are targeted extensively by another SECN monitoring protocol (see DeVivo et al. 2015). During field visits, plots are established in such a way that they do not contain more than a single broad habitat type. This is so summaries of vegetation trends can be reported (and analyzed where sample sizes are appropriate) at the broad habitat level.

The selection of plots to sample, with the number for each park pre-determined (see Sample Size Determination and Power Analysis), utilizes the GRTS sampling methodology to create a spatially-balanced set of monitoring sites for each of the SECN parks' broad habitat types. The GRTS technique uses reverse hierarchical ordering to map two-dimensional space (e. g., locations of plots in a park) into one-dimensional space, by giving each plot an ordered spatial address. Then, the program uses restricted randomization to order the addresses into a random, spatially balanced list of plots (McDonald 2004; Stevens and Olson 2004). The GRTS technique for SECN vegetation plot allocation is performed in the statistical program R v3.5.1, utilizing the spsurvey library (Kincaid and Olsen 2017). Shapefiles are produced for each park and/or management unit that contains plot centroid points. These points are placed in a spatially-balanced GRTS order as described above. Any sub-sample of points on this list will maintain spatial balance, if they are selected in consecutive order. For SECN parks not stratified by management units (i.e., CUIS, FOFR, FOMA, FOPU, FOSU, HOBE, KEMO, MOCR, OCMU), the selected sub-sequence is the first N points distributed across that park's broad habitat sampling frame. For parks stratified by management units (i.e., CAHA, CALO, CANA, CHAT, CONG, TIMU), the selected sub-sequence for each management unit is the first N points distributed across that unit's broad habitat sampling frame (where N is equal to the vegetation monitoring sample size, Tables 6 and 7). Each of these sub-sequences is the established set of the park's vegetation monitoring plot locations. An additional $7N$ plots are provided by the GRTS draw, which represent replacement points should any of the original selected points need to be excluded from sampling. Reasons for exclusion include:

- the plot contains privately owned land
- the plot contains non-vegetated surfaces (e.g., roads, manicured lawns, open water, beaches) or occurs on a trail or footpath (this exclusion minimizes vandalism and avoids negative visual impacts to park visitors)
- the plot spans multiple broad habitat types
- the plot contains sensitive archaeological resources
- sampling the plot would pose a safety risk (e. g., plot occurs along a cliff face)
- the plot is inaccessible (e. g., travel to and from the plot, and sampling the plot, cannot be accomplished in a 10-hour day) by boat or foot travel

When plots are rejected for any reason, the next unused plot number in the ordered list is chosen to replace it; refer to SOP 1.4.10 *Site Selection, Plot Establishment, and Return Visits* (Boyle 2018b) for rejection criteria and procedures.

It is possible that some parks will acquire tracts of land after the original site selection has been established. If the park in question is in the process of acquiring property, then the area of potential

acquisition will be included in our GRTS draw. If a new acquisition occurs after the site selection process, we will discuss with park managers the feasibility of extending the original grid into that new acquisition area.

Temporal Allocation

Field work for this protocol is conducted in spring, summer and early fall (May–September), during the growing, flowering and/or fruiting seasons of most plants in each park. All 15 network parks are sampled according to a four-year monitoring cycle; a few parks are sampled each year, followed by analysis and reporting of data from the sampled parks at the end of each sampling year. Every attempt will be made to re-sample plots within two weeks of the original sample date to ensure that vegetation metrics (e.g., cover) that vary over the growing season can be compared between different visits to the same plot. The year one panel consists of Cape Hatteras NS, Fort Matanzas NM, Fort Pulaski NM, and Timucuan EHP, for a total of 82 plots in dominant/co-dominant habitat types, 60 plots in less dominant types, and 5 randomly-selected plots for quality control resampling. The year two panel consists of Chattahoochee NRA, Cumberland Island NS, Fort Sumter NM, and Ocmulgee Mounds NHP, for a total of 91 plots in dominant/co-dominant habitat types, 48 plots in less dominant types, and 5 randomly-selected plots for quality control resampling. The year three panel consists of Congaree NP, Fort Frederica NM, and Kennesaw Mountain NBP, for a total of 90 plots in dominant/co-dominant habitat types, 24 plots in less dominant types, and 5 randomly-selected plots for quality control resampling. The year four panel consists of Cape Lookout NS, Canaveral NS, Horseshoe Bend NMP, and Moores Creek NB, for a total of 80 plots in dominant/co-dominant habitat types, 68 plots in less dominant types, and 5 randomly-selected plots for quality control resampling. A summary of the temporal design and scale of analysis for each monitoring element is provided in Table 8. Table 9 provides a timeline of fieldwork and reporting over the next 10 years.

Table 8. Monitoring elements, temporal design, and scale of analysis at Southeast Coast Network parks as part of the protocol for monitoring terrestrial vegetation.

Element	Temporal Design	Scale of Analysis
Vascular plant species richness	Recorded for all plots in a park in a single sampling season, conducted once every four years.	The plot is the sampling unit for analysis. Richness is represented as a total for the plot. These data are summarized for each park once every four years. Species accumulation curves (incorporating subplot to module scales) or similar methods may be used to estimate undersampling bias and confidence intervals. When multiple broad habitats are represented within a park, habitats may be summarized separately. Trend analyses require three sampling events per plot and may be performed separately for different habitat types within each park (requiring at least four plots per habitat type).
Vascular plant species relative frequency and constancy	Recorded for all plots in a park in a single sampling season, conducted once every four years.	The plot is typically the sampling unit, but nested subplot or module scales may be used for analyzing common species or guilds with high relative frequencies, since change will be more detectable when frequency proportions are at intermediate levels. Summaries and analyses typically focus on plant guilds or focal, common species. Data for each park are summarized after each sampling event, once every four years. Trend analyses require at least three sampling events per plot and may be performed separately for different habitat types within each park (requiring at least four plots per habitat type).
Woody stem (tree, ≥ 10 centimeters DBH) basal area, density, health condition, mapped location, growth, mortality, and recruitment	Recorded for all plots in a park in a single sampling season, conducted once every four years.	The plot is the sampling unit. Summaries focus on individual focal, common species. Data for each park are summarized after each sampling event, once every three years. Trend analyses require at least three sampling events per plot and may be performed separately for different habitat types within each park (requiring at least four plots per habitat type). Because it will take four sampling events to obtain three estimates of tree growth, mortality, and recruitment, trends analyses for these elements will not begin until after the fourth sampling event.
Woody stem (sapling, <10 cm DBH) basal area and density; woody stem (seedling, <137 cm tall) density	Recorded for all plots in a park in a single sampling season, conducted once every four years.	The plot is the sampling unit. Summaries focus on individual focal, common species. Data for each park are summarized after each sampling event, once every three years. Trend analyses require at least three sampling events per plot and may be performed separately for different habitat types within each park (requiring at least four plots per habitat type).

Table 8 (continued). Monitoring elements, temporal design, and scale of analysis at Southeast Coast Network parks as part of the protocol for monitoring terrestrial vegetation.

Element	Temporal Design	Scale of Analysis
Fuel loads of downed woody material	Recorded for upland classified plots in a park in a single sampling season, conducted once every four years.	The set of three 25-m transects is the sampling unit. Summaries focus on fuel load type. Data for each park are summarized after each sampling event, once every four years. Trend analyses require at least three sampling events per set of transects and may be performed separately for different habitat types within each park (requiring at least four transect sets per habitat type).
Status of cover class values of vascular species and strata	Recorded for all plots in a park in a single sampling season, conducted once every four years.	The plot is the sampling unit. Summaries and analyses typically focus on plant guilds or focal, common species. Data for each park are summarized after each sampling event, once every four years. Trend analyses require at least three sampling events per plot and may be performed separately for different habitat types within each park (requiring at least four plots per habitat type).
Condition of soil nutrient and texture values	Recorded for all plots in a park during the initial sampling event.	The plot site is the sampling unit. Data for each park are summarized after the initial sampling event, at the end of the first four years.
Vegetation classification	Recorded for all plots in a park in a single sampling season, conducted once every four years	The plot is the sampling unit. Vegetation association identification, using the National Vegetation Classification Standard, is summarized after each sampling event, once every four years.
Site characteristics – Geomorphology	Recorded for all plots in a park during the initial sampling event.	The plot site is the sampling unit. Data for each park are summarized after the initial sampling event, at the end of the first four years.
Site characteristics – Water	Recorded for all plots in a park in a single sampling season, conducted once every four years	The plot site is the sampling unit. Data for each park are summarized after the initial sampling event, at the end of the first four years.

Table 9. Timeline of vegetation monitoring activities in the Southeast Coast Network from 2019-2028. Panel 1: CAHA, FOMA, FOPU, and TIMU; Panel 2: CHAT, CUIS, FOSU, and OCMU; Panel 3: CONG, FOFR, and KEMO; and Panel 4: CALO, CANA, HOBE, and MOCR.

Timing	Fieldwork (veg)	Fieldwork (soil)	Reporting (Event and Status)	Reporting (Status and Trends)
Summer 2019 – Spring 2020	Panel 1	Panel 1	Panel 1	NA
Summer 2020 – Spring 2021	Panel 2	Panel 2	Panel 2	NA
Summer 2021 – Spring 2022	Panel 3	Panel 3	Panel 3	NA
Summer 2022 – Spring 2023	Panel 4	Panel 4	Panel 4	NA
Summer 2023 – Spring 2024	Panel 1	NA	Panel 1	NA
Summer 2024 – Spring 2025	Panel 2	NA	Panel 2	NA
Summer 2025 – Spring 2026	Panel 3	NA	Panel 3	NA
Summer 2026 – Spring 2027	Panel 4	NA	Panel 4	NA
Summer 2027 – Spring 2028	Panel 1	NA	NA	Panel 1
Summer 2028 – Spring 2029	Panel 2	NA	NA	Panel 2
Summer 2029 – Spring 2030	Panel 3	NA	NA	Panel 3
Summer 2030 – Spring 2031	Panel 4	NA	NA	Panel 4

Section 6. Data Management, Analysis, and Reporting

Data Management and Process Workflows

The Southeast Coast Network has adopted the data processing steps and quality control procedures utilized by the CUPN Vegetation Monitoring Protocol (White et al. 2011). Where necessary, the Southeast Coast Network has modified CUPN procedures and workflow specifications to maintain consistency with current I&M standards and with the SECN's approved data management plan (Wright et al. 2008). A full description of the SECN's Terrestrial Vegetation Monitoring protocol's data management plan and QA/QC practices is provided in SOP 2.4.05 *Data Management, Quality Assurance and Quality Control* (Boyle and Capece 2019). The data management workflow is as follows:

Step 1—Preparation

The field crew is trained on scientific methods and on data collection and processing procedures, park logistics are planned, field supplies are assembled following equipment lists, and paper datasheets are printed (10 different sheets per plot, plus spare copies of each).

Step 2—Maps and GPS

Park maps (both with topographic and color/infrared aerial backgrounds) are printed. Map images include plot locations, plot identification, UTM grids, park boundaries, and any other helpful field navigation features (e.g., roads, trails). X- and Y- coordinates of each plot are exported from ArcGIS into handheld GPS units.

Step 3—Data Acquisition

Field data are recorded by the field crew on paper datasheets for each plot, in accordance with all SOP instructions.

Step 4—Datasheet Review and Validation

Before leaving the plot, a member of the field crew reviews all datasheets for completeness. Datasheets are digitally scanned or photographed at the end of the field day to create a backup copy. The protocol lead or field crew leader checks each datasheet for completeness, realistic entries, the use of correct and current taxonomy for species identifications, and the correct spelling of Latin names.

Step 5—Plot Photographs, Soil Samples, and Plant Vouchers

Digital images of the plot are collected by a member of the field crew and shown to a second field crew member for validation. Images are loaded onto a field computer at the end of the field day. Soil bags are labeled by a member of the field crew and shown to a second field crew member to ensure they have the correct plot identifier, enough soil has been collected, and that bags are sealed tight. Soil samples are stored in a secure location at the end of the field day. Plant vouchers (when approved by park staff) are collected, labeled, and pressed.

Step 6—Accepted Datasheets

Validated datasheets are scanned and stored on the SECN share drive as a single file per sample event (i.e., all datasheets from a single plot and sample year, pdf format). Photographs are also stored on the SECN server.

Step 7—Data Entry, Processing, and Backup

All entries that were recorded on the paper datasheets are entered into the terrestrial vegetation monitoring database as soon as possible after data collection. This is completed upon return to the SECN office or, less frequently, on a field computer while on travel. The Southeast Coast Network uses a modified version of the CUPN database. The person entering data should be someone who participated in the data collection at the plot, or the project lead.

Step 8—Database Verification and Quality Review

As data are entered from paper datasheets or soil laboratory results into the database, multiple verification checks are performed. First, after entering each datasheet into the database, the data entry person compares each value in the database to each value on the paper datasheet to ensure all typed numbers match what was written. Second, a different crew member reviews all datasheets entered that day to again ensure that all typed data match the datasheet. This is the 100% check. Third, the data protocol lead reviews 10% of all datasheets, again for proper entry from the datasheet. This is the 10% check, and functions as quality review. If the protocol lead is the crew member who performs the 100% check, then the data manager or other data management staff performs the 10% check instead of the protocol lead. The final product at this stage is verified and quality-checked data in the database.

Step 9—Database Validation

Once data are verified as entered correctly, additional validation tests are completed by the protocol lead to ensure that data in the database are logically consistent and realistic. These steps include plotting data points, calculating summary statistics, and reviewing species lists. Any problems uncovered by this process prompt the protocol lead to go back to the database records and apply appropriate quality flagging and/or documentation where applicable. At the end of this stage, the product is validated data in the database.

Step 10—Accepted Database

After both verification and validation steps are complete, the data are classified as accepted, or certified if an approved quality assurance plan is in place.

Step 11—Protected Data Agreement

An accepted data set is processed to apply any record-level removal or obscuring to sensitive data, as required by park-specific data handling agreements. The output of this step is a .csv flat file. This is the version of the data made available publicly.

Step 12—Metadata Documentation and Data Delivery

All data that are accepted or certified are accompanied by metadata that describe the dataset and document the results of the quality review. The products here are accepted data and the associated

metadata, which can then be archived and uploaded to the master project database. These products should be completed within three months of the final sampling event for a given field season.

Step 13—Data Analysis and Product Development

Data are summarized, analyzed, and prepared for reports and presentations following the procedures outlined in the Data Analysis section. Vegetation Monitoring Event and Status Reports are created for each park during the winter and spring following a sampling event. After the first three sampling events per site are completed and summarized, more in-depth reports on ‘Status and Trends in Vegetation’ are prepared, including results of statistical analyses of cross-year trends.

Step 14—Product Posting and Distribution

Finalized products are distributed to parks and other stakeholders, and posted to the [Integrated Resource Management Application \(IRMA\)](#) portal. Report and presentation products are distributed to stakeholders as they are completed, and these products, in addition to the databases and scanned datasheets, are posted to the IRMA Data Store on an annual basis. All products posted will have the appropriate access applied.

Step 15—Protocol Operational Review

The annual operational review for the protocol addresses a variety of implementation topics, including how well the data management and QA/QC processes are working.

QA/QC

The Southeast Coast Network resamples approximately 5% of sampled plots annually to determine reliability of data collection. This quality control step is also employed by the Cumberland Piedmont Network and Gulf Coast Network vegetation monitoring protocols. The methods for quality control and assurance are detailed in SOP 2.4.05 *Data Management, Quality Assurance and Quality Control* (Boyle and Capece 2019).

Data Processing and Data Quality Levels

The data processing steps, their associated products, and their frequency of completion are listed in Table 10. Table 10 also introduces the three stages of data processing: raw, provisional, and accepted. Raw data are in their original form, either as a field datasheet, photo, or a raw entry into the database. Provisional data have undergone verification steps but are not suitable for general use. Accepted data (or certified data, if the QAP for the protocol is in place) are products from the provisional data step that have been validated and are fit for analysis and publication.

Table 10. Data processing steps for the SECN terrestrial vegetation monitoring protocol (adapted from Carlson et al. 2018).

Data Type	Data Stage	Processing Steps	Product Name	Timing
Datasheets	Field Recorded	1. Filled-in by hand in the field	Raw datasheets	At the end of each plot sampling event
	Raw	2. Reviewed for completeness	Verified datasheets	At the end of each plot sampling event
	Provisional	3. Reviewed by the protocol lead	Validated datasheets	At the end of each field sampling day, or within a week
	Accepted	4. Digitally scanned	Scanned, Accepted Datasheets	At the end of each field sampling day, or within a week
	Accepted	5. Paper copies are managed as long-term records	Local file storage of accepted datasheets	Within three months of field season's end
	Accepted	6. Scanned copies are published to NPS IRMA Data Store	Publication of accepted datasheets	Within 12 months of field season's end
Photographs	NA	1. Photos taken in the field	Raw photos	At the end of each plot sampling event
	Raw	2. Images reviewed for completeness	Verified photos	At the end of each plot sampling event
	Provisional	3. Images downloaded and renamed	Renamed and organized photos	At the end of each plot sampling event
	Accepted	4. Images are archived locally	Local archives of photos	Within 6 months of field season's end
	Accepted	5. Images used in reports to illustrate and verify quantitative analyses	▪ Event and Status Reports ▪ Status and Trend Reports	▪ By end of fourth year of each 3-year cycle ▪ After three data collection events for a given park
Database	NA	1. Data manually entered	Raw datasets	Within several weeks of the field sampling day
	Raw	2. Verification during data entry: self-check	Partially verified data	Within several weeks of the field sampling day

Table 10 (continued). Data processing steps for the SECN terrestrial vegetation monitoring protocol (adapted from Carlson et al. 2018).

Data Type	Data Stage	Processing Steps	Product Name	Timing
Database (cont)	Raw	3. Verification after data entry: 100% check performed by someone who did not enter the data	Partially verified data	Within several weeks of the field sampling day
	Raw	4. Verification after data entry: Protocol lead performs a 10% check of all datasheets for a given field season	Verified data	Within one month of field season's end
	Provisional	5. Summary statistics generated to identify outliers	Partially validated data	Within three months of field season's end
	Provisional	6. Species lists are checked for unexpected records	Validated data	Within three months of field season's end
	Accepted	7. Metadata created for the dataset	Accepted data	Within three months of field season's end
	Accepted	8. Database backends and metadata are published to NPS IMRA Data Store	Offsite archive and publication	Within twelve months of field season's end
	Accepted	9. Data are analyzed and reports generated	▪ Event and Status Reports ▪ Status and Trend Reports	▪ By end of fourth year of each three-year cycle ▪ After three data collection events for a given park

Data Archiving

Instructions for archiving and posting datasets are included in SOP 2.4.05. Once digital products are created, processed and approved in the steps above, the protocol lead, in coordination with the SECN data manager (data or photos) or managing editor (published reports), prepares them for posting to IRMA. The types of products that are posted on IRMA for this project include annual Vegetation Monitoring Event and Status Reports and Status and Trends in Vegetation reports (after three rounds of data collection per park, and may be more frequent after the first report), digital scans of data sheets, and .csv formatted exports of annual data sets from the SECN vegetation monitoring database. In their unfinished or provisional forms, these products are generally stored only on the SECN server. The SECN vegetation monitoring database is modified from the CUPN database, which is a customized Microsoft Access relational database application used for storage and manipulation of project data. This database has been developed according to table structure described by the Natural Resource Database Template (NRDT; NPS 2008a).

The timing of posting new products to IRMA is annually, if not more often. Products on IRMA can be shared with the public or classified as restricted access to specific individuals. Public access is given to final, approved reports or to datasets that are accepted or certified and from which protected data have been withheld, where appropriate. Restricted access on IRMA may be used for provisional products or versions of files that include protected information. All related data products beginning in 2018 are posted to the SECN Terrestrial Vegetation Monitoring Project (<https://irma.nps.gov/DataStore/Reference/Edit/2258943>). Refer to the IRMA website for upload and product linking instructions, and coordinate with the SECN data manager or managing editor when undertaking product upload steps.

When a product is posted on IRMA, the SECN managing editor or data manager, or national publications manager creates a reference record for it that is specific to the IRMA platform. The reference record contains citation information, relevant metadata and keywords. This is done for all products, including reports, other publications, data sets, or sets of field sheets. The digital version of the product is uploaded in association with that reference, making it available for discovery. Most products are organized by park, unless they apply to multiple parks. Finally, if new species records were identified for parks in a season, they are entered into the NPSpecies application manually; NPSpecies is the NPS system for maintaining park-specific species lists and observation data. NPSpecies is a function of IRMA. Where many new records need to be entered for a given season, the SECN data manager provides appropriate guidance and coordinates with NPSpecies administrators to execute a batch upload.

Procedure for Revising the Protocol

Over time, revisions to both the protocol implementation plan and SOPs are expected. Careful documentation of changes to the plan and a library of previous versions are essential for maintaining consistency in data collection and for appropriate treatment of the data during data summary and analysis.

The steps for changing the protocol (either the protocol narrative or the SOPs) are outlined in SOP 2.1.01 (Wright and Curry 2019). The protocol implementation plan and each SOP contain a revision log to fill out each time the main document or a SOP is revised. In this log, the SECN staff person briefly documents when and why the change was made and assigns a new version number. Revised protocol narratives must also be assigned a new report number by the National I&M Program Publication Manager. The new version of the SOP or protocol narrative is then archived in the appropriate SECN vital signs protocol folder on the SECN network drive and on the IRMA Data Store.

Data Analysis

After three complete sampling cycles, generalized linear mixed model analyses can be used to evaluate the data for trends. For some metrics, species are analyzed separately for change over time, but for others, species are grouped and analyzed together. Generalized models are used for some variables, to allow for non-Gaussian (non-Normal) distributions, such as negative binomial or Poisson (for count data) or binomial (for proportions). For analyses of cover class data, ordinal logistic regression (Guisan and Harrell 2000) or an ordinal beta hurdle model (Irvine et al. 2016) may

be used. Statistical analyses are performed in R (R Core Team 2019) or other open-source software, using a variety of statistical packages appropriate for the analyses. Focal variables for baseline status and trend within parks, in broad community types within parks, and in broad community types across parks include species richness, species frequency, species or guild coverage estimation, canopy closure, basal area, stem density, mortality rate, tree growth in terms of DBH, seedling and sapling abundance, and tree condition. The Southeast Coast Network also plans to utilize data collected on key stressors associated with ecosystems in the network as potential covariates during analysis. Data collected by other National Park Service and partner programs include fire history, weather and climate, visitor use/management activities, and landscape dynamics (e.g., land use change). These ancillary data may help account for variability in the relationship between certain response variables (e.g., tree growth or mortality rate) and make it easier to detect trends.

The network also plans to use multivariate approaches to further investigate vegetation community composition and changes over time using a block multi-response permutation procedure (MRPP) to test the null hypothesis of no change between survey periods in the understory vegetation plots. Tests of significance of change will be based on random permutations across years of within plot differences in species composition, calculated using a Euclidean dissimilarity measure and species presence/absence (Mielke and Berry 2001). These methods have been used successfully in the North Carolina Piedmont to investigate community changes in total and native species richness, as well as changes in herb and tree seedling composition over time in permanent fixed plots that span a range of soil and site conditions and a range of successional stage forest types (Taverna 2005). Other studies using similar analytical methods (MRPP and Nonmetric Multidimensional Scaling [NMDS]) at these same sites indicated accelerated vegetation changes associated with deer herbivory between 1977 and 2010 (Israel 2011). Ordination techniques, such as NMDS, can be used to assess the magnitude and direction of vegetation compositional change visually and with respect to environmental covariates. Palmquist et al. (2015) used similar analytics to evaluate the response of vegetation to changes in disturbance regimes in fire-adapted longleaf pine habitats in the outer Coastal Plain of North Carolina.

Reporting

For more details on analysis and reporting, see SOP 2.4.06 *Data Analysis and Reporting* (Boyle and Gregory 2019).

The data collected from the SECN vegetation monitoring protocol follows analysis and reporting schemes across two time intervals similar to the CUPN's Vegetation Monitoring Program:

- Annual Event and Status Report: data summaries on the key vegetation attributes for each broad habitat type within a park, following a single sampling season in each park (i.e., produced during the winter/spring following a sampling event).
- Status and Trends Report: analysis of changes (repeat measures) in key vegetation attributes over time across broad habitat types within a park, following three sampling iterations for each park. The trend reports include a condition assessment using standard symbology to depict current condition and trends for selected ecosystem parameters. The trend reports also

evaluate relationships between key stressors and key measures, including comparisons to regional datasets to assess how NPS lands factor into a landscape context.

During the winter/spring after each sampling year, data are analyzed to produce an Event and Status Report from each sampled SECN park. This report provides park managers and partners with an updated set of data and current status relevant to policy and management decisions. All or most of the monitoring elements listed in Table 5 are summarized, including the development of an ecological integrity assessment rating for vegetation ecosystems within parks. The Southeast Coast Network also analyzes changes in these same monitoring elements to produce a Status and Trends Report. These analyses typically take place once three sampling cycles have occurred within a park. Full descriptions of the steps in data analysis and reporting are in SOP 2.4.06 *Data Analysis and Reporting* (Boyle and Gregory 2019).

In addition to the two report formats, the Southeast Coast Network also produces annual resource briefs of key results for each park. These summaries report on resource status, monitoring progress, salient observed events, and related matters of general interest. Resource briefs are produced and updated on an annual basis, with the intent to provide readers a timely first look at the subject. Another type of potential report comes in the form of peer-reviewed publications and presentations. Publishing monitoring results in scientific journals or giving presentations at scientific meetings allows the network to reach the scientific community in a way that internal NPS reports cannot. Peer-reviewed publications may serve the purpose of promoting investigation by members of the scientific community, either independently or in cooperation with the network. Ultimately, publication in peer-reviewed publications and the collaboration that ensues should foster a greater understanding of ecosystem components and processes. Production of peer-reviewed articles also legitimizes monitoring results in a way that grey literature reports cannot, and renders SECN science more useful for science-based management actions where legal sufficiency is a prominent consideration.

Furthermore, it is the hope of the Southeast Coast Network to collaborate with other NPS I&M Networks to determine appropriate regional analyses that can be conducted with the vegetation monitoring data from our network. Contributing towards regional analyses will provide context for conditions and trends observed in SECN parks and strengthen our understanding of regional trends.

Section 7. Budget

The estimated annual cost of implementing the SECN Terrestrial Vegetation Monitoring Protocol is provided in Table 11, and is based on FY2019 dollars. The budget is calculated using an estimated sampling effort per plot plus additional data-management support costs, and is developed with a hypothetical SECN staff team for all work. Non-SECN personnel may be used for this sampling effort in future implementation years. In this case, the sampling effort/plot cost can be used as a guideline for developing necessary contracts and agreements. Also, individual parks may provide support for monitoring, including staff participation in fieldwork, logistical support, and site access assistance. However, the budget listed in Table 11 does not include support provided by the park or other partners. It should be considered a maximum cost estimate assuming full travel and personnel costs to implement the protocol.

The SECN botanist is the protocol lead and provides project direction and oversight. Fieldwork in the first year of implementation (2019) is performed by a single team of two individuals, the botanist (field lead) and a GS-7 biological technician (field assistant). Fieldwork in subsequent years is performed by two teams of two individuals, with each team including at least one member with advanced knowledge of the flora of the Southeast Coastal Plain and Piedmont. Data management, including all aspects of managing data throughout its life-cycle, is co-supervised by the SECN botanist and data manager.

Fieldwork occurs in each of the four summers of a four-year cycle, or implementation cycle (see Table 9). The winter and spring of each year is utilized for data analysis and reporting. A total of 343 primary focus plots (plus an additional five plots per year of QA/QC plots) plots are sampled across all 15 SECN parks targeted for this monitoring effort, and panels include:

- Year 1—82 plots (plus five QA/QC plots)
- Year 2—91 plots (plus five QA/QC plots)
- Year 3—90 plots (plus five QA/QC plots)
- Year 4—80 plots (plus four QA/QC plots)

In addition, a total of 200 secondary focus plots may be sampled across SECN parks should time and resources allow during a given sampling season. Panels for secondary plots include:

- Year 1—60 plots
- Year 2—48 plots
- Year 3—24 plots
- Year 4—68 plots

Table 11. Estimated annual operating cost (based on FY2019 dollars) for implementation of the Southeast Coast Network's Terrestrial Vegetation Monitoring protocol.

Category	Type	Cost/Day	# of days – Start Up Year (2019)	Total Cost – Start Up Year (2019)	# of days – All Other Years	Total Cost – All Other Years	Notes
Personnel	SECN Botanist (GS-12/2)	\$392	100	\$39,240	75	\$29,430	65 (startup year) / 40 (all other years) field days, 8 travel days, 15 data management days, 12 analysis and reporting days
	SECN Biotech (GS-7/1)	\$214	93	\$19,909	68	\$14,557	65 (startup year) / 40 (all other years) field days, 8 travel days, 20 data management days
	Biotech (GS-5/1 or equivalent)	\$173	NA	NA	48	\$8,294	40 field days, 8 travel days
	Botanist (GS-11/1 or equivalent)	\$305	NA	NA	63	\$19,956	40 field days, 8 travel days, 15 data management days
	SECN Data Manager (GS-12/5)	\$452	10	\$4,520	10	\$4,520	10 days data management
	Total Personnel Costs	NA	NA	\$63,669	NA	\$76,758	–
Equipment and Supplies	Field Supplies ¹	NA	NA	\$10,890	NA	\$2,000	Field sampling and safety supplies; plant identification supplies
	Vehicle Fuel / Oil	\$40	73	\$2,920	73	\$2,920	Assumes that the SECN supplies a vehicle during startup year and two vehicles during subsequent years.
	Total Equipment and Supplies Costs	NA	NA	\$13,810	NA	\$4,920	–

¹ refer to Table 1 in SOP 1.4.07 *Field Season Preparation* (Boyle 2018a)

² using the standard per diem rate (\$91 lodging + \$51 M&IE)

³ soil sample cost only calculated for years 2019, 2020, and 2021 of protocol implementation

Table 11 (continued). Estimated annual operating cost (based on FY2019 dollars) for implementation of the Southeast Coast Network's Terrestrial Vegetation Monitoring protocol.

Category	Type	Cost/Day	# of days – Start Up Year (2019)	Total Cost – Start Up Year (2019)	# of days – All Other Years	Total Cost – All Other Years	Notes
Travel	SECN Botanist (GS-12/2)	\$142 ²	54	\$7,668	46	\$6,532	54 travel + field days needed for startup year; 46 travel + field days for other years.
	SECN Biotech (GS-7/1)	\$142 ²	54	\$7,668	46	\$6,532	54 travel + field days needed for startup year; 46 travel + field days for other years.
	Biotech (GS-5/1 or equivalent)	\$142 ²	NA	NA	48	\$6,816	48 travel + field days for other years.
	Botanist (GS-11/1 or equivalent)	\$142 ²	–	–	48	\$6,816	48 travel + field days for other years.
	Total Travel Costs	NA	NA	\$15,336	NA	\$26,696	NA
Soil Sample Processing	Total Soil Sample Processing	NA	NA	\$3,500 ³	NA	\$3,500 ³	NA
Total	TOTAL ANNUAL COST	NA	NA	\$96,315	NA	\$111,874	Estimated total implementation cost for startup and subsequent field-year

¹ refer to Table 1 in SOP 1.4.07 *Field Season Preparation* (Boyle 2018a)

² using the standard per diem rate (\$91 lodging + \$51 M&IE)

³ soil sample cost only calculated for years 2019, 2020, and 2021 of protocol implementation

The Cumberland Piedmont Network estimates that 1.6 vegetation plots can be completed per day in their 14 parks, utilizing a single two-person field crew (White et al. 2011), although they later increased their crew size to three people. The Gulf Coast Network also estimates 1.6 plots/day for their eight parks, while utilizing a single, three-person field crew (Carlson et al. 2018). For both the Cumberland Piedmont Network and Gulf Coast Network, this equates to a total of eight plots per five-day week. The Southeast Coast Network assumes the same rate for its set of fifteen parks; however, because the network is utilizing two field crews in its second year and beyond of protocol implementation, it is estimated that a total of twelve plots per five-day week can be completed.

Section 8. Safety

Implementation of the SECN Terrestrial Vegetation Monitoring Protocol has multiple complex risks. Both prior to and during the implementation of this protocol, involved staff must evaluate risks at the programmatic, personnel, and site level. Programmatic-scale safety information is presented here and is also detailed in SECN SOP 3.1.01 *Reporting of On-Duty Injury and Illness* (SECN 2017).

Procedures to mitigate risks associated with specific activities, such as vehicle use and operation (including motorized boats) are provided in Appendix B—*Job Hazards Risk Assessment and Training and Proficiencies*.

Specific safety concerns include:

- Crew members spend many hours (and miles) driving to, between, and from sampling locations to conduct the requisite sampling.
- Crew members are regularly working in park areas outside of communications range (either by park radio or by cell phone).
- Crew members are frequently exposed to extreme heat and humidity and are working for extended periods of time in remote areas with potentially rapidly-changing and severe weather conditions.
- Crew members are frequently exposed to thorny or rash-causing plants, stinging and biting insects, treacherous terrain, and venomous and other hazardous animals.
- In specific cases, crew members travel by watercraft and UTV / ATV for site-access and are exposed to increased risks associated with use of this equipment.

Injury or loss of life while in transit to and from field sites and during sampling activities within sites—as well as while in transit to or from sampling sites via watercraft and UTV / ATV—are the most significant risks encountered when conducting this activity.

Based on the job hazard analyses and associated risk abatement measures, it was determined that this protocol can be safely implemented provided that Southeast Coast Network and partner staff members follow all referenced SOPs and recommended risk abatement strategies. In addition to SOPs, specific training needs for all staff have been identified, and includes certification in basic first aid. To increase the overall level of safety and awareness, obtaining additional levels of training beyond basic certification is encouraged.

Safety procedures are routinely reviewed with network staff and partners before field operations, as prescribed in SOPs. Personnel-level JHAs for staff are reviewed and revised annually as a part of the performance review cycle. Safety SOPs are reviewed at least annually and updated as necessary to ensure that they adequately mitigate risks to personnel, property, and the public. In addition to protocol-specific safety procedures and guidelines, SECN staff members follow the general guidelines set forth in the NPS Occupational Safety and Health Program Reference Manual (Directors Order #50B; NPS 2008b).

Section 9. Standard Operating Procedures and Deviations from Source Protocols

To ensure consistent implementation of this protocol over time, the following Standard Operating Procedures (SOPs) have been adopted from CUPN SOPs (and in one case, a GULN SOP; see Table 12) or developed as needed by SECN (Table 13). All approved versions of operational SOPs are available for download from the [IRMA Portal](#). A list of source protocols, deviations, and SECN safety standards can be seen in Table 14.

Table 12. Standard Operating Procedures required to implement the SECN Terrestrial Vegetation Monitoring Protocol in SECN parks. The table includes a brief description of changes from the source document to the SECN version. Additional details on these changes are provided at the start of each SECN SOP.

Topic	Source Protocol or SOP	Explanation of Differences	SECN Updated SOP	IRMA Record
Preparation for the Field Season	CUPN SOP 1: Field Season Preparation	Changes were made to the SOP to reflect the use of a single field crew during the first year of protocol implementation. Other minor editorial changes to equipment list were also made.	Boyle, M. F. 2018a. Field Season Preparation—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.07. Southeast Coast Network, Athens, Georgia.	2260349
GPS Use, Selection and Establishment of Sites	CUPN SOP 2: Using GPS	Combined into SECN SOP 1.4.10.	Boyle, M. F. 2018b. Site Selection, Plot Establishment, and Return Visits—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.10. Southeast Coast Network, Athens, Georgia.	2260350
	CUPN SOP 3: Site Selection and Plot Establishment	Plots in the SECN are always 20 x 20 m in size and dimensions are not altered based on habitat like in the CUPN protocol. The SECN sampling frame includes all natural and semi-natural vegetated habitats in parks or target units rather than only forested vegetation.		
Photo points	CUPN SOP 4: Plot Photo Points	A section was added to account for a photo taken at plot center with a 360° camera.	Boyle, M. F. 2019c. Plot photo points—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.1.05. Southeast Coast Network, Athens, Georgia.	2260348

Table 12 (continued). Standard Operating Procedures required to implement the SECN Terrestrial Vegetation Monitoring Protocol in SECN parks. The table includes a brief description of changes from the source document to the SECN version. Additional details on these changes are provided at the start of each SECN SOP.

Topic	Source Protocol or SOP	Explanation of Differences	SECN Updated SOP	Irma Record
Canopy Closure, Stand Height, and Tree Measurements	CUPN SOP 5: Canopy Closure and Stand Height Measurements CUPN SOP 6: Tree Measurements	Combined into SECN SOP 1.4.11. All woody species (trees, shrubs, and lianas) are reported in the SECN protocol; as opposed to only trees in the CUPN protocol.	Boyle, M. F. 2019d. Tree measurements—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.11. Southeast Coast Network, Athens, Georgia.	2260351
Diversity and Seedling/Sapling Density, Species Nomenclature	CUPN SOP 7: Herbaceous Plant and Seedling/Sapling Measurements <i>and</i> CUPN SOP 14: Recording Species Nomenclature and Data Field Descriptions	Minor editorial changes were made. Combined into SECN SOP 1.4.14	Boyle, M. F. 2019e. Species diversity and seedling/sapling measurements—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.14. Southeast Coast Network, Athens, Georgia.	2260353
Fuel Loads	CUPN SOP 8: Coarse Woody Debris	A section was added to include sampling for duff, litter, and fine woody debris as well, based on the FIREMON protocol (Lutes et al. 2006)	Boyle et al. 2019. Fuel load measurements—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.12. Southeast Coast Network, Athens, Georgia.	2260352
Vegetation Classification	CUPN SOP 9: U.S. National Vegetation Classification Measure	Minor editorial changes were made.	Boyle, M. F. 2019f. U.S. National Vegetation Classification identification—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.15. Southeast Coast Network, Athens, Georgia.	2260354
Soils	CUPN SOP 10: Soil Measurements	Minor editorial changes were made.	Boyle, M. F. 2019g. Soil measurements—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.16. Southeast Coast Network, Athens, Georgia.	2260355

Table 12 (continued). Standard Operating Procedures required to implement the SECN Terrestrial Vegetation Monitoring Protocol in SECN parks. The table includes a brief description of changes from the source document to the SECN version. Additional details on these changes are provided at the start of each SECN SOP.

Topic	Source Protocol or SOP	Explanation of Differences	SECN Updated SOP	Irma Record
QA/QC, Data Management	CUPN SOP 11: Data Quality Assurance and Quality Control <i>and</i> GULN SOP VEG09: Data Management and Quality Assurance / Quality Control <i>and</i> CUPN SOP 12: Data Management: Procedures upon Return from the Field	Combined into SECN SOP 2.4.05 Minor editorial changes were made to the GULN SOP VEG09. A data flow appendix was included to assist with use of the vegetation monitoring database.	Boyle, M. F., and P. Capece. 2019. Data management, quality assurance and quality control—version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.4.05. Southeast Coast Network, Athens, Georgia.	2260356
Analysis and Reporting	GULN SOP VEG10: Data Analysis and Reporting	Included a section on multivariate analysis techniques.	Boyle, M. F., and M. B. Gregory. 2019. Data analysis and reporting—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.4.06. Southeast Coast Network, Athens, Georgia.	2260357

Table 13. List of source protocols, deviations, and SECN administrative standard operating procedures included in the SECN Terrestrial Vegetation Monitoring Protocol.

Topic	Source Protocol or SOP	Explanation of Differences	SECN Updated SOP	IRMA Record
Photo Management	N/A	SECN has a network-wide photo management SOP in place.	Southeast Coast Network. 2017. Digital image management—Version 3.1. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.1.07. Southeast Coast Network, Athens, Georgia.	2243092
Metadata	N/A	N/A	Southeast Coast Network. 2016. Dataset and Metadata Publication—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.1.08. Southeast Coast Network, Athens, Georgia.	2238047
Protocol and Database Revisions	N/A	SECN has a network-wide protocol revision SOP in place.	Wright, W. and S. E. Curry. 2019. Revision of Southeast Coast Network protocols and standard operating procedures—Version 3.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.1.01. Southeast Coast Network, Athens, Georgia.	2260359
Authorship Guidelines	N/A	SECN has network-wide authorship guidelines.	Southeast Coast Network. 2019. Southeast Coast Network authorship guidelines—Version 3.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.1.03. Southeast Coast Network, Athens, Georgia.	2260360

Table 14. List of source protocols, deviations, and SECN safety standard operating procedures included in the SECN Terrestrial Vegetation Monitoring Protocol.

Topic	Source Protocol or SOP	Explanation of Differences	SECN Updated SOP	Link
Injury	SECN. 2019. Identification, treatment, and reporting of on-duty injury and illness—Version 4.2. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.01. Southeast Coast Network, Athens, Georgia.	SECN has a network-wide injury SOP in place.	Same as source, standardized SECN SOP	2237691
Park Communication	DeVivo, J. C., and S. L. Corbett. 2016. Communicating field operations with SECN parks—Version 3.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.07. Southeast Coast Network, Athens, Georgia.	SECN has a network-wide park communication SOP in place.	Same as source, standardized SECN SOP	2238044
Vehicle Use	Southeast Coast Network. 2016. Vehicle Use and Operation—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.03. Southeast Coast Network, Athens, Georgia.	SECN has a network-wide vehicle use SOP in place.	Same as source, standardized SECN SOP	2237830
Off Road Vehicle Use	Southeast Coast Network. 2016. Safe operations of off-highway vehicles—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.08. National Park Service, Athens, Georgia.	SECN has a network-wide off-road vehicle use SOP.	Same as source, standardized SECN SOP	2237833
Vehicle Accident	Corbett, S. L., and B. Smrekar. 2016. Motor vehicle accident reporting procedures—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.04. National Park Service, Athens, Georgia.	SECN has a network-wide vehicle accident SOP in place.	Same as source, standardized SECN SOP	2237832
Watercraft Operation	Asper, J.R., and A.C. Curtis. 2016. Safe operation of Southeast Coast Network watercraft—Version 2.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—3.1.04. National Park Service, Athens, Georgia.	SECN has a network-wide watercraft use SOP	Same as source, standardized SECN SOP	2237743

Literature Cited

- Abrams, M. D. 1998. The red maple paradox. *BioScience* 48:355–364.
- Baron, L. C. 2018. Monitoring coastal shoreline change in Southeast Coast Network parks: Protocol implementation plan. Natural Resource Report. NPS/SECN/NRR—2018/1744. National Park Service. Fort Collins, Colorado.
- Bates, D, M. Maechler, B. Bolker, and S. Walker 2015. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software* 67(1):1-48. Available at: <https://www.jstatsoft.org/article/view/v067i01> (last accessed February 2019).
- Boyle, M. F. 2018a. Field season preparation—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.07. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260349> (last accessed May 2019).
- Boyle, M. F. 2018b. Site selection, plot establishment, and return visits—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.10. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260350> (last accessed May 2019).
- Boyle, M. F. 2019c. Plot photo points—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.1.05. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260348> (last accessed May 2019).
- Boyle, M. F. 2019d. Tree measurements—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.11. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260351> (last accessed May 2019).
- Boyle, M. F. 2019e. Species diversity and seedling/sapling measurements—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.14. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260353> (last accessed May 2019).
- Boyle, M. F. 2019f. U.S. national vegetation classification identification—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.15. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260354> (last accessed May 2019).
- Boyle, M. F. 2019g. Soil measurements—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.16. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260355> (last accessed May 2019).

- Boyle, M. F., and P. Capece. 2019. Data management, quality assurance and quality control—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.4.05. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260356> (last accessed May 2019).
- Boyle, M. F., S. L. Corbett, B. D. Smrekar, and C. S. Harris. 2019. Fuel load measurements—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.4.12. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260352> (last accessed May 2019).
- Boyle, M. F., and M. B. Gregory. 2019. Data analysis and reporting—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.4.06. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260357> (last accessed May 2019).
- Carlson, J. E., J. Bracewell, W. Granger, and M. Segura. 2018. Monitoring vegetation in Gulf Coast Network parks: Protocol implementation plan. Natural Resource Report NPS/GULN/NRR—2018/1746. National Park Service, Fort Collins, Colorado.
- Comer, P. J., D. Faber-Langendoen, R. Evans, S. C. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, Virginia.
- DeVivo, J. C., C. J. Wright, M. W. Byrne, E. DiDonato, and T. Curtis. 2008. Vital signs monitoring in the Southeast Coast Inventory and Monitoring Network. Natural Resource Report NPS/SECN/NRR—2008/061. National Park Service, Fort Collins, Colorado.
- DeVivo, J. C., J. Asper, S. Eastman, N. M. Rankin, A. C. Curtis, C. J. Wright, E. Thompson, and M. W. Byrne. 2015. Protocol for monitoring coastal salt marsh elevation and vegetation communities in Southeast Coast Network parks. Natural Resource Report NPS/SECN/NRR—2015/985. National Park Service, Fort Collins, Colorado.
- DeVivo, J. C., L. Nelson, M. Kinseth, T. Philippi, and W. B. Monahan. 2018. Protocol for monitoring environmental setting for National Park Service units: Landscape dynamics, climate, and hydrology. Natural Resource Report NPS/IMD/NRR—2018/1844. National Park Service, Fort Collins, Colorado.
- Faber-Langendoen, D., J. Rocchio, M. Schafale, C. Nordman, M. Pyne, J. Teague, T. Foti, and P. Comer. 2006. Ecological integrity assessment and performance measures for wetland mitigation. NatureServe, Arlington, Virginia.
- Fancy, S. G., J. E. Gross, and S. L. Carter. 2009. Monitoring the condition of natural resources in US National Parks. *Environmental Monitoring and Assessment* 151:161–174.

- Federal Geographic Data Committee (FGDC). 2008. National vegetation classification standard, version 2: vegetation subcommittee, Federal Geographic Data Committee. FGDC-STD-005-2008 (Version 2).
- Foster, D. R., D. H. Knight, and J. F. Franklin. 1998. Landscape patterns and legacies resulting from large, infrequent forest disturbances. *Ecosystems* 1:497–510.
- Grossman, D. H., D. Faber-Langendoen, A. W. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid and L. Sneddon. 1998. International classification of ecological communities: Terrestrial vegetation of the United States. Volume I: The National Vegetation Classification Standard. The Nature Conservancy.
- Guisan, A., and F. E. Harrell. 2000. Ordinal response regression models in ecology. *Journal of Vegetation Science* 11(5):617-626.
- Irvine, K. M., T. J. Roadhouse, and I. N. Keren. 2016. Extending ordinal regression with a latent zero-augmented beta distribution. *Journal of Agricultural, Biological and Environmental Statistics* 21(4):619-640.
- Israel, K. A., 2011. Vegetation change in the Duke Forest, 1977–2010. Thesis submitted to the faculty of the University of North Carolina at Chapel Hill. Chapel Hill, North Carolina. 110 pp.
- Kincaid, T. M., and A. R. Olsen. 2017. spsurvey: Spatial survey design and analysis. R package version 3.4. Available at: <https://cran.r-project.org/web/packages/spsurvey/index.html> (last accessed March 2019).
- Lee, M. T., R. K. Peet, S. D. Roberts, and T. R. Wentworth. 2008. CVS-EEP protocol for recording vegetation, all levels of plot sampling, version 4.2. Carolina Vegetation Survey. Available at: <http://cvs.bio.unc.edu/protocol/cvs-EEP-protocol-v4.2-lev1-5.pdf> (last accessed February 2019).
- Leibfreid T. R., R. L. Woodman, and S. C. Thomas. 2005. Vital signs monitoring plan for the Cumberland Piedmont Network and Mammoth Cave National Park prototype monitoring program: July 2005. National Park Service, Mammoth Cave, Kentucky.
- Lutes, D. C., R. E. Keane, J. F. Caratti, C. H. Key, N. C. Benson, S. Sutherland, and L. J. Gangi. 2006. FIREMON: Fire effects monitoring and inventory system. Gen. Tech. Rep. RMRS-GTR-164-CD. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, Colorado.
- McDonald, T. L. 2004. GRTS for the Average Joe: A GRTS sampler for Windows. Available at: http://www.west-inc.com/biometrics_reports.php (last accessed February 2019).
- Mielke, P. W. Jr, and K. J. Berry. 2001. Permutation methods: A distance function approach. Springer Series in Statistics. Springer.

- Miller, K. M., and B. R. Mitchell. 2014. A new tool for power analysis of fixed plot data: Using simulations and mixed effects models to evaluate forest metrics. *Ecosphere* 5:1–23.
- National Oceanic and Atmospheric Administration (NOAA). 2014. Storm events database, Version 3.0, May 12, 2014. National Centers for Environmental Information. Available at: <https://www.ncdc.noaa.gov/stormevents/> (last accessed April 2019).
- National Oceanic and Atmospheric Administration (NOAA). 2018. Tides and currents map database. Center for Operational Oceanographic Products and Services. Available at: <https://tidesandcurrents.noaa.gov/> (last accessed April 2019).
- National Park Service (NPS). 2007. Natural resource database template version 3.2 documentation. Natural Resource Program Center, Office of Inventory, Monitoring, and Evaluation, Fort Collins, Colorado. 201 pp.
- National Park Service (NPS). 2008a. Data management guidelines for inventory and monitoring networks. Natural Resource Report NPS/NRPC/NRR—2008/035. National Park Service, Fort Collins, Colorado.
- National Park Service (NPS). 2008b. National Park Service occupational health and safety program reference manual 50B. Available at <https://www.nps.gov/policy/RM50Bdoclist.htm> (last accessed February 2019).
- National Park Service (NPS). 2016. NPSpecies: information on species in National Parks. Available at: <https://irma.nps.gov/NPSpecies/> (last accessed April 2017).
- Omernik, J. M. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,000). *Annals of the Association of American Geographers* 77(1):118-125.
- Palmquist, K. A., R. K. Peet, and S. R. Mitchell. 2015. Scale-dependent responses of longleaf pine vegetation to fire frequency and environmental context across two decades. *Journal of Ecology* 103(4) 998–1008.
- Peet, R. K., T. R. Wentworth, and P. S. White. 1998. The North Carolina Vegetation Survey protocol: a flexible, multipurpose method for recording vegetation composition and structure. *Castanea* 63:262–274.
- Perles, S. J., G. S. Podniesinski, E. Eastman, L. A. Sneddon, and S. C. Gawler. 2007. Classification and Mapping of Vegetation and Fire Fuel Models at Delaware Water Gap National Recreation Area: Volume 1 of 2. Technical Report NPS/NER/NRTR—2007/076. National Park Service. Philadelphia, Pennsylvania. Available at: https://www1.usgs.gov/vip/dewa/dewaappend_g.pdf (last accessed May 2019).
- R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: <http://www.R-project.org/> (last accessed March 2019).

- Sanders, S., S. E. Johnson, and D. M. Waller. 2006. General vegetation monitoring protocol for the Great Lakes Network, Version 1.0. National Park Service, Great Lakes Network, Ashland, Wisconsin.
- Segura, M., R. Woodman, J. Meiman, W. Granger, and J. Bracewell. 2007. Gulf Coast Network Vital Signs Monitoring Plan. Natural Resource Report NPS/GULN/NRR—2007/015. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/661666> (last accessed February 2019).
- Stevens, D. L., and A. N. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of American Statistical Association* 99(465):262–278.
- Taverna, K., R. K. Peet, and L. C. Phillips. 2005. Long-term change in ground-layer vegetation of deciduous forest of the North Carolina Piedmont, USA. *Journal of Ecology* 93:202–213.
- Tierney, G., B. Mitchell, K. Miller, J. Comiskey, A. Kozlowski, and D. Faber-Langendoen. 2016. Northeast Temperate Network long-term forest monitoring protocol: 2016 revision. Natural Resource Report NPS/NETN/NRR—2016/1184. National Park Service. Fort Collins, Colorado.
- Turner, M. G., V. H. Dale, and E. H. Everham. 1997. Fires, hurricanes, and volcanoes: Comparing large disturbances. *BioScience* 47:758–768.
- U.S. Department of Agriculture (USDA) Forest Service. 1999. A strategic plan for forest inventory and monitoring. Washington, District of Columbia.
- U.S. Environmental Protection Agency (EPA). Level III and IV ecoregions of the continental United States. Available at: <https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states> (last accessed February 2019).
- White, R., C. Nordman, L. Smart, T. Leibfreid, B. Moore, R. Smyth, and T. Govus. 2011. Vegetation monitoring protocol for the Cumberland Piedmont Network, Version 1. Natural Resource Report NPS/CUPN/NRR—2011/XXX. National Park Service. Fort Collins, Colorado.
- White, R., C. Nordman, L. Smart, T. Leibfreid, B. Moore, R. Smyth, and T. Govus. Draft (March 2017). Forest vegetation monitoring protocol for the Cumberland Piedmont Network, Version 2. Natural Resource Report NPS/CUPN/NRR—XXXX/XXX. National Park Service. Fort Collins, Colorado.
- Woodall, C., and M. S. Williams. 2005. Sampling protocol, estimation, and analysis procedures for the down woody materials indicator of the FIA program. General Technical Report NC-256. USDA Forest Service. North Central Research Station. St. Paul, Minnesota. 47 p.
- Wright, C. J., J. C. DeVivo, and K. Funk. 2008. Information management and archiving plan, Southeast Coast Inventory and Monitoring Network. Natural Resource Report NPS/SECN/NRR—2008/062. National Park Service, Fort Collins, Colorado.

Appendix A: Modifications to the Cumberland Piedmont Network Protocol and Justification for Changes

Summary

The Southeast Coast Network (SECN) has adopted the Cumberland Piedmont Network's (CUPN) Vegetation Monitoring Protocol (White et al. 2011) as the basis for its own terrestrial vegetation monitoring protocol implementation plan (this document). To accommodate the diverse and varied vegetation communities of the Southeast Coast region, some substantial modifications were necessary. The bulk of these modifications were related to differing sampling needs based on the range of habitat variation in SECN parks, and absence of ecological integrity measures in these same parks. Modifications were also related to down-stream procedural modifications following a few key changes.

This supplemental document lists and describes the major modifications that the SECN made to the CUPN protocol. Many of these are also elaborated upon in the relevant standard operating procedure (SOP) documents.

Major Modifications

Spatial Sampling Frame

The sampling frame used by the Cumberland Piedmont Network is forest and woodland communities within each park, and all such areas within whole parks are included. The Southeast Coast Network, in contrast, includes in its sampling frame all natural vegetated habitats from either whole parks or targeted park units. To reduce the effects of human disturbance, the Gulf Coast Network also specifically excludes a 14-meter buffer along park boundaries, roadways, and buildings, as well as between mapped vegetation units. As a result, roadside and infrastructure edge habitats are not included in any park-wide or unit-wide inferences (for a similar approach, see the integrated upland monitoring protocol for the Southern Colorado Plateau Network; DeCoster et al. 2012).

Sampling frames and spatial arrangements of plots were developed by the Southeast Coast Network to fit park-specific needs and constraints. Proposed plot locations for vegetation monitoring in SECN parks are presented in SOP 1.4.10—*Site Selection, Plot Establishment, and Return Visits*.

Broadly Defined Habitat Stratification

The Cumberland Piedmont Network does not stratify parks into broadly defined habitats to determine plot locations and sample size. The Southeast Coast Network uses broad habitat type polygons to pre-stratify the location of vegetation plots, and uses their relative size to determine the number of plots within each habitat sample. Furthermore, the Southeast Coast Network utilizes a staged approach to sampling across these types, whereby dominant and co-dominant habitats within a given park are the primary focus of sampling during an event year. Alternatively, less dominant types are only sampled within a park/year if time and resources allow.

Sampling frames and spatial arrangements of plots were developed by the Southeast Coast Network to fit park-specific needs and constraints. Proposed plot locations for vegetation monitoring in SECN parks are presented in SOP 1.4.10 *Site Selection, Plot Establishment, and Return Visits*.

Timing of Monitoring Effort

The Cumberland Piedmont Network initially proposed a two- and four-year sampling rotation for small and large parks, respectively, where eight plots are measured in each park in each year. This approach was later modified by CUPN (prior to year three field season), but the initial approach is still discernable in CUPN's annual sampling panels (B. Moore, personal communication). The Southeast Coast Network, in contrast, samples all 15 network parks in four consecutive annual sampling seasons in a four-year monitoring cycle. The Southeast Coast Network uses two reporting formats for delivering output from vegetation monitoring activities. The first of these is a Vegetation Monitoring Event and Status Report, which includes text, figures, and table summaries from the most recent sampling event on a park. This report is developed for each park in the monitoring framework during the winter and spring following a sampling event. The second document developed by the Southeast Coast Network is the Status and Trends in Vegetation report. These reports summarize the network's findings over the past three sampling events at a park, and place them in context with previous reporting intervals. These reports also include more in-depth analyses that test for temporal change in key vegetation metrics. After the first Status and Trends report, the network provides new updates on trends no less frequently than once per three sampling events, with the option of reporting after just one or two new events, to meet park-specific needs and interests. For both report types, the key metrics are directly linked to the project's monitoring objectives, as stated in the protocol implementation plan (Boyle et al. 2019).

Analysis and Reporting

One way the Cumberland Piedmont Network presents its findings for vegetation monitoring is in terms of ecological integrity. The Southeast Coast Network does not currently use this concept in its implementation. Quantitative vegetation data are available from reference sites across the South Atlantic geography, including sites that are in SECN parks described by the Carolina Vegetation Survey. However, integrity metrics have not been developed from these datasets. As such, in the current implementation, there is no modified version of CUPN SOP 13, and the Southeast Coast Network does not produce an ecological integrity scorecard. However, it is the network's hopes that ecological integrity indices will be developed in the future, if suitable data are available and resources allow. The methods currently employed by the Southeast Coast Network for data analysis and reporting are in SOP 2.4.06 *Data Analysis and Reporting* (Boyle and Gregory 2019).

Sampling Crew Logistics

The Cumberland Piedmont Network uses two field teams per season that can work simultaneously, with all operations being managed by the network. The Southeast Coast Network, in contrast, currently staffs only one field crew per year. The Southeast Coast Network anticipates utilizing a two-team approach in future sampling years.

Fuel Load Metrics

The Cumberland Piedmont Network measures volume of coarse woody debris (CWD) across two transects that bisect a typical CUPN vegetation monitoring plot. This fuel type is the primary driver of fire behavior in the forest and woodland types in the CUPN landscape. In the Southeast Coastal Plain, however, other fuel types are more responsible for influencing fire behavior and when collectively sampled describe the total fuel volume of a given site more accurately. Additional fuel types in the Southeast Coastal Plain that are primary drivers of a site's fire ecology include duff and litter depths, standing live and dead vegetation, fine woody debris (FWD), and CWD. The Southeast Coast Network has chosen to sample these additional elements in their vegetation monitoring plots to provide parks a local-scale accurate assessment of fuel loads in certain upland and fire-prone ecosystems.

SOP Modifications

The CUPN vegetation monitoring protocol includes an SOP that describe the usage of GPS units for navigating to plots and another that describes the procedure for establishing new plots. Because these techniques are so closely linked, the Southeast Coast Network chose to bundle them into a single SOP. Likewise, the Cumberland Piedmont Network has two separate SOPs that describe how to measure specific attributes of the large tree structure class (≥ 10 centimeter [3.9 in]) diameter at breast height) on its vegetation monitoring plots—diameter values by species and overall canopy coverage plus stand height. The Southeast Coast Network chose to bundle these two SOPs into a single document. Finally, the Southeast Coast Network chose to bundle the CUPN's Quality Control/Quality Assurance and Data Management SOPs into a single SOP.

The Southeast Coast Network also has a standard safety SOP outlining common safety practices associated with field monitoring activities in network parks for all protocols.

Literature Cited for Appendix A

- Boyle, M. F., and M. B. Gregory. 2019. Data analysis and reporting—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.4.06. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/profile/2260357> (last accessed May 2019).
- Carlson, J. E., J. Bracewell, W. Granger, and M. Segura. 2018. Monitoring vegetation in Gulf Coast Network parks: Protocol implementation plan. Natural Resource Report NPS/GULN/NRR—2018/1746. National Park Service, Fort Collins, Colorado.
- DeCoster, J. K., C. L. Lauver, M. E. Miller, J. R. Norris, A. E. C. Snyder, M. C. Swan, L. P. Thomas, and D. L. Witwicki. 2012. Integrated upland monitoring protocol for the Southern Colorado Plateau Network. Natural Resource Report NPS/SCPN/NRR—2012/577. National Park Service, Fort Collins, Colorado.
- White, R., C. Nordman, L. Smart, T. Leibfreid, B. Moore, R. Smyth, and T. Govus. 2011. Vegetation monitoring protocol for the Cumberland Piedmont Network, Version 1. Natural Resource Report NPS/CUPN/NRR—2011/XXX. National Park Service. Fort Collins, Colorado.

Appendix B: Job Hazards Risk Assessment and Training and Proficiencies

Job Hazard Analysis Introduction

Work Project/Activity: Driving Safety (Highway, Paved and Dirt Roads) and Towing.

Location: Southeast Coast Network Parks

Unit: SECN

Developed by: Eric Starkey

Job Title: Aquatic Ecologist

Date Prepared: 03 March 2017 (Boating) and 23 March 2017 (Towing)

Approved By: Brian Gregory

Required and/or Recommended Personal Protective Equipment (Boating and Towing):

- GPS Unit/Maps
- Cellphone
- Sunglasses
- Emergency blanket
- Emergency contact information
- Fire extinguisher
- First Aid kit
- Safety vests
- Reflective triangle
- Gloves
- Flashlight
- Road flare
- Jumper cables
- Vehicle jack
- Spare tire
- Can of Fix-a-Flat or similar
- Bearing grease
- Copy of SECN SOP 3.1.04 Motor Vehicle Accident Reporting Procedures—Version 2.0
- SF-94 State of Witness Form

- SF-91 Motor Vehicle Accident Report Form
- Motor vehicle accident operator responsibilities checklist found in SOP 3.1.04

All SECN employees who will tow a boat or cargo trailer must read and understand the brochure “Towing a trailer: Being equipped for safety” available from the U.S. Department of Transportation website at: www.nhtsa.gov/cars/problems/equipment/towing/index.htm. Driving and towing safety analysis parameters can be seen in Tables B-1 and B-2.

Table B-1. Driving Safety Job Hazard Analysis.

Tasks	Potential hazards	Recommended abatement actions
All tasks and procedures	Improper vehicle	Select appropriate vehicle for work needs, location, and driving conditions. Familiarize yourself with the vehicle and know where the controls are located. Obey manufacturer’s guidelines for use and towing.
	Lack of training	Take a defensive driving course. Obtain general safety training from a qualified operator before hauling trailers behind any vehicle (see towing JHA).
	General accidents	Complete First Aid and CPR training courses. Always carry standard PPE, which includes a first aid kit and road hazard/emergency kit. Report any accident (government-owned vehicle, leased, or personal-owned vehicle), regardless of extent. Complete forms SF-91 and SF-94 immediately if involved in an accident. Copies of these forms should ALWAYS be present in the vehicle. If you are using a POV or rental car for government travel, obtain copies of the forms before departure. Obtain a police report.
	Improper vehicle maintenance	Follow manufacturer’s recommended maintenance and make sure that vehicles are on a preventative maintenance plan.
Pre-departure	Fatigue	Adhere to NPS Official Travel Driving Policy (Policy memo 13-01, April 2013) and get a full night’s rest (~8 hours) prior to operation of a vehicle.
	Vehicle maintenance	Walk around the vehicle and perform an inspection for obvious items such as tire inflation, windshield wipers, and sufficient fuel to get to destination. Check for safety equipment, jack and spare tire prior to departure. Check oil and all fluids. Document. Replace windshield wipers annually, and replace tires when they exceed wear. Maintain a clean windshield.
	Unfamiliar route	Review maps and plan route prior to beginning your trip.
Fueling	Explosion	Turn off vehicle. Do not smoke or use cellular phone. Do not enter vehicle after pumping has begun. Touch metal to ground yourself. If using a gas can, place can on the ground prior to fueling.
Driving	Vehicle maintenance	Check oil and all fluids during every refueling. Document in log book. Maintain sufficient fuel to get to your destination. Maintain a clean windshield. Pull off the road in a safe location if a problem is suspected.

Table B-1 (continued). Driving Safety Job Hazard Analysis.

Tasks	Potential hazards	Recommended abatement actions
Driving (continued)	Inattentive driving	Review maps and plan route prior to beginning your trip. Always keep your eyes on the road. Be alert and practice defensive driving. Do not eat and drive and do not talk on the phone or text and drive.
	Fatigue	Adhere to NPS Official Travel Driving Policy (Policy memo 13-01, April 2013). Do not exceed a total of 10 hours of driving time behind the wheel. Employees embarking on travel after working a partial shift or attending training are limited to a maximum total work/driving period of 12 hours.
	Accidents	WEAR SEATBELTS AT ALL TIMES WHEN VEHICLE IS MOVING. Obey speed limits and drive defensively. Be conscientious of other drivers (e.g., the left lane is the passing lane and not a cruising lane, pass then get over; do not park too closely to other vehicles). Report any accident (government-owned vehicle, leased, or personal-owned vehicle), regardless of extent. Complete forms SF-91 and SF-94 immediately if involved in an accident. Copies of these forms should ALWAYS be present in the vehicle. If you are using a POV or rental car for government travel, obtain copies of the forms before departure. Obtain a police report.
	Limited visibility	Do not assume you are the only one on the road behind locked gates (day or night), people from other agencies may use these roads; be alert to the idea that others may be coming in from the field in the early a.m. - drive slow and keep right! Maintain windshield cleaner fluid level and clean both sides of windows regularly (remember back window); slow down; if blinded by sun or dust, proceed slowly or pull over and wait for hazard to pass; keep to the right-hand side of the road and drive with your lights on. Conduct a full walk-around of vehicle and place orange marker cones behind and/or in front of the vehicle to increase visibility if leaving the vehicle in a generally unsecure area (on a roadside or narrow road shoulder, in a road median, or in an otherwise high-traffic area).
	Fires	All vehicles must be equipped with a working fire extinguisher. The extinguisher must be appropriate for the use, class type, in date and fully charged. Never park a warm engine vehicle in tall grass. Dry vegetation, especially on 2-track roads, has the potential to ignite from hot engines and exhaust. Pay attention to fire conditions and consult with park staff prior to driving on un-paved surfaces in the park. Be alert of fire conditions. Do not enter uncontrolled burning areas with a vehicle. Avoid engine fuel spills. Minimize flammables in and near vehicle and work area. If a vehicle is on fire and the fire cannot be suppressed with an extinguisher, MOVE AWAY FROM THE VEHICLE. Under no circumstances should you re-enter the vehicle to remove belongings or equipment when a vehicle is burning.

Table B-1 (continued). Driving Safety Job Hazard Analysis.

Tasks	Potential hazards	Recommended abatement actions
Driving (continued)	Wildlife	Plan departure and arrival times to minimize wildlife strikes at dawn and dusk. Slow down where animals might be present to allow for reaction time. Do not swerve abruptly to avoid hitting an animal, if necessary it's better to ride out the impact.
	Weather	Keep informed on the current weather- check www.weather.com or www.wrh.noaa.gov . When using windshield wipers during rain, turn on headlights. Remove all frost and snow prior to starting your trip. Make sure vents are clear of snow to provide adequate airflow for defrosting. Do not drive in adverse weather conditions, the trip can be rescheduled.
	Vehicle security	Always lock vehicle, do not leave valuables in vehicle, and cover or otherwise keep from view any equipment left in vehicle.
	Narrow roads with bumpy or "washboard" surfaces	Maintain a safe speed (this may be below the legal speed limit) for the road conditions; stay clear to the right, especially on curves; drive with headlights on always; when turning around on mountain roads always "face the danger" (e.g., versus backing toward the cliff edge); the passenger should get out and spot for driver when backing up.
	Driving/Driving in Mud and Soft Sand	Check with local unit as necessary prior to driving on back roads, for items such as construction, washouts, blowdowns and closures. Obey all posted travel signs. Proceed slowly around corners and drive on the right side. Use 4-wheel drive (4WD) in appropriate situations. Always put vehicle in 4WD long before you think you might need it; if you begin to get stuck it is too late for the 4WD to engage. Do not cause extensive damage to unpaved roads by driving on them when too saturated. Avoid driving in ruts because the vehicle is susceptible to bottoming out. Get out of the vehicle to investigate all puddles to determine depth and if the bottom of the puddle is hard enough to support a vehicle. Walk through the puddle if necessary. Drive SLOWLY through puddles, as driving fast can flood the engine, and/or cause the vehicle to slide laterally. It may also erode and damage the road. Turn around in areas only where enough space on solid ground is available, have passengers get out to help direct, take your time.
	Fallen trees on road	For small trees, try and remove tree or cut with a handsaw and remove portion of tree; for large trees, notify support crew to remove tree.
Changing Tires	Hit by another vehicle	If possible, move vehicle to a safe/level location off the roadway. Wear a high visibility vest. Use reflective triangle and/or road flares.
	Injury	Park on level ground. Block tires. Ensure jack sits securely. Follow jack/vehicle instructions.
Breakdown	Hit by another vehicle	If possible, move vehicle to a safe/level location off the roadway. Wear a high visibility vest. Use reflective triangle and/or road flares. Call for assistance.

Table B-2. Towing Job Hazard Analysis.

Tasks	Potential hazards	Recommended abatement actions
All tasks and procedures	Improper vehicle	Select appropriate vehicle for work needs, location, and driving conditions. Familiarize yourself with the vehicle and know its tow capacity. Obey manufacturer's guidelines for use and towing. Do not exceed recommended towing weight of tow or tow vehicle.
	Lack of training	Take a defensive driving course. Obtain general safety training from a qualified operator before hauling trailers. All SECN employees who will tow a boat or cargo trailer must read and understand the brochure "Towing a trailer: Being equipped for safety" available from the U.S. Department of Transportation website at: www.nhtsa.gov/cars/problems/equipment/towing/index.htm Practice driving vehicle with trailer attached in a safe area until a comfort level is obtained.
	General accidents	Complete First Aid and CPR training courses. Always carry standard PPE, which includes a first aid kit and road hazard/emergency kit. Report any accident (government-owned vehicle, leased, or personal-owned vehicle), regardless of extent. Complete forms SF-91 and SF-94 immediately if involved in an accident. Copies of these forms should ALWAYS be present in the vehicle. If you are using a POV or rental for government travel, obtain copies of the forms before departure. Obtain a police report.
	Improper trailer maintenance	Follow manufacturer's recommended maintenance and make sure that the trailer is on a preventative maintenance plan.
Pre-departure	Improper trailer maintenance	Check tire pressure, spare tire, jack, bearing grease, and trailer lights.
	Hitching trailer to tow vehicle	Wear gloves. Have a coworker stand in a safe location to help guide the tow vehicle back and line up the ball with the trailer hitch. Use a hitch lock or safety pin at all times when towing. Ensure safety chains are installed correctly, crossed under the trailer and connected to the tow vehicle. Ensure tow vehicle has proper mirrors installed to view trailer appropriately. Walk around the trailer and perform an inspection for obvious items such as tire inflation. Ensure all trailer lights and brakes are operational before driving.
	Uneven / loose trailer load	Load trailer per manufacturer's guidance. Organize load logically so trailer can be hitched and unhitched easily (i.e., not too much weight in the front of the trailer). Remove, tie down, or store any loose objects (i.e. push poles, mooring lines, straps).
	Unfamiliar route	Review maps and plan route prior to beginning your trip. Avoid narrow and dead-end roads. Plan ahead of time for trailer parking. Be aware that states may have speed limits when towing that are not published on speed limit signage.

Table B-2 (continued). Towing Job Hazard Analysis.

Tasks	Potential hazards	Recommended abatement actions
Towing	Increased stopping distance	Maintain a safe speed and maintain a safe distance from other vehicles. Do not exceed recommended towing weight of tow or tow vehicle. Be aware that states may have speed limits when towing that are not published on speed limit signage. Ensure tow vehicle has proper mirrors installed to view trailer appropriately.
	Limited visibility	Maintain windshield cleaner fluid level and clean both sides of windows regularly (remember back window); slow down; if blinded by sun or dust, proceed slowly or pull over and wait for hazard to pass; keep to the right-hand side of the road and drive with your lights on. Insure tow vehicle has proper mirrors installed to view trailer appropriately. Conduct a full walk-around of vehicle/trailer and place orange marker cones behind and/or in front of the vehicle to increase visibility if leaving the vehicle in a generally unsecure area (on a roadside or narrow road shoulder, in a road median, or in an otherwise high-traffic area).
	Increased turning radius	Review maps and plan route prior to beginning your trip. Make wide enough turns such that the trailer clears any obstacles (i.e. curbs, cars, gas pumps).
	Improper trailer maintenance	Stop regularly to check tire pressure, spare tire, jack, bearing grease, and trailer lights.
	Uneven / loose trailer load	Stop regularly to check if the trailer load has shifted or if tie downs have come loose. Rearrange and tie down load as necessary.
	Backing up	Ensure tow vehicle has adequate visibility. Have a co-worker stand in a safe location to serve as a spotter for obstacles not visible to the driver.
Changing Tires	Hit by another vehicle	If possible, move vehicle to a safe/level location off the roadway. Wear a high visibility vest. Use reflective triangle and/or road flares.
	Injury	Park on level ground. Block tires. Ensure jack sits securely. Follow jack/vehicle instructions.
Breakdown	Hit by another vehicle	If possible, move vehicle to a safe/level location off the roadway. Wear a high visibility vest. Use reflective triangle and/or road flares. Call for assistance.

Job Hazard Analysis Introduction

Work Project/Activity: Boating

Location: Southeast Coast Network Parks

Unit: SECN

Developed by: Eric Starkey

Job Title: Aquatic Ecologist

Date Prepared: 04 May 2017

Approved By: Brian Gregory

Required and/or Recommended Personal Protective Equipment:

- Sunglasses
- Emergency blanket
- Sunscreen
- Emergency contact information
- GPS Unit/Maps/Charts
- Fire extinguisher
- First Aid kit
- Type I, II or III personal floatation device (PFD) for each person on board
- Type IV throwable PFD
- Sound producing device
- Visual distress signals for day and night
- Navigation lights
- Cell Phone and Satellite Locator Beacon (inReach)
- Copy of SECN SOP 3.1.04 Motor Vehicle Accident Reporting Procedures—Version 2.0
- SF-94 State of Witness Form
- SF-91 Motor Vehicle Accident Report Form
- Motor vehicle accident operator responsibilities checklist found in SOP 3.1.04
- An expanded list of boat safety equipment for motorized and non-motorized boats is shown in Table 1 of Safe Operation of SECN Watercraft SOP 3.1.02
- File float plan with the Southeast Coast Network

All SECN employees who operate a motorized vessel must complete the DOI motorboat operator's certification course (MOCC) and complete an eight- hour refresher course every five years (motorized boats only). Boating safety analysis parameters can be seen in Table B-3.

Table B-3. Boating Job Hazard Analysis.

Tasks	Potential hazards	Recommended abatement actions
All tasks and procedures	Lack of training	All SECN employees who operate a motorized vessel must complete the US Department of the Interior motorboat operator's certification course (MOCC). Complete an 8-hour refresher course every 5 years. It is advisable to practice with an experienced operator on waters where boat use will occur. It is also advisable that crew members are familiar with boat operations and safety procedures. Crew members must review the Safe Operation of Southeast Coast Network Watercraft SOP 3.1.02.
	Improper boat/engine maintenance	Follow manufacturer's recommended maintenance and make sure that the boat and motor are on a preventative maintenance plan. • Perform vessel inspection for obvious items such seaworthiness of craft, assure oil levels are good, and assure motor is in working order. Maintain vessel and proper safety equipment. Look for any damage to the hull. • For non-motorized vessels, ensure craft is in good condition. Before the start of the field season, fill the craft with water while on land and watch for leaks. Repair leaks immediately.
	General accidents	Complete First Aid and CPR training courses. Always carry standard PPE, which includes a first aid kit and road hazard/emergency kit. Report any accident (government-owned vehicle, leased, or personal-owned vehicle), regardless of extent. Complete forms SF-91 and SF-94 immediately if involved in an accident. Copies of these forms should ALWAYS be present in the vehicle. Obtain a police report.
Pre-departure	Improper maintenance	Check tire pressure, spare tire, jack, bearing grease, and trailer lights.
	Hitching trailer to tow vehicle	Review Towing JHA. Wear gloves. Have a coworker stand in a safe location to help guide the tow vehicle back and line up the ball with the trailer hitch. Use a hitch lock or safety pin at all times when towing. Ensure safety chains are installed correctly, crossed under the trailer and connected to the tow vehicle. Ensure tow vehicle has proper mirrors installed to view trailer appropriately. Walk around the trailer and perform an inspection for obvious items such as tire inflation. Ensure all trailer lights and brakes are operational before driving.
	Lack of communication	File a float plan with the SECN program manager and park contact.
	Unfamiliar route	Review maps and plan route prior to beginning your trip. When possible, use a marine GPS with preloaded waypoints and tracks.

Table B-3 (continued). Boating Job Hazard Analysis.

Tasks	Potential hazards	Recommended abatement actions
Boat launch/retrieval	Crowded boat ramp. Vehicle and boat traffic	Prepare the boat for launch and load equipment while parked away from the boat ramp. Tie boat off near the end of courtesy docks while waiting for co-workers.
	Slick boat ramp and trailer	Wear non-slip footwear. Step only on textured trailer surfaces.
	Falling into water	Maintain 3 points of contact while in the boat, pass gear to someone already in the boat, wear non-slip footwear.
	Drowning	Wear a flotation device at all times while on docks and in boats.
	Injury	Do not put hands or feet between boat and dock. Use boat fenders.
Underway	Falling into water	Maintain 3 points of contact while in the boat. Stay seated. Be prepared to receive wake from other boats and large waves. Use motor kill switch/tether. Use self-rescue or work with crew to re-enter the boat.
	Drowning	Wear a flotation device at all times while on docks and in boats.
	Marine debris	Designate a crew member to look out for debris. Avoid visible debris.
	Grounding	Designate a crew member to look out for shallow water. Review charts prior to navigation. Motor at a speed that will allow the captain and crew to change course before grounding occurs. A pre-navigation safety meeting includes discussion of what to do if the boat is soft grounded or hard grounded. The captain and crew must be prepared for an extended time on the boat and carry sufficient water, food and extra clothing. Unless at a dock, it is not advisable to leave a boat unattended.
	Large waves/boat wake	Large waves caused by wind or boat wake may rock the boat hard enough to cause a loss of footing or capsizing (see below). Avoid wake when possible and do not operate a boat in large waves. The captain and crew should be seated and holding on to the boat when preparing to receive a large wave. While conducting work, a lookout should be assigned to make the crew aware of incoming wake.
	Boat traffic	Avoid working in shipping channels. Make yourself visible/audible and take appropriate action to avoid collisions. Follow "rules of the road." Post a lookout.
	Foul weather	Check the forecast and wind speeds prior to departure and throughout the day. Cancel work and return to ramp if storms, high winds or lightning occurs. Be aware of rapidly building/approaching storm systems. Seek shelter before a storm arrives. No boat operation is to occur if a small craft or lake effect warning is issued or predicted for the area of operation. Boats should not be operated if sustained winds exceed 18 mph or wave conditions exceed 18 inches.
	Hypothermia	Boat operations will not occur below 45°F air temperature or 55°F water temperature unless all participants are wearing dry suits.

Table B-3 (continued). Boating Job Hazard Analysis.

Tasks	Potential hazards	Recommended abatement actions
Underway (continued)	Night operation	Boats should be operated between 30 minutes before sunrise to 30 minutes past sunset, unless the operator is delayed by conditions beyond normal control such as groundings or squalls. Navigation lights must always be carried.
	Breakdown	Carry basic tools. Use communication devices to call for assistance.
	Capsizing	Make sure all passengers can swim prior to departure. Avoid overloading the boat. Properly distribute weight. Aim the bow of the boat into the waves. Stay with the boat if capsized.
	Crew overboard	Do not lose sight of the person. Keep the engine on but in neutral. Use "reach, throw, row, and go" procedures.
	Request for towing assistance by public	Do not tow another vessel, call Coast Guard or other law enforcement to provide assistance.
	Beaching the boat	Approach the shoreline slowly. Beach on firm sediment but not rocks or oyster beds. Tie the boat up. Take the tide into consideration (incoming or outgoing). Do not leave the boat unattended.
	Tides	Be aware of when low and high tides will occur for the day. Changing tides may alter preferred routes to and from sites. The same route may not be optimal at the beginning and end of the work day. Plan ahead. No work should occur in shallow areas on a falling tide if low tide will occur after dark.

Job Hazard Analysis Introduction

Work Project/Activity: Vegetation Monitoring Fieldwork

Location: Southeast Coast Network Parks

Unit: SECN

Developed by: Forbes Boyle

Job Title: Botanist

Date Prepared: 14 February 2019

Approved By: Brian Gregory

Required and/or Recommended Personal Protective Equipment:

- Topical insect repellent or Permethrin-treated clothes
- Sunscreen
- Snake boots or chaps or gaiters
- Walking/hiking sticks
- GPS Unit/Maps
- First Aid kit
- Appropriate clothing: long pants, long-sleeved shirts, wide-brimmed hats
- Epinephrine injector (if known allergies to bees)
- InReach device
- Cell phone or park radio
- Appropriate footwear: leather or similar hiking boots in dry sites; rubber boots/waders for wet sites
- Equipment and supplies for planned sampling tasks in the field, including compass
- Emergency contact information
- Directions to nearest hospital from the park

Vegetation monitoring fieldwork safety parameters can be seen in Table B-4.

Table B-4. Vegetation Monitoring Fieldwork Job Hazard Analysis.

Tasks	Potential hazards	Recommended abatement actions
Pre-departure	n/a	File a Fieldwork Itinerary Form, which includes trip destination(s), schedule, and point of contact information at SECN and parks
Driving to/from site	Car Accident	Driver and all passengers to wear seatbelts at all times. Do not use cell phones while driving. Obey all driving laws and park in a safe location that will not obstruct traffic. Minimize travel during inclement weather. Use 4WD when necessary. Ensure that tires are properly inflated and check for tire damage regularly.
	Unimproved Roads	Maintain a safe speed for the road condition. Use 4WD when necessary. Ensure that tires are properly inflated and check for tire damage regularly. Always have a fully inflated spare tire and all equipment necessary for changing a tire. Be prepared to move sharp objects from road.
	Driver Fatigue	Do not drive if fatigued; pull over to rest or have another member of the field crew drive.
Safety briefing (on-site)	n/a	This briefing establishes member roles and responsibilities, team tasks and task sequences, and anticipated location-specific animal, plant and environmental hazards, communications, and contact procedures.
Hiking to access sampling sites	Rugged Terrain (tripping, falling)	Wear sturdy, well-fitting boots with good traction. When off-trail, take care to assess terrain conditions in order to determine safest route. Move slowly and deliberately when off-trail. Walking sticks may help to increase stability and push vegetation out of the way.
	Standing Water or Flash Floods	Before walking in stagnant flooded areas or water in general, test the water depth with a probe that is at least 1 meter long. If the water depth exceeds 1 meter, assess whether the team has the appropriate PPE to continue (waders). Do not try to walk, drive or cross floodwaters caused by flash floods.
	Loss of orientation	Ensure all crew members are knowledgeable with a map, compass and GPS. Keep track of current position, vehicle location, and pay attention to landmarks along your way. Use established trails as much as possible.
	Recently burned areas (stump holes, falling trees)	Recently burned areas have increased risk of falling trees, stump holes, and other hazards. Do not walk beneath leaning recently burned trees. Be on the lookout for burned out stump holes.
	Back and neck injuries from excessive backpack weight	Ensure pack fits appropriately and that all support straps are intact. Do not carry more than you are comfortable with, and never carry packs over 40 lbs. Wear appropriate footwear. Use teamwork to carry heavy and bulky items; carry heavy objects on the down-slope side when possible.

Table B-4 (continued). Vegetation Monitoring Fieldwork Job Hazard Analysis.

Tasks	Potential hazards	Recommended abatement actions
Fieldwork	Exposure to inclement weather conditions	Be aware and informed of expected weather conditions before and during field work and dress appropriately. Avoid prolonged exposure to sun and wear sunscreen greater than SPF-30. Keep hydrated and be alert for heat exhaustion and heat stroke in hot, humid conditions. When necessary, take appropriate breaks in the shade and slow pace to avoid overheating. If you are caught in a thunderstorm, avoid standing in water or near isolated tall trees and making contact with metal objects; seek shelter under a grove of smaller trees, squat low to the ground, keep feet together, tuck head down, close eyes and cover ears, and stay 50 feet apart from other people.
	Ticks	Spray clothing and skin with insect repellent and/or use Permethrin on clothing. Wear light colored clothing that fits tightly around wrists, ankles and waist. Cover trouser legs with high socks, boots, or duct tape. Tuck in shirt tails. Search the body on a regular basis, especially hair and clothing. If a tick becomes attached, use tweezers to grasp the tick as close to possible to the point of attachment and pull straight out with gentle pressure. Wash skin at point of attachment with soap and water. If possible, place the tick in an empty container of alcohol labeled with time and date of attachment/detachment. Watch for warning signs of illness, including a red spot on the bite area, fever, chills, headache, joint and muscle ache, and significant fatigue. Review the CDC documents related to tick-borne diseases (http://www.cdc.gov/ticks/diseases).
	Venomous snakes	Prior to sampling, put on appropriate boots; if working in areas of high snake density, consider wearing snake boots or chaps. During the sampling event, look and listen for snakes as you move through vegetation and around objects. Never reach into holes or cavities in or under trees, ground objects, rock ledges, or likely snake hideouts. Avoid disturbing venomous snakes and do not handle them for any reason. If bitten by a venomous snake, follow appropriate snakebite First Aid procedures and get medical help immediately—inform assisting personnel of the type of snake involved.
	Mosquitos	Wear long sleeves and long pants. Avoid heavy scents, such as strong soap, lotion or perfume. Use insect repellents and carry after-bite medication to reduce skin irritation.
	Other stinging/biting insects and animals, and poisonous plants	Know the park-specific hazardous plants and animals. Wear insect repellent and long sleeves and long pants. Avoid undue contact with spiders, centipedes, and other hazardous arthropods. Keep away from mammals observed in daylight hours exhibiting symptoms of rabies.
	Eye damage from plant material and rebar shards.	Wear glasses when working in tall vegetation that could stab into eyes, or when hammering rebar into the ground that could cause loosened pieced of metal to lodge into the eye. Avoid quick head movements when looking down into vegetation.
	Unexpected health emergencies	Prior to field sampling, all field crew should be up-to-date in CPR and First Aid training (every 2 years). Properly establish emergency notification and communication procedures, event routes, and POC for the SECN and park.

JHA Instructions for Driving Safety, Towing, Boating and Vegetation Monitoring Fieldwork

The JHA shall identify the location of the work project or activity, the name of employee(s) involved in the process, the date(s) of acknowledgment, and the name of the appropriate supervisor approving the JHA. The supervisor acknowledges that employees have read and understand the contents, have received the required training, and are qualified to perform the work project or activity.

Identify all tasks and procedures associated with the work project or activity that have potential to cause injury or illness to personnel and damage to property or material. Include emergency evacuation procedures (EEP).

Identify all known or suspect hazards associated with each respective task/procedure listed. For example:

1. Research past accidents/incidents.
2. Research the Health and Safety Code, or other appropriate literature.
3. Discuss the work project/activity with participants.
4. Observe the work project/activity.
5. A combination of the above.

Identify appropriate actions to reduce or eliminate the hazards identified. Abatement measures listed below are in the order of the preferred abatement method:

1. Engineering Controls (the most desirable method of abatement). For example, ergonomically designed tools, equipment, and furniture.
2. Substitution. For example, switching to high flash point, non-toxic solvents.
3. Administrative Controls. For example, limiting exposure by reducing the work schedule; establishing appropriate procedures and practices.
4. PPE (least desirable method of abatement). For example, using hearing protection when working with or close to portable machines (chain saws, rock drills, and portable water pumps).
5. A combination of the above. Use a copy of the JHA as justification for purchase orders when procuring PPE.

Emergency Evacuation Instructions

Work supervisors and crewmembers are responsible for developing and discussing field emergency evacuation procedures (EEP) and alternatives in the event a person(s) becomes seriously ill or injured at the worksite.

Be prepared to provide the following information:

1. Nature of the accident or injury (avoid using victim's name).
2. Type of assistance needed, if any (ground, air, or water evacuation).
3. Location of accident or injury, best access route into the worksite (road name/number), Identifiable ground/air landmarks.
4. Radio frequencies.
5. Contact person.
6. Local hazards to ground vehicles or aviation.
7. Weather conditions (wind speed & direction, visibility, temperature).
8. Topography.
9. Number of individuals to be transported.
10. Estimated weight of individuals for air/water evacuation.

The items listed above serve only as guidelines for the development of emergency evacuation procedures.

JHA and Emergency Evacuation Procedures Acknowledgment

I, the undersigned participant, acknowledge participation in the development of this JHA (as applicable) and accompanying emergency evacuation procedures. I have read them thoroughly and understand the provisions of these documents (the following shows a manual form with three questions to answer by hand: 1) Print name 2) Signature and 3) Date).

PRINT NAME

SIGNATURE

DATE

Training and proficiencies required or recommended for the safe implementation of this protocol.

Required Training and Proficiencies

- First Aid and CPR training for field workers (terrestrial ecology, coastal ecology, and water quality positions) renewed annually (American Red Cross training) or biannually (American Heart Association training).
- All employees riding or operating a motorized or non-motorized vessel will undergo a safety briefing by a certified operator or the SECN safety officer.
- Motorized boat operators must have a current Motorboat Operator's Certification Course (MOCC) certification.
- Read and understand the SECN Boat Operation SOP for positions that require operation or riding in a motorized vessel and complete a short written exam.
- All field staff must read and understand the document On-Duty Injury and Illnesses SOP and complete a short written exam.
- All SECN staff who operate a vehicle must complete a defensive driving course.
- All employees required to operate a government vehicle must read and understand the document Government Motor Vehicle Accident SOP and complete a short written exam.
- Read and understand the document Towing a Trailer: Being Equipped for Safety for all positions requiring towing of a trailer and complete a short written exam.

Optional / Recommended Training and Proficiencies

- Authorities, Roles, and Responsibilities (free online course).
- Blood borne Pathogens (free online course).
- Fall Protection (free online course).
- Fire Protection (free online course).
- Office Safety (free online course).
- Flammable and Combustible Liquids (free online course).
- Hand and Portable Powered Tools (free online course).
- Resources, References, and Standards (free online course).
- Personal Safety through Awareness (free online course).

- Laboratory Safety (free online course).
- Hazard Communication (free online course).
- First Responder Awareness Level (free online course).
- NSC Defensive Driving II (See Collateral Duty Safety Officer [CDSO] for more information).
- Personal Protective Equipment (free online course).
- Stress Management (free online course).

Appendix C: Power Analysis from Southeast Coast Network Vegetation Monitoring Plots Associated with Anuran and Bird Monitoring Stations

Introduction

A successful Inventory and Monitoring (I & M) program in National Parks must be poised to detect a wide range of structural and compositional changes in plant communities over time. If a program can rapidly assess and report on stressor-driven declines in a native plant species, for example, this may beneficially spur management action to prevent further loss. Yet the monitoring program's ability to provide such evidence rests heavily on the sampling design, which is subject to both park needs and logistical constraints. From a logistical perspective, there are almost always limits on the number of vegetation plots that can be monitored within a park. From a statistical standpoint, however, it would be optimal to monitor a very large number of plots, so that the program could expect to miss very few of the trends that are truly present (i.e., missed-change rate) and to very rarely claim that trends are present when they are in fact random noise (i.e., false-change rate). In statistical terminology, a larger sample size increases the statistical power of the analyses (1 minus the missed-change rate = a test's statistical power) while maintaining a low alpha level (false-change rate = alpha level).

One way to select an appropriate number of plots for monitoring is to perform a power analysis. A power analysis uses pilot data on spatial and/or temporal variation to estimate the smallest level of change that could be detected for a given number of plots, based on pre-selected levels of statistical power and the alpha level. For many I & M vegetation monitoring protocols, statistical power is set at 0.8 (i.e., 80%), and the alpha level is set at 0.1. These levels assume that managers would prefer to be alerted to, and possibly respond to, trends that are not real, rather than fail to detect true changes that have occurred. Further, several I & M offices including the Northeast Temperate Network (NETN) set their target 'minimum change detection' as being able to detect a 40% change in a given vegetation metric, with the hope that for some metrics, it is possible to detect even smaller amounts of change over time.

The Southeast Coast Network is preparing to monitor vegetation in long-term plots in 15 national parks in the southeastern U. S. (Boyle et al. 2019), following the sampling methods of the Cumberland Piedmont Network (White et al. 2011). The Southeast Coast Network will adopt the same standards for statistical power, alpha level, and minimum change detection as the NETN, which are listed above. To detect changes using a representative set of biological metrics that are potentially useful in describing important SECN communities, the network conducted a preliminary and limited power analysis. The Southeast Coast Network made use of the simulation-based power analysis from a published study in ten NETN parks (Miller and Mitchell 2014).

Methods

Vegetation trend data were available from SECN parks due to earlier efforts by the network to characterize vegetation communities at sites co-associated with anuran and avian monitoring stations. The simulation used fixed plot data at two parks—Cape Lookout National Seashore (CALO) and

Kennesaw Mountain National Battlefield Park (KEMO)—that represented typical (with respect to vegetation community types) coastal and inland forested areas in the network. The method used data from the two park visits to estimate temporal sampling variability (assuming there was no underlying trend) and then bootstrap-simulated three return visits for a specified number of plots. Several caveats regarding this analysis are warranted. Temporal sampling variability estimated from only two sampling events is likely an underestimate of true temporal sampling variability. Data collected as vegetation cover classes were converted to cover class mid-points and averaged for each plot; this approach is not appropriate for a formal analysis but provides a very rough estimate of potential power to detect change. This approach will also produce low power when looking for change in low cover proportions, because a large percentage change in a low number will be hard to detect. Higher percentage changes could be used to identify percentage changes in metrics like invasive species cover that would be relevant to managers.

Linear change was simulated by adding a fixed percentage of the mean metric value during each sampling event and ranged from a -50% to +50% total change in 5% increments. For example, to simulate a 50% change over four time intervals, the simulation added 16.7% to the mean value after each time interval, and temporal variation for each plot and sampling event was incorporated by randomly selecting (bootstrapping, with replacement) a difference between two sampling events from the distribution of pilot plot data for a park or community type. Each iteration of the simulation was analyzed using a mixed effects model with year and site (i.e., park or vegetation community type) as fixed effects and plot as a random effect. We used a power of 80% and type I error rate (α) of 0.10 to look at the power to detect change over three consecutive sampling events. The data were logit-transformed for metrics measured as proportions, and log-transformed for metrics measured as counts. For the analyses by vegetation class, we removed plots for vegetation classes where there were less than five plots representing the vegetation type.

Results

In general, the results from this analysis indicate a moderate degree of power to detect changes over the three simulated sampling events using some easily understood management-relevant vegetation metrics (Table C.1). Specific findings from this simulation indicated that species richness metrics have the smallest detectable amount of change, changes from five to ten percent were detectable at the park level and changes of ten to fifteen percent were detectable at the vegetation community level. Forb cover had a higher detectable amount of change at both the park (CALO-30% and KEMO-35%) and at the vegetation community level at KEMO (40 to 45%). Other community metrics showed some potential to detect changes at either the park level or within one or more community types with a single park. For example, graminoid cover changes within the 25 to 30 percent range were detectable at Kennesaw Mountain NBP overall, and changes in the 40 to 45 percent range were detectable within both forested vegetation types at Kennesaw Mountain NBP. However, greater than 50 percent change was needed at Cape Lookout NS before being detectable. Similarly, shrub cover exhibited detectable changes from 25 to 30 percent at Cape Lookout NS and in the coastal wax myrtle vegetation type, respectively, and deciduous seedling density metrics exhibited detectable changes from 30 to 25 percent at Kennesaw Mountain NBP and from 45 to greater than 50 percent in both major forest types monitored within the park. Seedling density and

evergreen shrub cover metrics were the least powerful with both metrics needing 50 percent or greater change in the community before being detectable at both park and community levels (Table C-1). These results suggest initial trend work may need to be focused on the use of richness-based metrics and that a more comprehensive look at power is warranted using more parks and years of monitoring data. Although the results suggest that power may be low for several important metrics, the network feels that the current sample sizes are warranted for initial protocol implementation because the sampling methods have been substantially revised and sampling variance is expected to be reduced under the new design. Once sufficient data are collected, SECN will revisit the power of this protocol to detect change over time, and implement appropriate modifications as needed.

Table C-1. Table of results of preliminary power analysis simulation conducted on data collected from KEMO and CALO. The table shows estimated minimum percent change detectable over 3 sample events for selected vegetation metrics used in the SECN Vegetation Monitoring Protocol. Simulation data are shown for all plots located within two network parks—Cape Lookout NS and Kennesaw Mountain NBP—and for a subset of plots located in the park's most common community types. (N, number of sites; mean, mean metric values; SD, standard deviation of means; Simulation parameters were 80% power with type 1 error [α] = 0.1).

Metric	Park or Community Type	N	Mean ¹	SD	% Decrease Detectable	% Increase Detectable
Species Richness	CALO	30	3.0647	0.4581	10	5
	Coastal Wax-myrtle Wet Shrubland	9	2.9455	0.3419	15	15
	Eastern North American Coastal Dune & Grassland	15	3.1232	0.5067	10	15
	KEMO	30	3.5912	0.1632	5	5
	South-Central Oak - Pine Forest & Woodland	15	3.5627	0.1716	10	10
	Ruderal Loblolly Pine / Sweetgum - Red Maple Forest	8	3.5975	0.1255	10	10
Forb Cover ²	CALO	30	-1.6747	1.4648	30	30
	Coastal Wax-myrtle Wet Shrubland	9	-1.7654	0.9958	50	>50
	Eastern North American Coastal Dune & Grassland	15	-1.4959	1.2386	>50	>50
	KEMO	30	-2.7524	1.7187	35	35

¹ For species richness and seedling density metrics, mean is in natural log-transformed values: $\ln(x + 1)$

² For cover metrics, mean is in logistic-transformed values: $\ln\left(\frac{x+\varepsilon}{1-x+\varepsilon}\right)$, where ε is the smallest non-zero x or the smallest value of 1-x, whichever is smaller (following Warton and Hui [2011]). Values below -3 represent true mean cover of less than 5%.

Table C-1 (continued). Table of results of preliminary power analysis simulation conducted on data collected from KEMO and CALO. The table shows estimated minimum percent change detectable over 3 sample events for selected vegetation metrics used in the SECN Vegetation Monitoring Protocol. Simulation data are shown for all plots located within two network parks—Cape Lookout NS and Kennesaw Mountain NBP—and for a subset of plots located in the park’s most common community types. (N, number of sites; mean, mean metric values; SD, standard deviation of means; Simulation parameters were 80% power with type 1 error [alpha] = 0.1).

Metric	Park or Community Type	N	Mean ¹	SD	% Decrease Detectable	% Increase Detectable
Forb Cover ² (continued)	South-Central Oak - Pine Forest & Woodland	15	-2.6707	1.6631	>50	>50
	Ruderal Loblolly Pine / Sweetgum - Red Maple Forest	8	-3.5290	1.0229	45	40
Graminoid Cover ²	CALO	30	-0.0458	1.8086	>50	>50
	Coastal Wax-myrtle Wet Shrubland	9	-0.0087	2.6642	>50	>50
	Eastern North American Coastal Dune & Grassland	15	0.0053	1.2845	>50	>50
	KEMO	30	-4.8791	2.4447	30	25
	South-Central Oak - Pine Forest & Woodland	15	-4.4085	2.5717	40	40
	Ruderal Loblolly Pine / Sweetgum - Red Maple Forest	8	-5.6626	1.5222	45	45
Shrub cover ² (evergreen)	CALO	30	-0.4590	3.8754	>50	>50
	Coastal Wax-myrtle Wet Shrubland	9	0.3972	4.7034	>50	>50
	Eastern North American Coastal Dune & Grassland	15	-0.1672	2.9431	>50	>50
	KEMO	30	-3.7994	1.8193	>50	>50
	South-Central Oak - Pine Forest & Woodland	15	-4.0176	1.6275	50	>50
	Ruderal Loblolly Pine / Sweetgum - Red Maple Forest	8	-3.9391	1.5780	>50	>50

¹ For species richness and seedling density metrics, mean is in natural log-transformed values: $\ln(x + 1)$

² For cover metrics, mean is in logistic-transformed values: $\ln\left(\frac{x+\varepsilon}{1-x+\varepsilon}\right)$, where ε is the smallest non-zero x or the smallest value of 1-x, whichever is smaller (following Warton and Hui [2011]). Values below -3 represent true mean cover of less than 5%.

Table C-1 (continued). Table of results of preliminary power analysis simulation conducted on data collected from KEMO and CALO. The table shows estimated minimum percent change detectable over 3 sample events for selected vegetation metrics used in the SECN Vegetation Monitoring Protocol. Simulation data are shown for all plots located within two network parks—Cape Lookout NS and Kennesaw Mountain NBP—and for a subset of plots located in the park’s most common community types. (N, number of sites; mean, mean metric values; SD, standard deviation of means; Simulation parameters were 80% power with type 1 error [alpha] = 0.1).

Metric	Park or Community Type	N	Mean ¹	SD	% Decrease Detectable	% Increase Detectable
Shrub cover ² (deciduous)	CALO	30	-5.4977	2.1183	25	25
	Coastal Wax-myrtle Wet Shrubland	9	-6.3576	1.6535	30	30
	Eastern North American Coastal Dune & Grassland	15	-5.0408	2.1802	50	>50
	KEMO	30	1.6457	2.2489	>50	>50
	South-Central Oak - Pine Forest & Woodland	15	2.3619	2.1620	>50	>50
	Ruderal Loblolly Pine / Sweetgum - Red Maple Forest	8	0.7260	1.2430	>50	>50
Seedling Density (deciduous)	CALO	30	0.0303	0.0695	>50	>50
	Coastal Wax-myrtle Wet Shrubland	9	0.0106	0.0318	>50	>50
	Eastern North American Coastal Dune & Grassland	15	0.0351	0.0898	>50	>50
	KEMO	30	0.8704	0.3313	30	35
	South-Central Oak - Pine Forest & Woodland	15	0.9444	0.3091	50	>50
	Ruderal Loblolly Pine / Sweetgum - Red Maple Forest	8	0.7268	0.2543	45	>50
Seedling Density (evergreen)	CALO	30	0.1982	0.4925	>50	>50
	Coastal Wax-myrtle Wet Shrubland	9	0.0689	0.1140	>50	>50

¹ For species richness and seedling density metrics, mean is in natural log-transformed values: $\ln(x + 1)$

² For cover metrics, mean is in logistic-transformed values: $\ln\left(\frac{x+\varepsilon}{1-x+\varepsilon}\right)$, where ε is the smallest non-zero x or the smallest value of 1-x, whichever is smaller (following Warton and Hui [2011]). Values below -3 represent true mean cover of less than 5%.

Table C-1 (continued). Table of results of preliminary power analysis simulation conducted on data collected from KEMO and CALO. The table shows estimated minimum percent change detectable over 3 sample events for selected vegetation metrics used in the SECN Vegetation Monitoring Protocol. Simulation data are shown for all plots located within two network parks—Cape Lookout NS and Kennesaw Mountain NBP—and for a subset of plots located in the park’s most common community types. (N, number of sites; mean, mean metric values; SD, standard deviation of means; Simulation parameters were 80% power with type 1 error [alpha] = 0.1).

Metric	Park or Community Type	N	Mean ¹	SD	% Decrease Detectable	% Increase Detectable
Seedling Density (evergreen) (continued)	Eastern North American Coastal Dune & Grassland	15	0.1874	0.5298	>50	>50
	KEMO	30	0.3040	0.3736	>50	>50
	South-Central Oak - Pine Forest & Woodland	15	0.3209	0.3010	>50	>50
	Ruderal Loblolly Pine / Sweetgum - Red Maple Forest	8	0.2739	0.5890	>50	>50

¹ For species richness and seedling density metrics, mean is in natural log-transformed values: $\ln(x + 1)$

² For cover metrics, mean is in logistic-transformed values: $\ln\left(\frac{x+\varepsilon}{1-x+\varepsilon}\right)$, where ε is the smallest non-zero x or the smallest value of 1-x, whichever is smaller (following Warton and Hui [2011]). Values below -3 represent true mean cover of less than 5%.

Literature Cited for Appendix C

- Miller, K. M., and B. R. Mitchell. 2014. A new tool for power analysis of fixed plot data: Using simulations and mixed effects models to evaluate forest metrics. *Ecosphere* 5:110. Available at: <http://dx.doi.org/10.1890/ES14-00113.1> (last accessed March 2017).
- Warton, D. I., and F. K. C. Hui. 2011. The arcsine is asinine: The analysis of proportions in ecology. *Ecology* 92(1):3–10.
- White, R., C. Nordman, L. Smart, T. Leibfreid, B. Moore, R. Smyth, and T. Govus. 2011. Vegetation monitoring protocol for the Cumberland Piedmont Network, Version 1. Natural Resource Report NPS/CUPN/NRR—2011/XXX. National Park Service. Fort Collins, Colorado.

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NPS 910/154085, May 2019

National Park Service
U.S. Department of the Interior



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