

South Florida/Caribbean Network

National Park Service
Inventory and Monitoring Division



Standard Operating Procedure FVM12

Data Analysis and Reporting—Version 1.0

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Summary

This standard operating procedure (SOP) provides instructions for summarizing, conducting analyses, and producing reports for South Florida/Caribbean Network (SFCN) forest monitoring data. The South Florida/Caribbean Network uses linear models to analyze trends in plant species, guilds, woody stem composition, and other selected vegetation and abiotic metrics. The network also examines forest vegetation changes using multivariate analytics for comparisons among network and other regional parks, forest vegetation types, and reference plots from other databases. Two primary reports with in-depth analyses are generated from this monitoring effort. The first type is the Focal Forest Monitoring Event and Status Report, and the second type is the Status and Trends in Focal Forest Report. Both reports are published on the National Park Service's Integrated Resource Management Application (IRMA) Data Store within one year of the most recent round of data collection. Annual Resource Briefs will be developed following each sampling event for a given park. The results will also be used in other publications.

Revision Log

Revision Date	Author	Changes Made	Reason for Change	New Version #

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Overview

This SOP describes how South Florida/Caribbean Network forest vegetation monitoring data are summarized, analyzed, reported, and published for broader dissemination. There are two time frames involved. The first time frame is annually, after a given focal community within a park has been sampled. At this stage, the network produces a Forest Monitoring Event and Status Report for each focal community by park, which includes text, figures, and tables for the most recent sampling event. The second time frame is after three rounds of data collection of a focal forest community type by park. At this interval, the network produces its Status and Trends in Forest report for each community type by park. These reports summarize the network's findings over the past three sampling events and places 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. Comparable reports will be produced based on index plots within forest communities of special management concern. Since the index plots were placed using professional judgment, results from them cannot be extrapolated beyond the specific plots sampled.

For both report types, the key metrics are directly linked to the project's monitoring objectives, as stated in the South Florida/Caribbean Network Forest Vegetation Protocol Implementation Plan (Whelan et al. 2020). Table 1 lists each of these objectives, the metric measured, the corresponding spatial scale, data collection methods for each vegetation metric, and the outputs of data summary and results. For the Status and Trends and plotted reports, data are summarized using Microsoft Access, Microsoft Excel, R (R Core Team 2019), and Primer (Clarke et al. 2014). Trend analyses are conducted separately for each focal forest community type in each park. They involve linear or generalized linear mixed models and multivariate analytics to test for change over time in species richness; percent coverage of plant guilds (tree, shrub, liana/vine, graminoid and herbaceous plants) or focal species; relative frequency of plant guilds or focal species; canopy closure, basal area, and stem density across tree species or tree groups (e.g., genera, fire tolerance level); and growth, diameter at breast height (DBH), mortality, and regeneration per tree species. See Details on Trend Analyses further below.

SOP Source and How It Was Modified

This SOP is an adaptation of SOP VEG10 *Data Analysis and Reporting—Version 1.0* (Carlson 2018) of the *Monitoring Vegetation in Gulf Coast Network Parks: Protocol Implementation Plan* (Carlson et al. 2018). The South Florida/Caribbean Network's overall vegetation monitoring approach (Whelan et al. 2020) is based on the *Cumberland Piedmont Network Vegetation Monitoring Protocol* (White et al. 2011). The analysis and reporting techniques utilized by the Cumberland Piedmont Network focus on summaries and trends in ecological integrity scores based on key attributes and stressors developed in the Vital Signs Monitoring Plan for the Cumberland Piedmont Network and Mammoth Cave National Park Prototype Monitoring Program (Leibfreid et al. 2005). However, like the Gulf Coast Network, the South Florida/Caribbean Network takes a less diagnostic approach to

vegetation community analysis. This is due to the lack of clearly identified ecological condition targets relative to forests in the Cumberland Piedmont Network. It is a long-term goal of the South Florida/Caribbean Network to develop ecological integrity assessment scores (EIA) similar to the Cumberland Piedmont Network and the Northeast Temperate Network (Tierney et al. 2016), and use these scores to report forest condition in each park. Currently, these targets are not defined for SFCN parks. The South Florida/Caribbean Network made minor editorial modifications to the GULN data analysis and reporting SOP for this SOP.

Table 1. Monitoring objectives, elements, sampling methods, collected data, and habitat types from which each element will be collected for the South Florida/Caribbean Network Forest Vegetation Monitoring Protocol.

Monitoring Objective	Element	Sampling Method	Data Collected
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.
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., forest community) of plots.

Monitoring Objective	Element	Sampling Method	Data Collected
Objective 1— status and trends	Woody stem (tree, ≥ 5 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 ≥ 5 centimeter DBH (1.37 meters above the ground) within each of the four 100 m ² (10 × 10 meter) modules and document their spatial location on the plot.	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.
Objective 1— status and trends	Woody stem (sapling, ≥ 1.37 m tall, < 5 cm DBH) basal area and density; woody stem (seedling, < 1.37 m 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.
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 (82-ft) 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
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.

Monitoring Objective	Element	Sampling Method	Data Collected
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.
Ancillary Data	Vegetation classification	Identify vegetation type for the plot using classification keys developed for each SFCN park.	Association type(s) for each plot.
Ancillary Data	Site characteristics	Estimate plot geomorphology (slope, aspect, landform, topographic position), and percent cover of water on the plot for the entire plot.	1. Slope (degrees) 2. Aspect (compass bearing) 3. Water (percentage) 4. Topographic position and landform are qualitative assessments.
Ancillary Data	Photo points	Three digital images are made of each plot.	Three digital image files.

Roles and Responsibilities for Data Analysis and Reporting

Data analysis is performed by the community ecologist. The community ecologist is responsible for leading data analysis and interpreting results for reporting. The community ecologist coordinates staff members and allocates tasks, selects data for analysis, identifies and performs analytical processes, and prepares figures and tables for reports. When necessary, the community ecologist will consult with outside subject matter experts for assistance with analysis and interpretation. Finally, the community ecologist writes or oversees the writing of the Event and Status reports, the Status and Trends reports, and associated resource briefs. Database extraction and data preparation are in cooperation with the network data manager.

Format and Content of Event and Status Reports

Forest monitoring data are collected and summarized for focal forest community types within SFCN parks over a five-year cycle. The Forest Monitoring Event and Status Reports are produced at the end of each sample year during the summer (i.e., 2020, 2021, 2022, 2023, and 2024 for the first cycle of data collection). The necessary data are ready for use within three months of each field season's end. At this stage, they have passed the validation and verification steps to become accepted or certified data (see SOP FVM10 *Data Quality Assurance and Quality Control—Version 1.0* [Patterson and Londoño 2019] for details). Once data are ready for analysis, the protocol lead prepares one Forest Monitoring Event and Status Report for each focal forest community type and submits it to the appropriate park unit. Over a twelve-month period, all reports are completed, distributed to parks and uploaded onto the NPS Integrated Resource Management Applications (IRMA) Data Store.

Each Event and Status Report follows a set format. It begins with a brief and general overview of the project's objectives, sampling period, and methods used in the park. The bulk of the report is dedicated to the results for the key forest vegetation metrics, as described below. The report also summarizes relevant weather and other covariate data, and notes unusual conditions or events in the park. The report sections use the following headings and content outlines.

Background and Objectives

This section overviews the purpose of the Inventory and Monitoring program (I&M) and the importance of focal forest monitoring in SFCN parks. This section then lists the protocol's monitoring objectives. If a given community type within the park has species or environmental stressors of particular interest or concern, they are also introduced in this section.

Summary of Methods

This section briefly details how forest monitoring data are collected by the network. For the specific focal forest type of interest, it summarizes the sampling design, spatial sampling frame, and frequency of sampling. It also explains the types of metrics recorded and at what spatial scale within the plot (Figure 1). This section is a summary of similar material from the South Florida/Caribbean Network Forest Vegetation Protocol Implementation Plan (Whelan et al. 2020). A map of the plot locations is provided for each park (see examples in SOP FVM03 *Plot Evaluation, Plot*

Establishment, and Return—Version 1.0 [Shamblin 2019]), and a general description of the focal forest community is included.

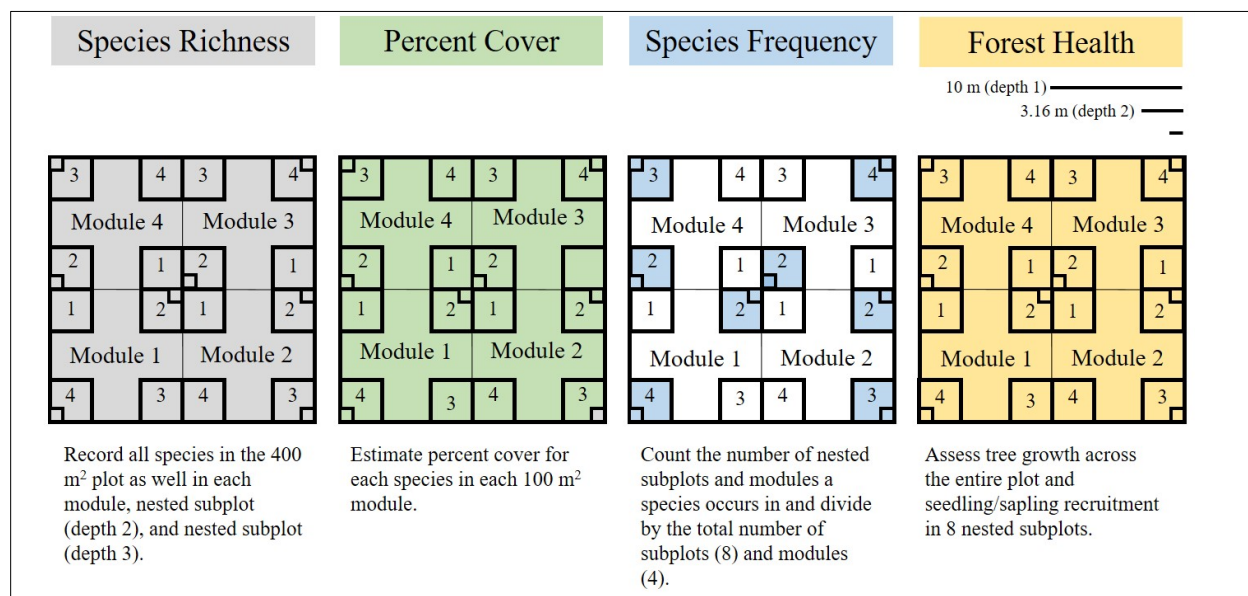


Figure 1. An example figure depicting the monitoring objectives and data types in the Forest Event and Status Report.

Results for Weather and Other Covariate Data

This section presents the weather and covariate data assembled for the years of interest. These data are not generally measured by the network itself, but are obtained either from sources within the park service (e.g., IMD central office, fire effects program, or as compiled by network staff), or from climate interpolation layers for the United States (e.g., PRISM Climate Group 2017). Available data may include fire history; elevation, slope and aspect; the mean, minimum and maximum monthly temperature for the sampling year plus the two preceding years; amount and frequency of rainfall (by month) during the sampling year plus the two preceding years.

In addition to these broad-scale data sets, the field crew collects some data or information at each plot that could be incorporated as covariate data. Potentially relevant information comes from the SFCN Veg Form 2—*Site Characteristics* datasheet (see SOP FVM03 *Plot Evaluation, Plot Establishment, and Return Visits—Version 1.0* [Shamblin 2019]), with its estimates of plot inundation by water (past and present) and the types and severity of disturbances on the plot. For more information on how these data are collected, see SOP FVM03 (*Plot Evaluation, Plot Establishment, and Return Visits—Version 1.0* [Shamblin 2019]).

This section also includes a subsection for qualitative observations of natural or anthropogenic agents that may affect vegetation within the plots or park. This can include comparisons of current and previous photo points for each plot. Additionally, when data are available, the time and place of recent disturbance events to the plots are documented in the report.

Results for Forest Monitoring

This is the largest section of the report, including a textual description and summary of results, as well as figures and tables depicting quantitative data summaries. The report includes:

- Textual description of results, which varies depending on the report's findings. Park-specific descriptions of the focal forest community are included where appropriate. The report provides the number of plots that were sampled and the total number of plant species present (native and invasive species separately). The report specifically mentions any new species documented on this visit.
- Table 1: a full list of vascular plant species that were documented during the sampling event, along with average cover and constancy values per species.
- Table 2: plot-level summary of species richness and woody stem metrics at the full plot scale. Species accumulation curves or similar approaches will be used to estimate undersampling bias and confidence intervals for species richness. Species richness will be supplemented with other metrics that are less sensitive to sampling error and provide more insight into species evenness (Gotelli and Chao 2013). See Table 2 for a possible template for this table.
- Table 3 and Figures: plot-level findings for percent cover and relative frequency for the following plant guilds: native forbs, invasive plants, graminoids, and herbaceous vines (non-lianas). For common species or guilds, relative frequency will also be reported for smaller spatial scales (module or subplots). See Table 3 for a possible template for this table.
- Quality assurance data: Quality assurance data from the 5% repeat sampling of plots within a year will be compared to initial data collected at the plots using Proportion of Specific Agreement or similar statistics.

Table 2. Hypothetical example of Table 2 in the Event and Status Report given to a South Florida/Caribbean Network park following the completion of park-wide sampling during a given sampling year. "PARK" is the four-letter park code, "COM" is the three-letter community code, and a focal forest community will have a minimum of eight plots.

Plot	Native Richness	Invasive Richness	Canopy Cover	Basal area per hectare	Stem density (400 m ²)	Sapling density (10 m ²)	Seedling density (1 m ²)
PARKCOM01	7	0	22	12.2	25	4	14
PARKCOM02	23	2	68	64.5	32	8	8
PARKCOM03	18	1	78	55.4	17	4	2
PARKCOM04	14	1	13	10.1	14	2	8
average	15.5	1	45.25	35.55	22	4.5	8

Notes from Field Work

This section includes a textual description of observations the crew made while sampling. This must include mention of any lost equipment, injuries, or near misses. It should also describe any evidence or sightings of invasive species (e.g., pythons) during field work, and any other field-crew observations deemed notable and relevant. Plant species or taxonomic groups that frequently pose identification challenges may also be discussed, including possible ways to resolve these challenges. The entire SFCN crew should be solicited for comment when completing this section.

Table 3. Example of Table 3 in the Event and Status Report given to a South Florida/Caribbean Network park following the completion of park-wide sampling during a given sampling year. “PARK” is the four-letter park code, “COM” is the three-letter community code, and a focal forest community will have a minimum of eight plots.

Plot	Native forbs, mean cover class	Native forbs, frequency (Depth 1- 2-3)	Invasive, mean cover class	Invasives, frequency (Depth 1- 2-3)	Grami- noids, mean cover class	Grami- noids, frequency (Depth 1- 2-3)	Herbaceous vines, mean cover class	Herbaceous vines, frequency (Depth 1-2- 3)
PARKCOM01	7.2	100-37.5- 25	1.1	0-0-0	6.0	100-75-75	2.2	25-0-0
PARKCOM02	5.7	100-25- 12.5	3.6	75-37.5-25	1.8	25-0-0	1.3	0-0-0
PARKCOM03	9.0	100-100- 75	2.8	25-0-0	8.4	100-100- 50	5.0	75-50-25
PARKCOM04	7.1	100-50- 12.5	2.1	50-0-0	4.1	50-25-25	3.2	25-0-0
average	6.6	100-53-31	3.1	37-9-6	5.8	69-50-37	3.9	31-12-6

Format and Content of Status and Trends Report

The Status and Trends Reports are in-depth data summary reports for each focal forest community, which are provided to park staff, collaborators, and the public through distribution on the NPS IRMA portal. These reports provide a comprehensive statement on the condition of focal forest communities in SFCN parks by summarizing all project-related monitoring in the prior three sampling events in each park (or fewer events, after the first report is completed). These reports also analyze data going back to the start of the monitoring effort, to determine if any of the monitored metrics are changing over time. Status and Trends Reports investigate the relationship between issues such as adjacent land influences on focal forest communities, climate change, the relationships among forest vegetation community variables and those of other vital signs, and determining ecosystem condition (i.e., integrity). They may also look across parks that have the same focal forest communities to determine if park-specific trends are occurring at a larger scale. Covariate data will be related to a response variable using generalized linear modeling and will allow estimates of the strength of the

relationship between changes in forest communities and the environmental variables. Additional investigations as part of the trends analysis will utilize multivariate techniques to explore relationships between the focal forest communities and covariate data utilizing techniques that match patterns in community data sets to a suite of observed environmental or climatic data (Clarke and Ainsworth 1993). If changes are detected, this report discusses potential drivers, including environmental or human-caused stressors.

The report includes an introduction; methods overview; results from analyses in textual, table, and graphic formats; and discussion or interpretation of those analyses. The report also includes, as an attachment, the complete and approved project data set for the past three sampling events. This report and data set constitute a resource condition reference for the park and the public. If warranted, this report includes a suite of formal recommendations for park resource managers that are based on monitoring outcomes and interpretation.

The Status and Trends Reports are created after three rounds of data collection in each focal forest community in each park. With the first year of data collection completed in 2020, the three rounds of data collection would be complete in 2030. Analysis and writing can begin after all relevant data sets have passed database verification and validation steps to become accepted or certified (SOP FVM10 *Data Quality Assurance and Quality Control—Version 1.0* [Patterson and Londoño 2019] for details). These steps are completed within three months after the final round of data collection for that report.

Each status and trends report is developed by the community ecologist in collaboration with outside consultants as necessary to ensure that analyses and interpretation are appropriate and comprehensive. Any recommendations made in this report: (1) must be consistent with the data collected by the SFCN staff and not exceed the data's scope; (2) must be additionally supported through literature review, whenever possible; (3) must reflect understanding of the resource; and (4) must be consistent with NPS and park resource management guidelines and policies. This report is reviewed, submitted, and published on IRMA as a formal report in the National Park Service's Natural Resource Reports (NRR) series, per NPS Inventory & Monitoring Program requirements and standards.

The Status and Trends Report includes the following sections:

Introduction

As with the "Background and Objectives" section in the Event and Status Reports, the introduction summarizes the project being reported, beginning with the South Florida/Caribbean Network's overall mission, followed by its specific monitoring objectives for forest vegetation. To give the study broader context, this section also provides a brief synopsis of what is known about key monitored focal forest communities and resource threats in the park. This synopsis is based on work by other investigators as well as on previous Event and Status Reports and Status and Trends Reports by the community ecologist.

Methods and Analyses

The methods and analyses section includes descriptions of the sampling methodology and analysis approaches taken. This section is basically unchanged for each new status and trends report, and follows the material in the *South Florida/Caribbean Network Forest Vegetation Protocol Implementation Plan* (Whelan et al. 2020) and all associated SOPs. The early paragraphs are the same as the Summary of Methods section in the Event and Status Reports, but the later, analysis-related paragraphs are different. Those later paragraphs include the steps in producing key variables and the statistical methods used for detecting trends in vegetation metrics over time.

Trends refer to how a variable or plot is changing over time. The South Florida/Caribbean Network plans to report temporal trends in species, guilds, and selected metrics using linear models for focal forest community data sets with three or more sampling events, specifically generalized linear mixed models (GLMM). Generalized linear mixed models were selected because, with permanent plots, they provide the ability to isolate habitat variability and across-year variability (Bourne et al. 2007; Bolker et al. 2009; Zuur et al. 2009). They also provide more flexibility with non-normal error distributions (Bourne et al. 2007), a common characteristic of vegetation data. More specifically, count data typically require a negative binomial or Poisson distribution, and proportion data may need a binomial distribution. 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. For most models, the initial sampling event will be the baseline, plot will be a random effect, and year will be a fixed effect. Depending on the metric and the scale of inference, focal forest community type or subplot (module or quadrat) may be additional random effects. Although sampling occurs at approximately the same time each year for a given park, seasonal effects may still be important for some analyses, and can be incorporated in multiple ways, such as by using sampling date as a generalized additive model (GAM) smooth function. Transformations will be used, where appropriate, to reconcile heterogeneity of variable type. Initial models (after three sampling events) will need to be simple to avoid over-parameterization. More complex models will be possible after more sampling events.

The network also plans to use multivariate approaches (Kruskal 1964) to further investigate forest 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 forest 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 stages and 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). Similar analysis techniques have been used to investigate hydrological restoration of mangroves and marshes in South Florida (Howard et al. 2017), and Caribbean dry forest tree species composition (Franklin et al. 2015). 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. Sah et al. (2018) used these types of techniques to investigate vegetative change in shrub and graminoid communities within the Everglades National Park. 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 outer Coastal Plain of North Carolina.

The network also plans to collect covariate data including climate variables (drought indices, rainfall and temperature departures). These covariates will be included in generalized linear mixed models to investigate potential relationships between the covariates and the response variables. These integrated analyses will be part of trends reporting once three initial data sets have been collected and reported.

The use of sessile, mostly long-lived organisms in fixed plots should reduce variability in presence and detections over time. For most variables, the network's ability to detect true trends should be relatively robust. However, based on initial power analyses of SECN vegetation data (Boyle et al. 2019), some vegetation metrics monitored by the network are more prone to low power-of-detection, such as cover of forbs, graminoids, and shrubs (evergreen and deciduous) and seedling density (evergreen and deciduous). Through extrapolation, it can also be assumed that trends for individual species, including percent cover or frequency, may be difficult to detect with a small number of plots, because variability in these metrics is likely to be high (i.e., a given species could well be absent from or rare in some plots and abundant in others). One option is to eliminate some metrics from trend analyses or to wait longer before analyzing for trends. Other options include increasing sample sizes and altering methods to reduce sampling variability. To help inform these decisions, the network will re-assess sample sizes in all parks after collecting data for the first two survey events.

Results for Weather and Covariate Data

This section combines material across previous Event and Status Report sections on weather and covariate data. Where appropriate, monthly or annual data are plotted to explore patterns in climate or disturbance over time. This section is cumulative from when the monitoring effort began, but it may include summaries specific to the most recent event, because its monitoring data are not reported elsewhere.

Results for Forest Monitoring

This is the largest section of the report, including a textual description and summary of results, as well as figures and tables depicting quantitative data summaries. The report is broken into four main sections, including:

1. Summaries of the current status of forest metrics from the two preceding Event and Status Reports, with information from the third, most recent sampling event added on or summarized separately. In the context of these summaries, there are descriptions of changes across the past three sampling events and changes relative to the previous Status and Trends reports. This section presents findings using textual descriptions, figures, and tables. In some cases, data from the past three events may be added into existing table formats, such as adding columns to Table 2 so that three sampling events are displayed for each forest metric.

When necessary, tables are split to accommodate the added columns. In other cases, the most recent event's data are presented alone in the same format as the Event and Status Report, and then graphs are used in later sections (see No. 3 below) to illustrate temporal patterns across several sampling events.

2. Visualization and analysis of trends in species richness over time in each focal forest community type, for invasive and native species separately. This section also includes graphical depictions of data over time. For analysis of change in species richness over time, all data are used going back to the beginning of the monitoring effort. Prior to conducting trend analyses, diagnostic plots and tests are performed to determine if variability in species presence (especially rare species or those that are challenging to detect) could result in insufficient power for detecting real trends. If so, data are plotted but potential trends are not assessed statistically. Additionally, species richness will be supplemented with methods and metrics that are less sensitive to sampling error and provide more insight into species evenness (Gotelli and Chao 2013).
3. Visualization and analysis of trends in percent cover or relative frequency of plant guilds and, if appropriate, common species for that focal forest community type. Data are graphed on a per-park and focal forest community type basis, possibly following the example Figure 2, which summarizes percent cover by major plant guild over three sampling events. For some or all plant guilds and some plant species, data on percent cover or frequency are subject to statistical analysis of changes across years. These analyses always go back to the first sampling event on the park and end with the most recent sampling event. This section presents findings using statistical summary tables, text, and time-series figures.
4. Visualization and analysis of trends in forest health metrics are reported by focal forest community type. Potential variables for analysis include canopy closure, basal area, and stem density across tree species, as well as stem density, growth, mortality, and regeneration for individual tree species or groups of trees that are relatively common and important for the park. Calculation of these metrics generally follows CUPN SOP 17 *Analyzing and Reporting Ecological Integrity* in Tierney et al. (2016). As with the other trend analyses, all data are used going back to the beginning of the monitoring effort.

Discussion

The discussion section interprets the results in the context of tree or forest ecology and in-park management needs. For example, apparent trends are described in relation to known events that may be acting as ecological drivers. The discussion aims to, whenever possible, distinguish natural forest dynamics within parks from human-induced consequences, e.g., relating declines in tree growth rates to local management activity or other specific events. The discussion addresses current and future management actions and activities that may affect the monitored forest communities.

Also in the discussion, the network's findings for each focal forest community type may be compared to related forest research and monitoring efforts in and around the region or country from the past and present.

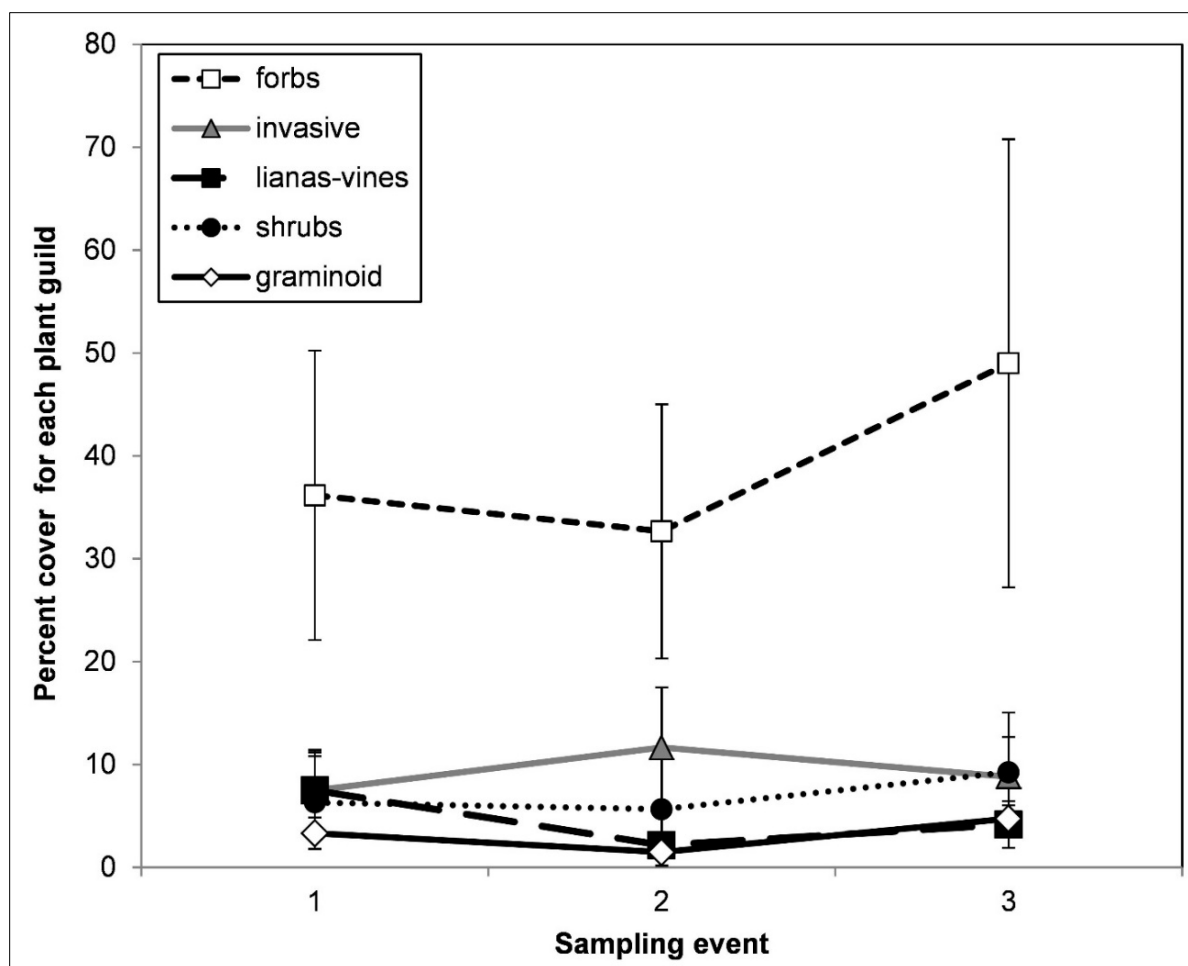


Figure 2. Example of a figure in the Status and Trends Report for a given park focal forest community, which displays three years of data for percent cover. Points depict averages across all plots within a park, and vertical bars are ± 1 standard error. This example is from the Gulf Coast Network SOP VEG10 *Data Analysis and Reporting—Version 1.0* (Carlson 2018).

Potential resources include peer-reviewed publications, graduate theses, and as appropriate, NPS monitoring reports such as those from the monitoring protocols of Boyle et al. (2019), Carlson et al. (2018), DeCoster et al. (2012), Folts-Zettner et al. (2011), Tierney et al. (2016) and White et al. (2011). Park-specific resources may also be used.

From these and other resources, the following materials are of interest for comparisons:

1. lists of species previously recorded on the park for assessing new records
2. the frequency or dominance of a species in an area, measured as percent cover or nested frequency using similar sampling techniques, or for trees, stem density within plots sized 400 square meters (4,305 square feet [sq ft]) or smaller
3. tree growth, mortality, and regeneration from studies of tracked trees

4. species richness and composition of assemblages in 1-square meter (10.8-sq ft), 10-square meter (107.7-sq ft), 100-square meter (1,076-sq ft) or 400-square meter (4,305-sq ft) plots
5. documented declines in target species and potential causal agents
6. studies of taxonomy and geographic ranges of focal species

Such comparisons may clarify whether a feature or phenomenon observed in a SFCN park is consistent with data collected elsewhere. Although these comparisons are desirable, it must also be noted that some of the park floras, and the regions around them, are relatively poorly studied.

Attached Data Sets

Following the same schedule as the report, the South Florida/Caribbean Network provides parks with access to all relevant data sets, project map layers, and other GIS products and metadata. These data sets will be posted along with the report file through IRMA, and can be made available on an external drive, or through remote server access if needed and requested by park personnel. The data tables and electronic database extract include all appropriate data fields, including collateral environmental data, time and location data, and project photo files and field notes.

Other Reporting

Resource Briefs

The resource brief series consists of two to three page summaries following a sampling event at a given park, to provide the park with a quick and readily accessible overview of SFCN projects. 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. Data content is limited to small tables, graphics showing major points of interest, and simple statements on resource status and condition. Likely resource brief audiences include park staff from all divisions and outside parties such as other parks and park visitors who may be interested in following the progress of resource monitoring in the park.

Journal Articles and Conference Presentations

Production of peer-reviewed scientific articles legitimizes monitoring results in a way that agency or internally produced reports and documents cannot, and renders SFCN science more useful for science-based management actions where legal sufficiency is a prominent consideration. The publication of monitoring results in scientific journals 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 will foster a greater understanding of ecosystem components and processes. Similarly, the presentation of findings at conferences allows the network to reach broader audiences. Attendance and presentation of data at meetings and conferences often fosters partnership efforts. All journal articles and presentations developed by the network are discussed with, and made available to, parks whose data are being presented.

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