

Gulf Coast Network

National Park Service
Inventory and Monitoring Division



Monitoring Terrestrial Vegetation in Gulf Coast Network Parks: Supplemental Materials Packet—Version 1.0

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Summary

This packet includes four sections to accompany the protocol narrative and standard operating procedures (SOP) for Monitoring terrestrial vegetation on Gulf Coast Network parks. Section A describes how the forest monitoring protocol of the Northeast Temperate Network was modified to create the Gulf Coast Network protocol and provides justification for major changes. Section B depicts the park sampling frames and plot locations within focal park units. Section C includes a power analysis of publicly available vegetation data from Jean Lafitte National Historical Park and Preserve. Section D includes Field Datasheets VEG. FORMS 1, 2 and 3, upon which all field data are collected.

Revision Log

Revision Date	Author	Changes Made and Justification	New Version #

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Section A: Modifications to the Northeast Temperate Network Protocol and Justification for Changes

Summary

The Gulf Coast Network (GULN) has adopted the Northeast Temperate Network (NETN) Long-Term Forest Monitoring Protocol (Tierney et al. 2016) as the basis for its own terrestrial vegetation monitoring Protocol Implementation Plan (Carlson et al. 2018a). To accommodate the diverse and varied vegetation communities of the Gulf Coast region, some substantial modifications were necessary. The bulk of these modifications were related to differing sampling needs in GULN parks or downstream procedural modifications following a few key changes.

This supplemental materials document lists and describes the major modifications the Gulf Coast Network made to the NETN protocol. Many of these are also elaborated upon in the standard operating procedure (SOP) documents to which they pertain. This document also includes two subsections with specific additional justification for the plot selection approach and vegetation sampling methods.

List and Explanation of Major Modifications

1. Monitoring Objectives

The NETN vegetation protocol describes 14 objectives that fall within five groups: landscape structure, stand structure, tree, understory, and soil. The NETN's 14 objectives are to determine status and trends in forest patch size, anthropogenic land use, stand structural class, snag abundance, coarse woody debris, biotic homogenization, forest floor conditions, soil chemistry, canopy closure, photopoints, growth and mortality rates, tree condition, tree regeneration, and exotic and indicator species cover. The Gulf Coast Network has four monitoring objectives that are structured and worded differently than the NETN objectives. They are similar, however, in that they include similar tree objectives, a modified version of the understory objectives, and a subset of the stand structure objectives. The first three GULN objectives are to determine status and trends in (1) plant species richness, (2) percent cover, and (3) plant relative frequency, as described in Section 3. The biotic homogenization and exotic and indicator species cover objectives of the NETN are based on the same data as these GULN objectives. The fourth GULN objective largely parallels the tree and stand structure objectives of the NETN protocol. The GULN objectives are therefore all closely related to NETN objectives, and they were written to be specific, measurable, achievable, realistic, and timely.

2. Spatial Sampling Frame

The sampling frame used by the Northeast Temperate Network is forest and woodland communities within each park, and all such areas within whole parks are included. The Gulf Coast Network, in contrast, includes in its sampling frame all natural vegetated habitats from either whole parks or targeted units. To reduce the effects of human disturbance, the network also specifically excludes up to 50 meter (164 feet [ft]) buffers along park boundaries, roadways, and buildings. 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 Gulf Coast Network to fit park-specific needs and constraints. Five of eight GULN parks do not have whole-park monitoring; for these, sampling is limited to selected park areas. Proposed plot locations for vegetation monitoring in GULN parks are presented in Supplemental Materials Section B: GULN Park Sampling Frames and Plot Arrangements. Additional details and justification for this modification, and for those described in #3, are included in the following subsection titled “Selection of Plot Locations within Parks.”

3. Selection of Plot Locations

The Northeast Temperate Network uses the Generalized Random Tessellation Stratified (GRTS) algorithm that identifies spatially-stratified points and places them in a sampling order from which plots can be dropped without compromising the spatially-balanced design. The Gulf Coast Network recognizes the values of this approach, but considers a spatially-balanced design to be less crucial when points are relatively few, given a set minimum for nearest-neighbor distance, and distributed within small parks or polygons. The spatial arrangement of vegetation monitoring plots within GULN parks is a simple random draw of points from target polygons. There is no spatial stratification for assigning plot locations, and there is at least 250 meters (820.2 ft) between points. More details on the GULN design are in GULN SOP VEG03 *Site Selection, Plot Establishment, and Return Visits—Version 1.0* (Carlson et al. 2018b) and Section B of this Supplemental Materials packet: GULN Park Sampling Frames and Plot Arrangements.

4. Timing of Sampling

The Northeast Temperate Network uses a four-year/four-panel rotating schedule for sampling parks, with some analysis and reporting occurring each year. The Gulf Coast Network, in contrast, samples all eight network parks in two consecutive annual sampling seasons in each three-year monitoring cycle, with the third year being used for all park analysis and reporting. An additional difference in the timing of sampling is that the Gulf Coast Network can start sampling before the prescribed sampling season dates for the Northeast Temperate Network of 1 June to 31 August. Fieldwork by the Gulf Coast Network may be scheduled between 1 April and 30 September.

5. Sampling Crew Logistics

The Northeast Temperate Network uses two field teams per season that can work simultaneously, with all operations being managed by the network. The Gulf Coast Network, in contrast, staffs only one field crew per year. Multiple parks may still be sampled simultaneously and semi-independently, however, through the involvement of non-NPS cooperators and/or contractors.

6. Plot Design and Sampling Methods

Nested frequency

The Northeast Temperate Network does not collect nested frequency data in its protocol, but the Gulf Coast Network does. The nested frequency design is described in GULN SOP VEG06 *Vascular Plant Species Presence, Cover, and Abundance—Version 1.0* (Carlson and Segura 2018a). This new SOP was created by combining and revising NETN SOP—10 and SOP—13. To collect nested frequency data, the GULN uses three sizes of square sampling units per 20 × 20 meter (65.6 × 65.6 ft) plot in the following quantities: eight 1 × 1 meter (3.28 × 3.28 ft) quadrats, eight 3.16 × 3.16

meter (10.36×10.36 ft) microplots, and four 10×10 meter (32.8×32.8 ft) subplots. The Northeast Temperate Network uses eight 1×1 meter quadrats and three 2-meter (6.56 ft) radius microplots per 20×20 meter plot. Only the 10×10 meter subplots are new relative to NETN SOPs, and they are simply the full plot divided into four quarters. Four of the 3.16×3.16 meter microplots of GULN SOP VEG06 replace the circular microplots of NETN SOP—10, and GULN co-locates them with the 1×1 meter quadrats. The 1×1 meter quadrats are unmodified relative to NETN SOP—13, except that they are spatially shifted along plot margins to fit two per 10×10 meter subplot (see Figure 3 in the protocol implementation plan; Carlson et al. 2018a).

Percent Cover Estimation

The Northeast Temperate Network estimates percent cover into unevenly spaced classes, such as the quadrat data scale of 0, < 1, 1-2, 2-5, 5-10, 10-25, 25-50, 50-75, 75-95, 95-100%. In this and similar scales, the mid-way categories are broader than the end point categories, which is intended to facilitate category assignment for the field crew. For analysis, the median value of each category is typically used, which can introduce problems due to unequal distribution of measurement error across the scale. For this reason, the Gulf Coast Network records percent cover as an estimated value from 0–100%, with increments of 1% acceptable. This approach follows the National Wetlands Inventory Protocol (US EPA 2016) as well as the National Capital Region Network’s Vegetation Monitoring Protocol (Schmit et al. 2014). Additional details on percent cover estimation are provided in SOP—VEG06 (Carlson and Segura 2018a).

Microplots for Percent Cover

The Northeast Temperate Network uses three circular microplots with total area of 37.7 square meters (123.7 ft^2) to measure the percent cover of shrubs and the percent cover of woody vines up to 2 meters above ground level. The Gulf Coast Network uses a similar total area of 40 square meters (four corner ‘B’ microplots) to measure percent cover of shrubs and woody vines (up to 2 meters), but microplots are differently shaped and arranged, and the network has added cover estimates for all other non-tree species with foliage rooted in or otherwise present the microplot. For both protocols, cover estimates in microplots are in addition to percent cover estimates for all species in eight 1×1 meter quadrats. The microplot-scale difference between NETN and GULN are explained in detail in GULN SOP VEG06 (Carlson and Segura 2018a). Because these changes may be fairly consequential in terms of field effort and analyses, the Gulf Coast Network has added a justification subsection further below, titled “Vegetation Sampling Methods”. Changes related to nested frequency are justified in that subsection as well.

Microplots for Seedling and Sapling Counts

In the three circular microplots, the NETN SOP—10 counts seedlings into four or five size classes, and it counts and measures the DBH of saplings. For GULN SOP—VEG06, seedlings and saplings are each counted into two size classes in the four corner ‘B’ microplots. Sapling DBH is not measured in the GULN approach, except to as needed to assign an individual plant to the correct size class.

7. Four SOPs Removed

The NETN protocol includes two SOPs that are specific to equipment used in the field. These are NETN SOP—3: How to use the GPS and NETN SOP—4: How to use the Rangefinder. The GULN protocol implementation plan does not include equivalent SOPs for these documents. Instead, the Gulf Coast Network has instructions in-house that are provided to field teams. These are not included as SOPs following the most recent protocol guidance.

The NETN protocol includes two SOPs that are specific to tree and forestry metrics. These are NETN SOP—11: Coarse woody debris and NETN SOP—14: Collecting and aging tree cores. The Gulf Coast Network does not include these two SOPs because they are not related to the GULN monitoring objectives.

The NETN protocol does not include a SOP for data entry, and the Gulf Coast Network has not added one. However, the Gulf Coast Network documents the steps of data entry in an In-House Document: Terrestrial Vegetation Data Entry.

8. Analysis and Reporting

One way the Northeast Temperate Network presents its findings for vegetation monitoring is in terms of ecological integrity. The Gulf Coast Network does not use this concept in its implementation. Given the wide range of habitat types measured in the GULN protocol, no single set of acceptable values for each metric would apply across parks or even, in some cases, within parks across habitat types. Also, given that some plant communities in the Gulf Coast Network are very poorly studied, there is little scientific data available for choosing a benchmark or reference state. As such, in the current implementation, there is no modified version of NETN SOP—17, and the Gulf Coast Network does not produce an ecological integrity scorecard. The methods currently employed by the GULN for data analysis and reporting are in GULN SOP—VEG10 Data Analysis and Reporting (Carlson 2018).

Additional Justification for Key Modifications

Selection of Plot Locations Within Parks

The Gulf Coast Network has deviated from the Northeast Temperate Network protocol in both the method of point selection and the intended sampling frame. Regarding the method, the Gulf Coast Network selected plot locations as random points, rather than using the GRTS algorithm that the Northeast Temperate Network used (see #3 above). In selecting plot locations, the Gulf Coast Network's only requirement was that the randomly located plots be at least 250 meters (820.2 ft) apart within each park's sampling frame polygons. Part of the reasoning for random point selection was to facilitate co-location of proposed vegetation plots and existing bird monitoring points. Random point selection was appropriate for both groups of organisms and had already been implemented for bird monitoring.

Regarding the intended sampling frame, the Gulf Coast Network did not use 'whole parks' as sampling frame polygons, but instead modified these polygons prior to point selection, by excluding buildings, paved areas, lawns, waterbodies and roads (paved and unpaved) plus an additional 50 meter [164 ft] buffer around roads, buildings, paved areas, and inside the park boundaries (excepting

San Antonio Missions NPH, which has 25 meter buffers [82 ft]). These buffers were used to exclude areas with greatest human impacts and the most likely to have plots disturbed or vandalized. Further, the initial polygon encompassed the whole park in only some of the GULN parks (#2 above). For three of eight parks (Vicksburg NMP, Jean Lafitte NHP&P and Palo Alto Battlefield NHP), polygons encompassed all natural, vegetated areas within the park. This approach allows for park-wide inference in those parks, excluding the edge habitats removed by 50-meter buffers around roads and buildings.

For five parks where the initial polygon did not encompass the entire park area, two approaches were taken for selecting polygons. For one park, Padre Island NS, plots were randomly located within four narrow, 200-hectare (494.2 ac) units that were evenly spaced to span the length of the 113 km-long (70 mile) island. For the remaining four parks (San Antonio Missions NHP, Natchez Trace Parkway, Big Thicket NP, and Gulf Islands NS), focal polygons were identified in 2014–2015 by park resource managers as areas of particular interest for initial monitoring efforts and as most-likely candidates for management in the event that significant, undesired change was detected. These parks each had between one and five targeted units that varied in size from 16 to 5,124 hectares (39.5 to 12,662 ac). In a facilitated meeting in 2014, the majority of park managers stated that they preferred the chosen targeted-unit approach over a park-wide draw of points that would allow for park-wide inference. Maps that depict sampling frames and the proposed plot locations for each park are included in Section B of this Supplemental Materials packet.

Vegetation Sampling Methods

The NETN protocol is for forest and woodland habitats, yet the Gulf Coast Network intends to use it more broadly, as its park habitats include semi-arid scrublands, coastal dunes, prairies, pine savannas, upland forests, bottomland forests, marshes, and swamps. Using the plot selection methods outlined in #2 and #3 above, a preliminary draw of 214 points placed 60% of GULN plots in forested or woodland habitats (half upland and half swamps/bottomlands), 27% in grasslands or marshes, and 13% in shrublands. See Table B-1 in Section B of this packet for more details. To broaden the Northeast Temperate Network's monitoring scope beyond forest and woodland communities, the Gulf Coast Network has modified the types and amount of data collected on park vegetation in two main ways. These changes are to add nested frequency measurements and to conduct additional percent cover estimates at the larger microplot area for most plants.

To facilitate trend detection in a broader range of community types, Gulf Coast Network has added the measurement of nested frequency for all plant species within the 20 × 20-meter (65.6 × 65.6-ft) full plot. This change follows methods that are widely used in grasslands (Critchley and Poulton 1998; James et al. 2009) as well as in the diverse habitats covered by the Carolina Vegetation Survey (Peet et al. 1998). This approach is preferred because it reduces concern about choosing the correct spatial scale for frequency measures a priori (target frequency: a species occurs in 50% of same sized-plots; target range: 20–80%; Interagency Technical Team 1999, Goslee 2006). Similar nested frequency methods are used by other I&M networks (e.g., Cumberland Piedmont Network Protocol by White et al. 2011; Heartland Network Protocol by James et al. 2009; and NETN protocol for

freshwater wetland monitoring by Miller and Mitchell 2013) and by the EPA in their National Wetland Conditions Assessment (EPA 2016).

To collect more percent cover data on non-woody species, the Gulf Coast Network has changed the NETN procedure to include percent cover estimates on all non-tree species in microplots, rather than only shrubs and woody vines in the microplots. This change results in two notable divergences from the NETN approach. First, the GULN estimates percent cover for herbaceous species at both the 10 m² and the 1 m² scale rather than just the 1 m² scale of NETN. Using this larger microplot scale increases the chances that less-common herbaceous species will be subject to percent cover estimates. Second, the GULN measures percent cover of herbs in the microplots without the artificial height cut-off of 1.5 meters. This change simplifies estimation procedures for the field crew and allows for whole-plant representation of tall herbaceous plants, of which there are many in the Gulf Coast region.

The Gulf Coast Network elected to estimate percent cover in the four corner microplots largely because it covers more area and requires less effort than adding several more quadrats. The Gulf Coast Network acknowledges that there may be trade-offs in terms of reliability of estimates between observers and over time at scales larger than 1 × 1 meter. There are nevertheless many examples where the same area (DeCoster et al. 2012) or even larger areas are used for percent cover estimates (e.g., the Carolina Vegetation Survey's 10 × 10 meter plots [32.8 × 32.8 ft]; Peet et al. 1998; see also USEPA 2016 and White et al. 2011). To address concerns about reliability, the Gulf Coast Network has elected to retain percent cover measures in the 1 × 1 meter quadrats, which are known to be repeatable and precise (K. Miller, pers. comm) and provide a means of comparison with NETN and many other networks.

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Section B: Gulf Coast Network Park Sampling Frames and Plot Locations

Summary

This supplemental materials document outlines the plot selection methodology, spatial sampling frames and proposed plot locations for the eight National Parks and Preserves that are covered by *Monitoring Terrestrial Vegetation in Gulf Coast Network Parks: Protocol Implementation Plan* (Carlson et al. 2018a). The processes and procedures of frame/polygon creation, plot placement and plot allocation are described in this document. Additional details and justifications are provided in the Protocol Implementation Plan (Carlson et al. 2018a) and the Gulf Coast Network (GULN) SOP—VEG03 *Site Selection, Plot Establishment and Return Visits* Version 1.0 (Carlson et al. 2018b). Table B-1 includes a preliminary assessment of the major vegetation types in each park that are represented by monitoring plots. Figures B-1 to B-8 depict target units and randomly-located points within parks, including 214 primary plot locations and 114 alternate plot locations. Each park is represented as one figure, either in a composite image of units within parks or the entire park area. The use of these specific locations is pending final approval by park management.

Overview of Methodology

Sampling frame selection within parks: To select appropriate sampling frames for each park, network staff first sought feedback from park management. Park input was obtained through a questionnaire followed by a facilitated meeting in 2014, as well as one-on-one conversations. Based on this feedback, the eight parks were divided into two categories: (1) three parks where the sampling frame was approximately the entire park, allowing the opportunity for park-wide inference (excluding 50 meter buffers around roads, paved areas, buildings and park boundary); and (2) five parks where only targeted units would be monitored, based on park-specific needs. For the second category, two to five targeted units were identified by park resource managers as areas of particular interest for initial monitoring efforts and as most-likely-candidates for management in the event that significant, undesired change is detected.

Polygon refinement and point selection: Once all target units were identified for each park, shapefiles of polygons were created and random points were selected using the following methods. First, the raw park polygons were edited according to recent shapefiles and satellite images to eliminate roadways, buildings, waterbodies, manicured lawns, and areas within the legislative boundary that are currently not under park ownership. To exclude areas most likely to be negatively impacted by human disturbance or tampering, roadways (paved and unpaved), buildings, and the internal edges of the whole park polygon were increased in size by buffers of 50 meters (164 feet [ft]) prior to being erased from the final polygon shapefile, using ArcGIS tools (version 10.2.3). For the two seashore parks only, sensitive or little-vegetated habitats were also removed (active dunes, beaches, tidal flats, and washover zones). Second, the requisite number of plots plus 50% extra as alternates were selected as random points, using the ‘genrandompnts’ command in the Geospatial Modelling Environment freeware program (GME; version 7.3.0). These points were required to be at least 250 meters (820 ft) apart, but there was no spatial stratification nor any stratification within

polygons based on habitat type. For San Antonio Missions NHP, it was impossible to fit all points within a unit and retain at least 250 meters (820 ft) between them. As a result, edge buffers at the Rancho Unit and the Missions Unit were reduced from 50 meters (164 ft) to 25 (82 ft) meters. Park-specific rationale and any other adjustments to the design are noted in the figure captions.

Whenever possible, the vegetation monitoring plots are co-located with ongoing survey points for Gulf Coast Network bird monitoring. These bird survey points are sampled by a single observer standing still for 10 minutes and recording all bird sounds and sightings. For three parks, co-location was not possible due to differing approaches or target areas. For the remaining five parks, between 21% and 100% of primary vegetation points were co-located with bird points. For that subset of vegetation plots, the bird observer's standing location is offset by 10 meters (typically to the south) of the vegetation plot boundary, and bird observers are given maps and instructed to avoid walking in plots. For these reasons, the bird surveys are not expected to affect vegetation dynamics in the plots.

Sample sizes within parks and units: After estimating the required time and effort, network staff determined that the Gulf Coast Network could sample no more than ~210 plots over two years across all eight network parks, with 10 of these plots resampled for QA/QC. Network staff also decided that plots should not be divided evenly among parks, because parks differed greatly in area and number of high-priority units. Thus, the number of plots was allocated based on park or unit sizes, within a lower limit of four plots per unit (based on a preliminary power analysis; Section C of this packet) and an upper limit of twelve plots per unit. The forested portion of Jean Lafitte NHP&P is the exception with eighteen plots, as explained below. Further, parks were allocated no fewer than ten plots total, which is also the smallest park sample size for the I&M Network on which this vegetation protocol is based (Northeast Temperate Network). Estimates of park or unit area were based on suitable sampling habitats only, and thus excluded infrastructure, lawns and water bodies. Within these constraints, scaling rules were set so that consistent guidelines could be applied across parks while also meeting the network-wide maximum of ~210. Additionally, efforts were made to maintain 0.5–25 plots per 100 hectares for all units, which was achieved in all but the largest three units (See Table 4 in Carlson et al. 2018a).

Scaling rules were as follows: (1) parks with one or two units and a total area of < 500 hectares (1,236 acres [ac]) received ten plots; (2) parks with one or two units and a total area between 500 and 1000 hectares (1,236–2,471 ac) received eleven plots; (3) parks larger than 1000 hectares (2,471 ac) or with more than two units received plots based on unit size alone, according to the following rules: (3a) units larger than 20 hectares (49.4 ac) received four plots; (3b) units between 20 and 70 hectares (49.4–173 ac) in area received five plots; (3c) units between 70 and 120 hectares (49.4–297 ac) in area received six plots; (3d) units between 120 and 170 hectares (297–420 ac) received seven plots; (3e) units between 170 to 500 hectares (420–1,253 ac) in area received eight plots; (3f) the largest units received either nine plots (500–1000 hectares or 1,236–2,471 ac), ten plots (1000–2000 hectares or 2,471–4,942 ac) or twelve plots (greater than 2000 hectares or 4,942 ac). Two exceptions to these scaling rules were made. One was for Naval Live Oaks Area, which has an unusually high number of habitat types within a small area of 252 hectares (623 ac). For this reason, it was allocated two additional primary plots and one additional alternate plot. The second exception was for Jean

Lafitte National Park and Preserve, following a strong request by the park for additional plots in the forested habitats of the preserve. To accommodate this, the whole-park polygon was divided into a marsh unit and forest unit, using vegetation height from LiDAR, and the forest unit was allocated eight extra plots. The number of plots allocated per unit and the size of each unit is provided in the figures below as well as in Table 3 of the Protocol Implementation Plan (Carlson et al. 2018a). The total number of plot allocated across all parks was 214, with an additional 115 plot locations selected as alternates.

Sample sizes by vegetation type: Vegetation monitoring plots were purposefully not allocated based on vegetation community type, with the exception of marsh and forest at Jean Lafitte NHP&P. Although plot locations were not stratified when assigned, their most-likely habitat types were assessed immediately afterwards from GIS layers of vegetation community maps or other sources. To make these assessments, only broad-level, physiographic classifications were used, in part due to differing terminology between vegetation map products. The results are in Table B-1, with the caveat that classifications are preliminary and require on-the-ground confirmation. A key finding is that only 60% of primary plot locations across Gulf Coast Network parks are in forests or woodlands. Of the remainder, 27% are dominated by herbaceous vegetation (marsh or prairie) and 13% are shrublands or dry scrublands. There are at least four plots per broad vegetation type within each park (Table B-1). Further, each park's most common vegetation type is represented by at least eight plots in that park, excepting San Antonio Mission NHP and Palo Alto Battlefield NHP, which have six or seven plots in the dominant vegetation type, respectively. A final, key observation is that the less-well represented habitats have the potential to transition into the better-represented habitats over time, and vice versa. Examples of this are shrublands and grasslands at Palo Alto Battlefield NHP and San Antonio Mission NHP, wet shrublands and swamps or marshes at JELA, and woodlands and shrublands at GUIS-NLO. This high potential for transition among habitat types in the gulf coast region was a strong factor in the original decision to select plots as a spatially random sample within whole-park or target-unit polygons that were not stratified by habitat type.

Table B-1. The broad-scale vegetation type of the proposed primary plot locations, based on park-specific vegetation community maps or other sources. *Shrublands include dwarf shrubs in xeric habitats, such as dunes.

Vegetation type	VICK	NATR	JELA	BITH	PAAL	PAIS	SAAN	GUIS-FL NLO	GUIS-FL isl.	GUIS-MS isl.	GUIS-MS DB	total
Forest and woodlands: upland to bottomland/swamp	10	28	17	56	–	–	6	6	–	–	5	127
Shrubland: usually < 5m tall; dry to wet*	–	–	4	–	4	–	4	4	5	8	–	28
Grassland, non-hydric soils	–	4	–	–	7	27	–	–	–	–	–	38
Open wetland or marsh	–	–	9	–	–	5	–	–	–	5	–	19
Totals	10	32	30	56	11	32	10	10	5	13	5	214

Park Maps

Figures B-1 to B-8 depict the targeted units within each of the network parks and the randomly located points that were selected for vegetation monitoring. Across all figures, the primary plot locations are shown as yellow circles, and the alternate plot locations are shown as blue circles, typically representing a 50% increase over the original plot allocation per park. The first three figures depict parks for which park-wide inference is largely possible (category one, as described above). These parks are Vicksburg NMP (Figure B-1), Jean Lafitte NHP&P (Figure B-2) and Palo Alto Battlefield NHP (Figure B-3). Although these sampling designs can accommodate park-wide inference (excluding the 50-m buffer along roads, paved areas and buildings), the extent of inference may be limited in practice, due to the inability to sample unsafe habitats, such as the steepest slopes at Vicksburg.

Plot selection for the remaining parks focused on targeted polygons within the whole park area (category two). These parks are Natchez Trace Parkway (Figure B-4), Gulf Islands National Seashore (Figure B-5), San Antonio Missions National Historical Park (Figure B-6), and Big Thicket National Preserve (Figure B-7). The eighth park, Padre Islands National Seashore, was also technically in the second category, although its sampling frame was also comparable to a spatially-stratified random approach (see Figure B-8 caption for more details).

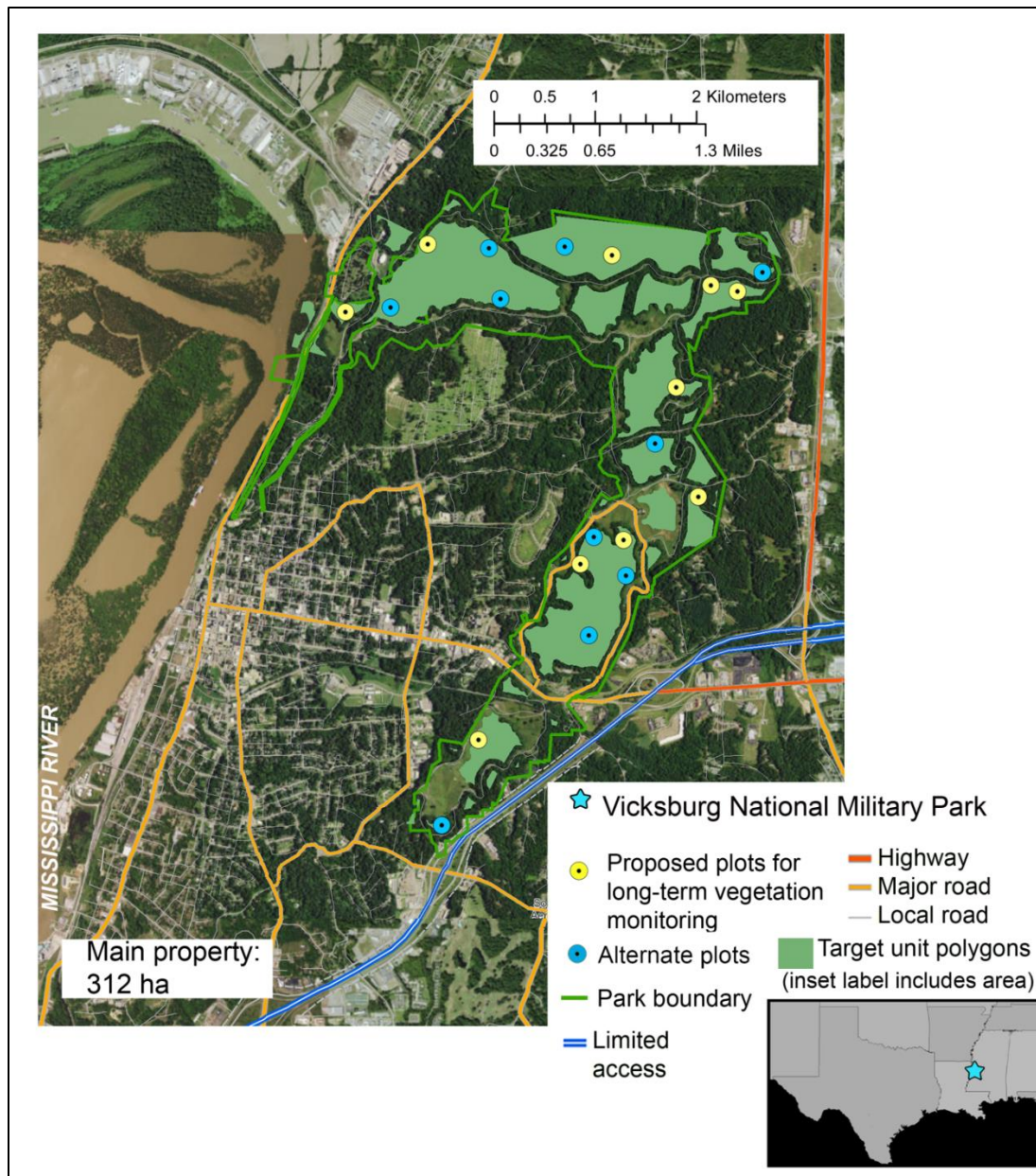


Figure B-1. Sampling frame and proposed plot locations for Vicksburg National Military Park in Vicksburg, Mississippi. There are 10 primary plot locations and 10 alternate locations. All plots are co-located with bird monitoring points. Ten, rather than five alternate locations were assigned at Vicksburg because some primary plots are likely to be on steep slopes that are unsafe for sampling. Areas excluded from the whole-park polygon were limited to manicured lawns, roads, park buildings and the buffers around them. As such, whole-park inference is largely possible at Vicksburg NMP, unless steep-slope plots are consistently excluded for safety reasons. Based on earlier vegetation mapping, potential plant communities for monitoring include forests of native hardwood trees (e.g., varying associations of cherry bark oak, water oak, sweetgum, pecan, tulip poplar, sycamore, and black locust) and successional communities (e.g., smooth sumac shrublands and grapevine associations).

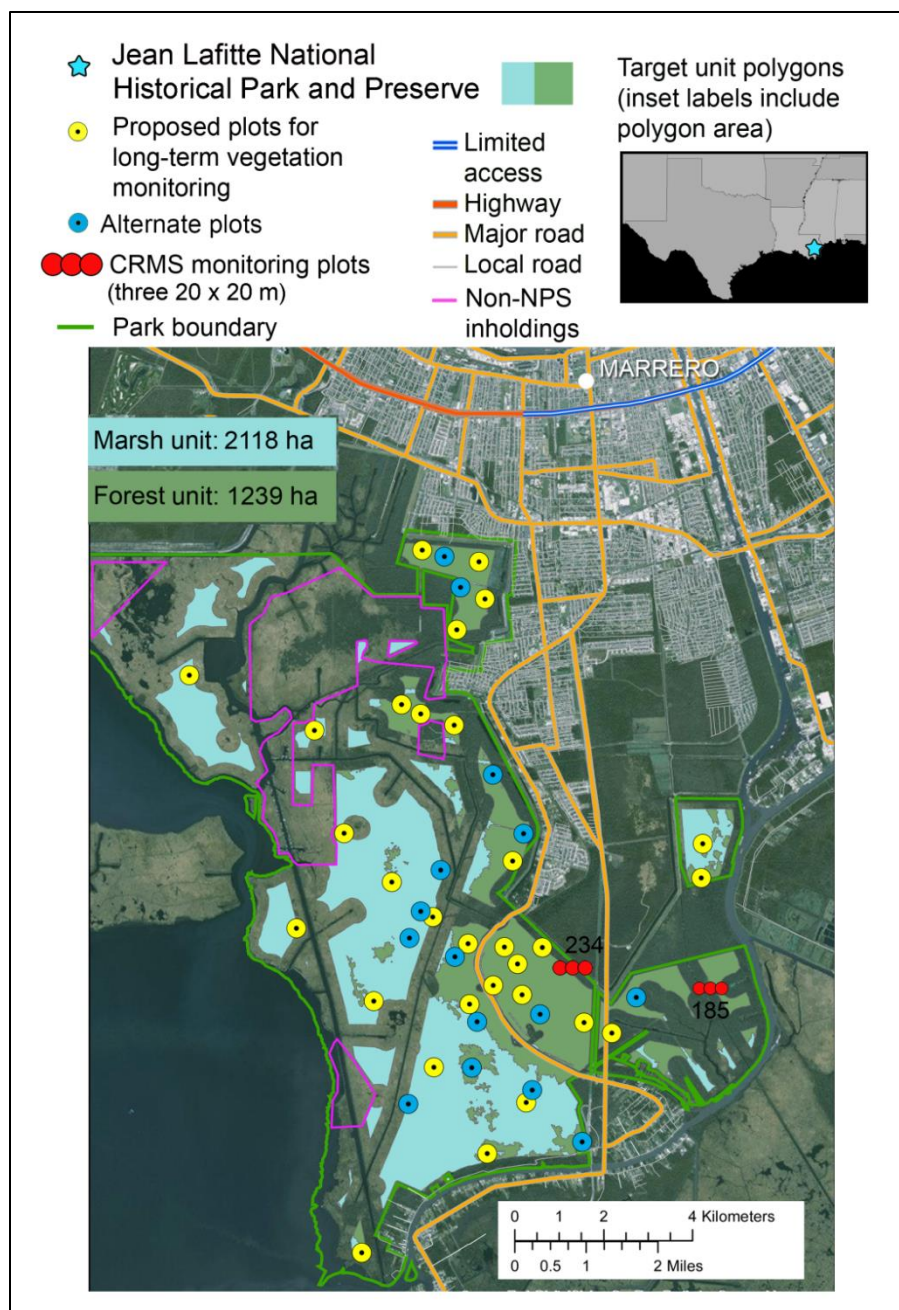


Figure B-2. Sampling frame and proposed plot locations for Jean Lafitte National Historical Park and Preserve in Marrero, Louisiana. There are 30 primary plot locations and 15 alternate locations. None of the plots are co-located with bird monitoring points. Areas excluded from the whole-park polygon were mainly canals, roads, open water, non-NPS inholdings within the legislative boundary and the buffers around them. As such, whole-park inference is largely possible at Jean Lafitte NHP. Park management requested a more intensive sampling effort within the park's swamp/bottomland forest habitats, relative to its marshes. The park was therefore divided into two main polygons, based on vegetation height from LiDAR data. Eighteen primary plots were assigned to the forested portion, and 12 primary plots were assigned to the marsh portion. Publicly available data from the six plots in two Coastwide Reference Monitoring System stations (CRMS 2016a,b) were used in the network's power analysis for this protocol (see Section C of this packet).

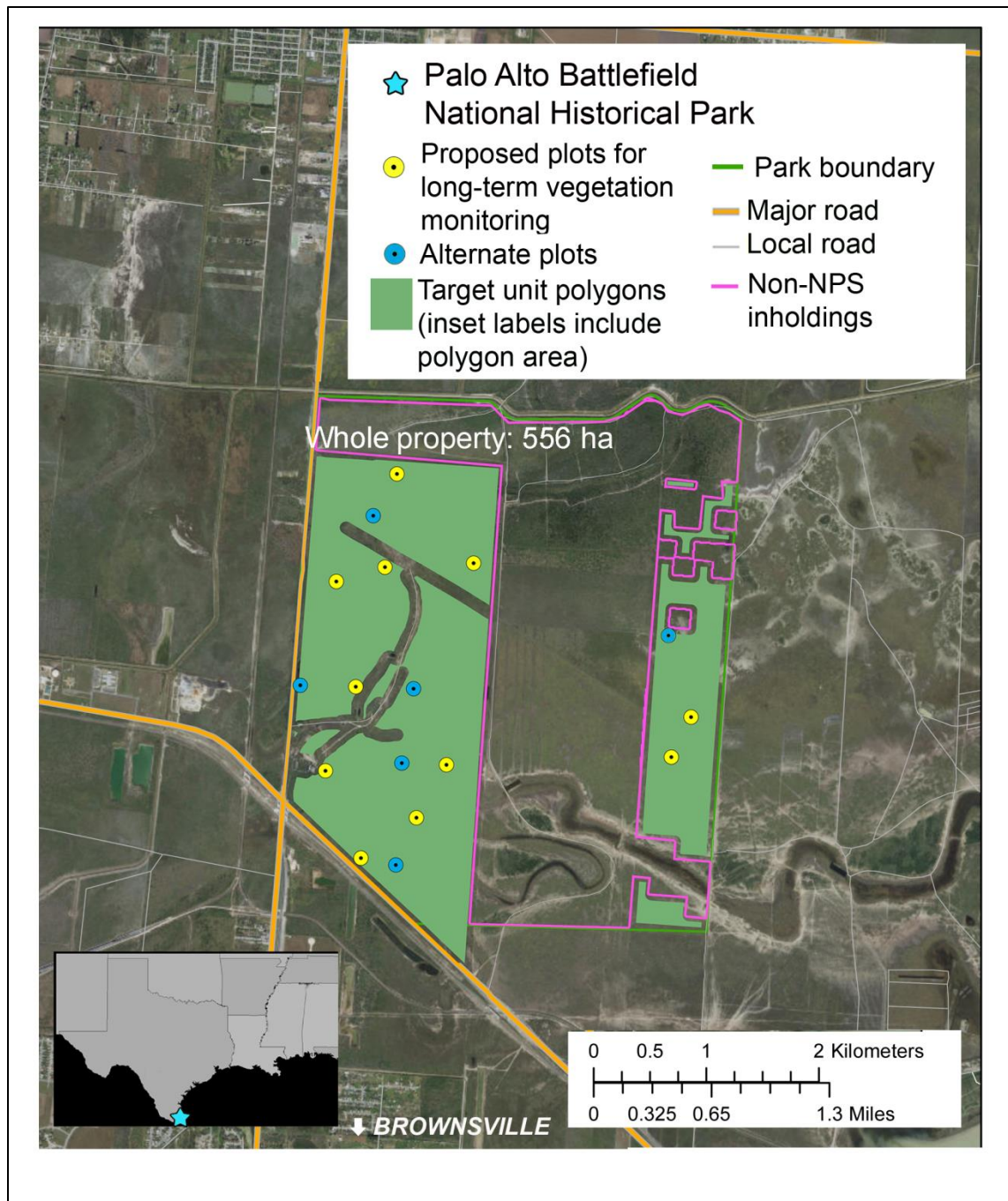


Figure B-3. Sampling frame and proposed plot locations for Palo Alto Battlefield National Historical Park in Brownsville, TX. There are 11 primary plot locations and 6 alternate locations within the park. The nine primary and five alternate plots in the main park property (western section) are co-located with bird monitoring points. The main property and the eastern section of newly acquired lands were treated as a single sampling frame for the 11 points. Collectively, these two sections covered the entire park area, save the roads, trails, buildings, private inholdings and the buffers around them. As such, whole-park inference is largely possible at Palo Alto Battlefield NHP. Based on earlier vegetation mapping, potential plant communities for monitoring include *Borrhichia frutescens* and *Spartina spartinae* prairie, and Tamaulipan thorn-scrub.

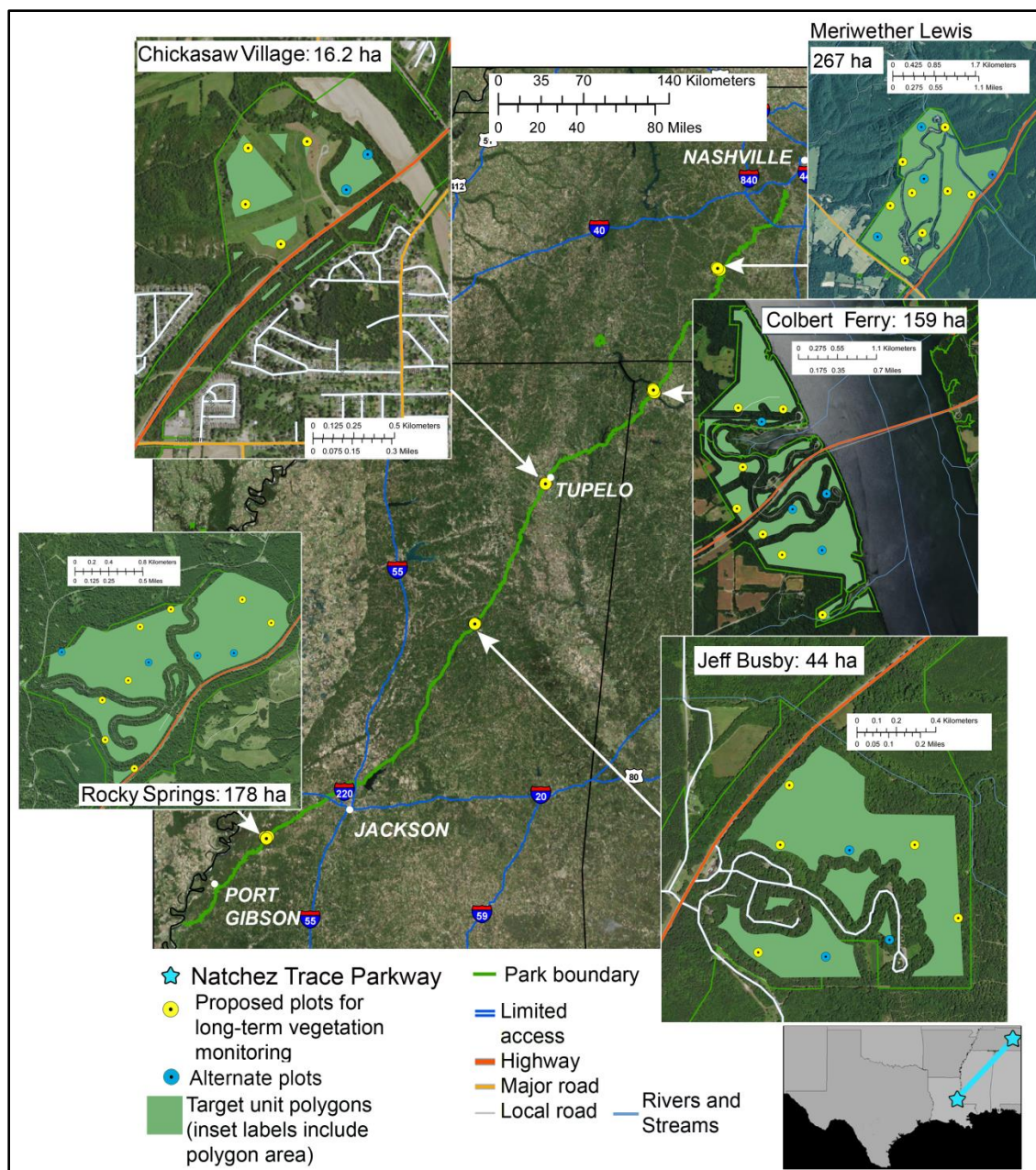


Figure B-4. Sampling frame and proposed plot locations for the Natchez Trace Parkway, with its southern terminus in Natchez, Mississippi, and its northern terminus 27 kilometers (17 miles [mi]) southwest of downtown Nashville, Tennessee. There are 32 primary plots and 17 alternate plots for the park. None of the plots are co-located with bird monitoring points because the network does not monitor birds in the parkway. Vegetation sampling will focus on five target units along the parkway, which were identified through input from park management. These areas are relatively large, continuous patches of natural vegetation that include representatives of southern, mid-section and northern park reaches. Outside of the target areas, the park property is frequently limited to narrow bands along both sides of the road. The five target units each have four to eight primary plots and two to four alternate plots. Based on earlier vegetation mapping, focal plant communities will be forests dominated by sweetgum, pine or several species of oaks. Plots in the Chickasaw Village Area are in a remnant patch of blackland prairie.

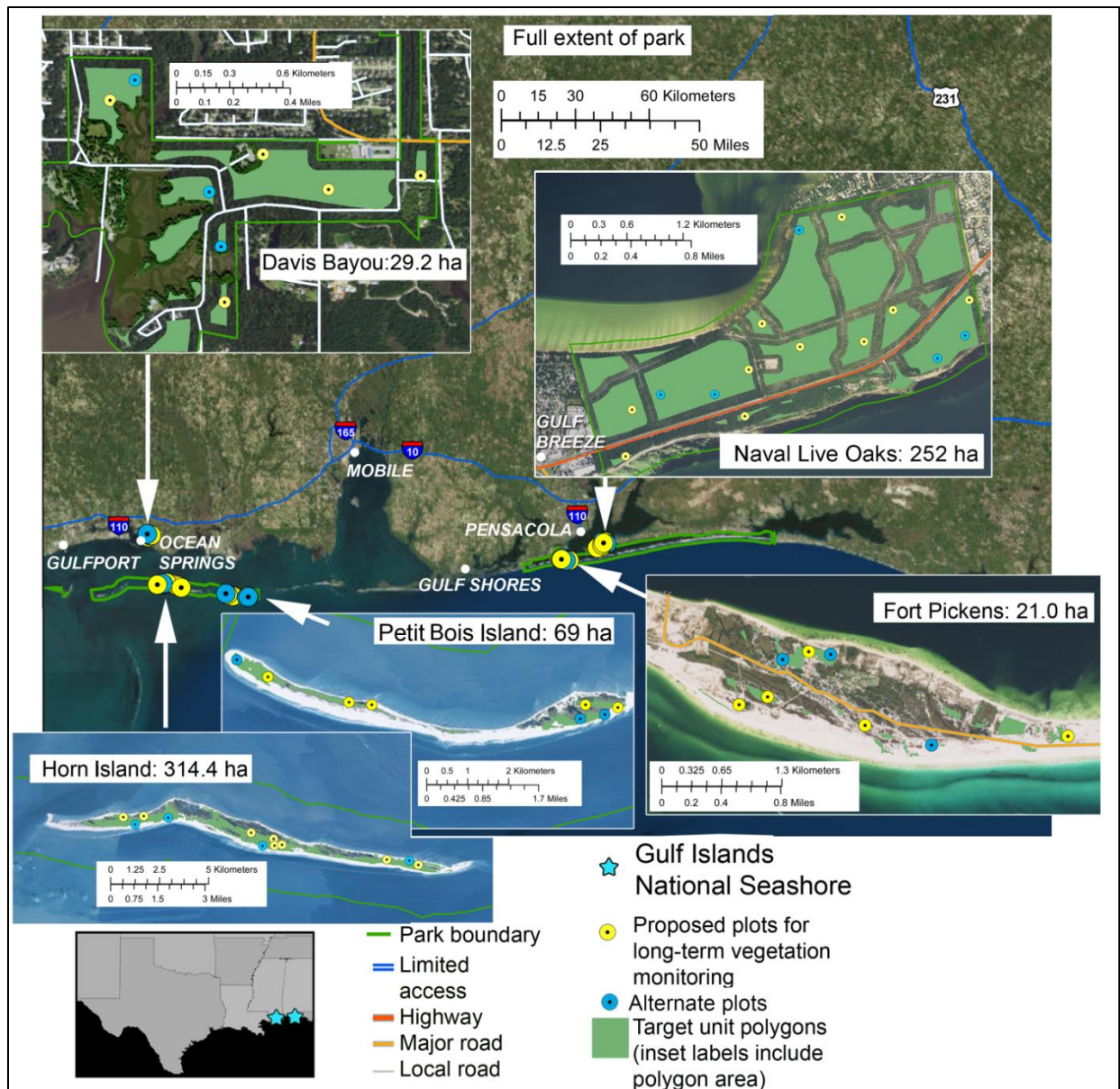
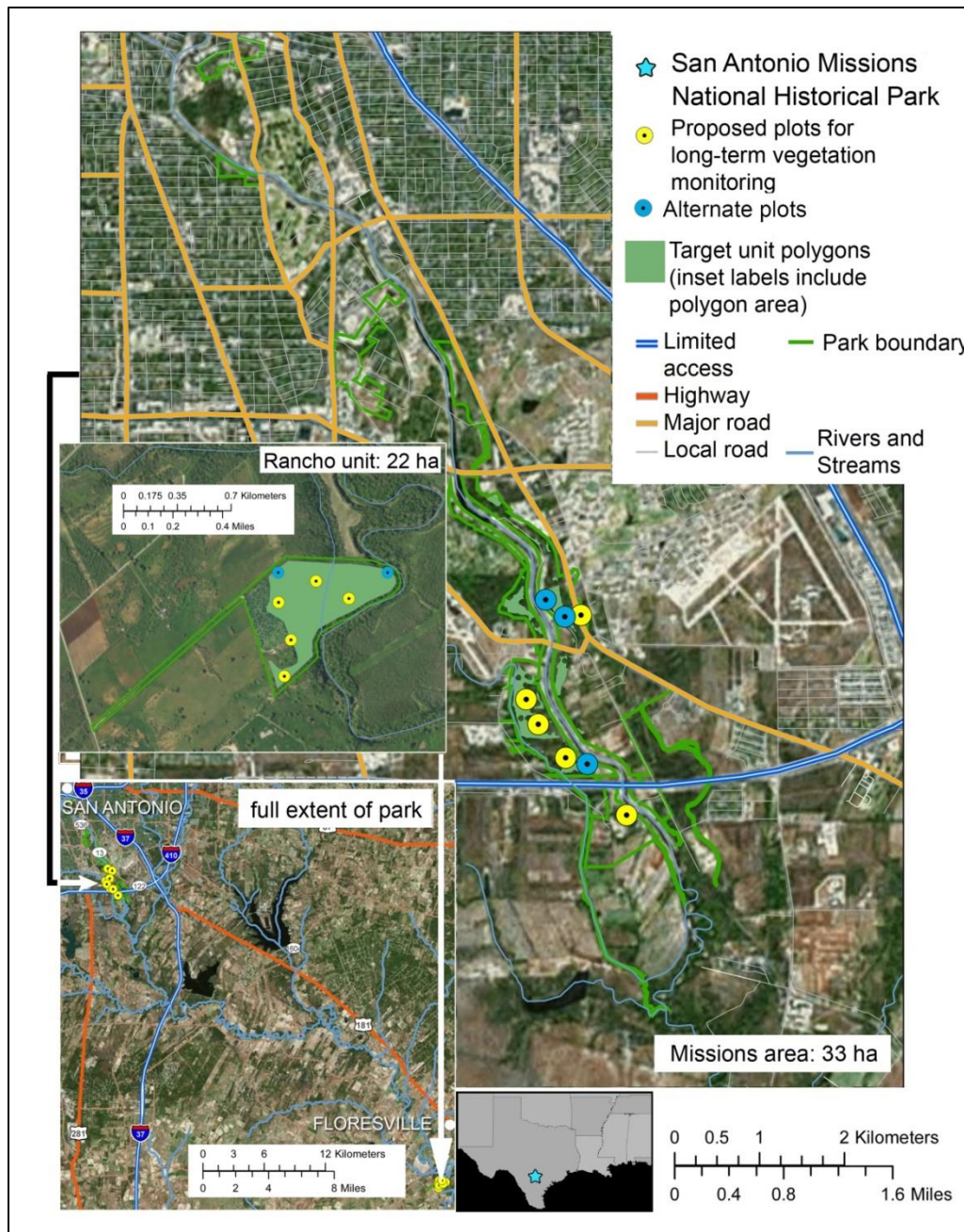


Figure B-5. Sampling frame and proposed plot locations for Gulf Islands National Seashore, which has a section near Ocean Springs, Mississippi, and another section near Pensacola, Florida. There are 33 primary plots and 18 alternate plots for the park. Vegetation sampling focuses on five target units—three on barrier islands and two on the mainland—that were identified through input from park management. As for all other parks, infrastructure, waterbodies and buffers were removed from target polygons, and unique to seashore parks, sensitive or little-vegetated habitats were also removed (active dunes, tidal flats, washover zones and beaches). The target units each have five to ten primary plots and three to five alternate plots. Vegetation monitoring points are co-located with bird monitoring points on Horn Island (7 of 8 primary plots), Davis Bayou (all 5 primary plots), and Naval Live Oaks (8 of 10 primary plots). Based on vegetation maps, focal plant communities in the Naval Live Oaks section are oak scrub, hickory-magnolia forests and sand, slash and longleaf pine. The Davis Bayou section consists of bayhead swamp, mixed hardwood forests, and wet pine flatwoods. The barrier islands are dominated by scrub-shrub (oaks) and grassland on and around dunes, with a few small stands of sand, slash and longleaf pine.



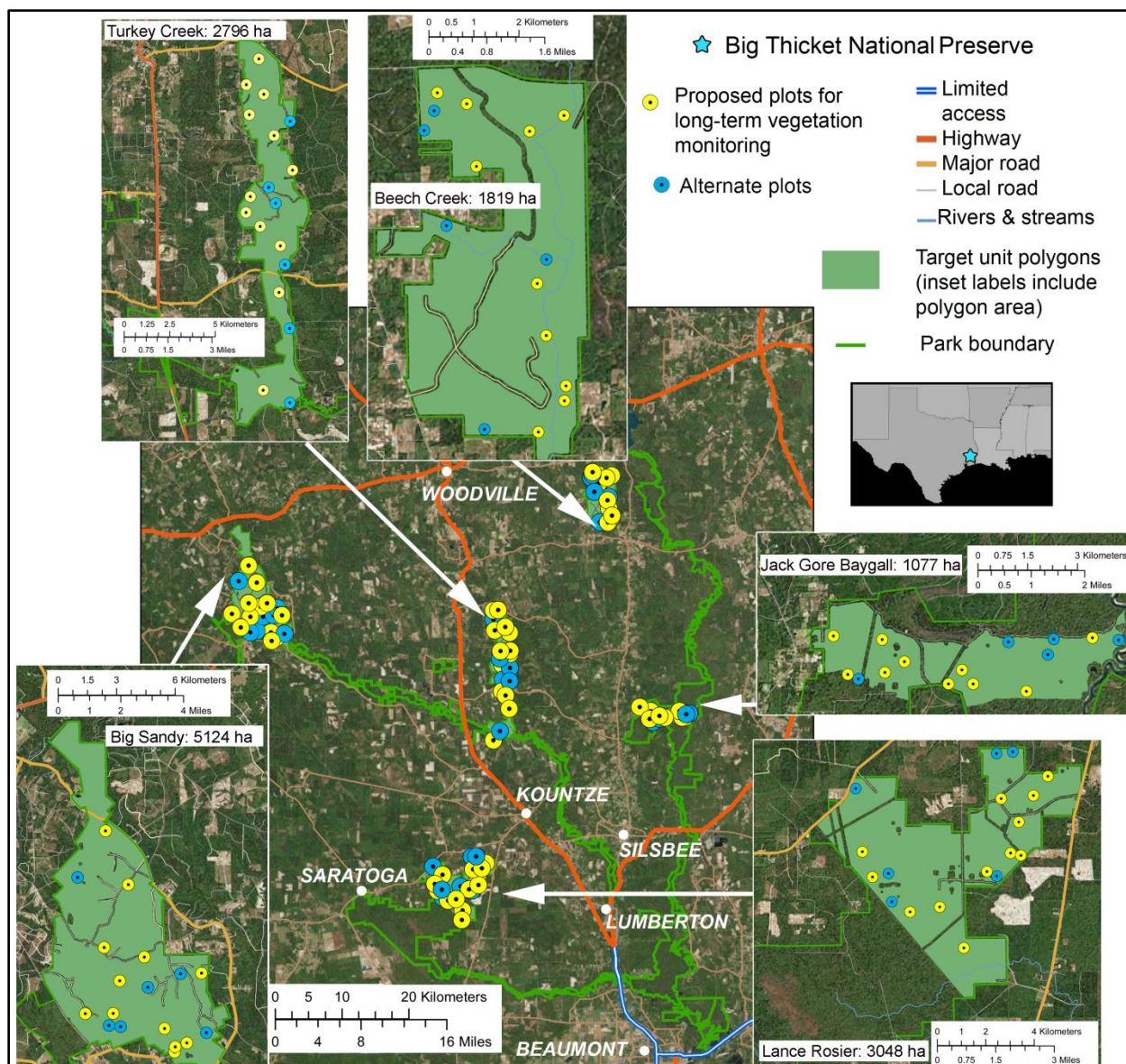


Figure B-7. Sampling frame and proposed plot locations for Big Thicket National Preserve, centered around Kountze, Texas. There are 56 primary plots and 28 alternate plots for the park. Vegetation sampling focuses on five large park units, which were identified through input from park management. Target polygons encompass all or most of the park unit except for Lance Rosier and Jack Gore Baygall, where only portions are included due to inaccessibility. Outside of the target units, the park property is frequently limited to narrow bands along waterbodies. The five target units have 10 to 12 primary plots and five to six alternate plots each. Only for the Turkey Creek unit are vegetation points co-located with bird points. Based on earlier vegetation maps, focal plant communities will include upland or slope pine/oak forests, floodplain forests, pine savannahs and baygalls dominated by red bay, black gum, sweetbay, inkberry and black titi.

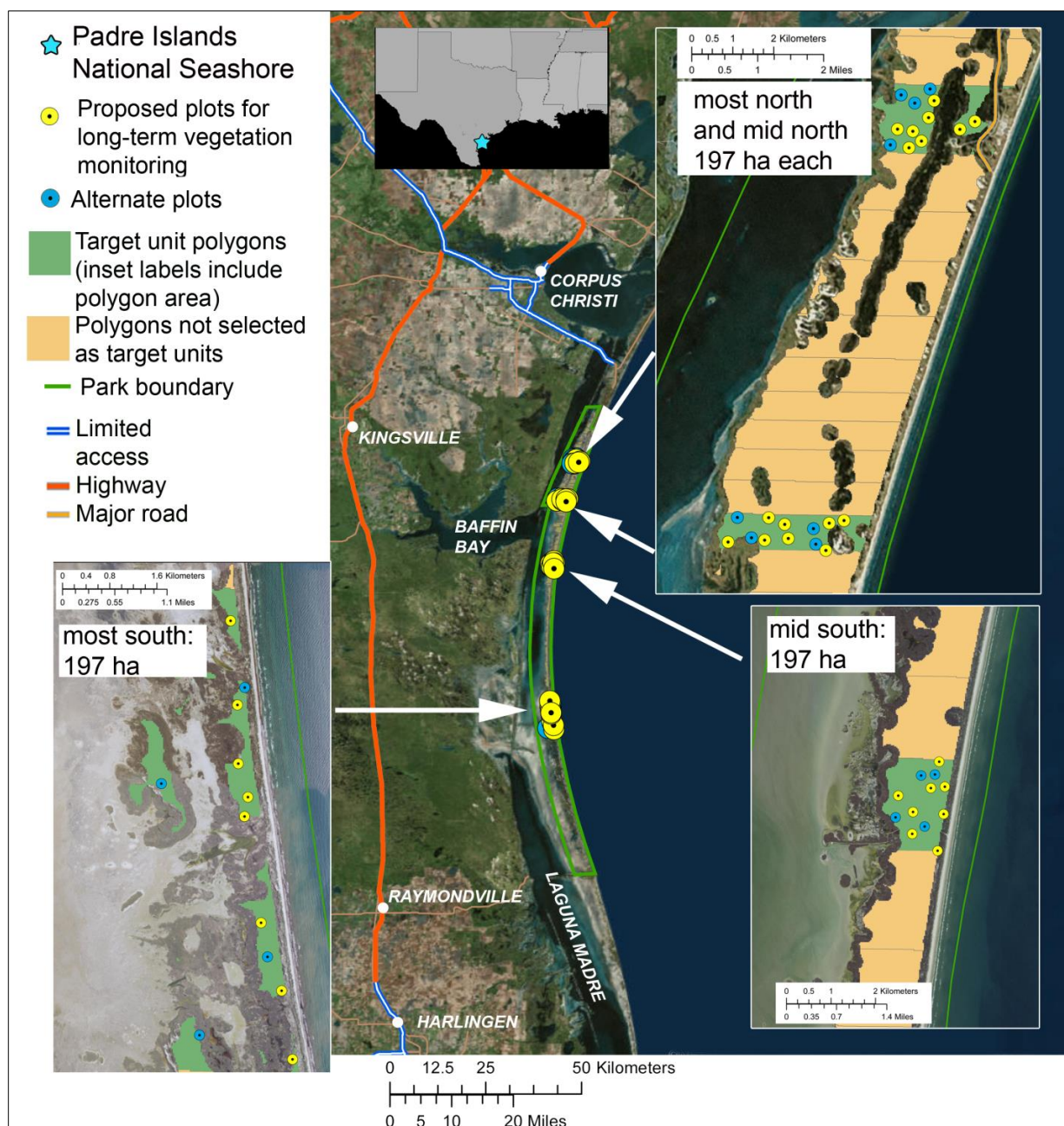


Figure B-8. Sampling frame and proposed plot locations for Padre Islands National Seashore, near Corpus Christi, Texas. There are 32 primary plots and 16 alternate plots. All of the primary plots are co-located with bird monitoring points. Plots were randomly located within four narrow, 196 hectare (0.75 square mile [mi²]) units that were at least 10 kilometers (6.2 mi) apart and were approximately evenly distributed along the 70 mile (113 km) island. The focal units were selected by first excluding roads (paved and unpaved), other paved surfaces, waterbodies, and then unique to seashore parks, tidal flats, washover zones, active dunes and beaches. The remainder of the island was then divided into 40 equal-area sections, numbered 1-40 north to south. The first focal unit was selected as a random draw from 1-10, after which three additional units were selected at intervals of ten. The four target units have eight primary and four alternate plots each. This sampling format was specifically requested by the park's management staff. Based on pre-existing vegetation maps, focal plant communities include vegetated dune communities and grasslands.

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Section C: Power Analysis of Coastwide Reference Monitoring System Vegetation Data in Jean Lafitte National Historic Park & Preserve

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 are based on the assumption that managers would prefer 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 Gulf Coast I & M Network (GULN) is preparing to monitor vegetation in long-term plots on eight national parks in the southeastern US (Carlson et al. 2018a), following the sampling methods of the NETN (Tierney et al. 2016). The Gulf Coast Network will adopt the same standards for statistical power, alpha level, and minimum change detection as the NETN, which are listed above. To determine a minimum number of plots that would enable detection of trends at these pre-set levels, the network has made use of the simulation-based power analysis from a published study on ten NETN parks (Miller and Mitchell 2014). The [R scripts and an example dataset from this study](https://www.esapubs.org/archive/ecos/C005/009/suppl-1.php) are publicly available (at <http://www.esapubs.org/archive/ecos/C005/009/suppl-1.php>), and these tools were the basis for the GULN power analysis presented here.

Methods

Data Source: Because the Gulf Coast Network lacks its own pilot dataset for vegetation monitoring, the power analysis is based on a small, publicly available dataset from one of its parks, Jean Lafitte

National Historical Park and Preserve (JELA). The [Coastwide Reference Monitoring System](https://lacoast.gov/crms2) of Louisiana (CRMS; <https://lacoast.gov/crms2>) has six vegetation monitoring plots in Jean Lafitte NHP&P, which have been subject to annual vegetation monitoring since at least 2011. The primary vegetation types are forested swamp and bottomland hardwood forest (e.g., Figure C-1).



Figure C-1. Bottomland hardwood forest in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve. Photo credits: Christopher Adams.

The six CRMS plots are split between two 200×200 meter (656×656 ft) stations, and these two stations are numbered 185 and 234 (see CRMS 2016a,b for data sources and Figure C-2 for site locations). The CRMS data are appropriate for this power analysis because of similarities in plot layout and vegetation sampling procedures. The plot size for CRMS is 20×20 meters (66×66 feet [ft]), within which there are three 2×2 meter (6.6×6.6 ft) microplots for percent cover and species richness (Figure C-3; see also Folse et al. 2012). For GULN, the plot size is also 20×20 meters, and within it there are four 3.16×3.16 meter (10.37×10.37 ft) microplots for percent cover and species richness (Figure C-2; see also GULN SOPs VEG03, Carlson et al. 2018b; VEG04, Carlson and Segura 2018a; VEG05, Carlson and Segura 2018b; and VEG06, Carlson and Segura 2018c).

Data Recorded: The 2012 and 2015 CRMS sampling events were used for the power analysis, as this interval matches the proposed Gulf Coast Network re-visit frequency of three years. On each visit, the CRMS team recorded the species identity and percent cover of all vascular plant species within the 2×2 meter microplots, using a continuous scale from 0–100% (approximately matching the

GULN percent cover data in 3.16 x 3.16 m microplots; Carlson and Segura 2018c). In the 20 × 20 meter plots, the CRMS team recorded the identity and DBH of all trees with DBH ≥ 5 centimeters (2 inches [in]). Because the GULN team will only measure DBH at ≥10 centimeters (3.9 in), the CRMS dataset was trimmed to only those trees. Additional variables were measured for the CRMS protocol (see Folse et al. 2012), but they were either not suitable for comparison with Gulf Coast Network or out of the scope for the current power analysis.



Figure C-2. Locations of the pre-existing vegetation monitoring plots within the Barataria Preserve section of Jean Lafitte National Historical Park and Preserve. The plots are part of the Coastwide Reference Monitoring System (CRMS), which produces publicly-available plant monitoring data for the Louisiana coast. There are three 20 x 20 m plots at each of the two stations, which are numbered 234 and 185. Several vegetation metrics were recorded in these plots in both 2012 and 2015, including plant species richness, percent cover, and basal area of trees. These data were the basis of a power analysis by the Gulf Coast Network, in preparation for their upcoming monitoring effort.

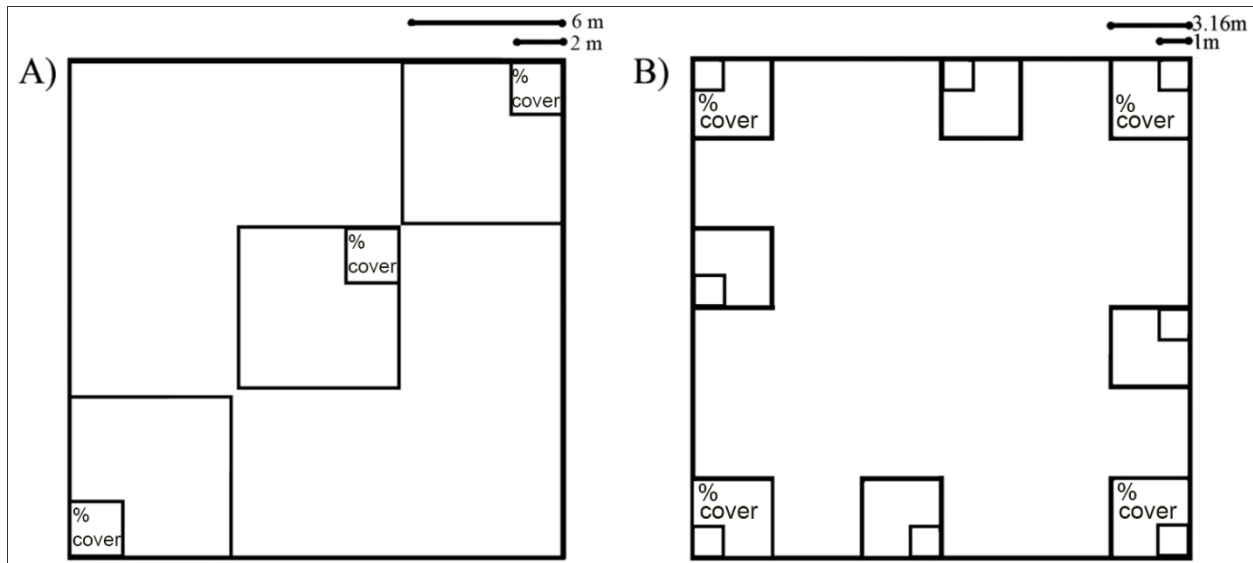


Figure C-3. Layout for (A) the CRMS forested swamp monitoring plots, which were sampled in 2012 and 2015 in Jean Lafitte National Historical Park and Preserve (JELA), and (B) the Gulf Coast Network vegetation monitoring plots. The variables relevant to the power analyses are measured in the 20 × 20 meter (66 × 66 ft) scale and in the sampling units labeled “% cover” in both (A) and (B). Data collected in the unlabeled sampling units are not used in the current power analyses.

Metrics Used in the Power Analysis: The focal vegetation metrics used in the power analysis were basal area of all live trees, percent cover of all native herbs, percent cover of all invasive herbs, native species richness and invasive species richness. Although additional metrics could be calculated, network chose this as a representative subset, and it also encompasses many of the key metrics used in Miller and Mitchell (2014). For all five metrics used here, the 2012 and 2015 values were summarized at the 20 × 20 meter scale to facilitate comparison of results across variables.

To calculate basal area of all live trees, basal area per tree (in square meters) was first calculated:

$$BA = \frac{\pi}{4 * 10000} * DBH^2$$

Next, this value was summed across all trees in a 20 × 20 meter (65.6 × 65.6 ft) plot and then divided by 0.04 to produce basal area per hectare. To calculate percent cover of native herbs, the CRMS dataset for 2 × 2 meter (6.6 × 6.6 ft) microplots was trimmed to only herbaceous species. Within each 2 × 2 meter microplot, individual cover estimates were summed across all native species, and then the three microplots within a 20 x 20 plot were averaged. These averages could equal over 100% due to spatial overlap among species. Calculation of percent cover of invasive herbs followed the same approach as native species, although there were many fewer invasive herbaceous species per plot (see results below). To calculate native or invasive species richness, both herbaceous and woody species were used. Species richness per 20 × 20 meter plot was the total number species detected across all three of the 2 × 2 meter microplots combined, with counts for native species and invasive species performed separately.

Settings for Power Analysis: Power analyses were performed using the approach and R script from Miller and Mitchell (2014). In this approach, the authors first created simulated datasets that were assigned varying degrees of change across years, ranging from a 50% decline to a 50% increase. These datasets were created by bootstrapping existing data for plant metrics like those described above, from plots in eight different parks that were each visited twice. The authors then performed mixed model analyses on the simulated data to determine whether the assigned change would be statistically significant at a given alpha level. In the network's version of these analyses, there was one notable modification. The original script was written to analyze several parks at once, so minor adjustments were necessary to accommodate a single-park dataset. Otherwise, the datasets were organized in the same manner, and the R code was run following descriptions in Miller and Mitchell (2014) including their in-script instructions.

The R scripts from Miller and Mitchell (2014) allowed the user to input several variables, including the number of survey events, the sample size in each park, and the alpha level. To simplify analyses and output, the Gulf Coast Network's power analyses focused on a single alpha level (0.1), two survey events, and two plot-level sample sizes: four or six. The sample size of four was chosen because it was under consideration as the minimum number of plots proposed for any Gulf Coast Network park unit. The sample size of six was chosen because there were six CRMS plots in the bootstrapped dataset. This is consistent with Miller and Mitchell (2014), who used the actual number of plots in each park as the sample size in their analyses (range across parks: five to forty-four plots).

The output variable of interest from the power analysis on CRMS data was the minimum detectable change at a power level of 80% or higher. When at least 80% power could not be achieved, results were reported as the power level associated with a 50% change, which was the highest minimum detectable change setting in the R script. Any metrics that failed to reach the 80% power analysis target were then subject to additional simulations to determine if a doubling in sample size from six to twelve could achieve the target value.

Results

Summary Statistics for Each Metric: The 2015 values for each of the five metrics tended to be higher than their 2012 values, with the exception of one or two sites for each metric (Table B-1). Relative to the other metrics, basal area of all live trees increased the least over the three-year period (mean = 8% change, with one plot reaching 17% change), whereas percent cover of native herbs increased the most; it increased as much as 151% (mean=80%), relative to its initial values. The invasive species metrics were fairly invariant, but this was in part because only two invasive species, *Triadica sebifera* and *Alternanthera philoxeroides*, were detected in the plots, and only the latter species ever had coverage over 10%.

Table B-1. Average values for the five focal vegetation metrics used in the power analysis. Data are from six CRMS plot in Jean Lafitte NHP&P, measured in both 2012 and 2015.

Site	Basal area		Native % cover, herbs		Invasive % cover, herbs		Native richness		Invasive richness	
	2012	2015	2012	2015	2012	2015	2012	2015	2012	2015
0185-01	20.5	21.7	83.0	134.4	33.3	13.3	16	16	1	1
0185-04	14.5	15.6	66.3	135.0	25.0	21.6	13	28	1	1
0185-08	9.6	9.8	48.3	55.0	11.0	16.3	16	19	2	1
0234-01	64.6	75.8	1.7	4.2	0.0	0.0	12	14	0	0
0234-04	63.6	68.1	6.0	5.4	0.0	1.0	14	14	1	1
0234-06	47.5	52.2	4.7	12.1	1.3	1.0	16	13	1	1

Power Analysis Results for Each Metric: Based on analyses of simulated data following Miller and Mitchell (2014), the four-plot design was sufficient to meet pre-assigned targets in three out of five vegetation metrics. In other words, four plots should allow detection of a 5–30% change in basal area of live trees, native herb percent cover and native species richness, with at least 80% power and a false-positive rate of 10% (Table C-2). Two of the five metrics did not meet targets for minimum change detection in a four- or six-plot design, however (Table C-2). To detect a 40–45% change in percent cover of invasive herbs at 80% power, twelve plots would be required. Similarly, for invasive species richness, a 35% change could be detected with 80% power using a twelve-plot design.

Table C-2. Results of power analyses on all five vegetation metrics for either four or six plots. Findings are reported in terms of the minimum detectable change over a three year interval (in 5% increments), followed by the statistical power of that test in parentheses. The alpha level was set at 0.1. Estimates were from simulations based on CRMS data for six plots, using R code from Miller and Mitchell (2014). Asterisks indicate values of 40% or lower, which meet the target (or better) for minimum change detection.

<i>Minimum detectable change in a given vegetation metric (statistical power)</i>					
Number of plots	Basal area	Native % cover, herbs	Invasive % cover, herbs	Native richness	Invasive richness
4	5% (≥80%)*	30% (≥80%)*	50% (45%)	25% (≥80%)*	50% (70%)
6	5% (≥80%)*	20% (≥80%)*	50% (65%)	20% (≥80%)*	50% (≥80%)

Interpretation

After two survey events in Jean Lafitte NHP&P, the four-plot design should allow for the detection of fairly small shifts in basal area, native species percent cover and native species richness. However, a larger number of plots would be needed to detect temporal changes in invasive species cover or richness at 80% power. The small number of invasive species in some plots and none in others led to

a decreased ability to detect significant change. 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 likely to be higher (i.e., a given species could well be absent from or rare in some plots and abundant in others).

These results nevertheless suggest that the proposed sampling design of 18 bottomland forest/swamp plots in Jean Lafitte NHP&P will meet and exceed all targets for statistical power and minimum detectable change in the five metric studied here. The likelihood of detecting very small changes is particularly high for basal area, percent cover of native herbs and native species richness, and it is relatively low for invasive species metrics.

If estimated variance from CRMS data is representative for future Gulf Coast Network sampling, even smaller sample sizes would be appropriate for implementation in Jean Lafitte NHP&P. Network staff expect, however, that variance will be greater in future sampling, because of the larger area covered and the inclusion of a wider range of habitat types. Additionally, not all focal metrics in the vegetation monitoring protocol could be subjected to power analysis using CRMS data, such that maintaining a relatively large number of plots is a prudent approach.

Although these power analysis results are informative for Jean Lafitte NHP, it is difficult to say whether they have any bearing on appropriate sample sizes for other network parks. The Gulf Coast Network covers a very wide range of vegetated habitats from Texas to Florida, and only two of the seven other parks (Big Thicket National Preserve and Gulf Island National Seashore) include swamp, bottomland forest or marsh-type vegetation that could exhibit similar levels of variability over time. As such, the network will re-assess sample sizes in all parks using the same power analysis approach after collecting data for the first two survey events.

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Section D: Field Datasheets VEG. FORMS 1, 2, and 3

GULN VEG. FORM 1: Site Measurements			Field-reviewed by (initial): _____	Post-field validation by (initial/date): _____ / _____																																																												
Site ID: _____	Park: _____																																																															
Instructions: 1. Plot establishment data (top half): Complete only during first visit; for return visits, datasheet will have this section filled in. 2. Physiographic class: Choose the class that best describes the plot area in terms of land form, topographic position and soil (see Field notes card for definitions). 3. Plot revisit (bottom half): Complete on first visit and all subsequent visits. 4. Disturbances: Record up to three disturbance codes from most to least important based on visual inspection of the plot. To be recorded, a disturbance must cause 'significant threshold damage' within the plot. Minor foliar or bole damage does not qualify. Only record disturbances that appear to have occurred since the previous inventory. If you record an unknown disturbance, attempt to capture a picture illustrating the disturbance.																																																																
Plot Establishment Date: ____/____/____ Time in (24 hr clock): ____:____ Time out: ____:____																																																																
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06/27/2018

Figure D-1 VEG. FORM 1: Site Measurements: This datasheet is used with SOP—VEG03 Site Selection, Plot Establishment and Return Visits (Carlson et al. 2018) and SOP—VEG04 Site measurements (Carlson and Segura 2018a).

[illegible]

Figure D-5. VEG. FORM 3: Vascular Plant Species Presence, Cover, and Abundance (Back): This is the back of the datasheet used with SOP—VEG06 Vascular Plant Species Presence, Cover and Abundance (Carlson and Segura 2018c).

Literature Cited for Section D

- Carlson, J.E., J. Bracewell and M. Segura. 2018. Site selection, plot establishment and return visits—Version 1.0. Gulf Coast Network Standard Operating Procedure NPS/GULN/SOP—VEG03. Gulf Coast Network, Lafayette, Louisiana. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2255905> (last accessed October 2018).
- Carlson, J.E. and M. Segura. 2018a. Site measurements—Version 1.0. Gulf Coast Network Standard Operating Procedure NPS/GULN/SOP—VEG04. Gulf Coast Network, Lafayette, Louisiana. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2255905> (last accessed October 2018).
- Carlson, J.E., and M. Segura. 2018b. Tree measurements—Version 1.0. Gulf Coast Network Standard Operating Procedure NPS/GULN/SOP—VEG05. Gulf Coast Network, Lafayette, Louisiana. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2255905> (last accessed October 2018).
- Carlson, J.E., and M. Segura. 2018c. Vascular plant species presence, cover and abundance—Version 1.0. Gulf Coast Network Standard Operating Procedure NPS/GULN/SOP—VEG06. Gulf Coast Network, Lafayette, Louisiana. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2255905> (last accessed October 2018).