Southeast Coast Network

National Park Service
Inventory and Monitoring Division

Standard Operating Procedure 1.4.10

Site Selection, Plot Establishment, and Return Visits—Version 1.1

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Summary

This standard operating procedure (SOP) provides instruction for establishing plots and collecting site-level information during both initial and revisit sampling years. Prior to establishing any plots, however, the protocol lead must ensure plot locations and marking procedures are approved by the natural resource manager at each park. These procedures may vary by park in response to individual park requirements.

The datasheet for plot establishment is SECN *Veg Form 1—Vegetation Plot Establishment* and the datasheet for site-level measurements is SECN *Veg Form 2—Site Characteristics*. Both datasheets are included in Appendix A of this SOP.

Revision Log

Revision Date	Author	Changes Made	Reason for Change	New Version #
March 2020	M.F. Boyle	A note to not collect quantitative data in certain circumstances was added to the slope, aspect, and terrain shape index elements within the Plot Establishment Years/Recording Site Characteristics section.	In foredune habitats, the complexity of multiple raised berms and ridges can yield any array of values for landform shapes, slope, and aspect.	1.1

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Overview

This SOP provides instructions for establishing plots and collecting site information for both plot establishment years and plot revisit years. Prior to the first field season, selected and alternate plot locations were generated using a generalized random-tessellation stratified (GRTS) sampling methodology in the program R (v3.5.1) within focal broadly described habitat polygons of Southeast Coast Network (SECN) parks and park management units. For nine of the fifteen parks, the sampling frame is the habitat types within the entire park area. For the remaining six parks, the polygons encompassed broad habitat polygons within specific park management units that were geographically separated or represented extremely stable habitat types (i.e., upland and wetland delineation on Congaree National Park [CONG]). Park sampling frames exclude buildings, paved or other roadways and trails, lawns, waterbodies, low marsh zones, and unvegetated beaches. Vegetation and land use layers were available as shapefiles from vegetation mapping efforts recently completed for SECN parks. Additional details on site selection, maps of plot locations, and R-code generated for the GRTS draw are in Appendix C of this SOP.

During plot establishment years, the field crew assesses whether pre-selected locations are suitable for monitoring. Plots may be removed from the sampling frame if they occur within low salt marsh or open water, span multiple broad habitat types identified in Table 3 of the SECN Terrestrial Vegetation Monitoring Protocol Implementation Plan (Boyle et al. 2019), present a safety hazard to the field crew, or other reasons (see below). For all acceptable locations, the field crew establishes the 20 × 20-meter plot (65.6 × 65.6 [ft] plot) with a compass, measuring tapes and seven permanent markers following the plot layout instructions described below. They also record GPS points for the plot center marker. All plots are oriented towards true north, and plot boundaries are measured as horizontal distances rather than slope distances. During plot establishment years, all GRTS selected (or their oversample/alternative locations) plots located in dominant or co-dominant broadly defined habitats are sampled. If time and resources allow, GRTS selected (or their oversample/alternative locations) plots located in habitat types representing 1–30% of the relative coverage within the sampling frame are sampled. During plot revisit years, the crew relocates any established plot following written directions and GPS coordinates, and they re-establish and re-mark the plot whenever markers have been damaged or removed.

It is important to ensure plot locations, marking procedures, and soil sampling methods have been approved by the natural resource manager at each park prior to plot establishment. These procedures may vary by park in response to individual park requirements.

SOP Source and How It Was Modified

This SOP is an adaptation of both SOP 2 *Using GPS (Based on use of the Garmin Map 76 or Map 78)—Version 1.2* and SOP 3 *Site Selection and Plot Establishment—Version 1.3* of the *Cumberland Piedmont Network Vegetation Monitoring Protocol* (White et al. 2011). For a general explanation of how the Southeast Coast Network modified the Cumberland Piedmont Network (CUPN) protocol and its SOPs, see the SECN Terrestrial Vegetation Monitoring Protocol Implementation Plan (Boyle

et al. 2019). The Southeast Coast Network made nine specific modifications to CUPN SOP 2 and 3, including: (1) the two CUPN SOPs are combined into one; (2) the SECN sampling frame includes all naturally-vegetated and semi-natural habitats in parks or target units, rather than forests and woodlands only; (3) parks were stratified into broadly defined habitat types and these polygons were used during the GRTS draw; (4) vegetation plot sizes and shapes cannot be modified in the Southeast Coast Network; (5) plots in the Southeast Coast Network are established initially by using a GPS and pacing procedure outlined by the Northeast Temperate Network (NETN; Tierney et al. 2016); (6) SECN plots can be shifted up to 10 meters if any portion of the plots occurs within a restricted category, rather than if more than ¼ of the plot occurs in a restricted category in the CUPN; (7) additional information on site hydrology similar to what is defined in the Gulf Coast Network vegetation monitoring effort (Carlson et al. 2018) was added; (8) areal cover percentages are estimated for each disturbance indicator located within a SECN vegetation plot; and (9) the Southeast Coast Network uses the FIREMON (Fire Effects Monitoring and Inventory System) protocol (Lutes et al. 2006) for fuel transect establishment—three fuel load transects 25 meters (82 feet [ft]) in length. The detailed list of modifications to CUPN SOP 2 and 3 is in Appendix B of this SOP.

Definitions

Magnetic north is the direction toward which the observer's compass needle points when in the northern hemisphere.

True north is the direction of the North Pole relative to the observer's position. True north is a fixed spatial location, but magnetic north varies across the landscape and over time. To find true north, use a magnetic declination chart or table to find the correct declination between true north and magnetic north for a given position and time (such as at NOAA's Magnetic Field Calculators website). Then, adjust the compass by dialing this declination into the faceplate. Most compasses have a setting ring on the bottom of the compass that allows for this correction. Simply turn the main compass ring so that the index pin is over the correct declination value for a park. Once this setting has been changed, it will not need to be changed until moving to a new park with a different declination. Take care to adjust the declination in the correct direction. Declinations will need to be updated yearly for each park before fieldwork begins. All plots will be oriented towards true north, regardless of whether this is upslope or downslope from the plot center point. Declination adjustment values for SECN parks in 2019 are listed in Table 1.

Plot size is 20 × 20 meters (65.6 × 65.6 ft) at all Southeast Coast Network parks.

Table 1. Declination adjustment values used for SECN parks, 2019–2022.

Park Code	Sample Year	Declination as of June 1, Sample Year	Compass Adjustment for Summer, Sample Year
CAHA	2019	10° 60' W	11° W
CALO	2022	10° 21' W	10° W
CANA	2022	7° 04' W	7° W
CHAT	2020	5° 17' W	5° W
CONG	2021	7° 43' W	8° W
CUIS	2020	6° 46' W	7° W
FOFR	2021	6° 57' W	7° W
FOMA	2019	6° 46' W	7° W
FOPU	2019	7° 19' W	7° W
FOSU	2020	8° 3' W	8° W
HOBE	2022	4° 24' W	4° W
KEMO	2021	5° 12' W	5° W
MOCR	2022	9° 26' W	9° W
OCMU	2020	5° 40' W	6° W
TIMU	2019	6° 44' W	7° W

Procedure

Plot Establishment Years

Plot Selection

Shapefiles of natural and semi-natural vegetation are obtained from output generated from the most updated vegetation mapping reports on SECN parks. Additionally, vegetation polygons on each park are cross walked to NatureServe's Ecological Systems (Comer et al. 2003) and finally to broad habitat categories defined by this SOP's lead author (see Table 3 of the SECN Terrestrial Vegetation Monitoring Protocol Implementation Plan [Boyle et al. 2019]). The sampling design framework for vegetation monitoring plot locations begins with a continuous draw of plot centroids across SECN park's broadly defined habitat polygons of natural and semi-natural vegetation. These polygons represent spatial coverage within current administrative boundaries, and exclude non-natural features such as roads, buildings, and manicured lawns, as well as non-targeted natural vegetation types (e.g., open water and low salt marsh). These polygons represent the sampling frame of vegetation monitoring on SECN parks.

For the following nine parks, the initial sampling frame includes broadly defined habitats within the entire park, with the above-mentioned excluded features: Cumberland Island National Seashore (CUIS), Fort Frederica National Monument (FOMA), Fort Matanzas National Monument (FOMA), Fort Pulaski National Monument (FOPU), Fort Sumter National Monument (FOSU), Horseshoe Bend National Military Park (HOBE), Kennesaw Mountain National Battlefield (KEMO), Moores Creek National Battlefield (MOCR), and Ocmulgee National Monument (OCMU). For the remaining six parks, the sampling frame was established across specific units (park-units) that represented either (1) clear geographical separation, such as island units along the coastal fringe (CAHA, CALO, and CANA) and spatially isolated units inland (CHAT and TIMU), or (2) ancient geomorphologic boundaries between uplands and wetlands (CONG). For these six parks, plots were distributed evenly among broadly defined habitats within the specified units. Finally, all polygons are subjected to the removal of a 14-meter (46-ft) buffer around all park and habitat boundaries. See Appendix C of this SOP for maps of park sampling frames and plot locations.

The selection of plots to sample was based on a continuous draw of plot centroids across SECN parks' broadly defined habitats and utilized the GRTS sampling methodology to create a spatially-balanced set of monitoring sites for each of the SECN parks. The GRTS technique uses reverse hierarchical ordering to map two-dimensional space (e.g., locations of plots in a park) into one-dimensional space, by giving each plot an ordered spatial address. The GRTS technique for the SECN vegetation plot allocation is performed in the statistical program R v3.5.1, utilizing the spsurvey library. The R-code used to generate plot locations for each park is in Appendix C of this SOP. Shapefiles are produced for each broadly defined habitat type; these points are placed in a spatially-balanced GRTS order using the ordering method previously mentioned. Any sub-sample of points on this list maintains spatial balance, if they are selected in consecutive order of the spatial address. Additional plots are provided by the GRTS draw, which represent alternate (or replacement) points should any of the original selected points need to be excluded from sampling. For each park habitat type, the number of alternate plots is seven times the number of selected plots (Select Plots = N; Alternate Plots = 7N).

During plot establishment years, all GRTS selected (or their oversample/alternative locations) plots located in dominant or co-dominant broadly defined habitats are sampled. If time and resources allow, GRTS selected (or their oversample/alternative locations) plots located in habitat types representing 1–30% of the relative coverage within the sampling frame are sampled.

After generating the ordered list of GRTS points for each of the 15 SECN parks, maps of the selected (and alternate) plot locations are sent to park managers to determine if any plots fall in exclusion areas. Reasons for plot exclusion include:

- any of the plot occurs within low salt marsh habitat or open water;
- any portion of the plot spans multiple broad habitat types, defined in Table 3 of the SECN Terrestrial Vegetation Monitoring Protocol Implementation Plan (Boyle et al. 2019);

- sampling the plot would pose a safety risk (e.g., plot occurs along a cliff face or abundance of unstable snags);
- the plot occurs on privately owned land;
- the plot includes non-vegetated surfaces (e.g., roads, manicured lawns, open water or beaches) or on a trail or footpath to minimize vandalism and avoid negative visual impacts to park visitors;
- the plot includes sensitive archaeological resources; or
- the plot is inaccessible (estimated travel to and from the plot, and sampling the plot, cannot be accomplished in a 10-hour day) by boat or foot travel.

Final field maps for each park targeted for sampling during a given year are printed and provided to field crews. These maps include (at a minimum) selected and alternate plots, and most recent trails, roads, aerial or topographic image layers. Selected and alternate plots are downloaded into field GPS units using the Open Source DNRGPS application, available from the Minnesota Department of Natural Resources (DNR) website. The datum for all coordinate values is NAD83, and the coordinate system is Universal Transverse Mercator (UTM). UTM zone 18 for Cape Hatteras NS and Cape Lookout NS; zone 17 for Canaveral NS, Congaree NP, Cumberland Island NS, Fort Frederica NM, Fort Matanzas NM, Fort Pulaski NM, Fort Sumter NM, Moores Creek NB, Ocmulgee NM, and Timucuan E&HP; and zone 16 for Chattahoochee River NRA, Horseshoe Bend NMP, and Kennesaw Mountain NBP. Immediately after uploading the plot coordinates, it is critical to check the GPS map to ensure that the plot locations are shown correctly on the screen to ensure the plot points are in the correct projection.

Navigating to Potential Plot Centroid

- At the beginning of the field day, the field crew determines which plots are sampled based on the relative accessibility of the first plot to the second, with a goal of completing two plots per day. Note: in very rugged or remote situations two plots per day may not always be possible (e.g., CONG).
- Using the GPS unit, select Find > Waypoints to navigate to the identified plot targeted for sampling. Navigate in the safest manner to the plot using the GPS navigation system and a handheld compass. Use walking trails or roads as much as possible.
- When nearing the pre-selected location, use the following method to locate the plot: as soon as the GPS is within 15 meters (50 ft) of the pre-selected location, continue exactly 10 steady paces (20 steps) in the direction of the pre-selected location and stop. Do not veer off course to avoid obstacles. This is the location of the center of the plot. Do not spend extra time using the GPS to pinpoint the location of the plot to meter-scale accuracy.
- Upon arrival at the plot location, ensure it is a vegetated landscape reflecting a natural or semi-natural community for the park. Make sure the plot center is greater than or equal to 20

meters (65.6 ft) from an archaeological site, a paved road, trail, undeveloped vehicle track, a perennial stream, a water body, a mowed area, or any obstacle that would interfere with plot establishment. Note that most of these features should have been excluded during point selection in GIS, but on-the-ground confirmation is essential. Also note if placement of the plot straddles two or more broad habitat types, or would include half coverage of low salt marsh. **Abundant poison ivy, dense brambles, and location near or along a hiking trail are not appropriate reasons for excluding a plot**. Plots are not located on top of earthworks in cultural parks if the plot establishment and measurement could disturb these cultural resources (check with park resource staff before setting up the plot). Do not install permanent markers, such as rebar, in an earthwork. If the site is a forested or non-forested wetland with standing water covering much or all the vegetation in the plot, do not discard the site. If water levels are unusually high, postpone installation and measurement where feasible and note that the plot should be revisited later in the season when water has receded. If the field schedule doesn't allow for postponing plot measurement and sampling can be implemented safely, then sample the plot and take extra care not to trample the plot.

- Plots may be moved a short distance (up to 10 meters [32.8 ft]) if any portion of the plot falls in a restricted category. Choose the most obvious direction that will allow for better plot placement. If a new location cannot be established within 10 meters of the original location, then the site is discarded.

- If the plot does not meet the criteria listed herein, or if the plot presents a safety hazard such as extremely steep slopes (i.e., > 30°/60% slope) or unstable snags, discard the plot and record the reason on the SECN *Veg Form 1—Vegetation Plot Establishment* datasheet. Add a new point to the list of plot locations for establishment by selecting the next unused location on the randomly-ordered list of alternate plots. If there is sufficient time, travel to the next-nearest location in the park where a plot is to be established and start this SOP again.

- When the field crew is satisfied with the location, set a chaining pin or tripod in the ground. Holding the GPS unit above this location, depress the "Enter" button on the unit for more than two seconds. A Mark Waypoints screen will appear. Rename the new Waypoint using the following naming conventions: <four letter park code><plot number>_<YYYY-MM-DD>. Hit "OK." Back at the Mark Waypoint Screen, toggle to the bottom left and highlight "Avg" and hit "Enter." A screen shows the averaging of waypoint data and a measurement count. When the count reaches >100, hit "Enter", then record the x and y UTM values, the UTM zone, the number of times averaged, and estimated GPS error on the SECN *Veg Form 1—Vegetation Plot Establishment* datasheet.

- Field crews should also, at this time, document directions to the plot from the starting point to aid future efforts in plot relocation. This information is captured on the SECN *Veg Form 1—Vegetation Plot Establishment* datasheet.

Marking the Plot Center

After selecting the plot for establishment, begin setting up the plot and gathering data. First, drive a piece of rebar into the ground at the plot centroid (where the chaining pin or tripod is located) approximately one inch remains visible above ground. Adhere a plastic surveyor's marker marked with "C" (for plot center) on the visible end (top) of the rebar.

Next, find two trees (>10 centimeters [3.9 inches {in}] diameter at breast height [DBH]) that appear to be in good health and are near plot center. If no large trees are present, attempt to find trees that are unique within the vicinity so that they can be easily rediscovered when revisiting the site. Tag trees should not be in line with each other relative to plot center; this will make it more difficult to relocate plot center. Mark each tag tree by attaching the tag at 1.27 meters (4.2 ft), 10 centimeters below DBH, from the ground with an anodized, numbered tag so it will be easy to find in future years. Record the tree's DBH using the diameter tape (rounding to the nearest centimeter), compass direction from the tree tag to the plot center, the number of the tag, and distance from tag tree to plot center on the SECN *Veg Form 1—Vegetation Plot Establishment* datasheet. Use a tape measure and measure to the nearest 0.1 meter. Record this information on the datasheet, along with the color of the tag, the tag number, and tree species for all tag trees. This process will make the centroid point much easier to find in future years and will make it easier to relocate the center should the rebar disappear. Tags should be affixed using a hammer and nail with the angle of the nail head lower than the point at which it goes into the tree so that the tag slides down the nail as the tree grows. The tags should generally face the direction in which teams accessed the plot. One exception to this rule is when the trees are very close to a trail. In this case, tags should be on the opposite side of the tree from the trail to avoid drawing the casual visitor's eye to it. Record the direction the tag is facing on the data sheet. In open habitats where tag trees are not available near plot center, consider adding additional site monumentation, such as PVC, to facilitate relocating plot center during future visits.

Laying Out the Plot

The standard SECN vegetation monitoring unit includes a 20 × 20-meter (65.6 × 65.6 ft) vegetation plot and three 25-meter (82-ft) fuel transects (Figure 1). The following steps should be followed to most efficiently establish the unit boundaries:

1. Starting at plot center, feed a 30-meter (98.4-ft) tape through the eyelet of a chaining pin, which should be placed on the center rebar. While crew member 1 holds the tape reel and compass, crew member 2 stretches the tape 10 meters (32.8-ft) to the west, following the directions and distance provided by crew member 1 (refer to Figure 2a, Step 1). If any large trees are directly in the path of this centerline, then simply continue around the tree as best as possible and pick up with your direction on the other side of the tree. When crew member 1 is satisfied with the direction and distance, crew member 2 affixes the end of the tape to the ground via a chaining pin through the end of the tape. Once the end of the tape is secure, crew member 2 places a wire pin flag at this point. This marks the center western point of the vegetation plot. Crew member 1 can place a wire pin flag at their location (plot center).

2. Using the two pin flags just placed by crew members 1 and 2 for guidance to stay on line, crew member 1 can now stretch the tape 10 meters (32.8 ft) to the east, stopping when the

tape reaches 20 meters (65.6 ft) to place a wire pin flag at this location. The 20-meter point marks the center eastern point of the vegetation plot (refer to Figure 2a, Step 2).

3. Standing at the center eastern point, feed a second 30-meter (98.4-ft) tape through the eyelet of a chaining pin, placed at the wire pin flag at this location. While crew member 1 holds the tape reel and compass, crew member 2 stretches the tape 10 meters (32.8-ft) to the north following the directions and distance provided by crew member 1 (refer to Figure 2a, Step 3). When crew member 1 is satisfied with the direction and distance, crew member 2 affixes the end of the tape to the ground via a chaining pin through the end of the tape. Once the end of the tape is secure, crew member 2 places a wire pin flag at this point. This marks the northeastern point of the vegetation plot.

4. Using the two pin flags just placed by crew members 1 and 2 for guidance to stay on line, crew member 1 can now stretch the tape 10 meters (32.8-ft) to the south, stopping when the tape reaches 20 meters (65.6-ft) to place a wire pin flag and chaining pin at this location. This marks the southeastern point of the vegetation plot. Crew member 1 feeds the tape through the eyelet of the chaining pin and stretches the tape 10 meters to the west, stopping when the tape reaches 30 meters (98.4-ft) to place a wire pin flag at this location (refer to Figure 2a, Step 4). This marks the central southern point of the vegetation plot.

5. Standing at the center western point, feed a third 30-meter (98.4-ft) tape through the eyelet of a chaining pin, placed at the wire pin flag at this location. While crew member 1 holds the tape reel and compass, crew member 2 stretches the tape 10 meters (32.8-ft) to the north following the directions and distance provided by crew member 1 (refer to Figure 2a, Step 5). When crew member 1 is satisfied with the direction and distance, crew member 2 affixes the end of the tape to the ground via a chaining pin through the end of the tape. Once the end of the tape is secure, crew member 2 places a wire pin flag at this point. This marks the northwestern point of the vegetation plot. Crew member 1 can place a wire pin flag at their location (center western).

6. Using the two pin flags just placed by crew members 1 and 2 for guidance to stay on line, crew member 1 can now stretch the tape 10 meters (41-ft) to the south, stopping when the tape reaches 20 meters (65.6-ft) to place a wire pin flag and chaining pin at this location. This marks the southwestern point of the vegetation plot. Crew member 1 feeds the tape through the eyelet of the chaining pin and stretches the tape 10 meters to the east, stopping when the tape reaches 30 meters (98.4-ft) and at the already marked central southern point of the plot (refer to Figure 2a, Step 6).

7. Back at plot center, feed a fourth 50-meter (164-ft) tape through the eyelet of a chaining pin, which should be placed on the center rebar. While crew member 1 holds the tape reel and compass, crew member 2 stretches the tape 10 meters (41 ft) to the south, until reaching the marked central southern point of the plot. Crew member 1 can use the two pin flags along this line to stretch the same tape 10 meters (41 ft) north to the center northern point of the vegetation plot. Place a wire pin flag at this location, which marks 20 meters (65.6 ft) on the

tape. Crew member 1 continues to stretch the fourth tape at a north bearing 15 meters (49.2 ft) beyond the vegetation plot, and places a wire pin flag at this location, which marks 35 meters (114.8 ft) on the tape. The 25-meter (82 ft) line from the plot centroid to this location marks the 0° fuel transect (refer to Figure 2b, Step 7). Wire pin flags are placed at the 5-, 7-, 10-, and 25-meter (16.4-, 22.9-, 32.8-, and 82.0-ft) point along this transect.

8. Use a fifth 30-meter (98.4-ft) tape to establish the northern vegetation plot boundary (refer to Figure 2b, Step 8). All the vegetation plot and module sides have been established once this step is complete. Once any needed adjustments are made and both crew members are satisfied with the tape layout, one crew member drives the remaining pieces of rebar into the ground at the necessary corners so approximately 1 inch (2.5 centimeters [cm]) remains visible above ground. Adhere a plastic surveyor's marker marked with "Mod-Corner" (for Module and Corner Numbers—e.g., 1–4 marker should be staked at the Module 1, Corner 4 plot corner) on the visible end (top) of each rebar. Including the one already driven at the plot center, a completed plot should have seven pieces of rebar driven (black circles on plot diagram, Figure 3). All vegetation, woody stem, and fuel transect 0° data should be collected at this time.

9. To establish the remaining two fuel transects, crew member 1 affixes the end of the 50-meter (164-ft) tape with a chaining pin at the plot centroid. Crew member 1 stretches the tape 25 meters (82 ft) at a 225° bearing, following the directions provided by crew member 2. Data are collected along this transect. Repeat the same procedure for the third fuel transect, following a bearing of 135° (refer to Figure 2c, Step 9). Wire pin flags are placed at the 5-, 7-, 10-, and 25-meter (16.4-, 22.9-, 32.8-, and 82.0-ft) point along each of these transects.

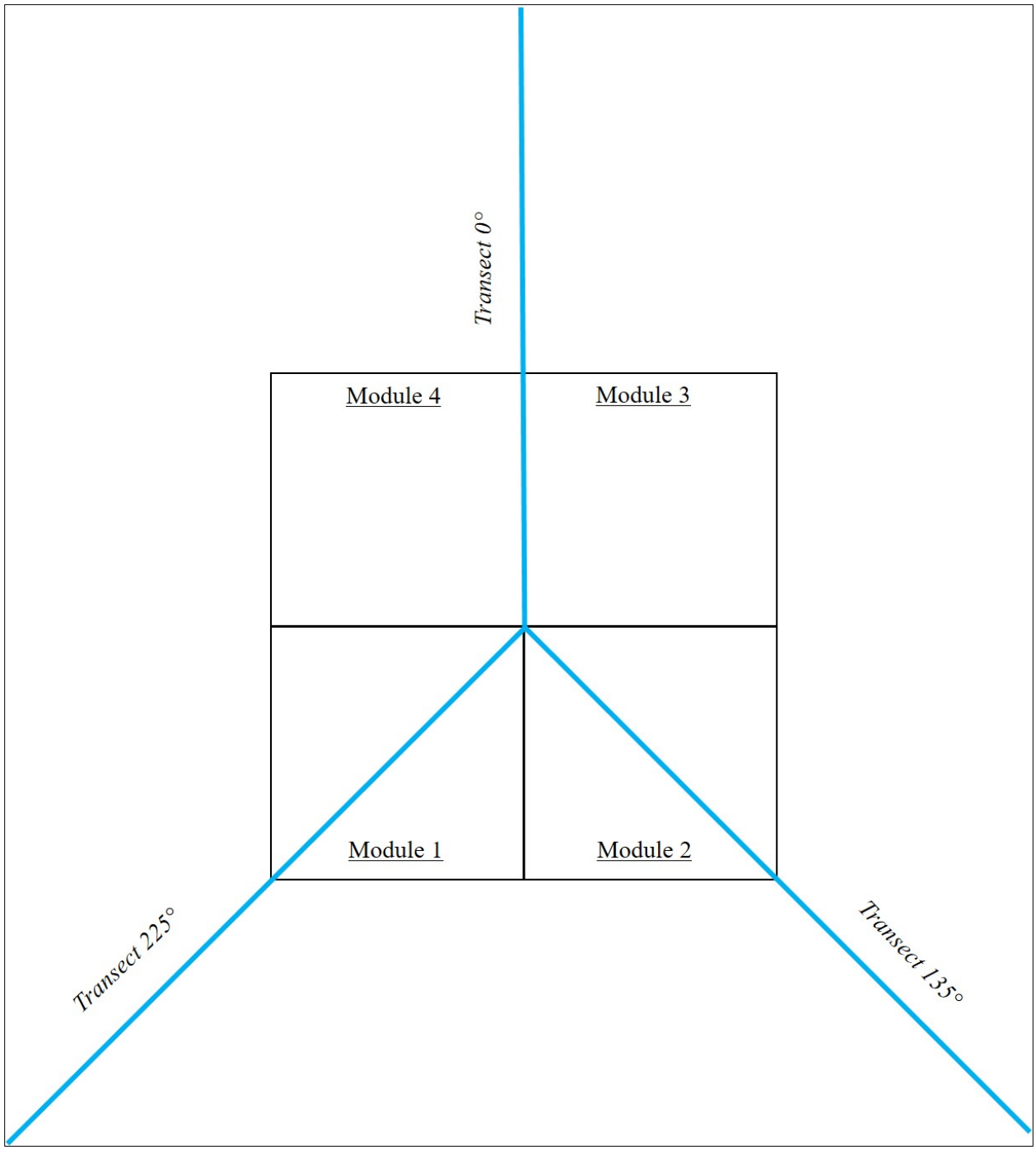

Figure 1. The standard Southeast Coast Network vegetation sampling unit, which includes a 20 × 20 (65.6 × 65.6 ft) modified Carolina Vegetation Survey plot (black lines; Peet et al. 1998) and three 25-meter (82-ft) fuel transects (blue lines).

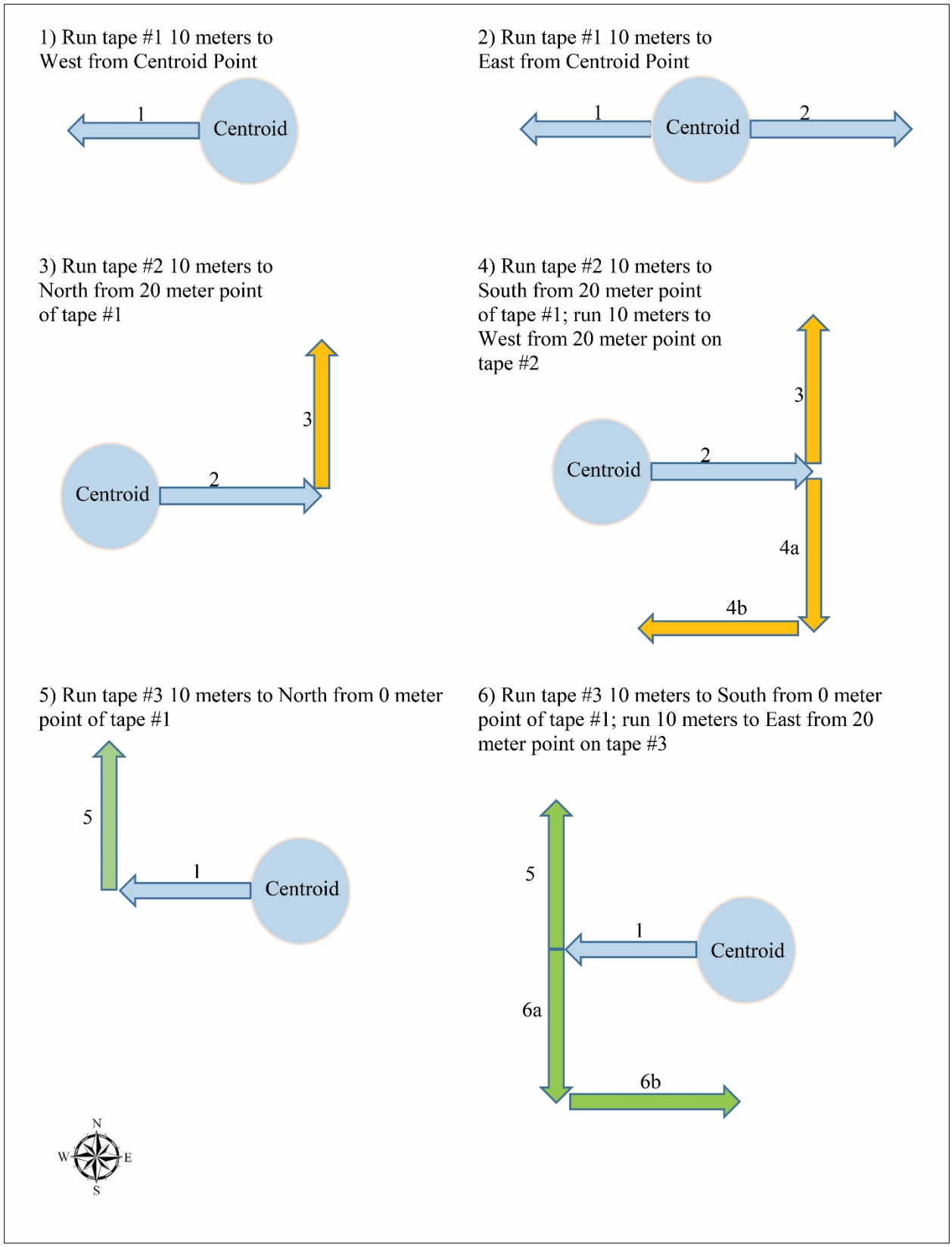

Figure 2a. Illustration of steps 1–6 for laying out the SECN vegetation sampling unit.

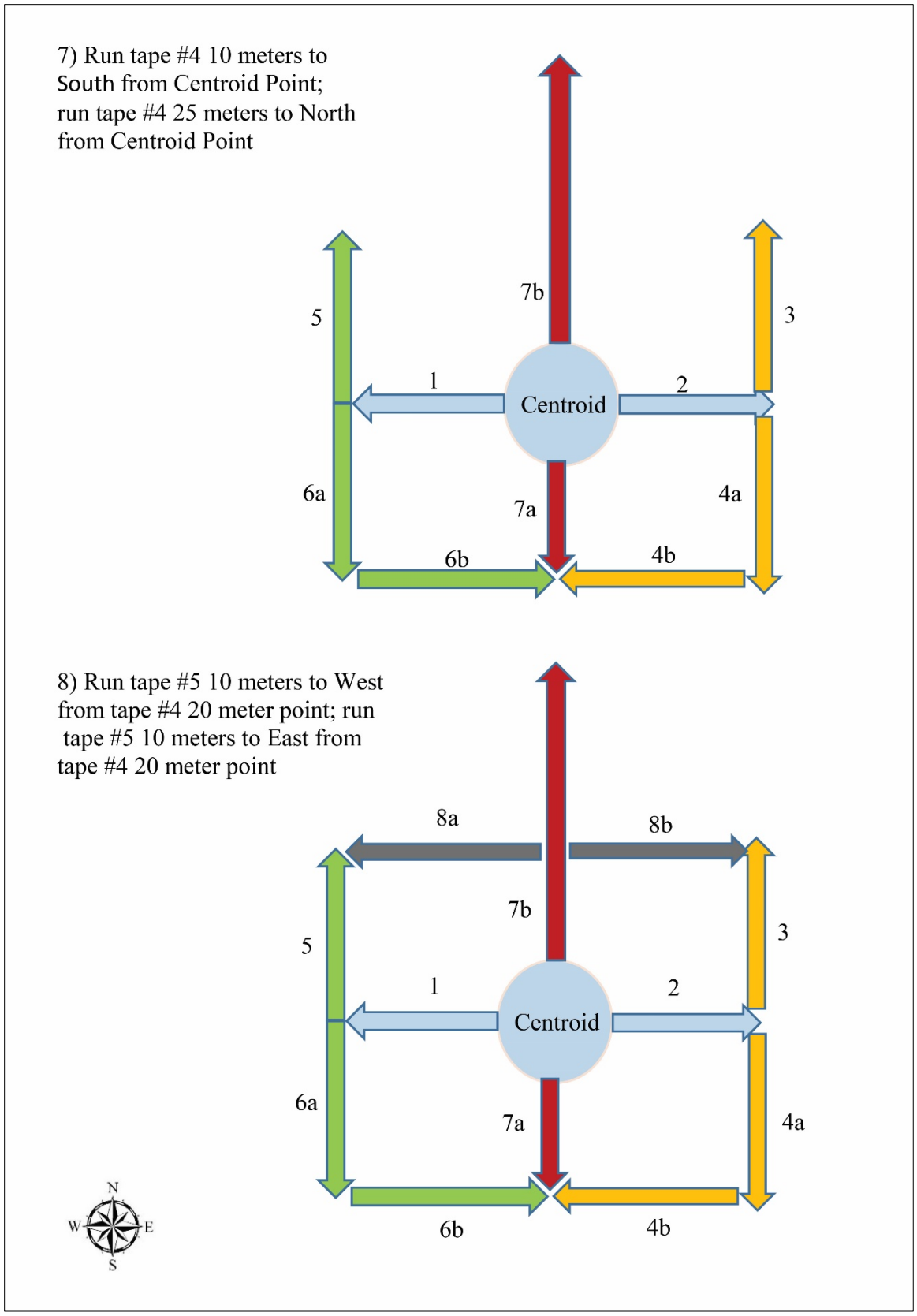

Figure 2b. Illustration of steps 7–8 for laying out the SECN vegetation sampling unit.

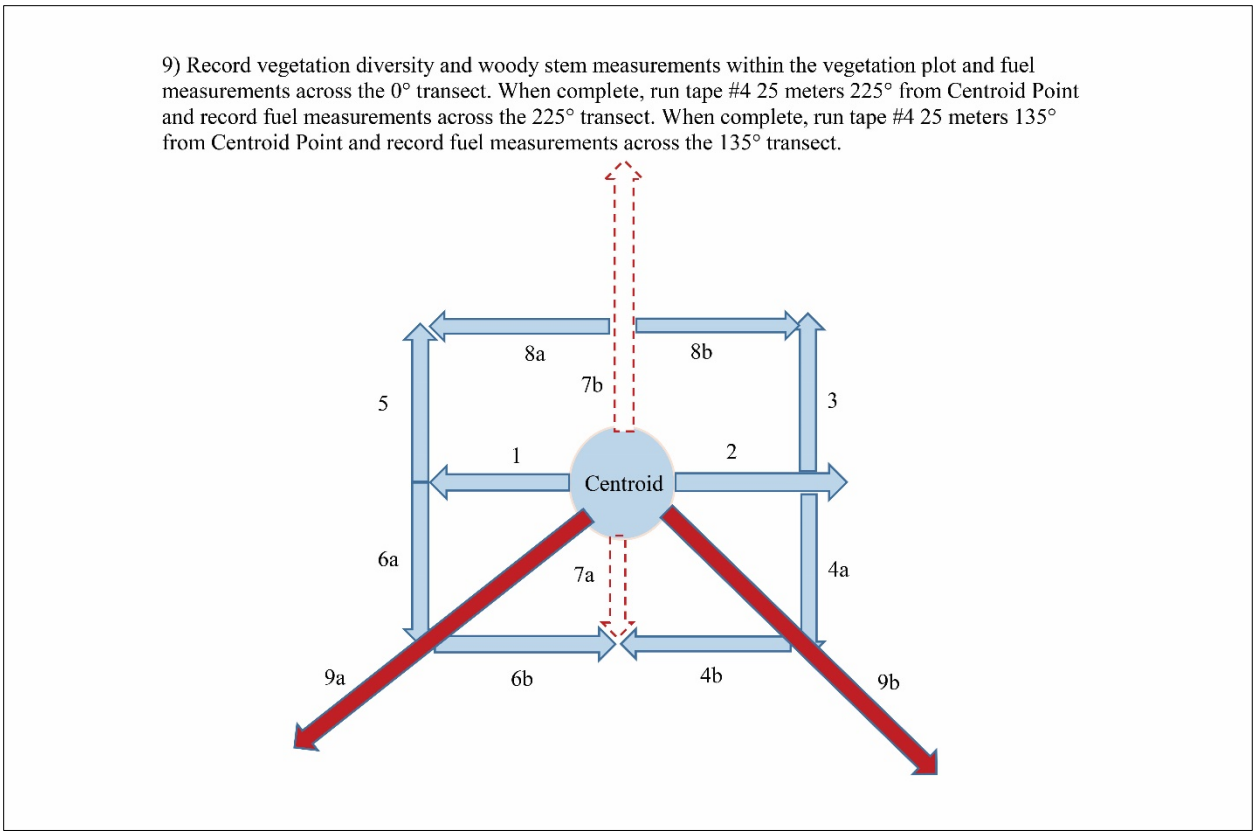

Figure 2c. Illustration of step 9 for laying out the SECN vegetation sampling unit.

Before moving on to other tasks, a crew member ensures the plot diagram and Plot Layout Notes are utilized to record all items to assist future teams in locating and laying out the plot as close as possible to its current layout. Look around the plot and sketch any landmarks likely to be present on future visits including downed trees and outcrops. Record where all rebar is driven and tag tree locations and tag numbers. Do not use the Plot Layout Notes section to document site characteristics, which are addressed on another datasheet.

There may be cases where parks will not allow rebar to be put into the ground or where there are other considerations that prevent rebar or tags. In these cases, field workers should provide clear notes on the plot datasheets to explain alternative permanent markings. If the plots cannot be marked, and survey grade GPS with sub meter accuracy is available and travel distances are not far, teams should use those units instead, taking GPS points at each of the locations on the plot where rebar would normally be placed. If teams cannot place the rebar in the exact location where it is supposed to go, try to place it 1 meter (3.3 ft) to the north. If this does not work, pick another location and give specific directions in plot layout notes and on the plot diagram detailing the actual location of the centroid point relative to the rebar.

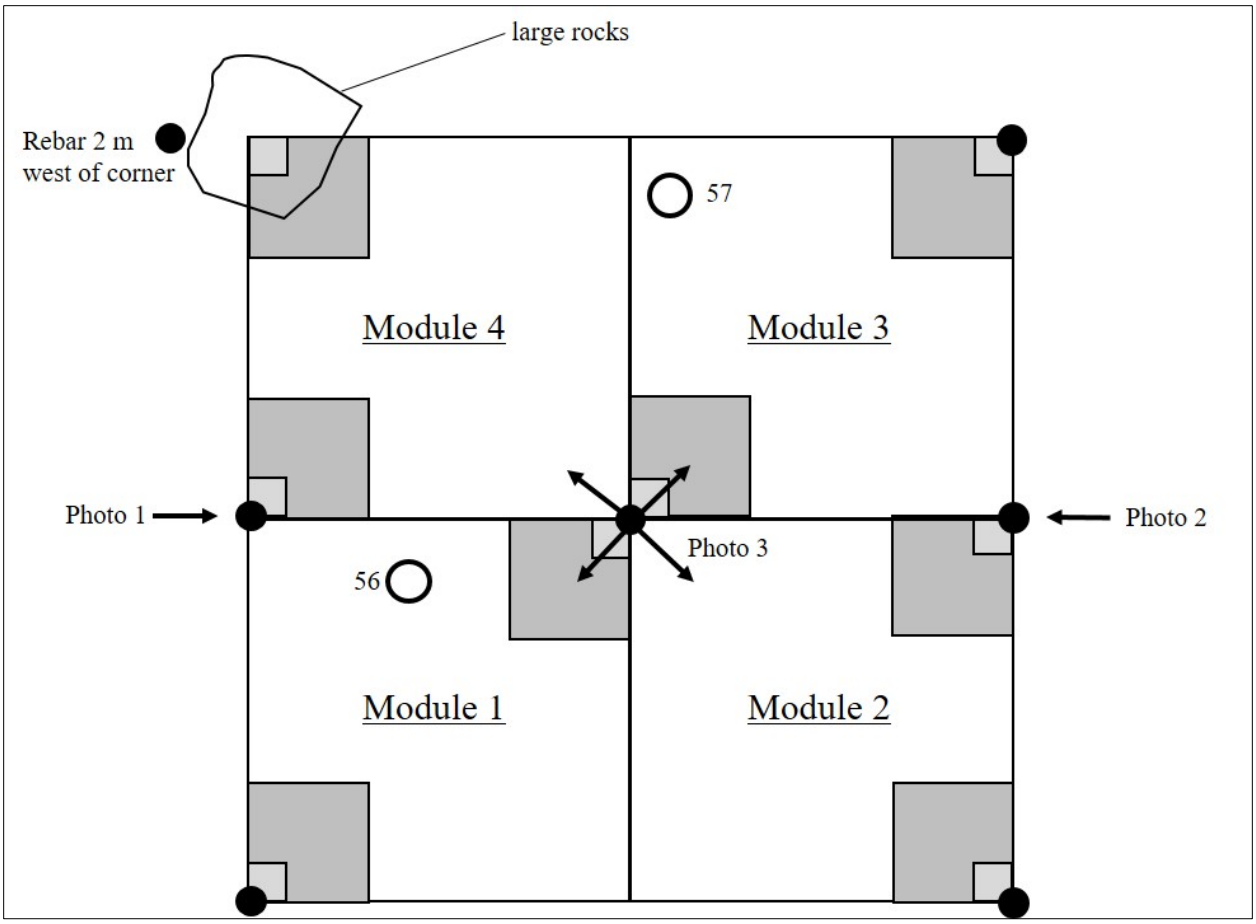

Figure 3. Plot diagram showing modules, rebar locations (closed circles), tag trees (open circles), plot irregularities, and photo point locations (arrows).

Recording Site Characteristics

Site Characteristic information is recorded on the SECN *Veg Form 2—Site Characteristics* datasheet.

Slope: Slope is calculated from the average of the absolute values of the terrain shape reading at aspect and 180° from aspect.

Aspect: Once done with slope, measure aspect in the same direction from which you measured slope. Aspect is measured by holding the compass in your hand so that the air bubble in the middle of the compass shows that the compass is perfectly perpendicular with the ground. At this point, you can adjust the outer black ring so that the red north point arrow matches the stationary red arrow embedded in the compass. You should be able to use the same sighting tree you used for the slope measurement to get the aspect reading. Record the aspect to the nearest 10 degrees.

Terrain shape index: The terrain shape index is calculated from slope estimates taken in eight directions around the plot. Slope at each location is recorded using a clinometer. To use a clinometer to record slope, the shortest crew member should first calibrate the device. Have the second (taller) crew member stand 10 meters (32.8 ft) away on level ground. The first crew member looks through

the clinometer lens keeping both eyes open simultaneously and points the device at the second crew member, looking for the place on their body where the clinometer reads 0-0. Once calibrated, the second crew member stands 10 meters directly at aspect from the first crew member. The first member 'shoots' the clinometer to the same position on the second member's body that they established when calibrating the clinometer. The value at this position is reported in degrees (make sure to record if the value is negative or positive). Repeat this procedure turning clockwise 45° from aspect; repeat six more times, always turning clockwise at a 45° bearing. Record all slopes to the nearest 5°.

(Note for Slope, Aspect, and Terrain Shape Index Measurements: These data are not taken in foredune habitats with multiple raised berms or ridges within a given plot; instead, a label of 'complex' is noted for all three measurements.)

Percent under water: Record the percentage of the 20 × 20 meter (65. × 65.6 ft) plot that has standing water visible on or above ground level. Estimate the percentage to the nearest 10% on a scale from 0–100%.

Water on plot code: Record the water source having the greatest impact on the plot using the codes below. This information will be recorded during the first visit and verified or updated on subsequent visits. It will be necessary to re-examine the plot for temporary water sources during each visit.

Codes:

- 0: None—no water sources on plot
- 1: Permanent streams or ponds
- 2: Permanent water in the form of deep swamps, bogs and marshes
- 3: Ditch/canal—human made channels such as for irrigation or drainage
- 4: Temporary streams
- 5: Flood zones—evidence of flooding when bodies of water exceed their natural banks
- 6: Vernal pool
- 7: Other water—specify in Plot Notes

Landform: Select only one landform type from the region-specific subset list in Grossman et al. (1998). Most coastal SECN park landforms will be either flat plain, tidal flat, or alluvial plain. Other landform types may be encountered in inland/Piedmont parks, including:

- Interfluve
- Gap/saddle
- Side slope

- Slope bench
- Fan Piedmont
- Cove
- Escarpment/face
- Bedrock outcrop
- Debris slope
- Rolling upland
- Ravine
- Seep/swale
- Levee
- Channel shelf
- Back swamp
- Basin/sag pond

Topographic position: This is a qualitative category system that relies on the field worker's best judgement of the landscape to determine the type that best fits the situation. Interfluve, high slope, midslope, lowslope, channel bed, and low level (terrace) are the most common topographic positions, though all are possible within Southeast Coast Network, and definitions are from Grossman et al. (1998):

- INTERFLUVE: (crest, summit, ridge): linear top of ridge, hill, or mountain; the elevated area between two fluves (drainageways) that sheds water to the drainageways.
- HIGH SLOPE: (shoulder slope, upper slope, convex creep slope): geomorphic component that forms the uppermost inclined surface at the top of a slope. Comprises the transition zone from backslope to summit. Surface is dominantly convex in profile and erosional in origin.
- HIGH LEVEL (mesa): level top of plateau.
- MIDSLOPE (transportational midslope, middle slope): intermediate slope position.
- BACKSLOPE (dipslope): subset of midslopes which are steep, linear, and may include cliff segments (fall faces).
- STEP IN SLOPE (ledge, terracette): nearly level shelf interrupting a steep slope, rock wall, or cliff face.

- LOWSLOPE (lower slope, foot slope, colluvial footslope): inner gently inclined surface at the base of a slope. Surface profile is generally concave and a transition between midslope or backslope, and toe slope.
- TOESLOPE (alluvial toeslope): outermost gently inclined surface at base of a slope. In profile, commonly gentle and linear and characterized by alluvial deposition.
- LOW LEVEL (terrace): valley floor or shoreline representing the former position of an alluvial plain, lake, or shore.
- CHANNEL WALL (bank): sloping side of a channel.
- CHANNEL BED (narrow valley bottom, gully arroyo): bed of single or braided watercourse commonly barren of vegetation and formed of modern alluvium.
- BASIN FLOOR (depression): nearly level to gently sloping, bottom surface of a basin.

Disturbance indicators: The field crew should observe the plot and its environs and document the presence of any recent or historic disturbance history within or very near the vicinity of the plot. When a disturbance indicator is noted within the plot, an estimated areal cover percentage is recorded to the nearest 10%, using two observers standing in opposite ends of the plot (one at the eastern edge of the plot, the other at the western edge of the plot). Areal cover is estimated from a consensus reached by the two observers. There are many choices for indicators of disturbance and each requires a certain level of familiarity with the signs that would indicate disturbance. An open-grown canopy tree in the plot is generally a much older and larger tree than all the other trees in the plot with unusually spreading branches indicating the plot was likely a farm or other cleared area with just one or a handful of trees in the past that grew in a full-sun, low competition environment. Sign of recent fire can be seen based on charring combined with a lack of a leaf or coarse woody debris layer. Sign of historic fire usually shows from heavy tree scarring, charcoal, and other signs of fire with signs of recovery that show the fire was more than one year ago. Signs of heavy deer browse include browse lines that match up with the height of the deer's reach, branches with deer browse marks on palatable species (e.g. *Euonymus americana*). Signs of recent or historic logging are generally given away by human cut stumps where the rest of the tree was removed. Historic plowing is often seen in forests and is most easily recognized by uniform rows of raised up soil (mini swales). Heavy erosion is common along streams and is generally checked if the creek or river is incised or embedded in a bed that is deeper than it would be naturally. There are many other indicators of disturbance (beavers, hog rooting, camping, windthrow, bush hogging, flooding) that can also be noted under "other indicators." There is also a section called "Notes (related to landform, terrain, position, or disturbance)" that can be used to further describe conditions already noted.

Equipment List

- Paper copies of maps; printed on Rite in the Rain paper
- GPS plus spare batteries
- Compass
- Clinometer
- Datasheets for plot establishment (SECN *Veg Form 1: Vegetation Plot Establishment*) and site-level measurements (SECN *Veg Form 2: Site Characteristics*); one set per plot, plus spare copies; all printed on Rite in the Rain paper
- Pencils
- 12-inch (30.5 cm) long rebar (× 7 per plot) plus pillowcase for rebar transport
- Permanent plastic surveyor's markers (rebar covers; × 7 per plot), labeled by subplot and corner
- Hammer with prongs
- Round numbered aluminum tree tags (#1–1000)
- Wood siding sinker head style aluminum nails
- Diameter tape, metric, fabric
- Open reel fiberglass tape, 30 meters (98.4 ft) (× 5)
- Open reel fiberglass tape, 50 meters (164 ft)
- Chaining pins, set of 11 plus Chaining Pin Quiver (× 2)
- Flagging tape
- Wire stake flags, bundle

Plot Revisit Years

Prior to Field Work

Print out corresponding resample form and plot and tree diagrams from the previous sampling effort for the set of plots to be sampled in each year. Make sure the most recent plot points are loaded into the field crew's GPS unit.

Navigating to the Plot

1. Field crews will navigate to the plot with the aid of a GPS unit, as before. However, crews should also be following the written directions to the plot. The written directions should

begin at an obvious starting point (e.g., the visitor center or road intersection) to the parking location, as well as from the parking location to the actual plot. If the written directions prove inadequate or unclear, update on the resample form. ***Note:*** *if there is an easier way to access the plot, go ahead and document that new way. Enter a new description for accessing the plot on the back of the sheet so that we can later replace the old directions with the new.*

2. Field crew should also take note of the travel time from vehicle to plot. Recognizing that some people travel faster than others and there may be obstacles this year that weren't in place a few years ago, travel time should be viewed as a realistic estimate (i.e., we are not concerned about differences of only a few minutes).

3. Once the navigator (person with the GPS) informs the field crew they are within a few meters of the plot, the crew should begin looking for tree tags and plot center rebar. A magnetic locator should be used to aid this process. The plot diagram and tag tree information should also be consulted at this point to aid in location of the center conduit. ***Note:*** *The original data sheet has information on which direction the tag is facing, which could be very helpful should the team have trouble finding the blue tags. This is also the time to update the tag tree DBH and any previously incorrect data on the tag trees.*

4. Once the center conduit is located, place an orange flag in the center conduit and record start time on the datasheet.

5. If the plot coordinates are discovered to be in error (i.e., the GPS did not lead you to the plot or at least close enough that tag trees or other markers are located without difficultly) then a new set of coordinates may need to be taken. However, do not automatically assume the coordinates stored in the GPS are in error. It is possible that satellite coverage may be poor and you may need to provide the GPS additional time to estimate location. It is recommended to move to plot layout, leaving the GPS at the plot center allowing it to continue to locate, before averaging and recording a new set of coordinates for the plot.

Laying Out the Plot

Follow the steps outlined in "Laying Out the Plot" section during Plot Establishment years. For any rebar that cannot be located in a reasonable amount of time, place a flag in the location where crew believes it should be located and attempt to find all the remaining plot rebar before making the decision to drive a new piece of conduit.

Recording Site Characteristics

For plot revisits, information on key environmental data including slope, aspect, terrain shape index (TSI) and landform are reviewed, and new measurements recorded if the original data do not match. However, these attributes very rarely change over the time periods in which we are working. Indicators of disturbance need to be assessed in the same way as a newly established plot, as these measures are independent between sampling years and are important to use as covariate data in the vegetation change analyses.

Equipment List

- Paper copies of maps; printed on Rite in the Rain paper
- GPS plus spare batteries
- Compass
- Datasheets for plot establishment (SECN *Veg Form 1—Vegetation Plot Establishment*) and site-level measurements (SECN *Veg Form 2—Site Characteristics*); one set per plot, plus spare copies; all printed on Rite in the Rain paper with pre-printed information like plot coordinates, directions to the plot, slope, and landform data.
- Pencils
- 12-inch (30.5 cm) long rebar (2–3 per plot) plus pillowcase for rebar transport
- Extra rebar (× 3)
- Permanent plastic surveyor's markers (rebar covers; seven per plot), labeled by subplot and corner
- Claw hammer
- Round numbered aluminum tree tags (#1–1000)
- Wood siding sinker head style aluminum nails
- Diameter tape, metric, fabric
- Open reel fiberglass tape, 50 meters (164 ft; × 4)
- Chaining pins, set of 11 plus Chaining Pin Quiver (× 2)
- Flagging tape (× 24)
- Wire stake flags, bundle
- Magnetic Locator

Table 2. Datasheet field descriptions for SECN *Veg Form 1—Vegetation Plot Establishment.*

Field Name	Field Description
Plot ID	Four letter (Sub) Park acronym plus three-digit GRTS order # (e.g., CONG010). This field will be pre-populated on revisit forms.
Start Date	The date that data collection starts in mm/dd/yyyy format (e.g., 05/17/2019).
Reviewed by	Initials of individual who reviewed completed data sheet for SOP VEG 02 elements. Ideally this should be someone other than individual who completed this portion of datasheet.
Park	For new plots, 4-letter park acronym (i.e., ABLI, CHCH, etc.)
Unit	For parks broken up by management units (CAHA, CALO, CANA, CHAT, CONG, TIMU), list the management unit or enter “N/A”.
QA/QC	Is this a "repeat" data collection effort, as designated by the GIS specialist for quality control purposes? Circle Yes or No.
Start Time	The time of arrival to the plot using local time.
Total Time	Total time needed to complete plot, rounded to nearest quarter hour (e.g., 2 hours and 45 minutes would be 2.75 hours)
Crew	Full name of all involved in the field data collection. Circle the name of the field crew leader (botanist).
GPS file name	For new plots (or revisit plots whose coordinates are incorrect), file name created by field observer in the hand-held GPS (i.e., what did you name the point in the GPS device when you saved it?). Naming convention is <park or sub park acronym><3 digit GRTS order>. (e.g., CUIS079).
GPS model	For new plots (or revisit plots whose coordinates are incorrect), the model of the GPS unit used in the field to acquire coordinates for the plot (e.g., Map 76cs).
GPS Unit ID	For new plots (or revisit plots whose coordinates are incorrect), unique identifier assigned to the GPS unit used in the field (e.g., SECN001, 465, 470). May also use the last 3 digits of the serial number.
Field UTM X	For new plots (or revisit plots whose coordinates are incorrect), the 6-digit latitude of the plot center, also known as easting, as recorded (and saved) in the field with the GPS. (e.g., 579129).
Field UTM Y	For new plots (or revisit plots whose coordinates are incorrect), the 7-digit longitude of the plot center, also known as northing, as recorded (and saved) in the field with the GPS. (e.g., 4116209).
Zone	The UTM zone the plot is located in.
# times averaged	For new plots (or revisit plots whose coordinates are incorrect), utilize the averaging function on the GPS unit, and record the number of iterations or times the point is averaged. Although not always possible it is recommended to allow unit to complete 100 iterations.

Field Name	Field Description
GPS Error	For new plots (or revisit plots whose coordinates are incorrect), record the horizontal error estimate from the GPS (in meters).
Elevation (m)	For new plots (or revisit plots whose coordinates are incorrect), elevation recorded from GPS unit in meters.
WAAS enabled	Yes, No, or Unknown
Directions to Plot	Starting from a road, known trail head, etc. provide detailed directions to aid another crew in returning to the plot. Ideally include GPS coordinates for where your vehicle was parked or where you accessed the area. This field will be pre-populated on revisit forms, correct/update if necessary.
Travel Time from Vehicle	Length of time taken to travel from vehicle to plot, recorded in minutes. This field will be pre-populated on revisit forms, correct/update if necessary.
Permanent Plot Established	For new plots, circle Yes or No; If no, provide criteria/justification for not establishing plot (e.g., on private land, within mowed field, etc.). Use criteria found in SOP VEG 02.
Compass declination	Record the compass declination adjustment setting used on the compass utilized for plot establishment.
Tag #	Number on tag attached to "tag tree" for plot. Ideally these trees (two per plot) should be large and distinctive and within 5m of centroid of plot.
Tag Color	Color of tag attached to tag tree.
Tag Tree Species	Record the 7-character species code of tag tree (e.g., LIRITUL for Tulip Tree, QUERALB for white oak, etc.). This field will be pre-populated on revisit forms, correct if necessary.
DBH of Tag Tree	DBH of tag tree (rounded to nearest cm).
Direction Tag is Facing	Compass bearing (1-360°) the tag is facing. This is determined by standing with tag at your back and compass held out directly in front of you. This field will be pre-populated on revisit forms, correct if necessary.
Direction from Tag Tree to Plot Center.	Compass bearing (1-360°) from tag tree to plot center. Typically plot center marked by rebar stake. Stand with back to tag tree aiming compass at center conduit. This field will be pre-populated on revisit forms, correct if necessary.
Distance from Tag Tree to conduit	Measured distance from tag tree to plot center. Typically plot center marked by rebar stake. Measure to nearest tenth meter. Don't guess, use tape. This field will be pre-populated on revisit forms, correct if necessary.
Plot Layout Notes	Record any unusual plot features or problems encountered during plot setup. Note any problem or irregularities inserting plot markers. This field will be pre-populated on revisit forms, correct/update if necessary.
Plot Diagram	Diagram which is used to add any notes about particularly important plot features such as rock outcrops, trails, etc. Plot conduit locations, tag tree numbers and location of plot photo points. Update/correct if necessary on revisit plots and check "updated" box. Check each soil sample location if soil samples were taken.

Table 3. Datasheet field descriptions for SECN *Veg Form 2—Site Characteristics*.

Field Name	Field Description
Plot ID	Four letter (Sub) Park acronym + three digit GRTS order # (e.g., CONG010). This field will be pre-populated on revisit forms.
Start Date	The date that data collection starts in mm/dd/yyyy format (e.g., 05/17/2019).
Reviewed by	Initials of individual who reviewed completed data sheet for SOP VEG 02 elements. Ideally this should be someone other than individual who completed this portion of datasheet.
Slope (degrees)	Predominant slope of plot measured with compass/clinometer. This field will be pre-populated on revisit forms, correct if necessary.
Aspect (degrees)	Predominant aspect of plot measured with compass. This field will be pre-populated on revisit forms, correct if necessary.
Landform	Circle landform that best characterizes the location of the plot. This field will be pre-populated on revisit forms, correct if necessary.
McNab indices: Terrain Shape Index	Using clinometer, while standing at plot center, record slope in degrees at aspect and then at 45 degree increments around the plot going in clock-wise fashion. This field will be pre-populated on revisit forms, correct if necessary.
Topographic position	Best estimate of topographic position. This field will be pre-populated on revisit forms, correct if necessary.
Indicators of Disturbance	Check all that apply in terms of disturbance indicators. For “Other Indicators”, describe indicator. Record cover % (to nearest 10%) of each indicator.
Plot Submerged (percent)	The overall areal cover of standing water across the plot (to nearest 10%).
Water on Plot (type)	Circle the water type that best characterizes the source of the water.
Notes (related to landform, terrain, position, or disturbance)	Use this box to further describe selections chosen above on datasheet. Do not use this space for plot layout notes.

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Appendix A. Field data forms

SECN Vegetation Monitoring Protocol
Veg Form 1 – Vegetation Plot Establishment

Plot ID _____ (plot acronym + GRTS Order #)

Start Date_____ (mm/dd/yy)

SOP VEG02 – Site Selection, Plot Establishment, and Return Visits Reviewed by: _____

Park _____ Unit _____ QA/QC Plot: Yes or No

Start Time _____ Total Time _____

Crew _____ (circle crew leader)

GPS file name_____GPS model_____GPS Unit ID _____

Field UTM X _____m E Field UTM Y_____m N NAD 83 Zone 16 17 18 (circle one)

times averaged _____ GPS error_____ Elevation: ____ m WAAS enabled Yes or No or Unknown

Directions to plot (Be specific, Including where parked, landmarks used, if any gate keys needed, etc.)

_____

_____

_____

_____

_____

Approximate Travel Time from Vehicle to Plot _____ minutes

Permanent Plot Established (circle one) Yes or No (if no, provide justification below)

_____

_____

Compass Declination _____° (SECN parks range from 4 - 11°)

Tag 1
Tag #_____Tag Color_____

Tag Tree Species_____

DBH of Tag Tree_____cm

Direction Tag is facing (0-360°) _____

Direction from Tag Tree 1 to Plot Center (0-360°)
_____

Distance From Tag Tree 1 to Plot Center
_____.__ (m)

Tag 2
Tag #_____Tag Color _____

Tag Tree Species _____

DBH of Tag Tree_____cm

Direction Tag is facing (0-360°) _____

Direction from Tag Tree 2 to Plot Center (0-360°)
_____

Distance From Tag Tree 2 to Plot Center
_____.__ (m)

office use only (print initials and mm/dd/yy)

Form Validated By_____Form Entered By_____Form Modified By_____
Reason for Modification_____
Data Verified By_____Data Validated By_____Certified Date _____

SECN_Vegetation_Monitoring_Protocol
Data_Form_20190306

1

Figure A-1. Sample of SECN Veg Form 1—Vegetation Plot Establishment page 1 of 2.

SECN Vegetation Monitoring Protocol **Plot ID** _____ **Start Date**_____
Veg Form 1– Vegetation Plot Establishment **(plot acronym + GRTS Order #)** **(mm/dd/yy)**

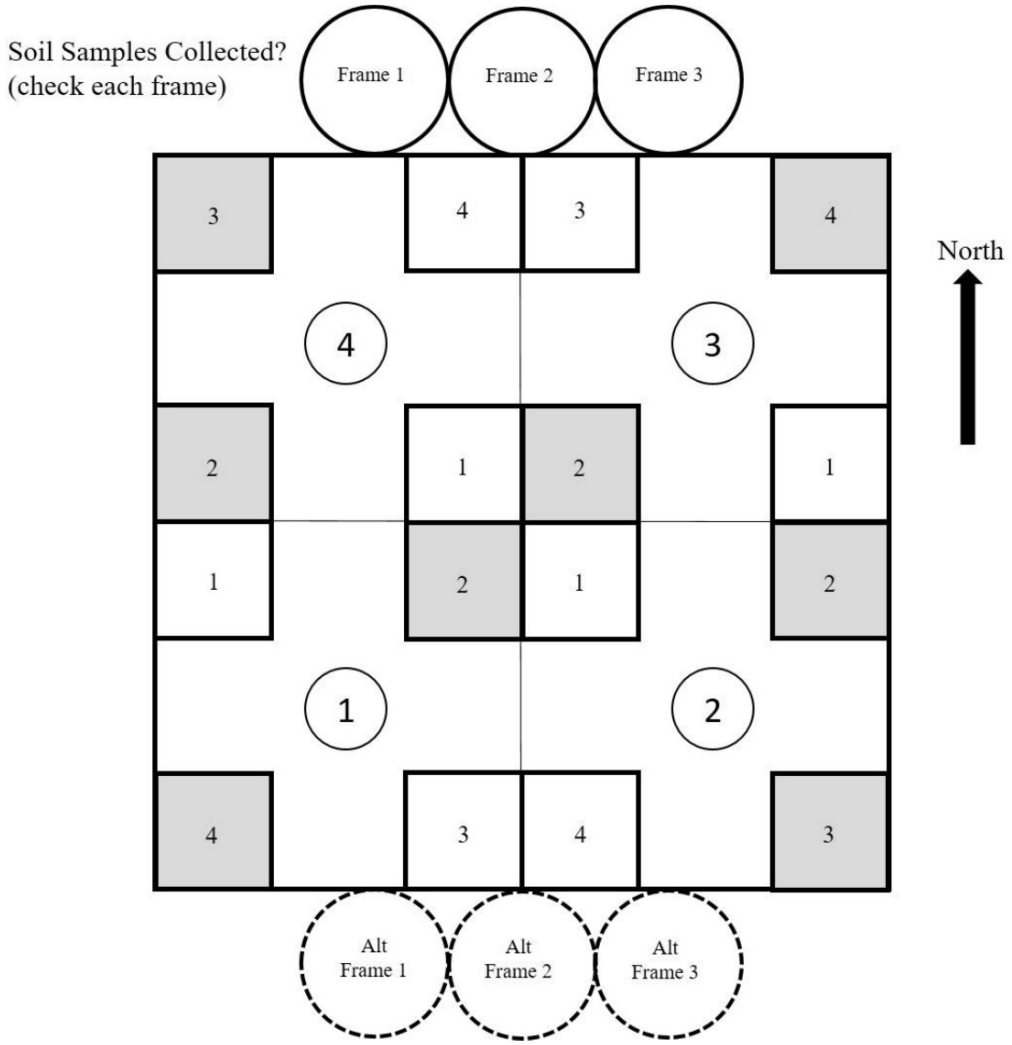
Plot Layout Notes (Unusual plot features, irregularities, or was plot moved?) _____

_____

_____

_____

_____



SECN_Vegetation_Monitoring_Protocol
Data_Form_20190306

Figure A-2. Sample of SECN *Veg Form 1—Vegetation Plot Establishment* page 2 of 2.

SECN Vegetation Monitoring Protocol
Veg Form 2 Site Characteristics

Plot ID _____ (plot acronym + GRTS Order #)

Start Date_____ (mm/dd/yy)

SOP VEG02 – Site Selection, Plot Establishment, and Return Visits

Reviewed By:_____

Slope (degrees): _____

Aspect (degrees): _____

Landform (circle one)

interfluve	**flat plain**
gap/saddle	**tidal flat**
side slope	**ravine**
slope bench	**seep/swale**
fan piedmont	**alluvial plain**
cove	**levee**
escarpment/face	**channel shelf**
bedrock outcrop	**backswamp**
debris slope	**basin/sag pond**
rolling upland	

Other _____

Topographic Position (check one)

- ☐ **Interfluve (crest, ridge, summit)**
- ☐ **High slope (shoulder, upper, convex)**
- ☐ **High level**
- ☐ **Midslope**
- ☐ **Backslope (cliff)**
- ☐ **Step in slope**
- ☐ **Lowslope (lower, foot, colluvial)**
- ☐ **Toeslope**
- ☐ **Low level (terrace)**
- ☐ **Channel wall (bank)**
- ☐ **Channel bed (valley bottom)**
- ☐ **Basin floor (depression)**
- ☐ **Other** _____

MCNAB INDICES (degrees) + for upslope/-for down	**TSI: Terrain Shape Index (site microtopography)**
At aspect	
45°	
90°	
135°	
180°	
225°	
270°	
315°	

Indicators of Disturbance (check all that apply)	**Cover (nearest 10%)**
☐ **Open grown canopy tree in plot**	_____
☐ **Sign of homesite/barn/cemetary present**	_____
☐ **Sign of fire within past year**	_____
☐ **Sign of historic fire (> 1 year ago)**	_____
☐ **Sign of heavy deer browse**	_____
☐ **Sign of feral hog damage**	_____
☐ **Sign of recent or historic logging (stumps)**	_____
☐ **Sign of historic plowing (ruts, terraces)**	_____
☐ **Sign of historic pasturing (barbed wire)**	_____
☐ **Heavy erosion along streams**	_____
☐ **Other indicators**_____	_____
☐ **None**	

Is plot submerged Y / N (circle one); if yes, report % (to the nearest 10%)_____

Water on Plot Code (see below for description of codes) _____

0 None—no water sources on plot
1 Permanent streams or ponds
2 Permanent water in the form of deep swamps, bogs, marshes
3 Ditch/canal—human-made channels such as for irrigation or drainage
4 Temporary streams
5 Flood zones—evidence of flooding when bodies of water exceed their natural banks
6 Vernal pool
7 Other water—specify in Plot Notes

Notes (related to landform, terrain position, or disturbance):

SECN_Vegetation_Monitoring_Protocol
Data_Form_20190306

3

Figure A-3. Sample of SECN *Veg Form 2—Site Characteristics*.

Appendix B. Modifications to CUPN SOP 2 and SOP 3 for SECN SOP 1.4.10

The SOP 2 *Using GPS (Based on use of the Garmin Map 76 or Map 78—Version 1.2* and SOP 3 *Site Selection and Plot Establishment—Version 1.3* of the *Cumberland Piedmont Network Vegetation Monitoring Protocol* (White et al. 2011) were modified to create this SOP. The major modifications to these SOPs are listed and explained below.

Combination of SOP 2 and 3

The Cumberland Piedmont Network wrote a separate SOP describing the use of Garmin GPS units. Because of the linkage between GPS use, navigating to plots, and recording of plot location information in the field, the Southeast Coast Network decided to combine these into a single SOP.

Changes to Plot Selection Approach

The Cumberland Piedmont Network approach to plot selection focuses on park-wide inference for forest and woodland habitats, whereas that of the Southeast Coast Network focuses on whole parks (at nine of fifteen parks) or targeted units within parks (at six of fifteen parks) that are deemed by parks as high-priority. Natural and semi-natural habitats to sample in the Southeast Coast Network include forests, woodlands, shrublands, and herbaceous habitats.

Broadly Defined Habitat Stratification

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

Plot Sizes and Shape are Fixed

Plot sizes can be modified from a standard 20 × 20-meter (65.6 × 65.6 ft) shape to either a 20 × 10-meter (65.4 × 32.8 ft) or 10 × 10-meter (32.8 × 32.8 ft) array to fit the plot in the targeted sampling frame in the CUPN SOP 3. The Southeast Coast Network has chosen to maintain a consistent plot size and array (20 × 20 meter) across all parks and habitats to more accurately assess status and trends of vegetation across park-wide and landscape-wide scales. This technique removes the inherent sampling error attributed to differing scales of inference (e.g., smaller plots have a lower error rate of species detection than larger plots).

Plot Center Establishment

The Southeast Coast Network uses the GPS and pacing procedure outlined by the Northeast Temperate Network (Tierney et al. 2016), where once the handheld GPS is within 15 meters (49.2 ft) of the centroid, the crew member responsible for navigation moves ten steady paces in the direction

that the GPS identifies. The CUPN protocol suggests that the crew navigate as close to the point as time allows.

No Restricted Categories

Southeast Coast Network plots must be shifted up to 10 meters (32.8 ft) if any portion of the plots occurs within a restricted category, rather than if more than ¼ of the plot occurs in a restricted category in the Cumberland Piedmont Network.

Additional Site Characteristics Pertaining to Water

The CUPN vegetation monitoring approach focuses on upland forests and woodlands, while the SECN approach focuses on all natural and semi-natural vegetation types, including wetlands. Because of this, the Southeast Coast Network has adopted additional site characteristic measurements from the Gulf Coast Network vegetation monitoring protocol (Carlson et al. 2018). These are a description of the percentage of water on the plot, and a water on plot qualitative descriptor.

Cover Estimates for Disturbance Indicators

The CUPN records presence of disturbance indicators on its forest monitoring plots without calculating an estimated coverage of each indicator. The SECN approach estimates a plot-level percent cover for each disturbance indicator observed on each vegetation plot. Although these estimates may be imprecise, compared with data taken from vegetation richness and cover and woody stem density, they can provide a categorical importance estimate (low, medium, high) of each disturbance indicator.

Three Fuel Load Transects are 25 meters (82 ft) in Length

The Cumberland Piedmont Network records Coarse Woody Debris (CWD) along two 40-meter (131.2-ft) transects that cross the primary vegetation plot. The Southeast Coast Network has chosen to employ the transect design of the FEAT/FIREMON Integrated (FFI) fuels monitoring system (Lutes et al. 2009) to account for additional fuel types that are more meaningful to fire behavior in the Southeastern Coastal Plain—duff or litter, fine, as well as coarse woody debris, and fuel bed size. Following the FIREMON protocol (Lutes et al. 2006), the Southeast Coast Network has chosen to record fuel load variables across three 25-meter (82-ft) long transects. Transects are arranged spatially in the pattern used by the Northeast Temperate Network (Tierney et al. 2016).

Appendix B Literature Cited

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Appendix C. Southeast Coast Network Park Sampling Frames and Plot Locations

Summary

This appendix outlines the plot selection methodology, spatial sampling frames and proposed plot locations for the 15 National Parks and Preserves covered by *Terrestrial Vegetation Monitoring in Southeast Coast Network Parks: Protocol Implementation Plan* (Boyle et al. 2019). The processes and procedures of frame and polygon creation, plot placement, and plot allocation are described in this document. Additional details and justifications are provided in the Protocol Implementation Plan (Boyle et al. 2019) and this SOP. Tables C-1, C-2, and C-3 include a preliminary assessment of the broadly defined habitat types in each park that are represented by monitoring plots. Figures C-1 to C-15 depict target units and randomly-located points within parks, including 343 primary plot locations plus 343 alternate/replacement plots, and 200 secondary plot locations. Each park is represented as one figure, either in a composite image of units within the park 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 preliminarily removed non-target land use and vegetation cover polygons from shapefiles generated by vegetation mapping inventory reports done on SECN parks from 1998 to 2018 (see Table 2 in Boyle et al. 2019). The resulting shapefiles represented, to the best of the network's knowledge, all natural and semi-natural broadly defined habitat types for SECN parks, excluding open water and low salt marsh habitats. Input was solicited in November and December 2018 from park staff to determine if the sampling frames for their parks represented these vegetation types or if polygons should be removed based on other reasons (e.g., sensitive cultural or archeological sites; non-administrative areas). In all parks, the primary sampling frame was essentially all dominant and co-dominant broadly defined habitat types within the park's administrative boundary, allowing the opportunity for habitat-wide inference within these types (excluding a 14-meter (46 ft) buffer around park and broad habitat boundaries). Dominant habitats represent greater than 60% of the aerial coverage of the pre-defined non-excluded broadly defined habitat types, while co-dominant habitats represent greater than 30% of the coverage. The secondary sampling frame was any broad habitat type that covers between 1 and 30% of the park's pre-defined non-excluded types. In five parks, the sampling frame was further subdivided into geographically isolated units (CAHA, CALO, CANA, CHAT, and TIMU); in one park, the sampling frame was divided into a wetland and upland unit because of their clear geological separation (CONG). Broad habitat types that cover less than 1% of the park's pre-defined non-excluded types are not a focus of this monitoring effort, unless park-level needs arise.

Sample sizes within parks, park-units, and habitat types

The Southeast Coast Network estimates field crews can target monitoring efforts within 80–142 vegetation plots per year, sampling up to 543 plots over four years across all fifteen national parks. A total of 343 (82 in Year 1, 91 in Year 2, 90 in Year 3, and 80 in Year 4) of these plots occur in

dominant or co-dominant broadly defined habitat types and are the primary focus of this monitoring effort. The remaining 200 (60 in Year 1, 48 in Year 2, 24 in Year 3, and 68 in Year 4) plots are located in the secondary sampling frame. These plots are the secondary focus of this monitoring effort, and are sampled only if time and resources allow. An additional 5% of the primary-focus plots are resampled every year for quality assurance and quality control measures. Finally, another 13 plots are located in habitat types that cover less than 1% of the park or park-unit's pre-defined non-excluded habitat types. However, unless park-level needs arise to sample these plots, they are not sampled. The sample size of these 'index' style plots is 1/habitat type and is not useful for detecting meaningful trends in vegetation at the park level over time.

Southeast Coast Network staff decided that plots should not be divided evenly among parks, because parks differed greatly in area and the number and size of broadly defined habitat types. Thus, the number of plots was allocated based on park (or park-unit) and broadly defined habitat sizes, within a lower limit of four plots per dominant and co-dominant habitat type in the smallest network parks. For network parks and park-units greater than 100 hectares (247 acres [ac]), sampling intensity was set at 1–5 plots per 100 hectares within each dominant and co-dominant habitat type, which was achieved in all but one single habitat type within a park-unit (CONG-Wetland, see Table 6 in Boyle et al. 2019). This sampling intensity is similar to efforts described in the NETN forest monitoring protocol (Tierney et al. 2016). The complete scaling rules for sample size determination were as follows:

<u>For each dominant and co-dominant habitat types within a park or park-unit of</u>

- greater than 800 hectares (1,977 ac), sample intensity was set at 1–2 plots per 100 hectares
- 500–800 hectares (1,236–1977 ac), sample intensity was set at 1–3 plots per 100 hectares
- 100–500 hectares (247–1,236 ac), sample intensity was set at 1–5 plots per hectare
- 20–100 hectares (49.4–247 ac), sample size was set at 5 plots
- less than 20 hectares (49.4 ac), sample size was set at 4 plots

<u>For each secondary-focused habitat type (1–30% coverage) within a park or park unit</u>

- sample size was set at 4 plots

<u>For each index-focused habitat type (< 1% coverage) within a park or park unit</u>

- sample size was set at 1 plot

Sample size allocation is shown in Tables C-1, C-2, and C-3. Maritime upland forests account for the highest percentage (24%, 81 of 343) of primary plot locations across the SECN parks. Other dominant and co-dominant habitats well-represented by plots include maritime open uplands (e.g.,

fore- and back dune vegetation) (20%, 68 of 343), Coastal Plain alluvial wetlands (20%, 67 of 343), maritime tidal wetlands (other than low marsh) (9%, 30 of 343), and Piedmont upland forests (8%, 29 of 343). Other dominant and co-dominant broadly defined habitats with plots allocated to them include maritime nontidal wetlands (e.g. dune swales), and Coastal Plain open uplands and woodlands (e.g., longleaf pine flatwoods). Successional/semi-natural vegetation types across all three physiographic provinces are also well-represented by plots (13%, 46 of 343).

Several broad habitat types located on SECN parks and park-units include only secondary-focus plots. These include Coastal Plain and Piedmont nonalluvial wetlands (e.g., depression wetlands), Coastal Plain upland forests, invasive vegetation types, Piedmont alluvial wetlands, and Piedmont open uplands.

Table C-1. Broad-scale habitat types of the proposed plot locations for Southeast Coast Network vegetation monitoring in North Carolina, based on park-specific vegetation maps. Maritime open uplands include foredune and back dune ecosystems; maritime nontidal wetlands include swales within back dune ecosystems.

Physio-graphic Province	Habitat Type	CAHA Bodie Island	CAHA Buxton	CAHA Hatteras	CAHA Ocracoke	CALO Cape Lookout	CALO N. Core Banks	CALO S. Core Banks	CALO Shackleford Banks	MOCR	Total
Coastal Plain	Alluvial Wetlands	–	–	–	–	–	–	–	–	5[a]	5
	Nonalluvial Wetlands	–	–	–	–	–	–	–	–	4[b]	4
	Semi-natural/ Successional	–	–	–	–	–	–	–	–	5[a]	5
Maritime	Tidal Wetlands – other	4[b]	8[a]	4[b]	6[a]	4[b]	8[a]	4[b]	4[b]	–	42
	Nontidal Wetlands	–	–	–	–	4[b]	1[c]	–	1[c]	–	6
	Open Uplands	8[a]	8[a]	8[a]	8[a]	6[a]	10[a]	8[a]	8[a]	–	64
	Upland Forests and Shrublands	1[c]	4[b]	1[c]	1[c]	4[b]	1[c]	4[b]	–	–	16
	Semi-natural/ Successional	4[b]	4[b]	4[b]	4[b]	–	–	–	–	–	16
Totals	**Primary**	**8**	**16**	**8**	**14**	**6**	**18**	**8**	**8**	**10**	**96**
	Secondary	**8**	**8**	**8**	**4**	**12**	–	**8**	**4**	**4**	**56**
	Index	**1**	–	**1**	**1**	–	**2**	–	**1**	–	**6**

[a] Primary plots

[b] Secondary plots

[c] Index plots

Table C-2. Broad-scale habitat types of the proposed plot locations for Southeast Coast Network vegetation monitoring in Florida and South Carolina, based on park-specific vegetation maps. Maritime open uplands include foredune and back dune ecosystems; maritime nontidal wetlands include swales within back dune ecosystems; Coastal Plain open uplands and woodlands include fire-maintained longleaf pine flatwoods and savannas.

Physio-graphic Province	Habitat Type	CANA Apollo Beach	CANA Oak Hill	CONG Uplands	CONG Wetlands	FOMA	FOSU	TIMU Cedar Point	TIMU T. Roosevelt	TIMU Thomas Creek	Total
Coastal Plain	Alluvial Wetlands	–	–	–	56[a]	–	–	–	4[b]	4[b]	64
	Nonalluvial Wetlands	–	–	–	4[b]	–	–	–	–	–	4
	Open Uplands and Woodlands	4[b]	8[a]	4[b]	–	–	–	–	1[c]	–	17
	Semi-natural/ Successional	–	–	8[a]	4[b]	–	–	–	–	–	12
Maritime	Tidal Wetlands – other	–	1[c]	–	–	–	–	–	–	4[b]	5
	Nontidal Wetlands	8[a]	6[a]	–	–	–	–	4[b]	4[b]	4[b]	26
	Open Uplands	1[c]	4[b]	–	–	4[b]	4[a]	–	–	–	13
	Upland Forests and Shrublands	4[b]	4[b]	–	–	5[a]	4[a]	8[a]	7[a]	8[a]	40
	Invasive Vegetation	4[b]	4[b]	–	–	–	4[b]	–	–	–	12
Totals	**Primary**	**8**	**14**	**8**	**56**	**5**	**8**	**8**	**7**	**8**	**122**
	Secondary	**12**	**12**	**4**	**8**	**4**	**4**	**4**	**8**	**12**	**68**
	Index	**1**	**1**	–	–	–	–	–	**1**	–	**3**

[a] Primary plots

[b] Secondary plots

[c] Index plots

Table C-3. Broad-scale habitat types of the proposed plot locations for Southeast Coast Network vegetation monitoring in Alabama and Georgia, based on park-specific vegetation maps. Maritime open uplands include foredune and back dune ecosystems; maritime nontidal wetlands include swales within back dune ecosystems; Coastal Plain open uplands and woodlands include fire-maintained longleaf pine flatwoods and savannas.

Physio-graphic Province	Habitat Type	CHAT Mid	CHAT North	CHAT South	CUIS	FOFR	FOPU	HOBE	KEMO	OCMU	Total
Coastal Plain	Alluvial Wetlands	–	–	–	–	–	–	–	–	6[a]	6
	Open Uplands and Woodlands	–	–	–	4[b]	–	–	–	–	–	4
	Upland Forests	–	–	–	–	–	–	–	–	4[b]	4
	Semi-natural/ Successional	–	–	–	–	–	–	–	–	4[b]	4
Maritime	Tidal Wetlands – other	–	–	–	4[b]	4[b]	8[a]	–	–	–	12
	Nontidal Wetlands	–	–	–	4[b]	–	–	–	–	–	4
	Open Uplands	–	–	–	4[b]	–	–	–	–	–	4
	Upland Forests and Shrublands	–	–	–	44[a]	5[a]	4[b]	–	–	–	53
	Semi-natural/ Successional	–	–	–	1[c]	5[a]	1[c]	–	–	–	7
Piedmont	Alluvial Wetlands	4[b]	4[b]	4[b]	–	–	–	4[b]	4[b]	–	20
	Nonalluvial Wetlands	–	–	1[c]	–	–	–	4[b]	1[c]	–	6
	Open Uplands	–	–	–	–	–	–	4[b]	4[b]	–	8
	Upland Forests	6[a]	7[a]	8[a]	–	–	–	4[b]	8[a]	4[b]	37
	Semi-natural/ Successional	5[a]	7[a]	4[b]	–	–	–	8[a]	8[a]	–	32
Totals	**Primary**	11	14	8	44	10	8	8	16	6	125
	Secondary	4	4	8	16	4	4	16	8	12	76
	Index	–	–	1	1	–	1	–	1	–	4

[a] Primary plots

[b] Secondary plots

[c] Index plots

Park Maps

Figures C-1 to C-15 depict the targeted sampling frames within each SECN park-unit and the randomly located points that were selected for vegetation monitoring. Across all figures, the primary GRTS identified selected plot locations are shown as blue circles, primary GRTS identified alternate plot locations are shown as pink triangles, and secondary plots (GRTS identified select and alternate) are shown as white squares. Area (in hectares) is provided for each park-unit, and represents the total of each sampling frame (non-excluded broad habitat types). North is towards the top of each map page.

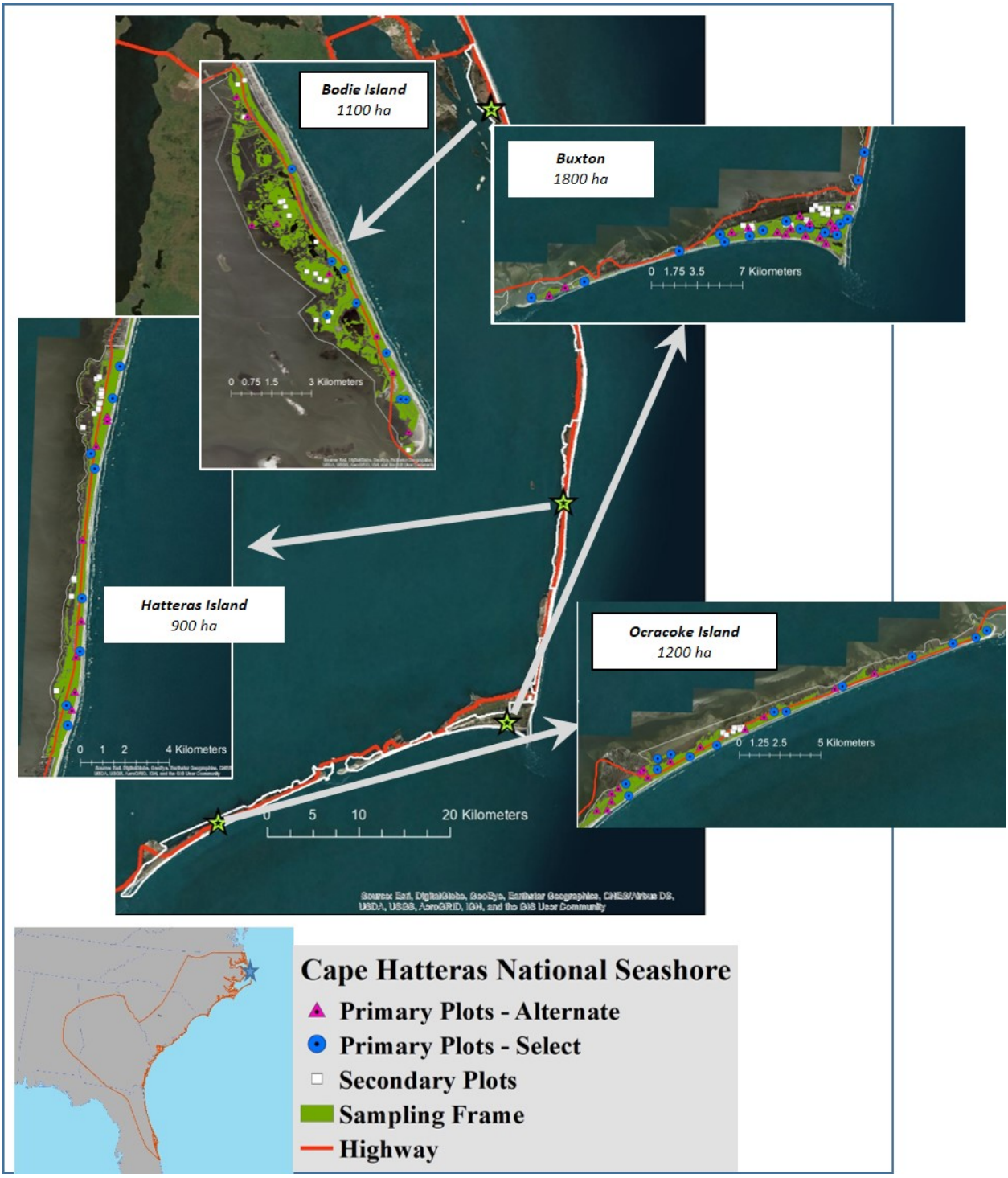

Figure C-1. Sampling frame and proposed plot locations for the Cape Hatteras National Seashore in northeastern North Carolina. There are 46 primary plots, 28 secondary plots, and 3 index plots (not shown) for the park. Vegetation sampling will focus on four target management units within the seashore, 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.

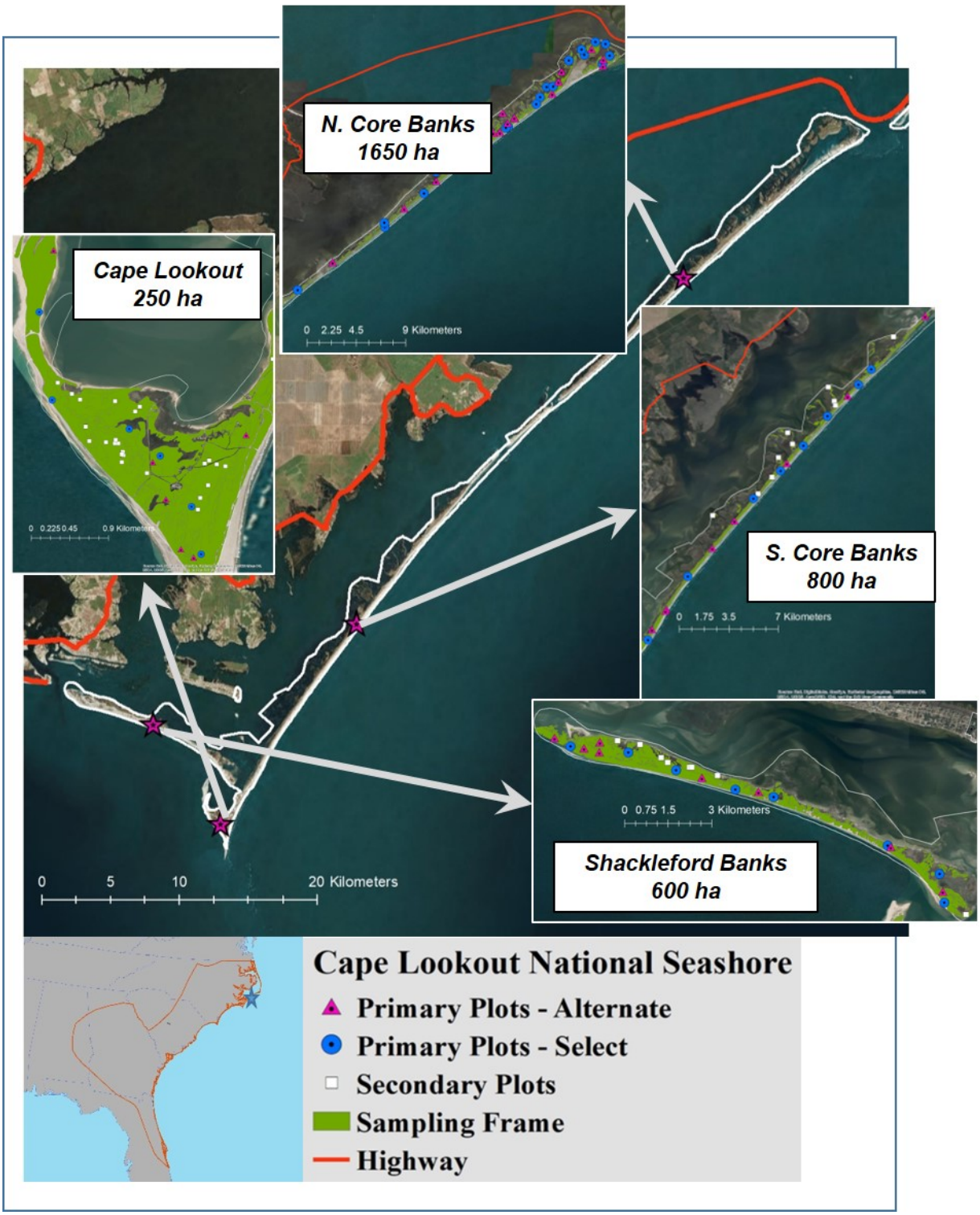

Figure C-2. Sampling frame and proposed plot locations for the Cape Lookout National Seashore in northeastern North Carolina. There are 40 primary plots, 24 secondary plots, and 3 index plots (not shown) for the park. Vegetation sampling will focus on four target management units within the seashore, 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.

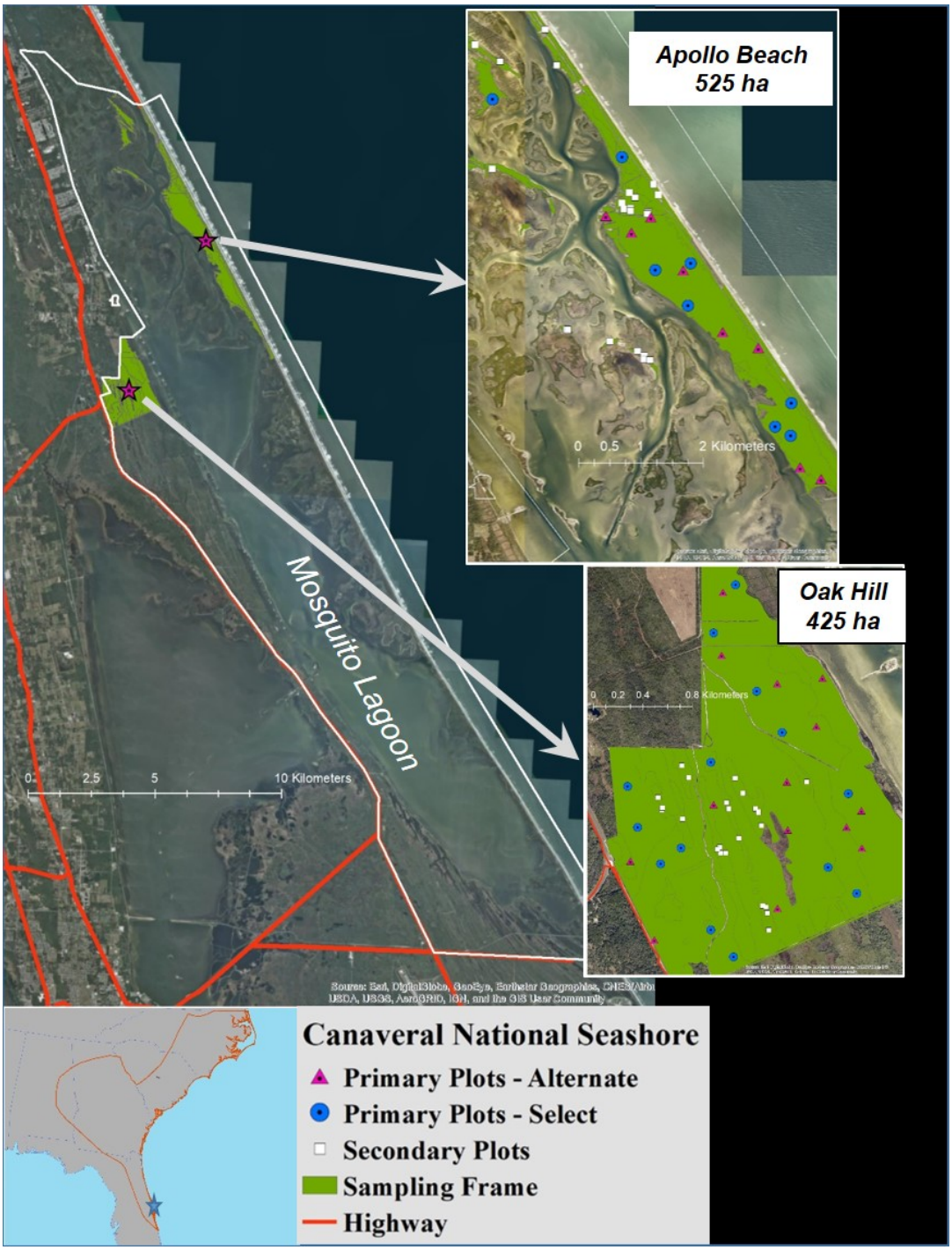

Figure C-3. Sampling frame and proposed plot locations for the Canaveral National Seashore in central Florida. There are 22 primary plots, 24 secondary plots, and 2 index plots (not shown) for the park. Vegetation sampling will focus on two target management units within the seashore, which were identified through input from park management. Plots are distributed only on areas that are solely administered by the National Park Service; the majority of the acreage within Mosquito Lagoon and the south is co-administered by NASA and US Fish and Wildlife Service. Park staff chose to not implement vegetation monitoring on these sites.

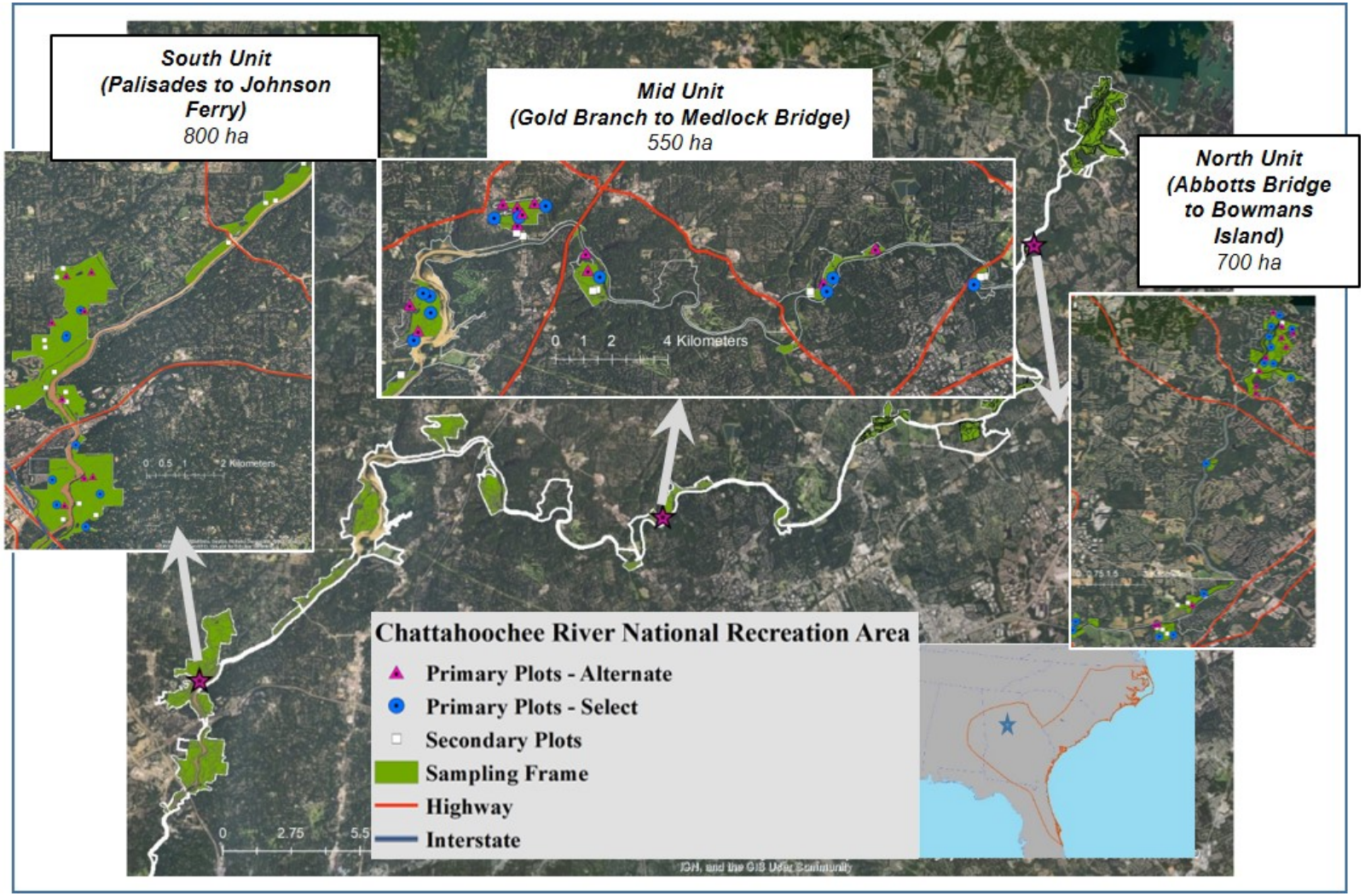

Figure C-4. Sampling frame and proposed plot locations for the Chattahoochee River National Recreation Area in northern Georgia. There are 33 primary plots, 16 secondary plots, and 1 index plot (not shown) for the park. Vegetation sampling will focus on three target management units within the recreation area, 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.

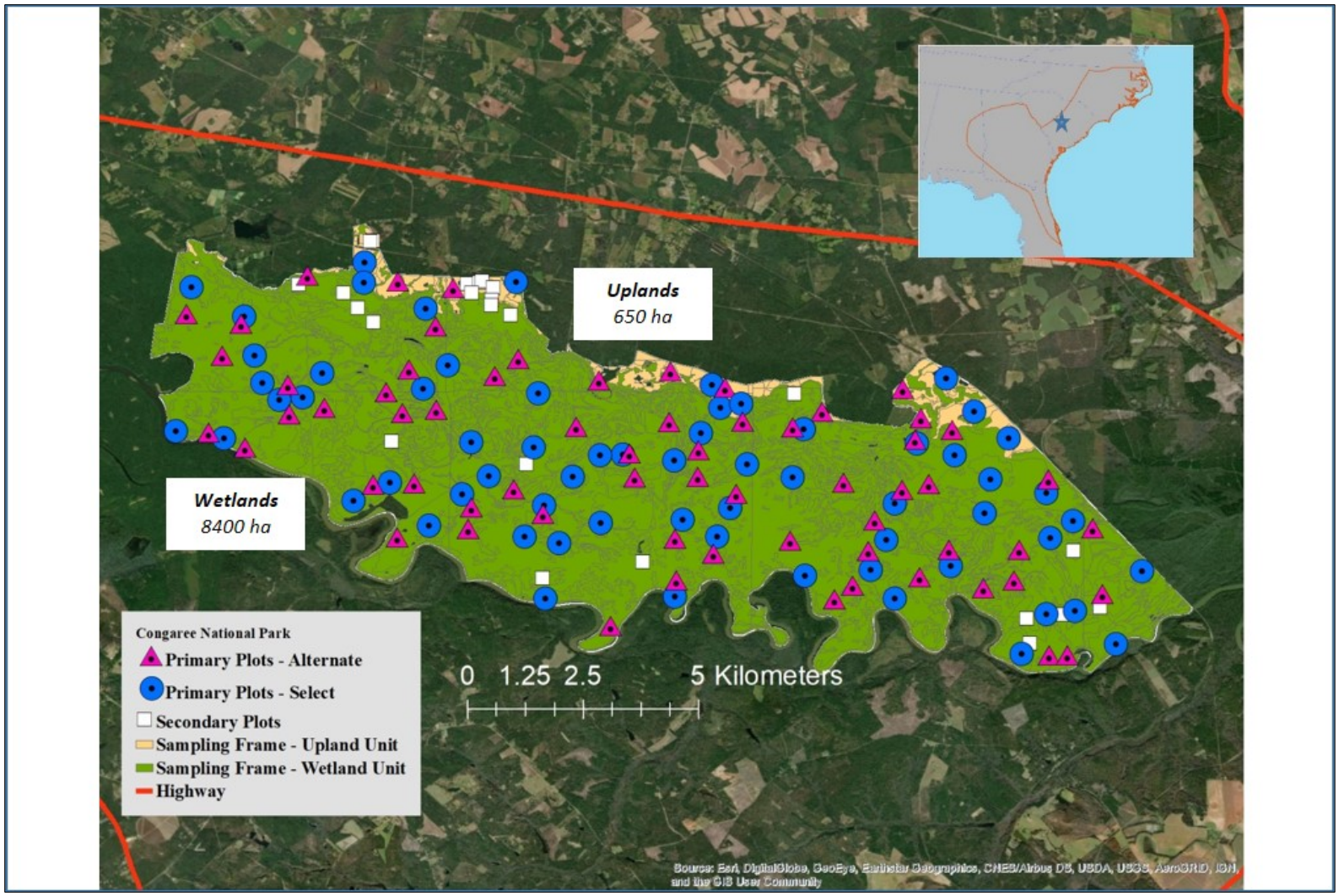

Figure C-5. Sampling frame and proposed plot locations for the Congaree National Park in central South Carolina. There are 64 primary plots and 12 secondary plots for the park. Vegetation sampling will focus on two target management units—uplands and wetlands—within the park, which were identified through input from park management.

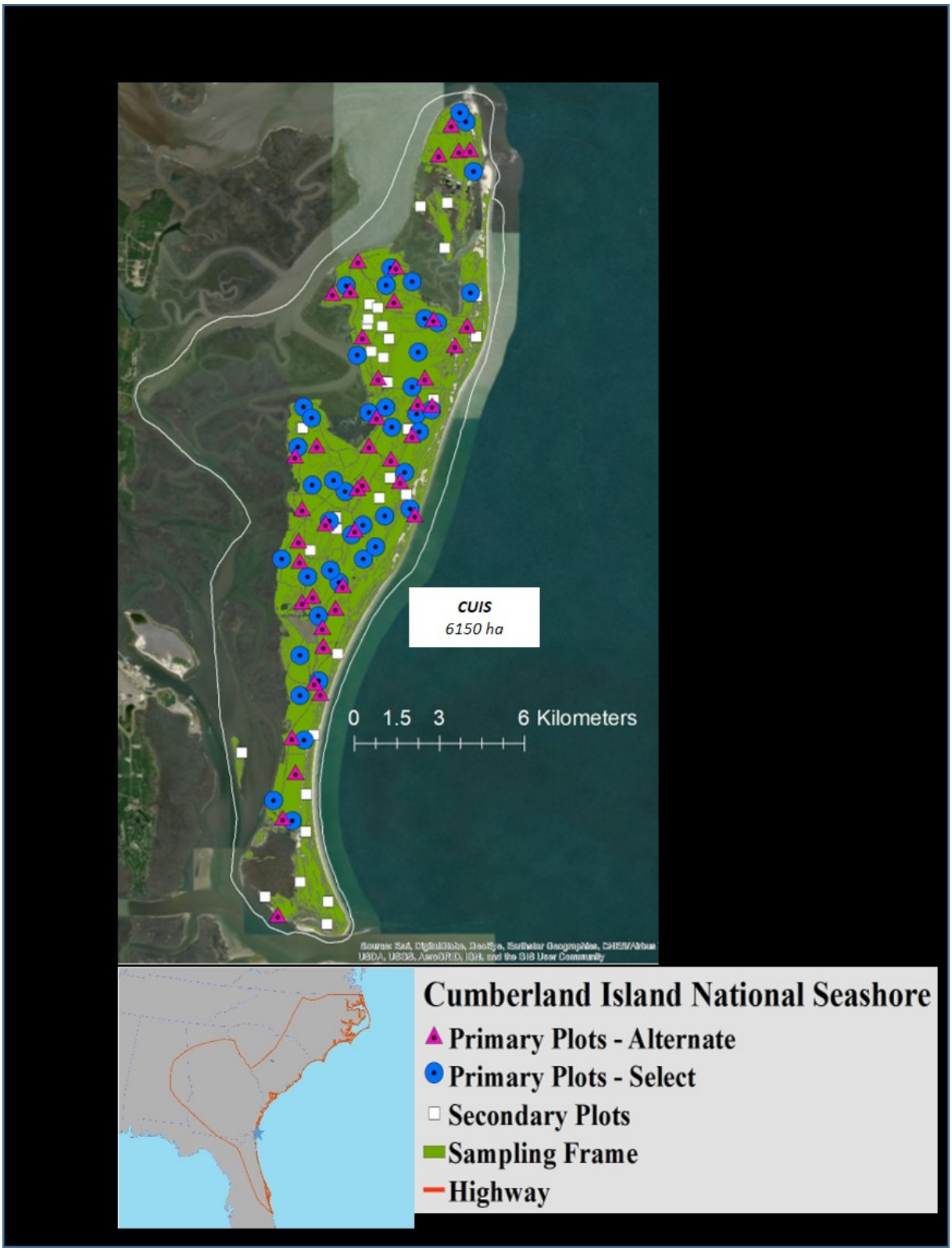

Figure C-6. Sampling frame and proposed plot locations for the Cumberland Island National Seashore in southeastern Georgia. There are 44 primary plots, 16 secondary plots, and 1 index plot (not shown) for the park.

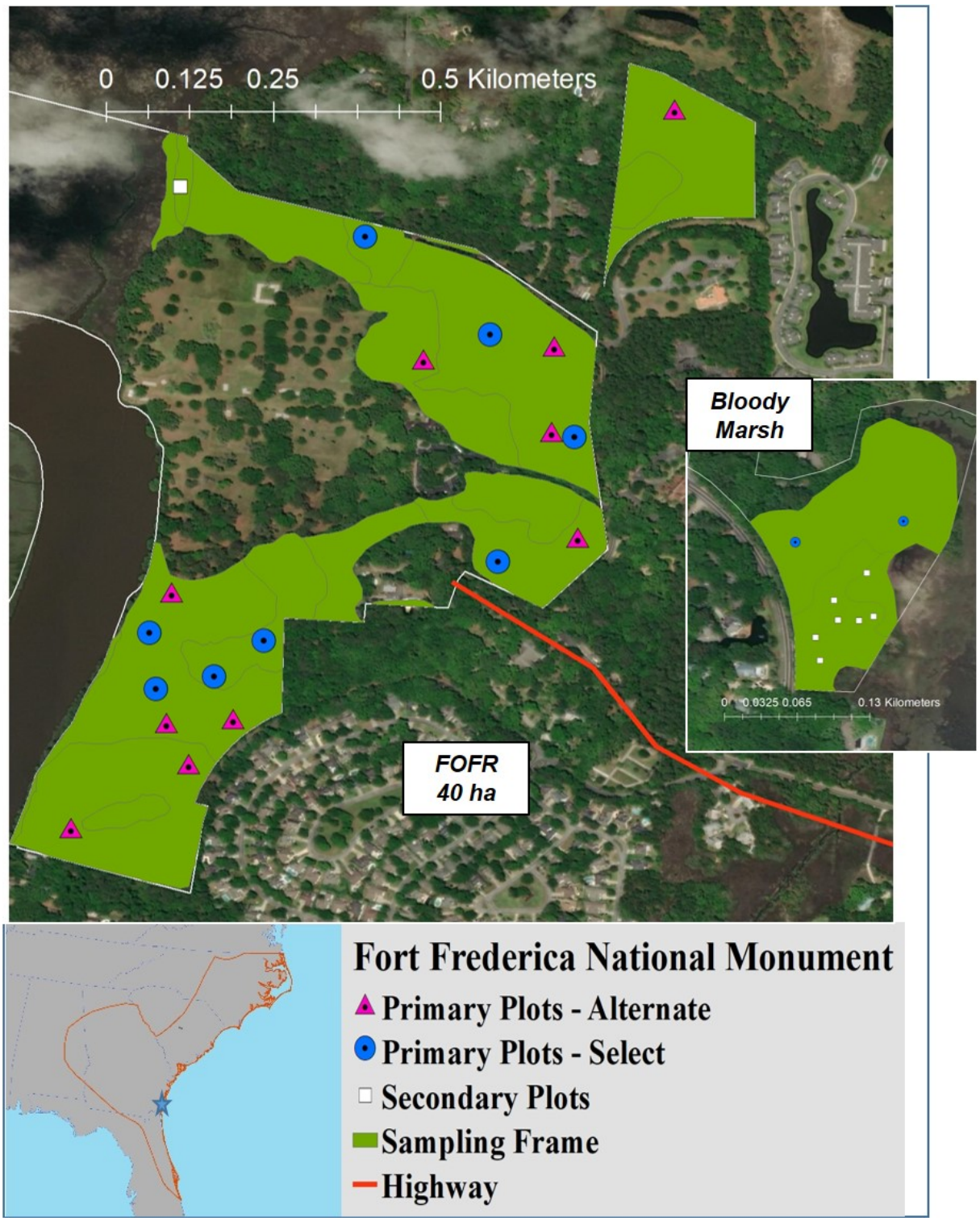

Figure C-7. Sampling frame and proposed plot locations for the Fort Frederica National Monument in southeastern Georgia. There are 10 primary plots and 4 secondary plots located on the park. Plots are randomly located across the park, including two primary plot locations at the remote Bloody Marsh Unit of the Monument.

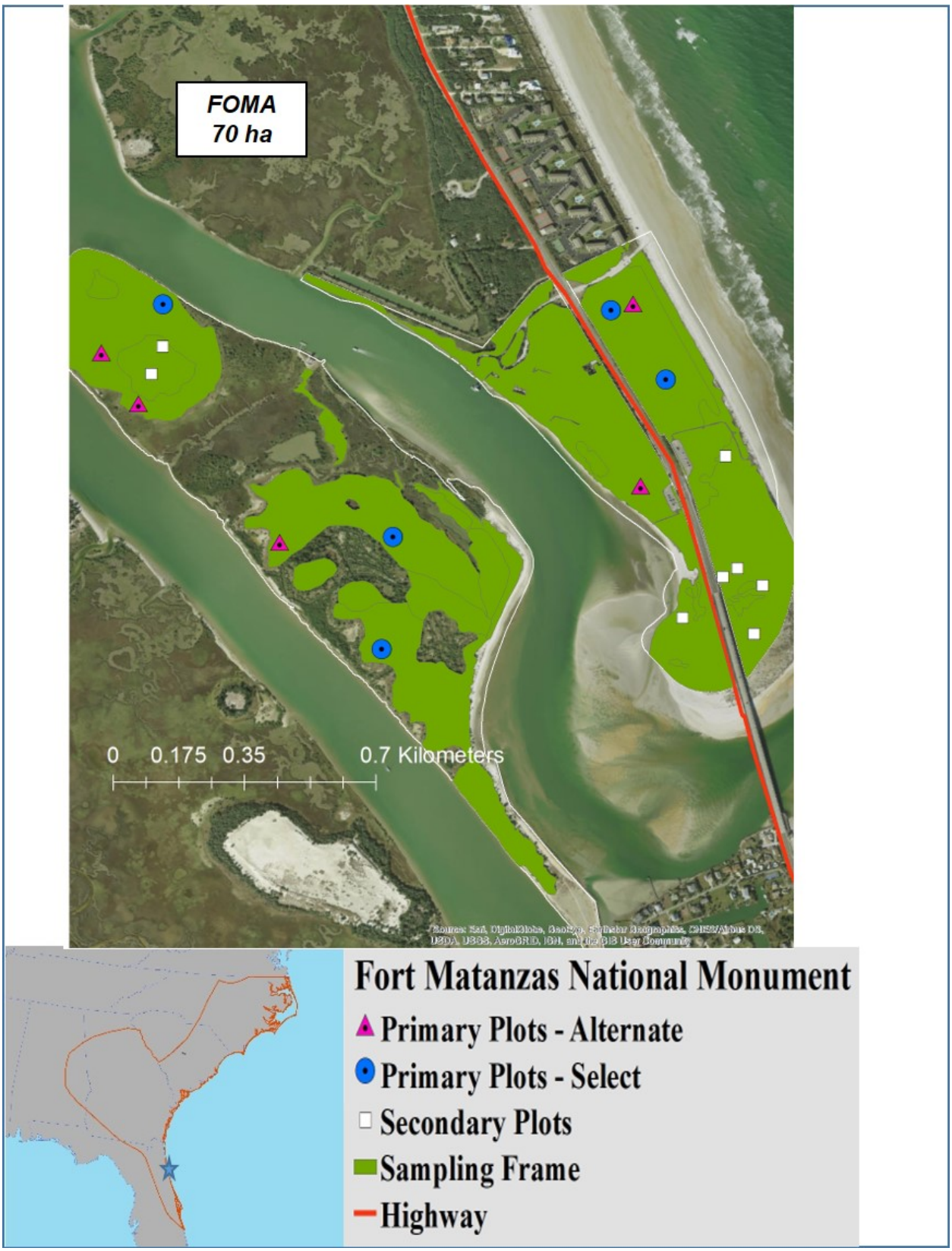

Figure C-8. Sampling frame and proposed plot locations for the Fort Matanzas National Monument in northeastern Florida. There are 5 primary plots and 4 secondary plots located on the park.

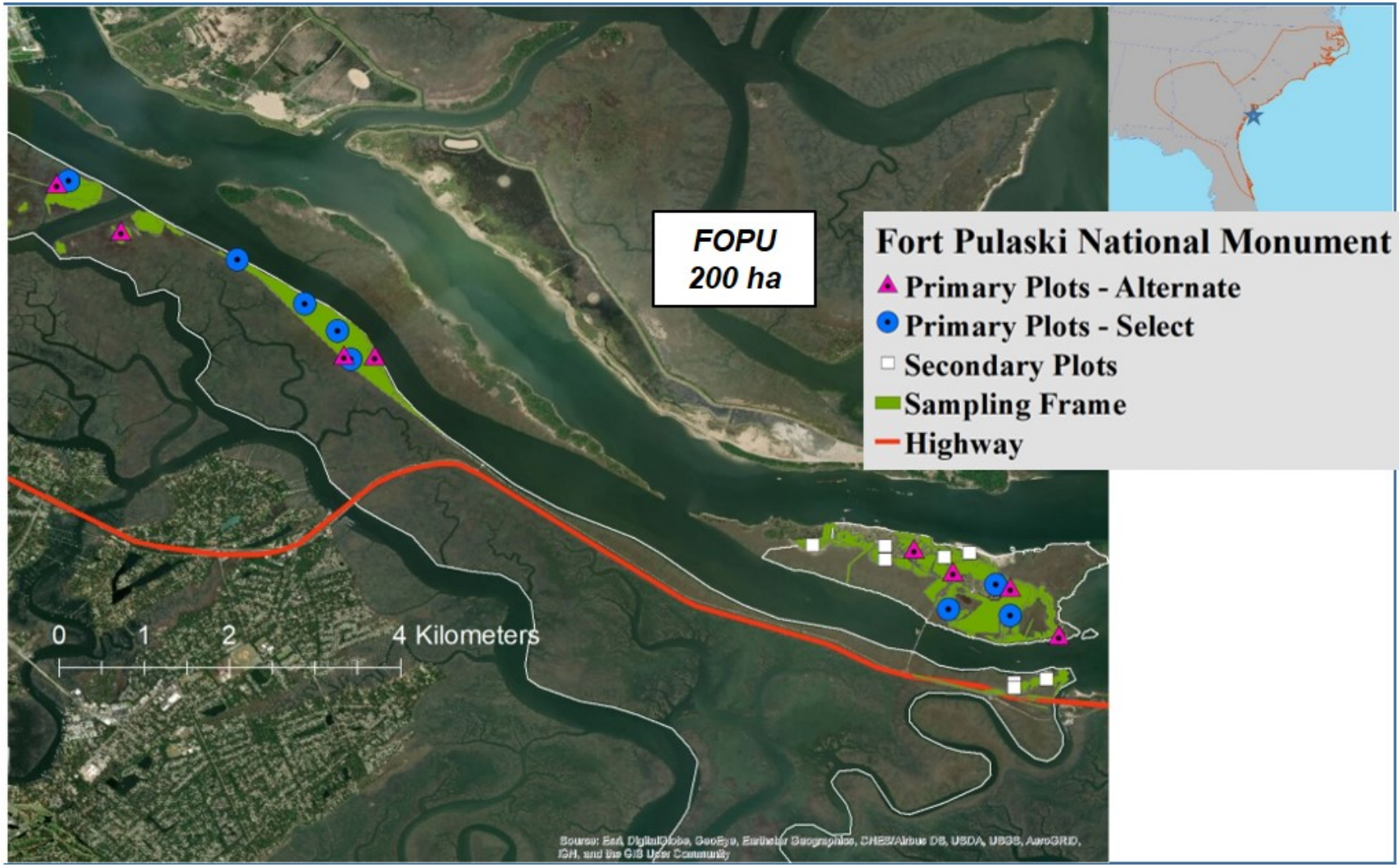

Figure C-9. Sampling frame and proposed plot locations for the Fort Pulaski National Monument in coastal Georgia. There are 8 primary plots, 4 secondary plots, and 1 index plot (not shown) for the park.

Figure C-10. Sampling frame and proposed plot locations for the Fort Sumter National Monument in coastal South Carolina. There are 10 primary plots and 10 alternate plots for the park. Plots are randomly located across the park.

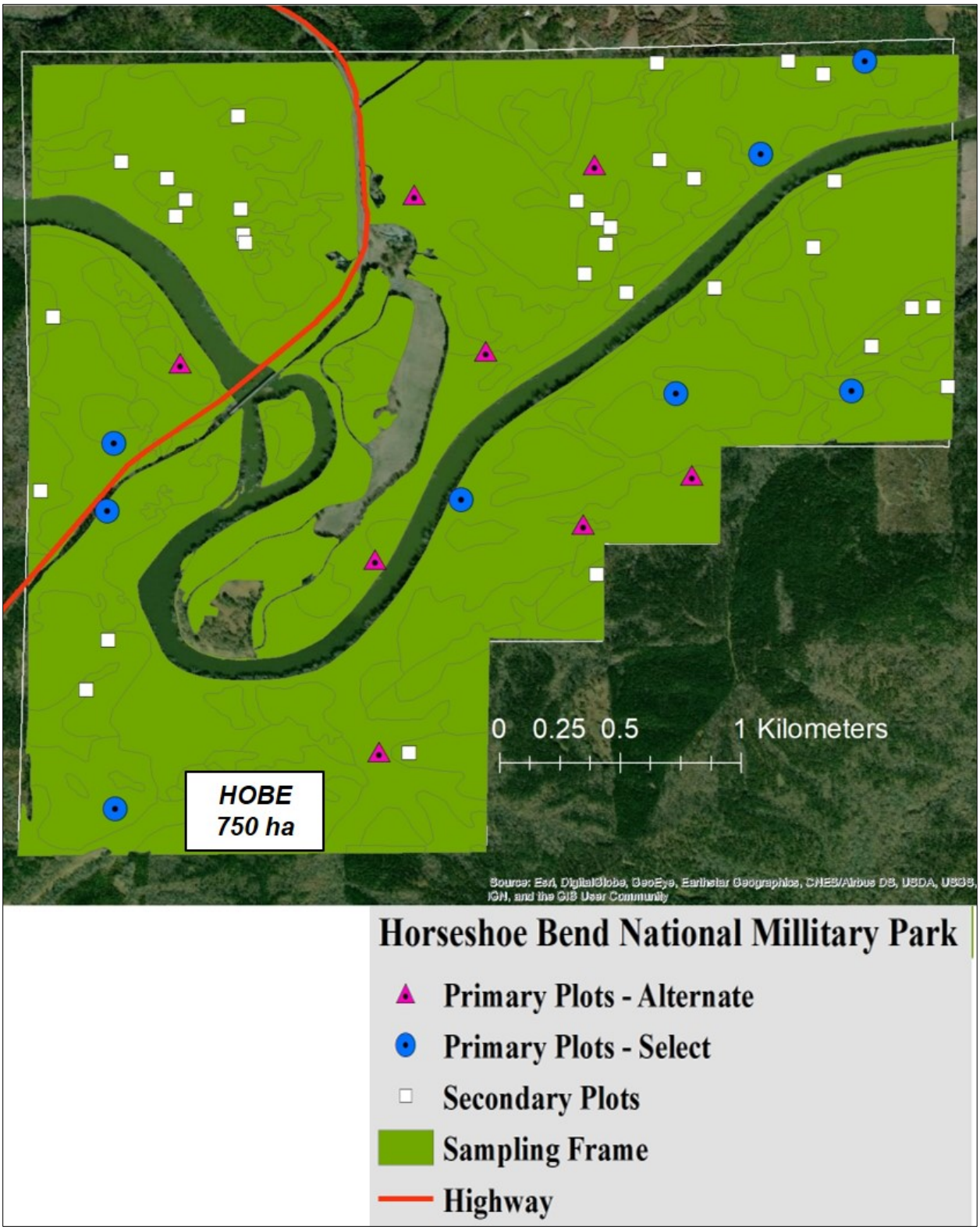

Figure C-11. Sampling frame and proposed plot locations for the Horseshoe Bend National Military Park in eastern Alabama. There are 8 primary plots and 16 secondary plots located on the park.

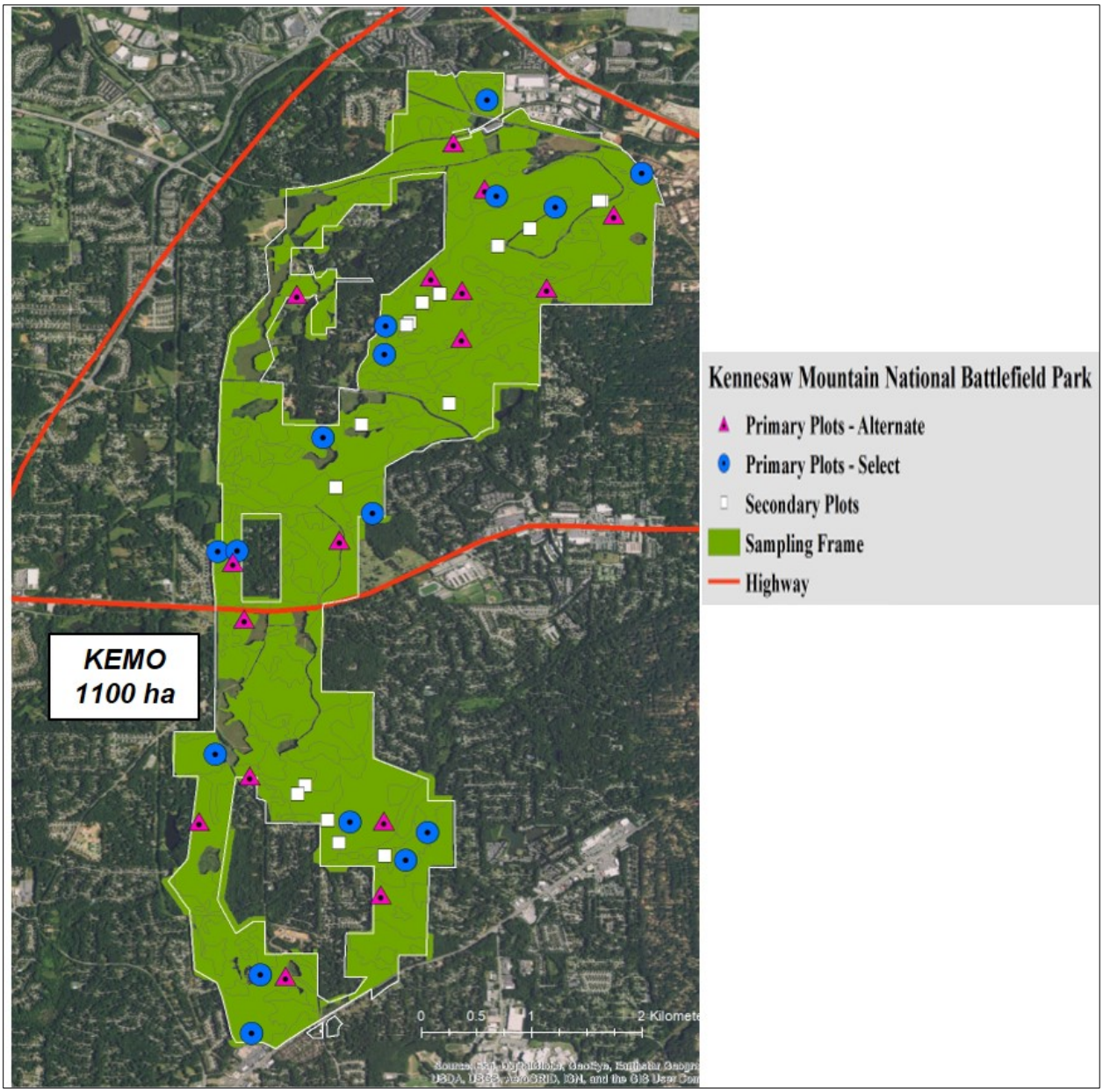

Figure C-12. Sampling frame and proposed plot locations for the Kennesaw Mountain National Battlefield Park in northern Georgia. There are 16 primary plots, 8 secondary plots, and 1 index plot (not shown) for the park. Plots are randomly located across the park.

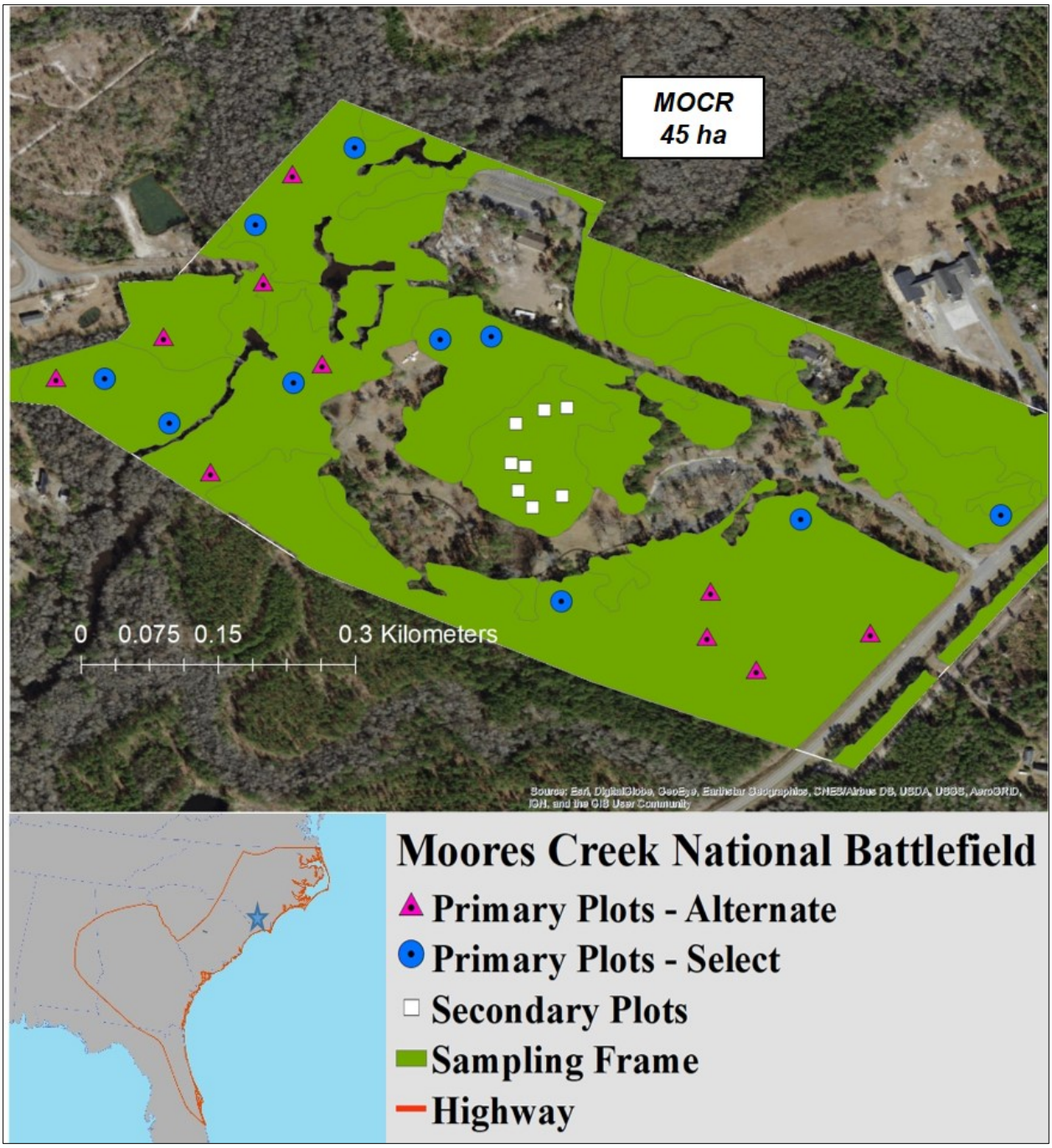

Figure C-13. Sampling frame and proposed plot locations for the Moores Creek National Battlefield in southeastern North Carolina. There are 10 primary plots and 4 secondary plots located on the park. Plots are randomly located across the park.

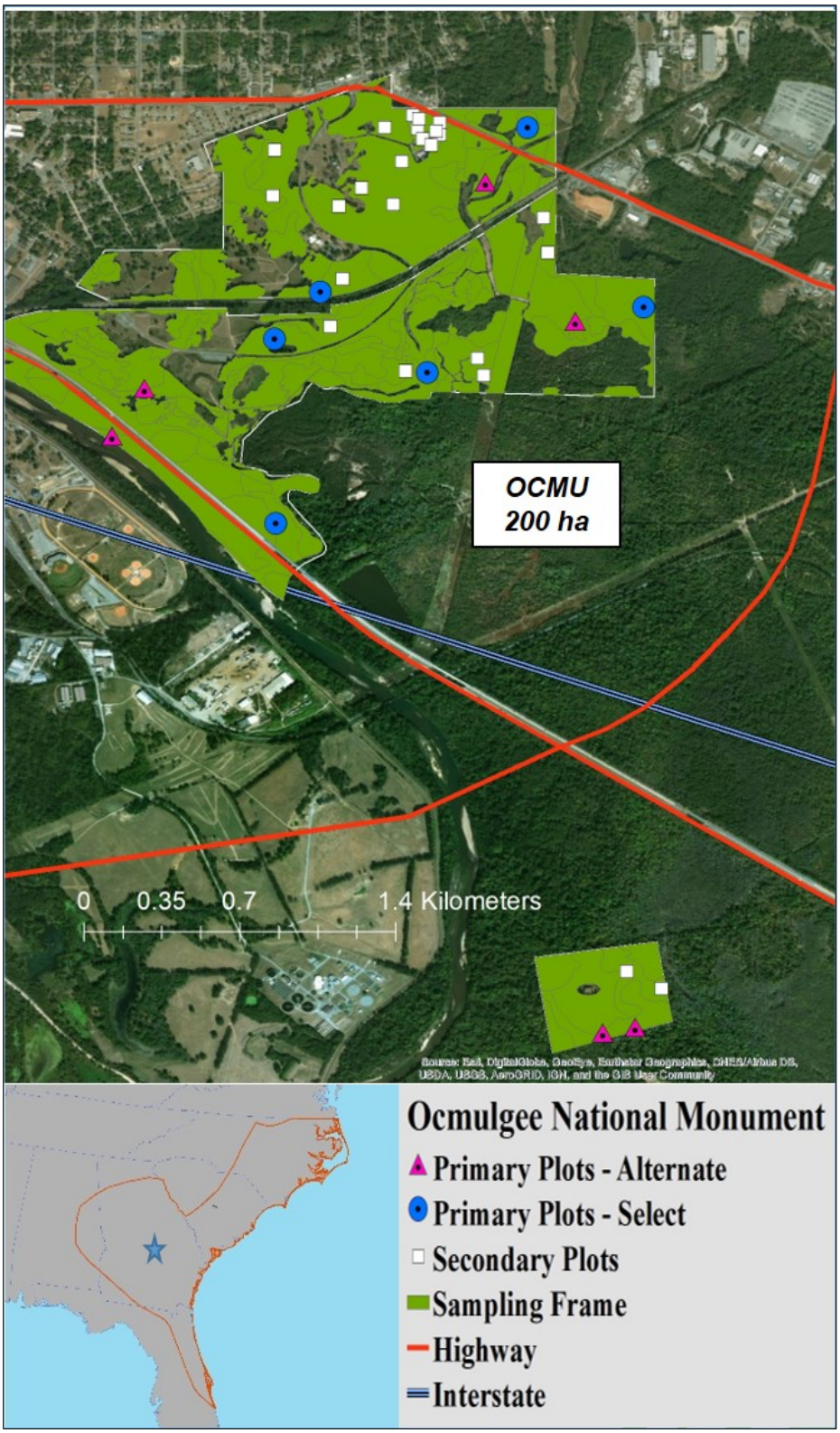

Figure C-14. Sampling frame and proposed plot locations for the Ocmulgee National Monument in south-central Georgia. There are 6 primary plots and 12 secondary plots located on the park. Plots are randomly located across the park.

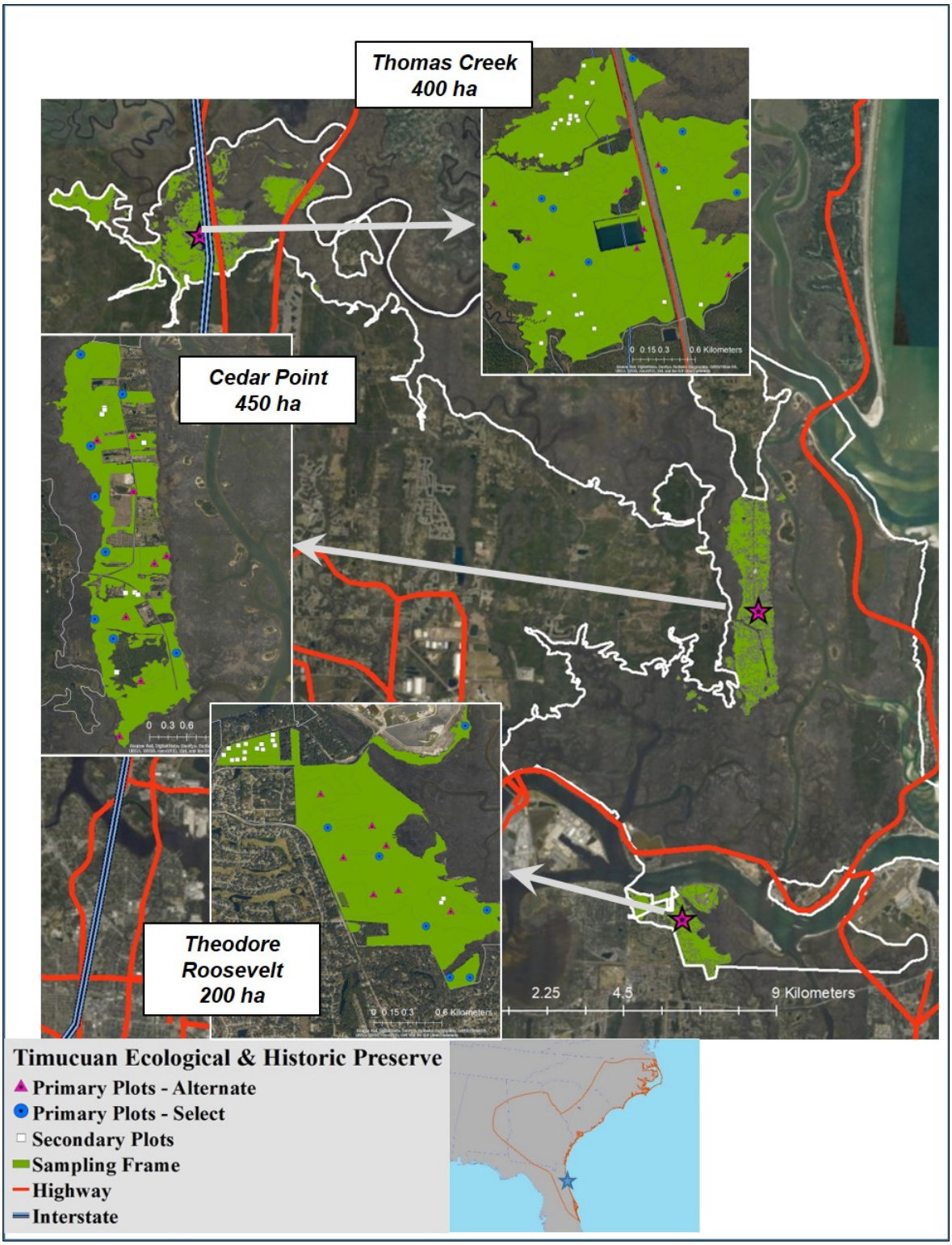

Figure C-15. Sampling frame and proposed plot locations for the Timucuan Ecological & Historic Preserve in northeast Florida. There are 23 primary plots, 24 secondary plots, and 1 index plot (not shown) for the park. Vegetation sampling will focus on three target management units within the park, which were identified through input from park management.

R-code For Generating SECN Vegetation Monitoring Plots

The code below describes input and output for the approach the SECN used for generating vegetation monitoring plots. The code utilizes a GRTS technique with the primary run a continuous draw of plot centroids across all sampling frames buffered 14 meters (45.9-ft) from the edge. Ellen Cheng (NPS Southeast Region Quantitative Ecologist), Tom Philippi (NPS I&M Program, Quantitative Ecologist), and Jacob McDonald (NPS SECN, Fluvial Geomorphologist) provided guidance with performing the GRTS draw. Ellen Cheng is the author of the code below.

```
##################################################

# Tom's original code ran 3 alternatives:

# Stratify by (unlikely to change) broad habitat, let GRTS spread
across management units

# Stratify by management units, let happenstance

# Single GRTS draw for entire park

# Test draws with ss tabulated by broad habitat & management unit

# Test areas with different buffers target population vs sample
frame

# Buffer by broad_habitat as well as frame/non-frame

# try Union to ecological systems (broad_habitat)

# Primary run is Continuous draw of plot centroids

# alternative is Tile to 20m*20m grid then finite draw

# 20*20m plots 4 intensive modules

# buffer 12m from edges

# buffer 20m as test

##################################################

# Now, we're trying alternative # 4, based on 4/24/19 SECN meeting
with T.Philippi, B.Mitchell, E.Cheng: Stratify by broad habitat for
the dominant habitat types in each management unit, so GRTS is
stratified by BOTH habitat type and management unit

# Modifying T.Philippi's code to create Alternative # 4

# Some management unit boundaries have also been updated since last
version
```

```
# Sample sizes for each MU-habitat provided by SECN, using rules
defining dominant and co-dominant habitat types and approximately
with target 1-2 plots / 100 ha

##################################################

# THE CODE BELOW IS FOR ALTERNATIVE 4.....

rm(list=ls())

mapdir <- "veg_maps" # folder with vegetation maps

pkgList <- c('rgdal', 'rgeos', 'gdalUtils', 'maptools', 'spsurvey',
'plyr', 'plotKML', 'tidyverse', 'magrittr')

inst <- pkgList %in% installed.packages()

if (length(pkgList[!inst]) > 0)

  {install.packages(pkgList[!inst],repos = 'https://cloud.r-
project.org/')}

lapply(pkgList, library, character.only = TRUE)

##################################################

# Grab the data and table of sample sizes

sample_sizes <- read_csv("SECN_VegSampleSize_ByBDH.csv")

# >>> Need to rename habitat types in 'sample_sizes' to match the
names used in shapefiles

# 'Maritime Nontidal Wetlands' should be changed to 'Maritime
Nontidal Wetland Vegetation' EXCEPT FOR TIMU units

# 'Coastal Plain Open Uplands and Woodlands' should be changed to
'Coastal Plain Upland Open and Wooded Vegetation' ONLY FOR CANA-Ohl
& CANA-Apb

# 'Coastal Plain Open Uplands and Woodlands' should be changed to
'Coastal Plain Upland Open and Woodland Vegetation' ONLY FOR  CONG-
Upl & CUIS

# 'Piedmont Upland Forests' should be changed to 'Piedmont Upland
Forest'

# 'Coastal Plain Alluvial Wetlands' should be changed to 'Coastal
Plain Alluvial Wetland Vegetation' EXCEPT FOR TIMU units

# 'Coastal Plain Nonalluvial Wetlands' should be changed to
'Coastal Plain Nonalluvial Wetland Vegetation'
```

```
# 'Tidal Wetlands' should be changed to 'Tidal Wetlands - Other'
ONLY FOR TIMU_Unit-ThomasCreek_NEW2veg

# 'Piedmont Alluvial Wetlands' should be changed to 'Piedmont
Alluvial Wetland Vegetation'

# 'Piedmont Nonalluvial Wetlands' should be changed to 'Piedmont
Nonalluvial Wetland Vegetation'

# 'Piedmont Open Uplands' should be changed to 'Piedmont Open
Upland Vegetation'

# 'Maritime Nontidal Wetland Vegetation' should be changed to
'Maritime Nontidal Wetlands'

sample_sizes$HABITAT[sample_sizes$HABITAT=="Maritime Nontidal
Wetlands" & !grepl("TIMU-", sample_sizes$UNIT)] <- "Maritime
Nontidal Wetland Vegetation"

sample_sizes$HABITAT[sample_sizes$HABITAT=="Coastal Plain Open
Uplands and Woodlands" & sample_sizes$UNIT %in% c("CANA-Apb",
"CANA-Ohl")] <- "Coastal Plain Upland Open and Wooded Vegetation"

sample_sizes$HABITAT[sample_sizes$HABITAT=="Coastal Plain Open
Uplands and Woodlands" & sample_sizes$UNIT %in% c("CONG-Upl",
"CUIS")] <- "Coastal Plain Upland Open and Woodland Vegetation"

sample_sizes$HABITAT[sample_sizes$HABITAT=="Piedmont Upland
Forests"] <- "Piedmont Upland Forest"

sample_sizes$HABITAT[sample_sizes$HABITAT=="Coastal Plain Alluvial
Wetlands" & !grepl("TIMU-", sample_sizes$UNIT)] <- "Coastal Plain
Alluvial Wetland Vegetation"

sample_sizes$HABITAT[sample_sizes$HABITAT=="Coastal Plain
Nonalluvial Wetlands"] <- "Coastal Plain Nonalluvial Wetland
Vegetation"

sample_sizes$HABITAT[sample_sizes$HABITAT=="Tidal Wetlands" &
sample_sizes$UNIT=="TIMU-Tcr"] <- "Tidal Wetlands - Other"

sample_sizes$HABITAT[sample_sizes$HABITAT=="Piedmont Alluvial
Wetlands"] <- "Piedmont Alluvial Wetland Vegetation"

sample_sizes$HABITAT[sample_sizes$HABITAT=="Piedmont Nonalluvial
Wetlands"] <- "Piedmont Nonalluvial Wetland Vegetation"

sample_sizes$HABITAT[sample_sizes$HABITAT=="Piedmont Open Uplands"]
<- "Piedmont Open Upland Vegetation"

# Get the names of all shapefiles
```

```
sflist <- list.files(mapdir, pattern = ".*\\.shp$") # creates a
vector of all shapefiles in the maps folder. glob2rx("*.shp")
changes wildcard or globbing pattern into regular expression

sflist <- sub(".shp", "", sflist, fixed = TRUE) # strip file
extension. There are 27 files here, one for each management unit.

# Fix notation to match sample_sizes to sflist. There is no pattern
consistent enough to use. But just alphabetizing both vectors
worked--matched them up correctly.

linkfile <- data.frame(sflist = sort(sflist), sslist =
sort(unique(sample_sizes$UNIT)), stringsAsFactors = FALSE)

# create shortcut habitat name

sample_sizes$HAB_SHORT = gsub(" and ", " ", sample_sizes$HABITAT)

sample_sizes$HAB_SHORT <- sapply(strsplit(sample_sizes$HAB_SHORT, "
"), FUN = function(x)

  toupper(paste(substring(x, 1, 1), collapse = "")))

  draws <- sample_sizes %>%

  mutate(sname = paste0(UNIT, "_", HAB_SHORT)) %>%

  left_join(linkfile, by = c("UNIT" = "sslist")) %>%

  rename(MU = UNIT, fname = sflist, SampleSize = SAMPLE_SIZE,
Broad_Habi = HABITAT)

draws$fname <- as.character(draws$fname)

# here, 'MU' is 4-digit Park code followed by hyphen then
management unit; 'Broad_Habi' is broad habitat type,  matching the
habitat column in the GIS files; 'SampleSize' is the number of
samples to draw from that MU-habitat; 'HAB_SHORT' is my abbreviated
code for the habitat type; 'fname' is the name of the corresponding
shapefile; 'sname' is my abbreviated code for the MU-habitat (i.e.,
stratification unit).

# delete the lock files that got zipped & copied across

# this is somewhat safe as this use-case is read-only

dlist <- list.files(mapdir, pattern = ".*\\.lock$", full.names =
TRUE)

if (length(dlist) > 0) file.remove(dlist)

# Within each original shapefile (one per MU), dissolve polygons by
Broad_Habi.
```

```
maplist <- vector("list", length = length(sflist))

names(maplist) <- as.character(sflist) # this is the abbreviated
MU-habitat name

# NOTE: In the loop below there are 3 instances of discarded Z-
dimension warning. "In readOGR(mapdir, i, stringsAsFactors = FALSE)
: Z-dimension discarded""CHAT_Unit-Mid_Clip_veg". These are for:

# > CHAT_Unit-Mid_Clip_veg

# > CHAT_Unit-North_Clip_veg

# > CHAT_Unit-SouthNew_Clip_veg

options(warn=0)

for (i in names(maplist)) {

  tmp <- readOGR(mapdir, i, stringsAsFactors = FALSE)

  tmp$MU <- as.character(linkfile$sslist[linkfile$sflist==i])

  tmp2 <- aggregate(tmp, by = list(ids = tmp$Broad_Habi), head, n =
1)

  tmp2@data <- tmp2@data[,c("Broad_Habi", "MU")]

  tmp2$Area <- gArea(tmp2, byid = TRUE) # calculate area for each
broad habitat type (w/in each MU), in sq.m. (10,000 sq.m. = 1 ha)

  maplist[[i]] <- tmp2

}

# Each element of maplist is a management unit with one polygon
feature for each broad habitat type.

# We need to buffer those polygons by negative distances

# ZONES RANGE FROM 16 TO 18. Except for zone difference, CRS =
"+proj=utm +zone=XXXXX +datum=NAD83 +units=m +no_defs +ellps=GRS80
+towgs84=0,0,0"

saveRDS(maplist, "maplist.RDS")

buffdist <- -14  # in m

# buffer by Broad_Habi and MU. Since each maps is only of a single
management unit, also buffers by MU.

BuffUnitHabMaps <- vector("list", length = length(maplist))

names(BuffUnitHabMaps) <- names(maplist)
```

```
for (i in 1:length(maplist)) {

   BuffUnitHabMaps[[i]] <- gBuffer(maplist[[i]], byid = TRUE, width
= buffdist) # expands the shape to include the area (or in our
case, exclude the area)

   BuffUnitHabMaps[[i]]$Area <- gArea(BuffUnitHabMaps[[i]], byid =
TRUE) # this is the area of each broad habitat type, within each
MU, after subtracting out the buffer

} # for i over maplist


# for each park, what fraction of the area are in each Broad_Habi?

bigBuffTab <- ldply(BuffUnitHabMaps, .fun = slot, name = "data") #
grab the data component of each list element and combine into one
big data frame

MUBuffAreaTab <- bigBuffTab %>%

  group_by(MU) %>%

  summarize(MUBuffArea = sum(Area))


bigBuffTab %<>%

  rename(ID = .id, BuffArea = Area) %>%

  left_join(MUBuffAreaTab, by = "MU") %>%

  mutate(FracMUArea = BuffArea/MUBuffArea)

write_csv(bigBuffTab, "bigBuffTab.csv")


# Function to create design object

MUHabDesign <- function(fnameCode, oversampMult = 7) {

  tmp <- data.frame(draws[draws$fname == fnameCode, c("Broad_Habi",
"SampleSize")])

  design <- sapply(tmp[tmp$SampleSize>0, "Broad_Habi"],

      FUN = function(x)

      assign(x,
```

```
     list(
     panel=c(Panel=tmp$SampleSize[match(x,tmp[,"Broad_Habi"])]),
     over=tmp$SampleSize[match(x,tmp[,"Broad_Habi"])] *
oversampMult,
     seltype="Equal")),
     simplify=FALSE)
  return(design)
} # bottom MUHabDesign


# Now loop through each of the shapefiles
Habdraw <- vector("list", length = length(BuffUnitHabMaps))
names(Habdraw) <- names(BuffUnitHabMaps)
options(warn=2)
for (i in 1:length(BuffUnitHabMaps)) {
  nam = names(BuffUnitHabMaps)[i] # could have used names directly
in for-statement, but easier this way for trouble-shooting with
options(warn=2)
  Habdraw[[nam]] <- grts(design = MUHabDesign(fnameCode = nam),
     DesignID = 'MU-Hab',
     SiteBegin = 1,
     type.frame = 'area',
     src.frame = 'sp.object',
     sp.object = BuffUnitHabMaps[[nam]],
     att.frame = NULL,
     stratum = "Broad_Habi",
     shift.grid = TRUE,
     shapefile = FALSE)
  # set CRS of draw
  proj4string(Habdraw[[nam]]) <-
CRS(proj4string(BuffUnitHabMaps[[i]]))
```

```
  Habdraw[[nam]]$Broad_Habi <- Habdraw[[nam]]$stratum
  cat(i, "Stratified by MU and Broad_Habi\n")
  with(Habdraw[[nam]]@data, table(Broad_Habi, MU, panel))
}
MUHabGRTS <- ldply(Habdraw, .fun = slot, name = "data") %>%
  rename(sfname = .id)
checkresults <- MUHabGRTS %>% # confirm sample sizes are correct
  mutate_if(is.factor, as.character) %>%
  group_by(MU, Broad_Habi, panel) %>%
  summarize (n = n())

write_csv(MUHabGRTS, "MUHabGRTS.csv")
saveRDS(Habdraw, "MUHabGRTS_sp.RDS")
```

Appendix C Literature Cited

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