

# South Florida/Caribbean Network

National Park Service  
Inventory and Monitoring Division

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## Mangrove-Marsh Ecotone Monitoring

### *Standard Operating Procedures*

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## Standard Operating Procedure 1

## Purpose

## Revision Log

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## Procedures

Field methods for the ecotone work are described in SOP 5 *Mangrove-Marsh Ecotone Field Methods—Version 1.0*. Before each scheduled field assessment, proper preparation is essential to collecting good data. Below is a list of the items and training that need to be taken care of before fieldwork.

### Imagery Acquisition and Digitizing

There are several sources of high quality aerial imagery covering Everglades National Park and the surrounding areas of South Florida, such as the Coastal Everglades Restoration Project (CERP), Florida Department of Revenue (FDOR), and National Agriculture Imagery Program (NAIP). It is likely that imagery sources will change over time, but effort should be made to maintain consistency. New aerial imagery used to digitize the mangrove-marsh ecotone must be 1 meter (3.2 feet [ft]) or better resolution and have positional accuracy of  $\pm 3$  meters (9.8 ft) or better. Coastal Everglades Restoration Project (CERP) 2009 and FDOR 2012 imagery were used to digitize the mangrove-marsh ecotone monitoring lines during the pilot assessment of 2010–2014. Aerial imagery is typically flown in the spring, when water levels are low. However, aerial imagery acquisition and fieldwork may occur at any time because the mangrove-marsh ecotone is visible at all water levels.

The monitoring schedule for ecotonal movement will vary depending on the availability of aerial imagery of sufficient quality (less than or equal to 1 meter [3.2 ft] spatial resolution and with a positional accuracy of  $\pm 3$  meters [9.8 ft] or better). Digitizing the mangrove-marsh ecotonal boundary using new aerial imagery is the first stage of the monitoring process and cannot begin until imagery is produced and released. Our preferred return period for ecotonal monitoring is approximately every 10 years. The frequency of reassessment for this project reflects the time scale over which vegetation communities are expected to show detectable movement based on our examination of historical imagery and similar work done by others (Krauss et al. 2011, Ross et.al. 2000, Ross et.al. 2013).

After aerial imagery acquisition, digitizer training is performed before actual line digitization (digitizer training is outlined in SOP 2 *Mangrove-Marsh Ecotone Methods for Digitizing, Updating the Ecotone Line, and Creating Marker Points—Version 1.0*). When digitizer training is completed and digitizers are cleared for actual line digitization, it will take approximately 28 days to digitize all 14 segments. If necessary, and if time and resources permit, a training helicopter flight will be scheduled. Such a flight will collect GPS tracklines along the leading mangrove ecotone edge, familiarize the digitizer with the vegetation in a regional context at and around the ecotone, and resolve questionable imagery signatures (e.g. does this unusual patterning indicate small mangroves under the sawgrass canopy?).

## Field Preparation

Preparation for fieldwork takes place after the digitizing process, except when gaining approval from the Everglades National Park Wilderness Committee. Approvals by the Everglades Wilderness Committee may take up to six months, so this process should be started while still digitizing lines. Pre-field work tasks include contacting Everglades National Park and Big Cypress National Preserve resource managers to let them know that fieldwork for this project will soon be taking place, determining what approvals and procedures by the Wilderness Committees are required, and inviting park staff to participate in the monitoring.

After receiving approvals, schedule helicopter time for fieldwork and make sure all crewmembers are up to date on their required helicopter trainings. Before starting official fieldwork, a training session will be conducted on the proper methods of determining the ecotone in a field setting, filling out the datasheet, estimating species cover, and use of the sub-meter Global Navigation Satellite System (GNSS) receiver to collect coordinates. Training exercises will be conducted in Everglades National Park or Biscayne National Park and will be led by the botanist and/or the community ecologist.

In many instances during the year, helicopter availability and scheduling may be difficult (e.g. helicopter assigned to fires, helicopter maintenance, or helicopters all booked by other researchers). Allow a year's time to complete all fieldwork. During high water months (June–October) water levels in Everglades National Park and Big Cypress National Preserve may be too high for the helicopter to land. Certain marker points close to airboat trails may be monitored during this time by use of an airboat.

## Pre-Fieldwork Training

Prior to each field season, the network must ensure all field personnel fully understand field procedures by conducting training sessions. Crew preparation involves careful review and discussion of the protocol, in addition to training sessions led by designated personnel (botanist or community ecologist) in which training plots are set up and measured in a field setting. Training includes both demonstration of all measurements by trainers, and hands-on practice of all measurements by trainees.

Training must emphasize the critical importance of careful, accurate, and consistent data collection to this long-term monitoring program. Trainers must express the importance of exact adherence to SOP instructions to prevent bias in measurements that will inhibit the networks' ability to detect long-term trends.

At least two training plots will be used as training sites. If the trainer (botanist or community ecologist) or the trainees feel more training is necessary, additional training plots will be scheduled. For training purposes, field sites that are easily accessible and do not require a helicopter will be chosen. It would be dangerous and expensive to transport multiple individuals by helicopter to a field-training site. Instead, a walk-in site around the Mahogany Hammock area of Everglades National Park would be a good area for training in a gradual ecotone setting. For training in an abrupt

ecotone setting, an airboat is used to transport personnel to sites in Taylor Slough in southern Everglades National Park.

### **Identifying the Ecotone**

Training is conducted in the field, where the trainees will start in the marsh habitat and walk toward the ecotone. Personnel will be trained to identify a gradual and an abrupt marsh-mangrove ecotone. A gradual marsh-mangrove ecotone is an area where open marsh transitions to mangrove cover of 50% cover. This gradual ecotone can range from a few meters to a kilometer or more. For training purposes, an area not exceeding 20 meters (65.6 ft) will be chosen. An abrupt mangrove ecotone is an area where open marsh is immediately replaced by mangrove cover of near 100%.

### **Filling out the Datasheet and Vegetation Estimates**

During field training, the trainees will be instructed in filling out datasheets. This also serves as training for estimating vegetation cover by stratum and by species. The trainees will start in the marsh habitat, measure a 5 × 5 meter (16.4 × 16.4 ft) plot, and estimate overall vegetation cover for the plot. Next, cover estimates for the tree stratum on the marsh side is estimated and then estimated by individual tree species. This process is repeated for the shrub and then the herb layers within the marsh habitat. This process is then duplicated for the mangrove side of the ecotone.

All observers independently record their estimates of the variables on separate datasheets. These data are used to estimate inter-observer variability and provide estimates of data quality. Variations beyond standards provided in the Data Quality Standards (Appendix D in *South Florida/Caribbean Network Mangrove-Marsh Ecotone Monitoring: Protocol Narrative* [Moser et al. 2019]) will trigger training at additional points.

### **Canopy Height Training**

This includes use of a telescoping height pole to orient trainees on height estimation. Additionally, canopy height estimates will be practiced based on the height of people in the crew. For example, a crew member approximately 1.8 meters (5.9 ft) in height can be used in the field to estimate heights. An example would be that shrub height is one and a half times taller than the 1.8-meter tall person, arriving at an estimated height of 2.7 meters (8.9 ft).

### **Using a Submeter GNSS Receiver to Collect Ecotone Coordinates**

Training in the use of a sub-meter GNSS receiver can take place anywhere outside the office building (but preferably in the field during the training session). Training includes setting up the unit, turning on the unit, creating and then opening a data collection file, averaging point coordinates, filling in required attributes, and placing the GPS in sleep mode while traveling between sites.

### **Helicopter Hover Method training**

The procedures in SOP 13 *Methods for Testing Accuracy of Coordinates Taken from a Hovering Helicopter—Version 1.0* will be performed every 10 years before the start of fieldwork utilizing a helicopter. There are likely to be changes from the previous sampling event including updated GPS unit, new pilot and field personnel, or another make of helicopter with different dimensions. See SOP 13 for procedures concerning this training exercise.

# Ecotone Marker Point Monitoring Fieldwork Preparation and Equipment

Ecotone marker points are monitored after the digitized ecotone lines have been completed. See SOP 2 *Mangrove-Marsh Ecotone Methods for Digitizing, and Updating the Ecotone Line—Version 1.0* for a description of the digitizing process.

The entire generalized ecotone line was divided into 42 segments, and based on a random starting segment, every third segment was selected for digitization. This process resulted in 14 segments. Each segment includes four GIS-derived marker point locations situated at 0.1, 1, 2, and 2.9 kilometers (0.06, 0.6, 1.2, and 1.8 miles [mi]) along the generalized ecotone. Most marker points are visited by helicopter with the secondary mode of transportation being an airboat. The finalized ecotone line and projected ecotone marker point locations are then uploaded to two GPS units (one used for navigation to the marker points and one for backup in case the first unit stops working or gets submerged in the water) (see SOP 9 *Using Garmin Handheld GPS Units—Version 1.0* for uploading data on these units). A sub-meter GNSS receiver is used to test the accuracy of the digitized line in the field (see SOP 10 *Using Trimble Geo 7X GPS Unit—Version 1.0*).

Before fieldwork, make sure the helicopter or airboat “go-no go” checklist and Field Safety Sign-out Sheet are filled out. The following is a list of the gear needed for marker point monitoring:

- Flight suits, flight helmets, flight gloves, and all-leather boots for helicopter
- Airboat—make sure airboat and trailer are in good running order and the fuel tank is full (See Airboat JHA in Z:\Safety\)
- Airboat action packer – Extra airboat motor parts and belts, tools, protective eye goggles, protective ear muffs and ear plugs, flares, come-along and associated straps in case airboat gets stuck
- Extra gas for the airboat (20 gallons [75.7 liters (L)] for the farthest locations)
- Truck—make sure tires are properly inflated and that truck is in good running order (See Truck JHA in Z:\Safety\)
- GPS units with loaded ecotone line and projected marker locations (See SOP 9 *Using Garmin Handheld GPS Units—Version 1.0*). A handheld GPS (e.g. Garmin 60CSx) for navigating from the helicopter to the marker point. A GPS chartplotter (e.g., Garmin 478 or 640 unit that can be securely attached to the helicopter dashboard) for pilot navigation to marker points
- Sub-meter GNSS receiver (e.g. Trimble Geo7X) to gather sub-meter accuracy for each marker location (See SOP 10 *Using Trimble Geo7X GPS Unit—Version 1.0*)
- External antenna for sub-meter GNSS receiver

- Clipboard with datasheets and pencils
- Camera
- Compass—one for each crew member
- Telescoping height pole and meter stick when sites are arrived at by airboat or by hiking
- Park radio and emergency locator beacon unit
- 5-gallon (18.9 liters [L]) water cooler with water and ice (when using airboat) for staff hydration
- First-aid kit

## **Post Fieldwork Equipment Needs and Storage**

Upon completion of fieldwork the equipment will need to be cleaned and properly stored to ensure equipment is not damaged during periods of non-use.

### **Sub-meter GNSS receiver**

After all GPS points are downloaded, inspect the unit to make sure nothing is broken (cracked case or screen, wire attachments not clogged with vegetation) before storing the device on its charging cradle. If the unit does develop a cracked screen or case, then send the unit for repairs.

### **Airboat**

The airboat hull (both inside the airboat and outside hull) and rudders are cleaned with boat soap. Propellers are cleaned with Simple Green cleaner. The gas tank is filled and a fuel stabilizer (STA BIL has been used in the past) is added if the airboat is not to be used for the following month or more. Store the airboat in its designated parking place outside the garage with its associated cover. General maintenance occurs annually and involves changing of motor oil and gear oil. Every two to three years, depending on amount of airboat usage, spark plugs and spark plug wires will need to be replaced.

### **South Florida/Caribbean Network Fleet Vehicles**

These vehicles are on a maintenance schedule and are taken in for preventive maintenance. There are designated National Park Service parking spaces outside the garage for fleet vehicle storage.

### **Helicopter Gear**

Helicopter flight suits, flight gloves, and helmets are stored in a helmet bag with helmets and suits assigned to individuals. It is imperative that employees using a flight helmet ensure that the helmet is serviceable before each flight. The DOI Flight Helmet Users Guide provides detailed information on what to look for to determine whether the helmet is serviceable, and what to do if the helmet needs repair. The guide can be viewed at [OAS Aviation Helmet Standards](#).

## Other Gear

Other equipment such as handheld GPS units, first aid kits, emergency locator beacons, park radios, cameras, clipboards, and the telescoping height pole are all inspected for damage, and if there is no damage, then these items are stored in their respective areas on shelves in the office. If items are damaged, then they will be repaired (or sent for repairs).

## Literature Cited

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**National Park Service**  
**Inventory and Monitoring Division**



## Purpose

## Revision Log

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## Introduction

The South Florida/Caribbean Network (SFCN) mangrove-marsh ecotone monitoring segments were systematically chosen across the entire multi-park ecotone so that the entire mangrove to freshwater marsh ecotonal boundary in peninsular South Florida is represented. The ecotone segments are spread across the southern and western coast of Everglades National Park (EVER) and the southwestern corner of Big Cypress National Preserve (BICY) in order to allow trends to be inferred across the entire multi-park ecotone. Access to ecotone segments requires travel by helicopter, airboat, or on foot. Each 3-kilometer (1.8-mile [mi]) segment will have four marker point locations where the ecotone line will be ground-truthed and vegetation data gathered (see Figure 5.1).

## Aerial Imagery and Ecotone Digitization

There are several sources of high quality aerial imagery covering Everglades National Park and the surrounding areas of South Florida, such as the National Agriculture Imagery Program (NAIP), Florida Department of Revenue (FDOR), and Comprehensive Everglades Restoration Plan (CERP). It is likely that imagery sources will change over time, but effort should be made to maintain consistency. New aerial imagery used to digitize the mangrove-marsh ecotone must be 1 meter (3.2 feet [ft]) or better resolution and have positional accuracy of  $\pm 3$  meter (9.8 ft) or better. National Agriculture Imagery Program imagery was used to digitize the mangrove-marsh ecotone monitoring lines during the pilot assessment of 2010–2014.

## Ecotone Line Digitization Training

Training is an important method to improve consistency between digitizers. Before creating a new ecotone line, even experienced digitizers must begin by digitizing at least three training segments using segments digitized during a previous time step. One segment (segment 11) will be dominated by abrupt ecotone edges; one will be comprised of predominately gradual transitions (segment 13); and one will be a mixture of abrupt and gradual transitions (segment 14; Figure SOP 2-1; see also Figure 10 in the protocol narrative [Moser et al. 2019]). Digitizers will not have access to the official line during the digitizing process. When complete, the distance between the official line and the digitizer's line will be measured using the nearest-neighbor analysis approach (see SOP 4 *Analysis of Area between Two Digitized Lines—Version 1.0*). The average of these distances must be less than 7 meters (23 ft) before they can begin digitizing current imagery. If the trainee fails to meet the required re-digitization accuracy, another subset of two more segments will be digitized. This will be repeated until the trainee attains the necessary skills required to interpret the different types of ecotone boundaries.



**Figure SOP 2-1.** These segments are used for line digitization training. Segment 11 exhibits abrupt ecotone edges (left photo). Segment 04 exhibits a mixture of abrupt and gradual transitions (middle photo). Segment 13 exhibits gradual transitions (right photo).

## Digitizing—Overview of GIS Steps

The digitizing process for mangrove-marsh ecotonal movement will be done at the scale of 1:500 in a GIS program. The steps below are written for ArcGIS v10.5, but could be replicated in other programs such as QGIS.

- Open the ArcGIS project file for ecotonal monitoring found on the server at:  
Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\spatial\_info.
- Load base imagery for digitizing.
- If necessary, make black image borders transparent by right-clicking each image layer, selecting Properties, clicking on the Symbology tab, placing a check in the “Display Background Value” box, and ensuring that all three values are at “0.”
- Open ArcCatalog. Navigate to the folder  
(Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\spatial\_info\year imagery was flown) in which the project is to be saved and right click on it. Select New → Shapefile.
- In the Name field, name the new layer by starting with “Ecotone”, adding the year imagery was flown, and the digitizer’s last name separated by underscores (e.g. Ecotone\_2013\_Shamblin.shp).
- In the “Feature Type” dropdown menu, select the Polyline option. The coordinate system used by the SFCN office can be chosen by selecting Edit → Select → Projected Coordinate Systems → UTM → NAD 1983 → NAD 1983 UTM Zone 17N.prj
- Move the new shapefile to the top layer.
- Right click the new shapefile and select “Open Attribute Table.”

- In the Table view, click the Table Options button in the upper-left corner and click on ‘Add Field...’ In the Name box, type in “Digitizer” and select a Type of “Text.” The default Field Properties are acceptable. Click OK.
- Repeat the previous step, but add additional fields for:
  - Name: “Imagery”, Type: Text
  - Name: “Scale”, Type: Text
  - Name: “Region”, Type: Text
  - Name: “Segment”, Type: Text
  - Name: “Year\_Digitized”, Type: Short Integer
  - Name: “Length\_m”, Type: Long Integer
- Close the Attribute Table by clicking the small X in the upper-right corner.
- Activate the Editor Toolbar in ArcMap. Select “Start Editing” from the dropdown menu labeled “Editor.” In the “Start Editing” menu, highlight the folder or database from which data are to be edited.
- Ensure that the layer in which the new polyline is to be created is selected in the “Layer” dropdown menu.
- Zoom to 1:500 scale while digitizing. However, frequently zoom out to maintain perspective of the larger area to be digitized.
- Select “Create New Feature.” This option in the “Task” dropdown list creates a new feature according to the shapefile option selected.
- Select the pencil icon to the left of the “Task” dropdown menu.
- Ensure that the segment boundaries (geo\_Segments feature class) are visible. Also ensure that edge snapping has been turned on in the Editor toolbar. Then click the mouse to place the first point of the ecotone line. It is important to ensure that the start of the digitized line snaps to the segment boundary.
- Click the mouse along the ecotone to be digitized, clicking to create more vertices for turns or curves. Double clicking will complete the feature. When continuing the line or after accidentally double clicking, the line can be continued by snapping the start of a new line to the end of the previous line. Additional rules and examples of how to make digitizing decisions are covered in the next section.
- Periodically select “Save Edits” from the “Editor” dropdown menu.

- Complete the line by snapping the endpoint to the segment boundary and double-clicking. When digitizing is complete, save edits once again and then select “Stop Editing” from the menu.
- Once a segment is complete, right click the layer and select “Open Attribute Table.”
- Highlight all rows for that segment and right click to merge all polylines to form one consecutive line. Inspect the merged line for gaps.
- In the Attribute Table click in the empty cells to enter the following details:
  - Digitizer – the full name of the digitizer (e.g. Brooke Shamblin)
  - Imagery – year and name of imagery used (e.g. 2013 USDA NAIP)
  - Scale – the scale at which digitizing occurred (e.g. 1:500)
  - Region – the region where the segment resides (e.g. Shark Slough)
  - Segment – the name of the segment that was digitized (e.g. 7)
  - Year\_digitized – the year when the digitized line was created in ArcGIS (e.g. 2018)
- Repeat steps for each additional segment polyline.
- After completing all segments, open the Attribute Table, right-click the “Length\_m” field, and select “Calculate Geometry.” Ensure that the Property is set to “Length”, the Coordinate System is “UTM Zone 17N”, Units are “Meters [m]” and click OK. This populates the field with the calculated length of the digitized line.
- Import the final file into the geodatabase.

## Delineating the Ecotone

### Overview

Digitizing a repeatable ecotone line is a complex exercise. The rules described below cover important decisions related to the most common features encountered along the ecotone. Some individual variation in line work decisions is expected, but these rules should help minimize those differences between digitizers and time steps. These rules clarify the decision-making process and produce an average deviation of 7 meters (23 ft) or less when the same line is digitized more than once.

### Digitizing Rules

Snap to Segment Boundaries: Display the segments and utilize snapping within ArcMap to ensure that there are no gaps between the digitized line and the segment boundaries. To accomplish this start the digitizing process by opening ArcMap and adding the 3-kilometer (1.9-mi) segment boundaries (geo\_Segments) from the geodatabase. Change their symbology to an empty fill color and a bright border color (e.g. red). Zoom to a regional perspective of 1:10,000 scale, and follow the segment

boundary inland to a point where the green mangroves end and the lighter colored (green or tan) marsh vegetation begins. In this transition area switch to 1:500 scale and snap the beginning of the digitized line to the segment boundary (Figure SOP 2-2). The best way to accomplish the snapping in ArcGIS is to click the Editor toolbar, select Snapping, Snapping Toolbar, and ensure that Edge Snapping is enabled. When finishing each segment, the end of the digitized line will be snapped to the other side of the segment boundary.

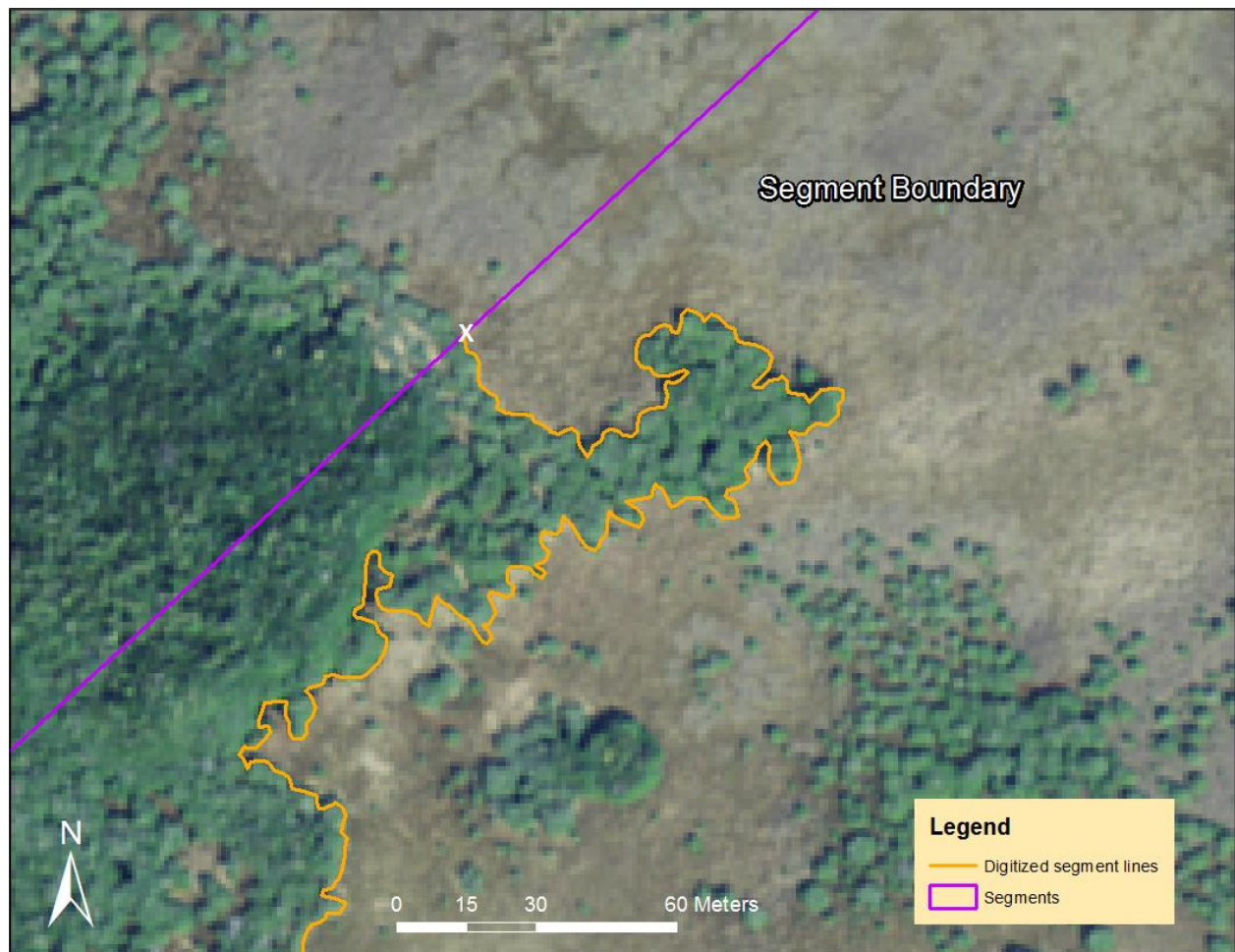


**Figure SOP 2-2.** The X marks the starting point where the digitized line (orange line) is snapped to the segment boundary (purple line). Imagery is 2013 National Agriculture Imagery Program at a scale of 1:1,000.

Scale: Digitize at a 1:500 scale along the mangrove edge, occasionally zooming out to approximately 1:10,000 to get a larger view and see the ecotone within a landscape context.

Hard Edge Rule: In many cases, the open marsh habitat abruptly ends and the mangrove ecotone will have a hard edge of 80–100% mangrove cover on the mangrove side and low mangrove cover (20% or less) on the marsh side (Figure SOP 2-3). Digitize along this strong edge when it exists. An almost solid, high density, hedge appearance in the field characterizes the abrupt, well-defined, mangrove ecotonal edge, and it is this edge that is digitized. Single individual or small groups of short statured

mangrove shrubs beyond 3 meters (9.8 ft) from the edge remain on the “marsh” side of the ecotone line.

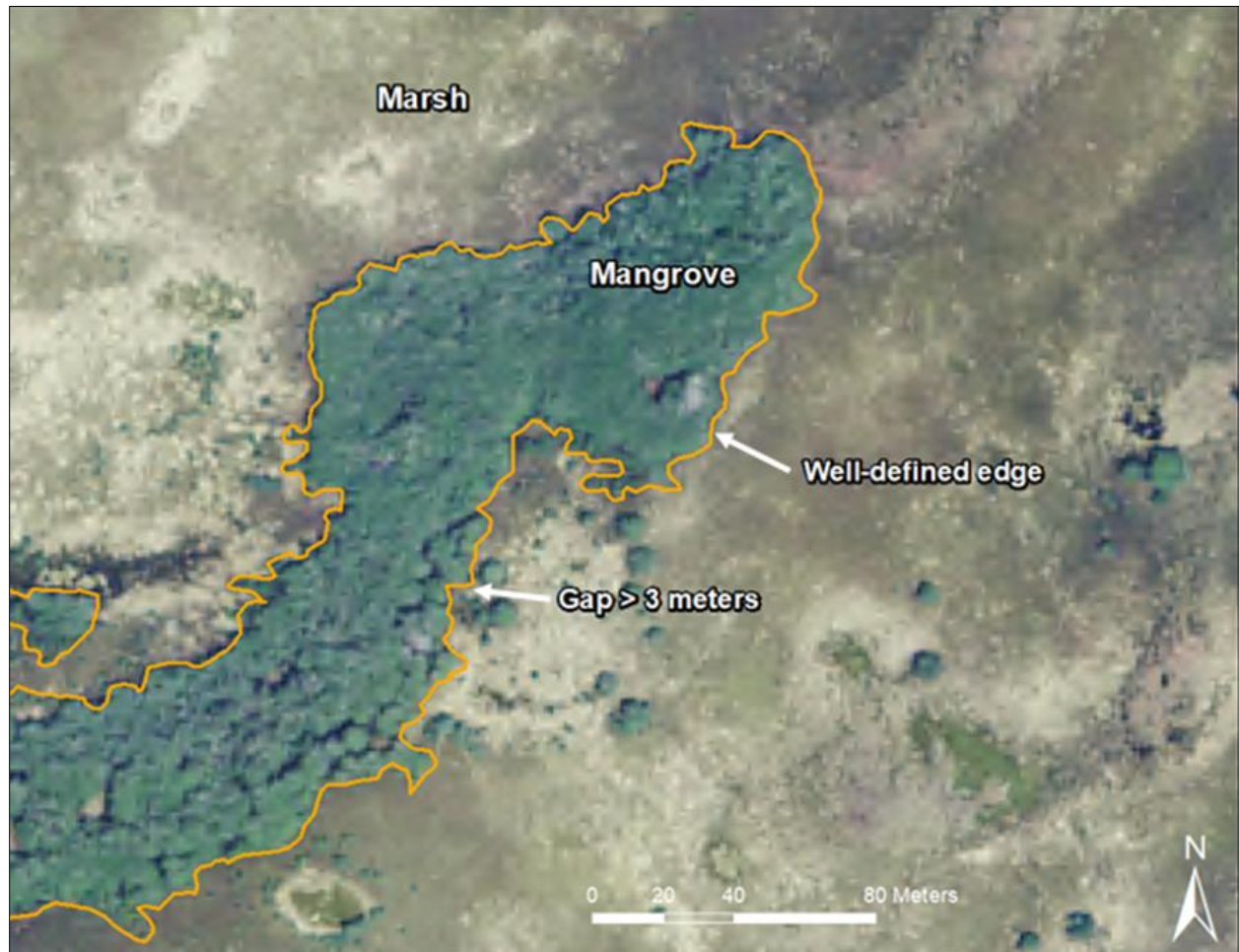


**Figure SOP 2-3.** Example of an abrupt ecotone change. The open marsh habitat with low mangrove cover (20% or less) abruptly ends at an area of high mangrove cover of near 100%. The orange line shows the digitized ecotone line. A small area of dense mangroves is not included because it is greater than 3 meters (9.8 ft) from the hard ecotone line. Imagery is 2013 National Agriculture Imagery Program at a scale of 1:1,250.

3-Meter and Minimum Mapping Unit Rule: Gaps in cover at or under 3 meters (9.8 ft) in length should be crossed. Conversely, gaps greater than 3 meters (9.8 ft) should not be crossed (Figure SOP 2-3). However, gaps less than 3 meters to a feature (e.g., a single bush) that is also less than the minimum mapping unit of 16 square meters (172 square feet [ft<sup>2</sup>]) in area (i.e., a 4 × 4 meter [13.1 × 13.1 ft] square or 2.25 meter [7.4 ft] radius circle) are not digitized even if within 3 meters (Figure SOP 2-4). These are often single small shrubs and sometimes difficult to clearly detect on the imagery. A different exception to the 3-meter rule is that digitization crosses airboat trails, even if greater than 3 meters wide (Figure SOP 2-11).

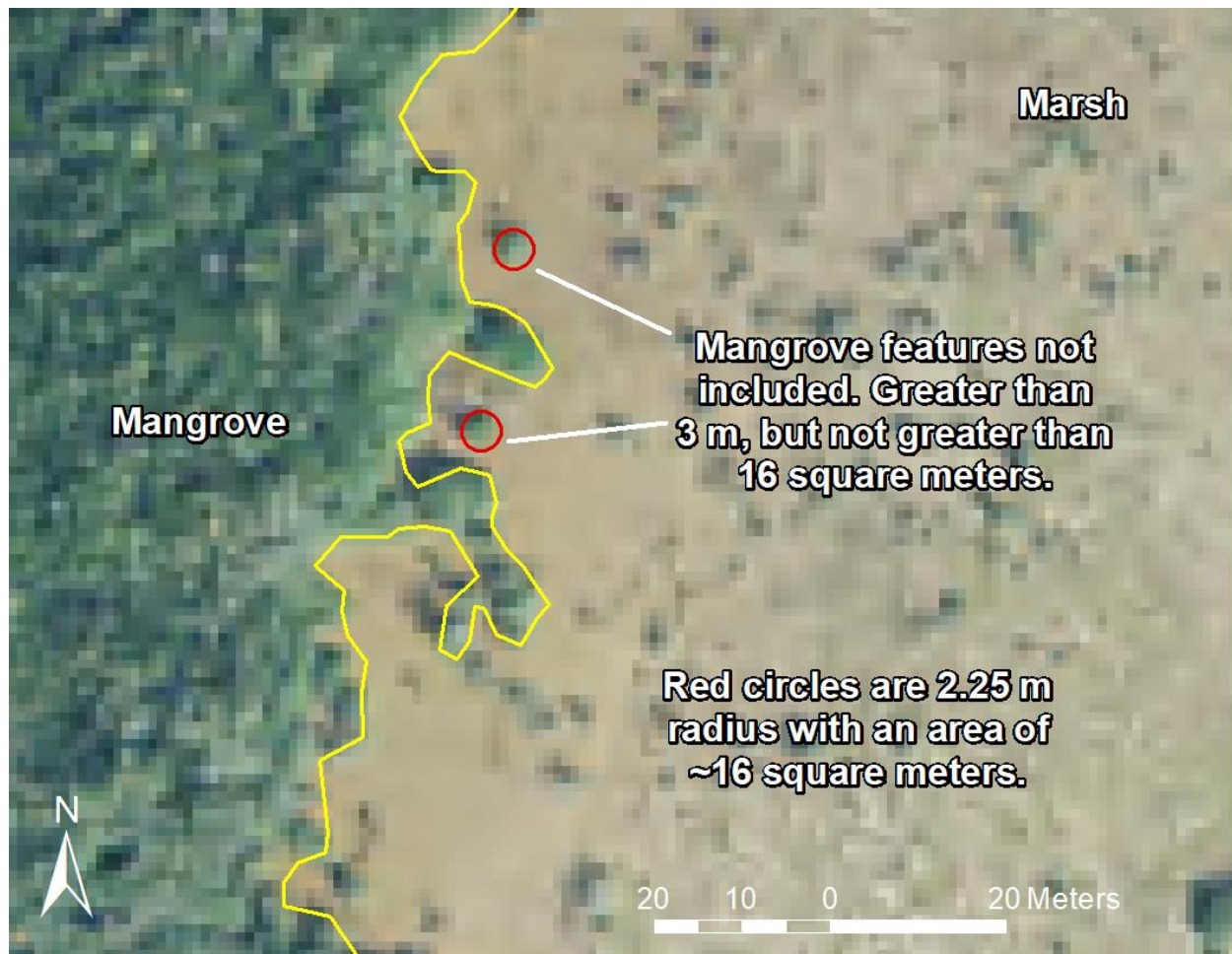


**Figure SOP 2-4.** Applying the 3-meter (9.8-ft) and minimum mapping unit rule. Gaps less than 3 meters to a feature (e.g., a single bush) that are also less than the minimum mapping unit of 16 square meters in area (i.e., a  $4 \times 4$  meter [ $13.1 \times 13.1$  ft] square or 2.25 meter [7.4 ft] radius circle) are not digitized even if within 3 meters from a solid mangrove edge. The red circles in the figure signify the minimum mapping unit. Imagery is 2013 National Agriculture Imagery Program at a scale of 1:500.

Where Well-Defined Edge Degrades: There will also be cases where the ecotone is less sharply defined. In these cases the tree line will go from a nearly continuous cover (80–100%) of mangrove to a more open transition (mangrove cover less than 80%) where the mangroves will be interspersed with open water or freshwater graminoids (Figure SOP 2-5). In this more open transition zone, the location of the ecotone will be where the visually estimated mangrove cover drops below 50%.

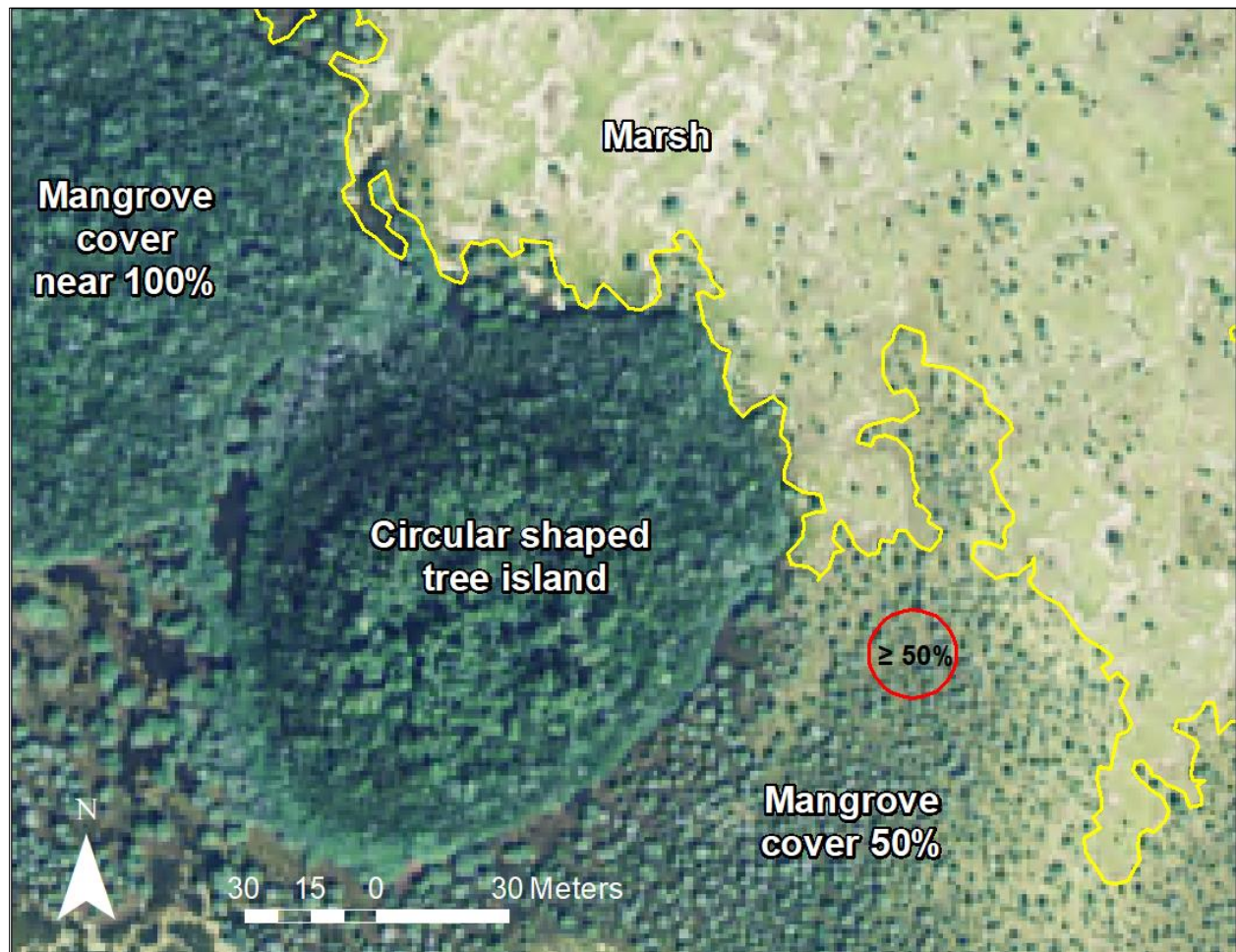


**Figure SOP 2-5.** Example where the ecotone is gradual. In these cases the transition will go from 80–100% mangrove (or imbedded tree island) cover to a more open transition (mangrove cover greater than or equal to 50%). The ecotone is digitized where the mangrove cover signature drops below 50%. A 10-meter (32.8-ft) radius circle (red circle) can be employed as a visual aid to help estimate mangrove cover within a particular aerial imagery signature. Imagery is 2013 National Agriculture Imagery Program at a scale of 1:1,000.

When a gradual ecotone is encountered, a 10-meter (32.8 ft) radius circle can be used as a visual aid to determine whether a particular aerial imagery signature (i.e. a patch of vegetation with a consistent visual pattern) meets the 50% mangrove cover rule (Figure SOP 2-6). To create the circle, first ensure that the Draw toolbar is visible. If it is not, right-click on any toolbar and put a check next to the Draw toolbar. To create the circle, find the Draw toolbar and click the small down-arrow next to the Rectangle tool. Change the shape to a Circle. Then click on the map, and while continuing to hold

that click, drag the mouse outward to generate a circle. The radius of the circle is shown in the lower-right corner of the screen. When the radius is approximately 10 meters (32.8 ft), release the click and the circle will appear on the screen. Do not worry about making it exactly 10 meters at this point, as the shape will be fine-tuned in the next steps. Double-click the newly created circle to see its Properties. On the Symbol tab change the fill color to no color, the outline to red, and the outline width to 2. On the Size and Position tab, uncheck the 'As Percentage' box and then type "20" for the width and height. Click OK.

Then move the circle onto a representative patch of habitat (aerial imagery signature), and use this visual aid to help estimate mangrove cover. The circle is not meant to be placed directly on and follow the line, but is used to decide whether to include or exclude a particular signature on the aerial imagery. Any signature with greater than 50% mangrove cover that is larger than the minimum mapping unit is included, even if individual, component shrubs fall below this threshold.

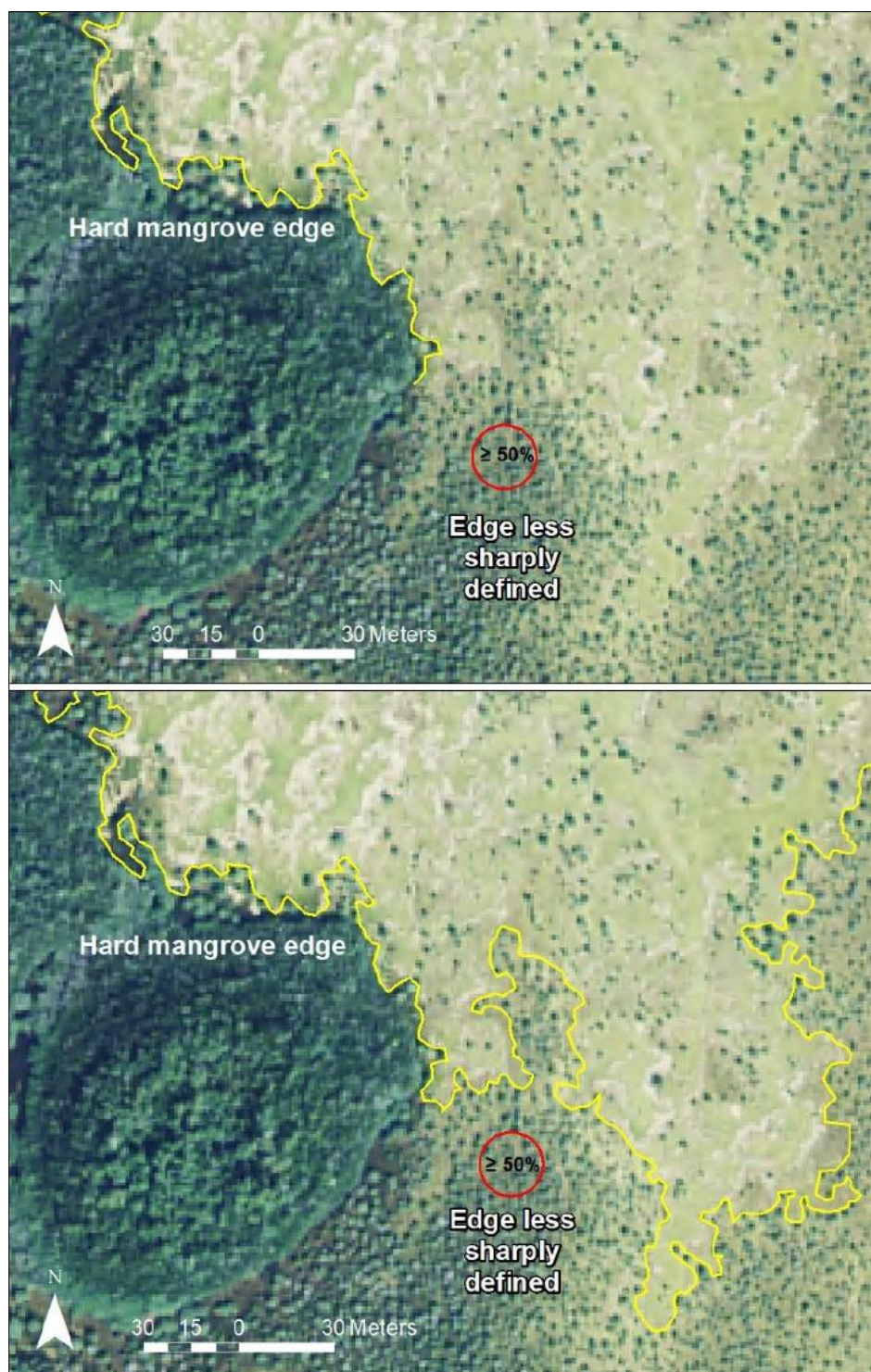


**Figure SOP 2-6.** A circle is moved over the map to help determine if the signatures on the imagery represent greater than or equal to 50% mangrove cover. Top figure shows the digitized line following a hard mangrove edge and the use of the red 10-meter (32.8-ft) radius circle to aid the digitizer in deciding where to place the line when the ecotone signature changes. Bottom figure shows where the digitizer continued the line with the aid of the red 10-meter radius circle. Imagery is 2013 National Agriculture Imagery Program at a scale of 1:1,000.

Open Water Rule: Cross open water with the digitized ecotone line if the width of the gap is at or under 3 meters (9.8 ft; Figure SOP 2-7). Gaps of open water greater than 3 meters (9.8 ft) are not crossed (Figure SOP 2-8). Instead, digitize the mangrove edge without crossing open water.



**Figure SOP 2-7.** Example of a gap in the mangrove-marsh ecotone that is less than 3 meters (9.8 ft) in width. The digitized line (orange line) crosses over this gap and then continues to follow the mangrove zone (2013 USDA NAIP imagery). Imagery is 2013 National Agriculture Imagery Program at a scale of 1:700.

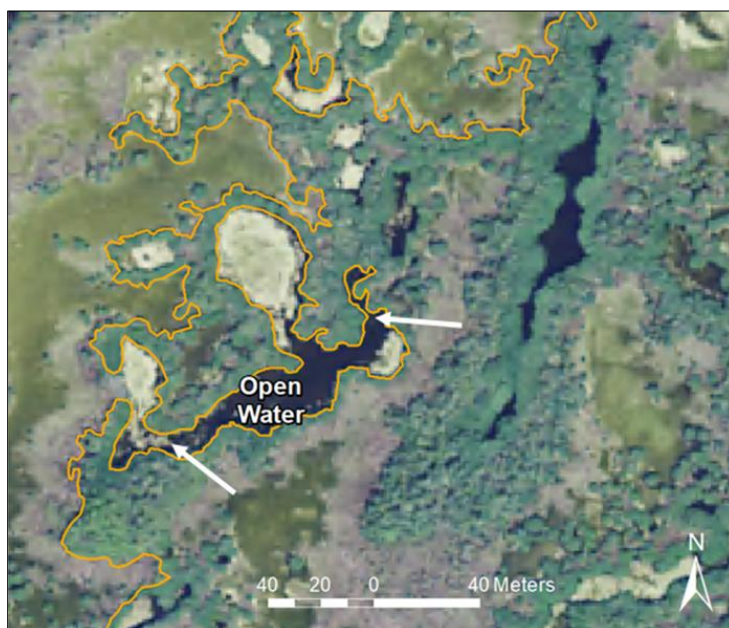


**Figure SOP 2-8.** Example of open water gaps greater than 3 meters (9.8 ft) that the digitizer did not cross with the digitized ecotone line. White arrows indicate where the open water gaps are greater than 3 meters. The digitized line (orange line) follows the edge of the mangrove zone without crossing open water. Imagery is 2013 National Agriculture Imagery Program at a scale of 1:1,100.

Embedded patches: There will be cases where a patch of sawgrass or some other freshwater graminoid vegetation will be embedded within the mangrove zone. When mangroves of at least 50% cover surround a freshwater graminoid patch, the patch is ignored (Figure SOP 2-9). Likewise, a patch of mangroves embedded within the marsh zone but not connected to the mangrove zone is also ignored (Figure SOP 2-10).



**Figure SOP 2-9.** Example of a sawgrass patch embedded within the mangrove zone. In this case the sawgrass patch is not included as part of the marsh and does not impact the placement of the ecotone line. Imagery is 2013 National Agriculture Imagery Program at a scale of 1:850.

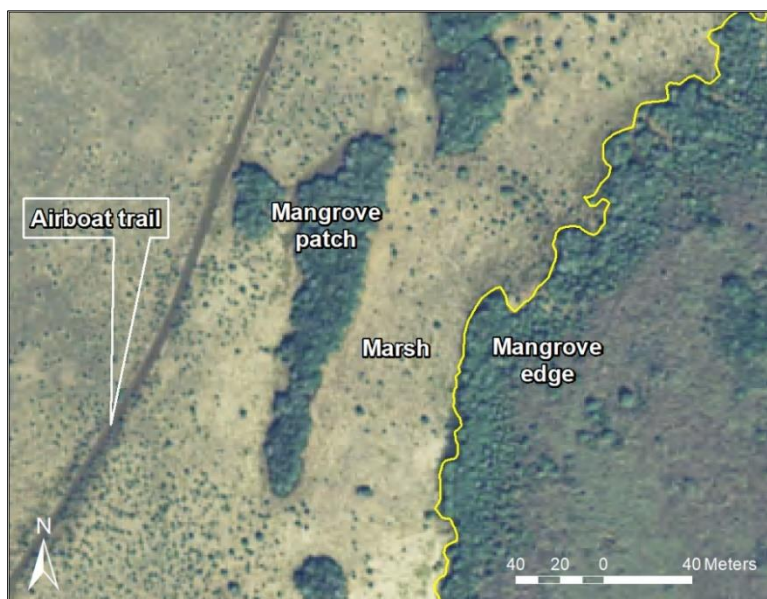


**Figure SOP 2-10.** Example of a mangrove patch embedded within the marsh zone. In this case the mangrove patch is not included as part of the mangrove ecotone and does not impact the placement of the ecotone line. Imagery is 2013 National Agriculture Imagery Program at a scale of 1:1,250.

Digitize across airboat trails: When the ecotone intersects an airboat trail (seen as white or dark lines through the area), continue digitizing the line across the airboat trail, because airboat trails are artificially-created breaks in the mangrove or marsh zones (Figure SOP 2-11).

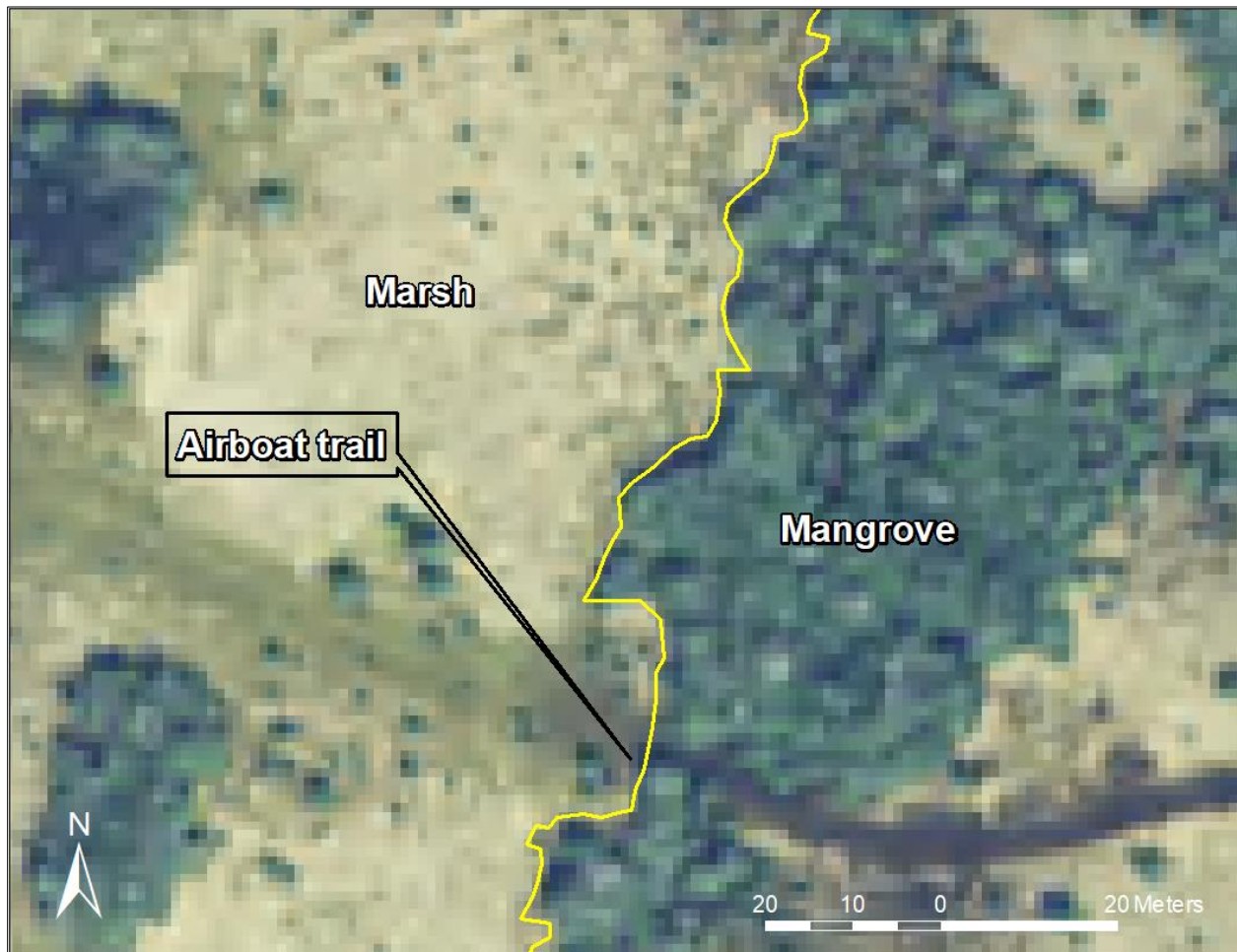


**Figure SOP 2-11.** This figure shows the appearance of an airboat trail. In this case the airboat trail is included within the mangrove portion of the ecotone. Even though the gap occupied by the airboat trail may be greater than 3 meters (9.8 ft), it is treated as an artificial gap in the mangroves and crossed over. This is an example of an exception to the 3-meter gap rule where not crossing the gap would cut off a significant section of the mangrove community. Imagery is 2013 National Agriculture Imagery Program at a scale of 1:500.

Tree islands: Tree islands generally have a circular or teardrop-shaped appearance and many are surrounded by a thin buffer of mangroves. Because of the difficulty of discerning this thin ring of mangroves, if a tree island touches adjacent mangroves, it is included as part of the mangrove zone (Figure SOP 2-12).

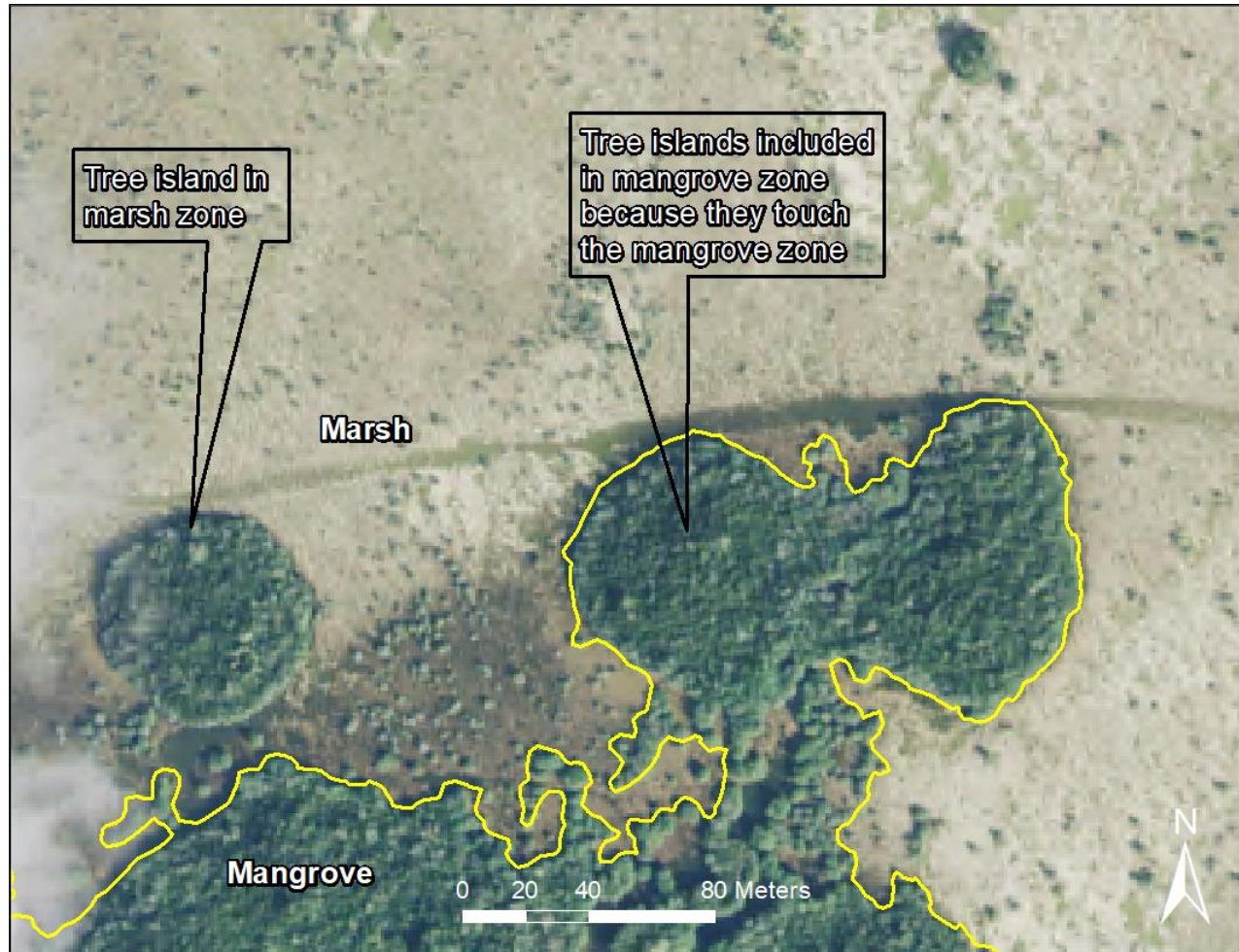


**Figure SOP 2-12.** Tree islands generally (but not always) have a circular or teardrop-shaped appearance. If a tree island touches adjacent mangroves, it is included as part of the mangrove zone. Imagery is 2013 National Agriculture Imagery Program at a scale of 1:1,400.

## Reviewing Each Ecotone Segment

After each ecotone segment line has been digitized, a second person reviews the digitized line to check for adherence to the rules. Either the SFCN botanist or community ecologist will check the digitized linework of other technicians or interns. If the botanist is the primary digitizer, then the community ecologist will check the digitized linework.

Any deviations or concerns are discussed and may result in a need to modify a portion of the segment or to digitize the entire segment again. Modifying the ecotone line within the same sampling event

can be achieved by using the Editor toolbar to turn on Editing, clicking the “Edit Vertices” tool, and double-clicking the line to display all vertices. With the vertices displayed, they can be moved individually to new positions. When finished make sure to click “Save Edits” to save the modifications made to the line. Then click “Stop Editing” when finished.

## **Updating the Ecotone Line**

When creating a new ecotone line with newly acquired imagery (generally every 10 years), use the segment polygons to determine the start and end points. With the new imagery, digitize a new line for each segment using the above procedures. The previous digitized line can then be loaded into ArcMap and the differences between the old line and the new line can be analyzed to determine change over the ten-year span (see SOP 3 *Analysis of Distance between Two Digitized Lines—Version 1.0* and SOP 4 *Analysis of Area between Two Digitized Lines—Version 1.0*).

## **Creating New Marker Points**

After line digitization, new GIS-derived marker points need to be created so that they can be visited in the field. To assist with marker point placement, marker point guidelines were created within each segment at 0.1, 1.0, 2.0, and 2.9 kilometers (0.06, 0.62, 1.2, and 1.8 mi) along the generalized ecotone. These guidelines are parallel to the segment boundaries and extend both upslope (inland) and downslope from the generalized ecotone line. The marker points at the edges of each segment were moved 100 meters in from the edges (0.1 and 2.9 kilometers [0.06 and 1.8 mi]) to reduce the likelihood that the final field placement would be beyond the digitized segment. The GIS-derived marker points are created at the most upslope intersection of the marker point guidelines and the newly digitized ecotone (Figure SOP 2-13). In some extremely sinuous areas there may be more than one location where the marker point can be placed. In these situations, the marker point is placed at the upslope (most inland) ecotone location.

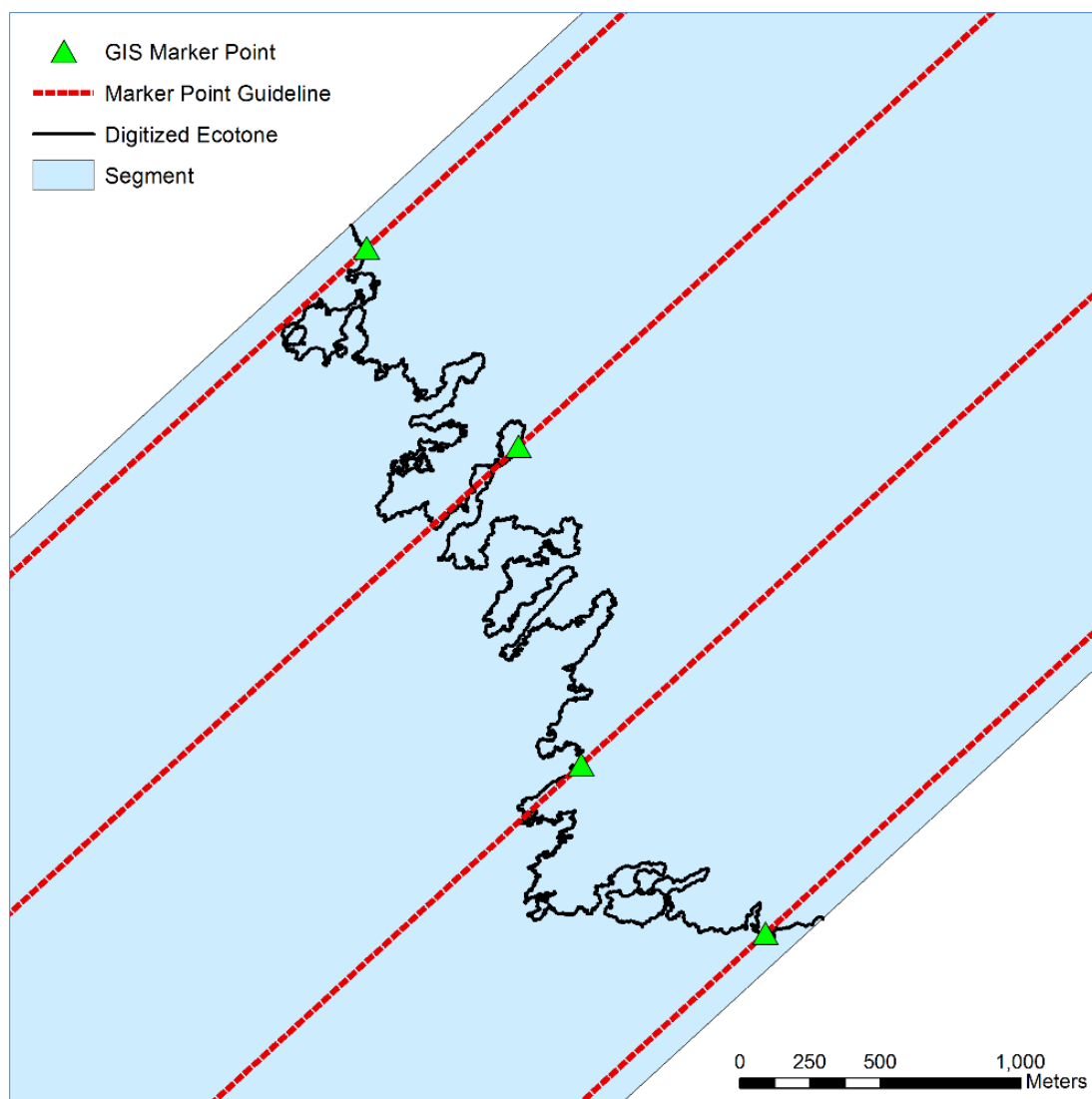


**Figure SOP 2-13.** On each segment (blue polygon) four GIS-derived marker points are created. Each marker point (green triangle) is placed at the most upslope intersection of the digitized ecotone (black line) and the marker point guidelines (red, dashed lines).

The steps to create these ground truth locations are as follows:

1. Open ArcMap, click on the Add Data icon, and navigate to the geodatabase (Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\data\SFCN\_Mangrove\_Marsh\_Ecotone.mdb) to add the following feature classes to the map document:
  - a. geo\_Marker\_Points\_GIS
  - b. geo\_Marker\_Point\_Guidelines
  - c. geo\_Segments
  - d. newly digitized ecotone line

2. In the Table of Contents window, right click on the geo\_Marker\_Points\_GIS feature class and select Edit Features > Start Editing.
3. The Create Features window should be displayed on ArcMap. If not, click on the Editor menu and select Editing Windows > Create Features. The Create Features window will display all the editable features found in the ArcMap document.
4. In the Create Features window click on the geo\_Marker\_Points\_GIS feature class. On the bottom of the Create Features window, there will be a Construction Tools sub-window. Click on “Point.”
5. From the Editor toolbar, click Snapping and then Snapping Toolbar to turn on snapping options. Click Snapping and then ensure that Intersection Snapping is enabled.
6. Zoom in to a segment polygon from the geo\_Segments feature class, where the digitized ecotone line feature class and the geo\_Marker\_Point\_Guidelines feature class intersect. Click on this intersection to digitize a new point for the geo\_Marker\_Points\_GIS feature class. If the digitized ecotone line and geo\_Marker\_Point\_Guidelines feature classes intersect in more than one spot, use the most upslope location (Figure 2-13).
7. In the Table of Contents right-click on the geo\_Marker\_Points\_GIS feature class and select Open Attribute Table. The attribute table for the feature class will appear. It should contain the feature point that was just created. The OBJECTID field will be populated while the other fields will display “<NULL>.”
8. In the attribute table click in the ‘Region’ field and type in the name of the region where this marker point resides (e.g. “Shark Slough”).
9. In the attribute table click in the ‘Segment’ field and type the number of the segment where this new marker point was digitized (e.g. 9).

**Note:** To determine the number of the segment where the new point was digitized click on the Identify icon and then click on the segment polygon where the new point was digitized. The Identify window will appear, displaying the field and attributes for the segment polygon that was clicked on. The field “Segment\_Name” displays the number of the segment.

10. In the attribute table click in the ‘Marker\_ID’ field and type the name of the marker point using the following format: SegmentNumber\_MarkerPointNumber\_YearOfCreation\_GIS (e.g. 09\_1\_2018\_GIS). This will create a unique marker point name that can be differentiated from the GPS coordinates that will eventually be collected when this point is visited.

**Note:** The marker point numbers in a segment go from 1 through 4, starting from the left (west) and going to the right (east).

11. In the attribute table click in the 'Imagery\_Year' field and type in the four digit year of the imagery that was used during digitizing (e.g. "2013").
12. In the attribute table click in the 'Creation\_Date' field and type in the date the new marker point was created (e.g. "08/28/2016").
13. After all edits to the Attribute Table are complete, click the Editor menu and choose 'Save Edits.' Finally, click the Editor menu again and choose 'Stop Editing.'

## Literature Cited

Moser, J., R. B. Shamblin, T. A. Fotinos, A. J. Atkinson, J. L. Chandler, M. Londoño, J. M. Patterson, and K. R. T. Whelan. 2019. South Florida/Caribbean Network mangrove-marsh ecotone monitoring: Protocol narrative. Natural Resource Report NPS/SFCN/NRR—2019/1923. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2260295> (last accessed May 2019).



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# Nearest Neighbor Procedure

This procedure can be used to calculate the average linear distance between two lines by generating a set of equally spaced points along one line and using the Near tool to calculate the nearest distance to the second line. This technique works regardless of the separation between lines. However, it is recommended that all regions with large differences (10 meters [32.8 feet {ft}] or more) be manually checked and edited to resolve major differences in interpretations (See SOP 7 *Mangrove-Marsh Ecotone Data Quality Assurance and Quality Control Procedures—Version 1.0* and SOP 2 *Mangrove-Marsh Ecotone Methods for Digitizing and Updating the Ecotone Line—Version 1.0*).

1. Open ArcMap, click on the Add Data icon, and then add the lines to be compared.
2. Use the Generate Points Along Lines tool to create a shapefile containing points spaced every 10 meters on the first ecotone line: Search for “Generate Points” → *Generate Points Along Lines (Data Management)* → Input: first ecotone line → Output: “Year\_Segment\_DigitizerInitials\_10m\_points” → Point Placement: DISTANCE → Distance: 10 Meters → Click OK.
3. Use the Near tool (Figure SOP 3-1) to measure distances from all points to the second ecotone line. Search for “Near” → Select *Near (Analysis)* → Input: “Year\_Segment\_DigitizerInitials\_10m\_points” → Near Features: second ecotone line → Click OK.

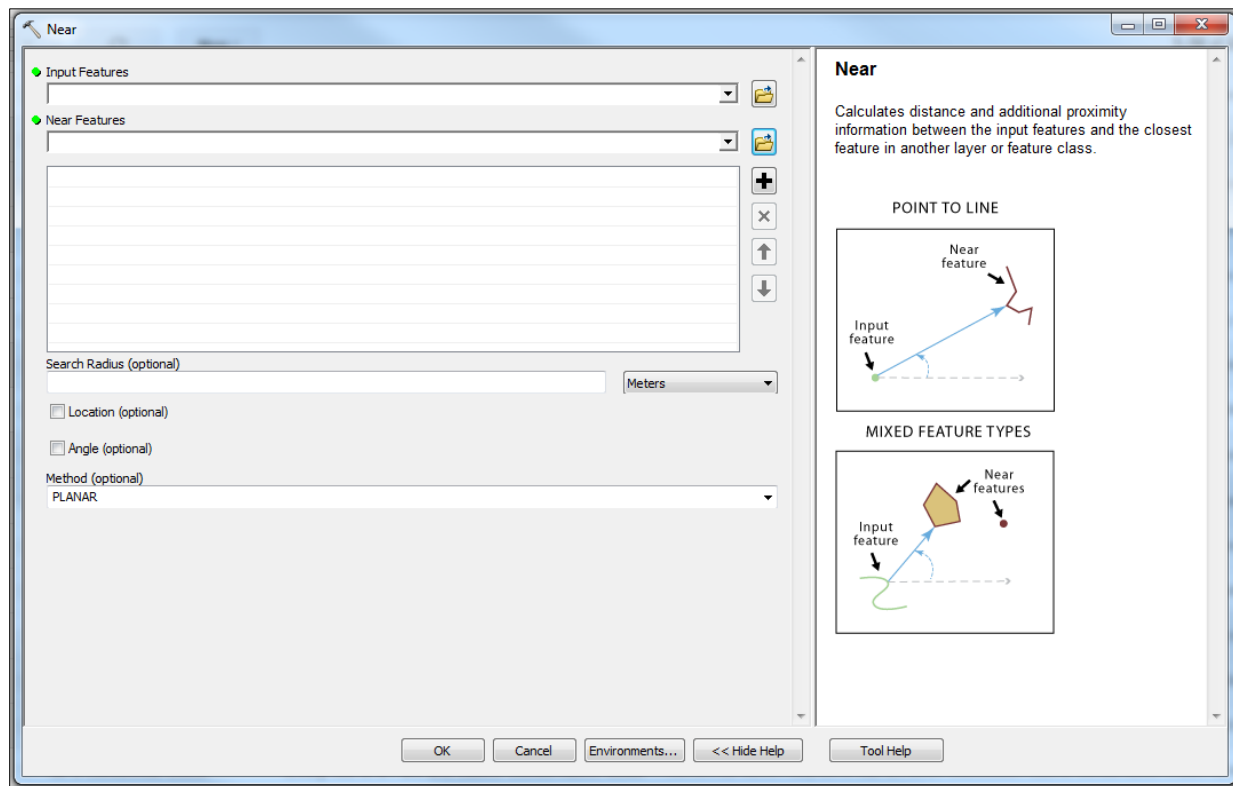


Figure SOP 3-1. The Near tool in ArcGIS 10.3.

4. Export the attribute table from the points shapefile to Excel: Open the attribute table of the points shapefile → Click on *Table Options* → Select *Export* → Input: “Year\_Segment\_DigitizerInitials\_points\_near” → Select .txt as file type → Click *OK* → Import the .txt file to Microsoft Excel using the *From Text* option under *Get External Data* in the *Data* tab.
5. Calculate the mean, median, max, min, standard deviation (or other summary statistics) of the distances in Excel or by importing and analyzing in R. Data can also be subset by region, segment, etc.

## Nearest Neighbor with Directionality Procedure

This procedure is a derivation of the nearest neighbor procedure that assigns directionality to each distance measurement. To start this process, follow SOP 4 *Analysis of Area between Two Digitized Lines—Version 1.0* to create polygons of change between the two lines. Then use the steps below to generate points and assign directionality to those points. Points that are “mangrove expansion” (upslope) are designated as positive distances. Points that are “marsh expansion” (downslope) are designated as negative distances. The purpose of this measurement is to remove the back and forth movement of the digitized line and to focus on any consistent mangrove expansion or marsh expansion bias (or movement) that exists.

1. Open ArcMap, click on the Add Data icon, and add the lines to be compared.
2. Use the Generate Points Along Lines tool to create a shapefile containing points spaced 10 meters on the first ecotone line: Search for “Generate Points” → *Generate Points Along Lines (Data Management)* → Input: first ecotone line → Output: “Year\_Segment\_DigitizerInitials\_10m\_points” → Point Placement: *DISTANCE* → Distance: 10 Meters → Click *OK*.
3. Run the Polygons of Change analysis in SOP 4: *Analysis of Area between Two Digitized Lines* which creates a polygon file with shapes labeled as either “mangrove expansion” or “marsh expansion”.
4. Run the Spatial Join tool to join the polygons and points together. Search for “Spatial Join” → Select *Spatial Join (Analysis)* → Target Features: “Year\_Segment\_DigitizerInitials\_10m\_points” → Join Features: “geo\_Year1\_Year1+t\_Segment\_polygons” → Output Feature Class: “Year\_Segment\_DigitizerInitials\_10m\_Joined” → Join Operation to *JOIN\_ONE\_TO\_ONE* → Click *OK*.
5. Use the Near tool (Figure SOP 3-1) to measure distances from all points to the second line. Search for “Near” → Select *Near (Analysis)* → Input: “Year\_Segment\_DigitizerInitials\_10m\_Joined” → Near Features: second ecotone line → Click *OK*.

6. Export the attribute table from the points shapefile to Excel: Open the attribute table of the points shapefile → Click on *Table Options* → Select *Export* → Input: “Year\_Region\_Segment\_DigitizerInitials\_points\_near” → Select *.txt* as file type → Click *OK* → Import the *.txt* file to Microsoft Excel using the *From Text* option under *Get External Data* in the *Data* tab.
7. Add a new column to the spreadsheet named “Directional Distance”. In this new column create a formula that uses an IF statement to check the “Change\_Type” column. If that column displays “Marsh expansion” the distance should be changed to a negative. Any other value should remain a positive distance. For example, the formula may resemble:
  - a. =IF(L2="Marsh expansion",-N2,N2)
8. Calculate the mean, median, max, min, standard deviation (or other summary statistics) of the directional distances in Excel or by importing and analyzing in R. Data can also be subset by region, segment, and change type (i.e. mangrove/marsh expansion).

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## Purpose

## Revision Log

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## Polygons of Change Analysis

This method calculates the area of mangrove or marsh expansion between two digitized lines. These steps are written for year1 and year1+t lines, but the same technique can be employed to analyze two ecotone lines created with the same imagery (i.e. digitizer comparison). The overall process is to convert each digitized line to a polygon within a segment and then to union those polygons together. The final steps add attributes and summarize the results.

16. Open ArcMap, click on the Add Data icon, and navigate to the geodatabase (Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\data\SFCN\_Mangrove\_Marsh\_Ecotone.mdb) to add the following feature classes to the map document:
  - a. geo\_Segments
  - b. year 1 digitized ecotone line
  - c. year 1+t digitized ecotone line
17. In the Table of Contents window, right-click on the geo\_Segments feature class and select Export Data. In the Export Data screen click on the folder icon. In the Saving Data window navigate to the Mangrove-Marsh Ecotone spatial info folder for year 1 (Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\spatial\_info\Year1\)) and set the following inputs:
  - a. Name: geo\_Segments\_year1 (e.g. geo\_Segments\_2008)
  - b. Save as type: Shapefile
  - c. Click Save and then click Yes when asked to display the exported data on the map.
18. Repeat Step 2 but use the following inputs:
  - a. Name: geo\_Segments\_year1+t (e.g. geo\_Segments\_2018)
  - b. Save as Type: Shapefile
  - c. Click Save and then click Yes when asked to display the exported data on the map.
19. The geo\_Segments\_year1 and geo\_Segments\_year1+t shapefiles will now appear in ArcMap. The original geo\_Segments feature class can be removed in the Table of Contents by right-clicking and choosing 'Remove.'
20. Start an editing session for the geo\_Segments\_year1 shapefile by right-clicking in the Table of Contents window → *Editor Features* → *Start Editing*. Choose the 'geo\_Segments\_year1' feature.

21. Select all the digitized linework for year1 by right-clicking the year1 digitized line and choose 'Selection' and then 'Select All.'
22. Click on the Split Polygons icon found in the Advanced Editing window in the Editor toolbar. In the Split Polygons window that appears set the following inputs:
  - a. Target: geo\_Segments\_year1
  - b. Cluster Tolerance: leave the default value of 0.001
  - c. Click OK

**Note:** If the Split Polygons or Advanced Editing tools window are not showing click on Editor → More Editing Tools → Advanced Editing.

23. When the Split Polygons tool has completed, each segment polygon should be partitioned into two separate polygons (i.e. the area above the ecotone line and the area below the ecotone line). Click on the Edit Tool icon and select the top partition of each edited segment (the portion above the ecotone) and press the 'Delete' key to remove it (Figure SOP 4-1).

**Note:** If a particular segment is not bisected by the Split Polygons tool it is probably because the digitized line did not snap to the segment edges. The digitized line should be modified so that it does touch the edge, and then the Split Polygon tool can be rerun.

**Note:** Segment 10 is bisected by the park road and the ecotone on each side of the road is disconnected. Each side of the park road will need to be treated as a separate polygon for this technique to work.

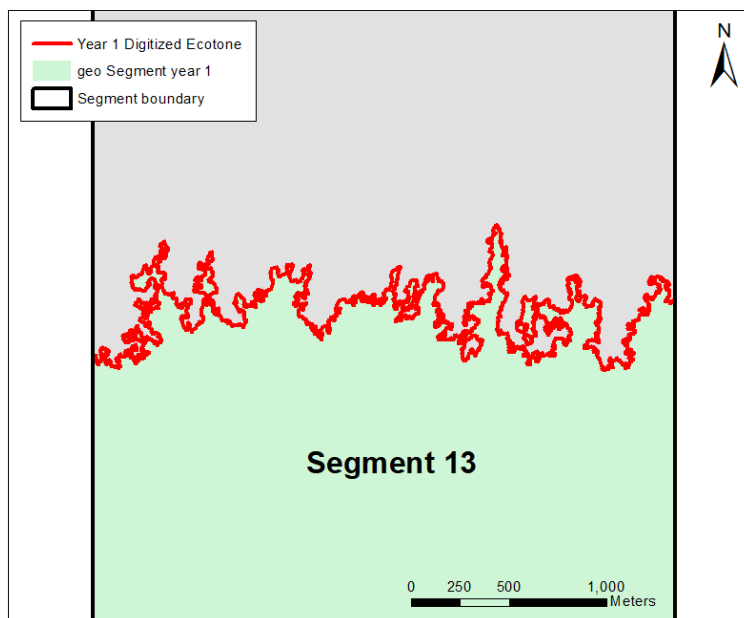


**Figure SOP 4-1.** The map shows the Segment 13 split by the year 1 digitized ecotone line. The top (gray) portion of the polygon is not needed for this analysis, so it is removed in step 8.

9. Review the attribute table and pay particular attention to any rows with duplicated 'Segment\_Name' values. These duplicated rows are likely caused by complicated linework that bisected the segment edge in more than one location. Review each duplicate by zooming to a single row and determining if it should be part of the ecotone polygon or should be deleted. If it should be included, merge the rows together by highlighting both rows, and then choosing 'Merge' from the Editor toolbar.
10. Click the Editor menu and choose 'Save Edits.' Finally, click the Editor menu again and choose 'Stop Editing.'
11. Repeat Steps 5 through 10 but this time the geo\_Segments\_year1+t shapefile and year 1+t digitized ecotone line will be utilized. Follow each of the steps very carefully and be sure to use the appropriate inputs and naming conventions as required. In many cases, the inputs and names will change.
12. Click on the Geoprocessing menu → Union. In the Union window that appears set the following inputs:
  - a. Input Features: year1 and year1+t segment polygon layers created in the previous steps (e.g. geo\_01\_2008 and geo\_Segments\_2018)
  - b. Output Feature Class: click on the folder icon and navigate to the geodatabase (Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\data\SFCN\_Mangrove\_Marsh\_Ecotone.mdb) and set the following inputs:
    - i. Name: geo\_Year1\_Year1+t\_Segment\_polygons (e.g. geo\_2008\_2018\_01\_polygons.shp).
    - ii. Save as type: Feature class
    - iii. Click Save
  - c. Back in the Union window the Output Feature Class input will update. Leave all of the other defaults the same.
  - d. Click OK.
13. The new union polygon feature class will appear on the ArcMap document. In the Table of Contents right-click this feature class → *Edit Features* → *Start Editing*.
14. Open the attribute table for the new union feature class. There will be three rows of records/attributes. Select the record that depicts the area of overlap between the year1 and year1+t segment polygon shapefiles. This will be the record/attribute that has an area listed under the Shape\_Area field much larger than the other two records. Click on the Delete Selected icon in the attribute table to delete this record that represents areas of no change between the two polygons.

15. Click the Editor menu and choose 'Save Edits'. Finally, click the Editor menu again and choose 'Stop Editing.'
16. Open again the attribute table for the new union feature class. Click on the Table Options icon → *Add Field*. In the Add Field window that appears set the following inputs:
17. Name: Change\_Type
18. Type: Text
19. Length: 20
20. Click OK
21. In the Table of Contents window, display the union feature class as a hollow polygon with a bright color as the outline. Go back to the attribute table of the union feature class and select the first record. Zoom out until all selected polygons are visible. Make sure to display both ecotone lines along with the aerial imagery used to digitize the most recent ecotone line. If the area within the selected polygons is marsh habitat then the polygon is depicting marsh expansion. If the area within the selected polygons is in mangrove habitat then the polygon is depicting mangrove expansion.
22. Once the type of habitat change has been determined go back to the attribute table and right-click the Change\_Type field → *Field Calculator*. Inside the text box at the bottom half of the Field Calculator type the habitat change label (i.e. "mangrove expansion" or "marsh expansion") in quotation marks.
23. Repeat Steps 17 through 18 but this time select the second record in the union feature class. This record should contain polygons that are of the other type of habitat change (e.g. if the first record = marsh expansion, the second record = mangrove expansion; Figure SOP 4-2).

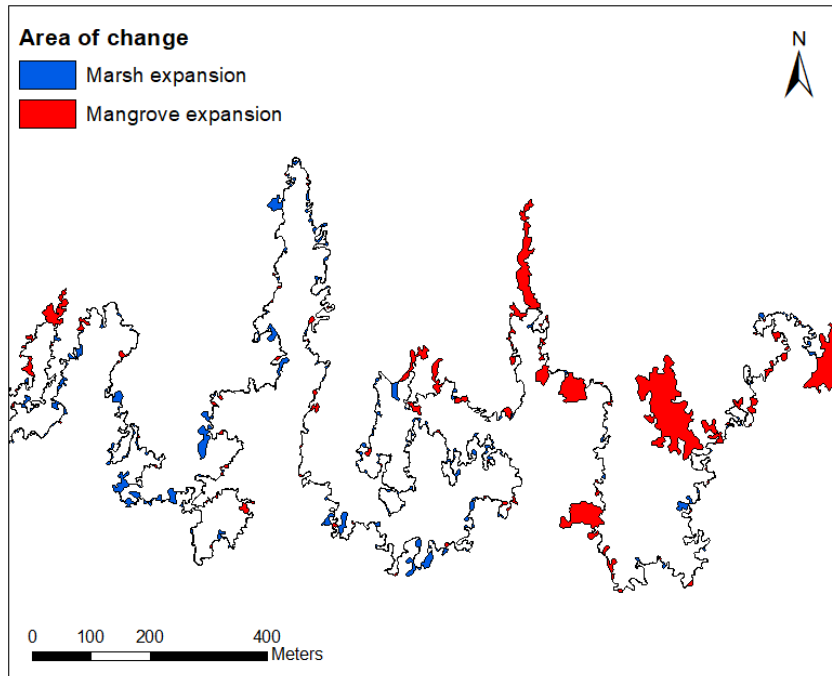


**Figure SOP 4-2.** This map shows the area of change between a fictionalized year 1 and year 1 + t. The polygons in red represent mangrove expansion, and the polygons in blue represent marsh expansion.

24. Start an editing session for the union feature class by right-clicking in the Table of Contents window → Editor Features → Start Editing.
25. Open the attribute table for the union feature class and select the only two records/attributes that were analyzed in the previous steps.
26. Go to the Advanced Editing toolbar and click on the Explode Multipart Feature tool icon. Now open the attribute table for the union feature class. The polygons that comprised the original two records/attributes analyzed in the previous steps have been partitioned out and listed as individual features. Each record/attribute will have a corresponding area calculated in the Shape\_Area field as well as a habitat change type category displaying under the Change\_Type field. Summary statistics can be derived for the polygons containing marsh expansion or mangrove expansion.

Click the Editor menu and choose 'Save Edits.' Finally, click the Editor menu again and choose 'Stop Editing.'

# South Florida/Caribbean Network

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## Standard Operating Procedure 5

### *Mangrove-Marsh Ecotone Field Methods—Version 1.0*

#### Purpose

This standard operating procedure (SOP) outlines the procedures for marker point establishment and monitoring in the field. The goal is to “ground-truth” the digitized line to the earth by comparing a field-determined placement of the ecotone point with the location of the digitized line. The purpose of the vegetation data is to provide ancillary descriptive data about the composition of the “mangrove” and “marsh” sides of the ecotone that in turn may inform management about the hydrology and water quality at the interface. The South Florida/Caribbean Network developed these methods based on pilot work conducted in 2010 (Appendix B *Mangrove-Marsh Ecotone Pilot Project Report*; Moser et al. 2019) as well as additional pilot work from 2011–2018.

#### Revision Log

| Revision Date | Author | Changes Made | Reason for Change | New Version # |
|---------------|--------|--------------|-------------------|---------------|
|               |        |              |                   |               |
|               |        |              |                   |               |
|               |        |              |                   |               |
|               |        |              |                   |               |
|               |        |              |                   |               |

# Marker Point Establishment

## Ground Method

Prior to collection of marker points, a logistical plan must be worked out so groups of marker points can be assessed in a cost-effective manner. Accessibility of points is affected by water level, density of vegetation, and management guidance. Ecotone marker point establishment is performed after the digitized ecotone lines have been completed and the GIS-derived marker points have been generated (see SOP 2 *Mangrove-Marsh Ecotone Methods for Digitizing and Updating the Ecotone Line—Version 1.0*).

Upon arriving in the general vicinity of an ecotone marker point via helicopter, airboat, or other method, use a handheld GPS unit to navigate to the marker point coordinate (see SOP 9 *Using Garmin Handheld GPS Units—Version 1.0*). Once you are as close to the ecotone location as possible, evaluate the vegetation on either side of the marker point to determine that it is representative of a mangrove-marsh ecotone and identify the ecotone point. Based on field vegetative characteristics determine the ecotone location. The ecotone point is defined as the point where mangrove cover greater than 50% gives way to a more open freshwater marsh environment dominated by sawgrass (*Cladium jamaicense*) or spikerush (*Eleocharis* spp.). In the ecotonal marsh area, a few mangrove shrubs or trees may still be present, but their cover will be less than 50%. The freshwater herbaceous vegetation cover will increase substantially, or this area will consist of open water (see Appendix B *Mangrove-Marsh Ecotone Pilot Project Report* [Moser et al. 2019] for more information). Similar decision rules are used as during the mapping of the ecotone using aerial imagery, e.g., in areas of the landscape with a degraded ecotone edge, cover of mangroves is evaluated within a 10-meter (32.8-feet [ft]) radius circle to establish the ecotone edge. Both field crew members consult and agree upon the location of this ecotone point.

Once the ecotone point has been determined by best professional judgment, use a survey grade sub-meter GNSS unit with external antenna such as the Trimble Geo7X with Tempest antenna to collect coordinates at the marker point (see SOP 10 *Using Trimble Geo7X GPS Unit—Version 1.0*). At the beginning of each day, create a new data file on the Trimble Geo7X. Name the file using the date created (YYYYMMDD), and “\_ecotone” (e.g. 20180415\_ecotone). Place the point of the antenna pole at ground level, extend the top of the pole above head level (2 meters [6.6 ft]), and make sure the pole is level when collecting data. Be sure to set the antenna height correctly (a typical height is 2 meters) before collecting data. Allow the unit to average at least 100 data points before finalizing the coordinate. Be sure to fill in all requested feature data (marker point name and notes) on the GPS. Back at the office, the marker points will be plotted in ArcGIS, and the distance from the marker points to the digitized line will be measured using the ArcGIS measuring tool (Figure SOP 5-1).

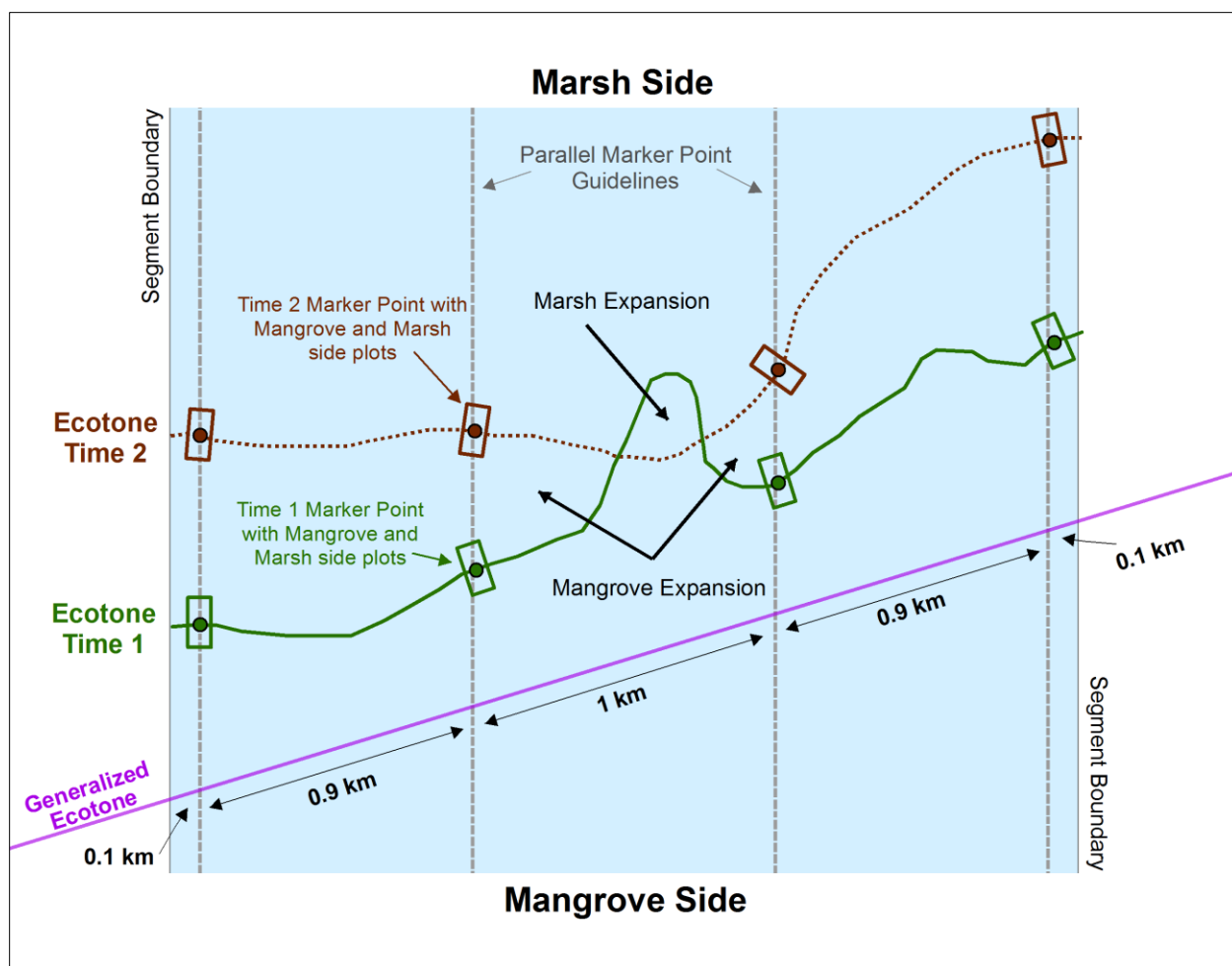


**Figure SOP 5-1.** Example of the movement of an ecotone with Time1 (solid black line), Time2 (dotted black line), the marker points (circles), and associated vegetation plots (boxes around circles). Note: plots not drawn to scale.

## Helicopter Method

In some cases, it may not be possible to land the helicopter at the marker point due to the nature of the environment (vegetation too thick to land, substrate too soft or muddy). In these cases, the marker point data collection will need to be made from a hovering helicopter. Since this process requires disassembling the Trimble GPS unit and mounting the antenna on the helicopter dashboard, it will be necessary to flag these inaccessible marker points and revisit them either later in the flight when ground accessible marker points are completed for the day, or have the final field helicopter flight dedicated to sampling these inaccessible marker points.

The Trimble GPS circular antenna is mounted on the dashboard of the helicopter. Attach the Trimble GPS unit to the external antenna and attach the antenna to the two metal hooks on the dashboard of the helicopter using the two magnets on the antenna. Use a piece of tape to secure the antenna at a third point. The distance from the middle of the antenna to the outside edge of the helicopter's passenger side skid is measured and later added to the GPS point correction.

Once in the general vicinity of an ecotone marker point, the botanist (positioned in the helicopter's front passenger side seat) guides the pilot to align the passenger side skid over the nearest ecotone edge. The height of the helicopter should be approximately 2 meters (6.6 ft) above the canopy in forested mangrove communities and 10 meters (32.8 ft) above the canopy in dwarf mangrove communities. The overall goal is stay at least 10 meters above the ground surface to maintain a safe operating altitude.

Depending on wind direction, the helicopter can be positioned over the mangroves or the marsh, as long as the passenger skid is aligned with the ecotone edge. A compass bearing is taken to record the direction of the front of the helicopter (direction of travel). The pilot is then instructed to hover the helicopter over the ecotone edge for approximately 30 seconds while the botanist takes the GPS mark, averaging the GPS unit for 30 positions. This is fewer positions than the ground method because the helicopter pilot will have a harder time keeping the helicopter steady after a 30-second period. The Trimble unit has a counter built in showing the number of positions the unit has averaged for a particular coordinate.

Back in the office after all points have been collected and the coordinates have been differentially corrected, add the shapefile with the corrected coordinates to ArcMap. Offset the hover points by the bearing and distance between the GPS unit and the helicopter skid point used to mark the ecotone location. The offset bearing will be the direction of travel of the helicopter minus the correction angle (minus 90° from the front of helicopter). Use the ArcMap measure tool to find the distance between the ground and corrected marker point at each sampled location. Summary statistics of the differential between the ground and hover points can then be calculated (Figure SOP 5-2).

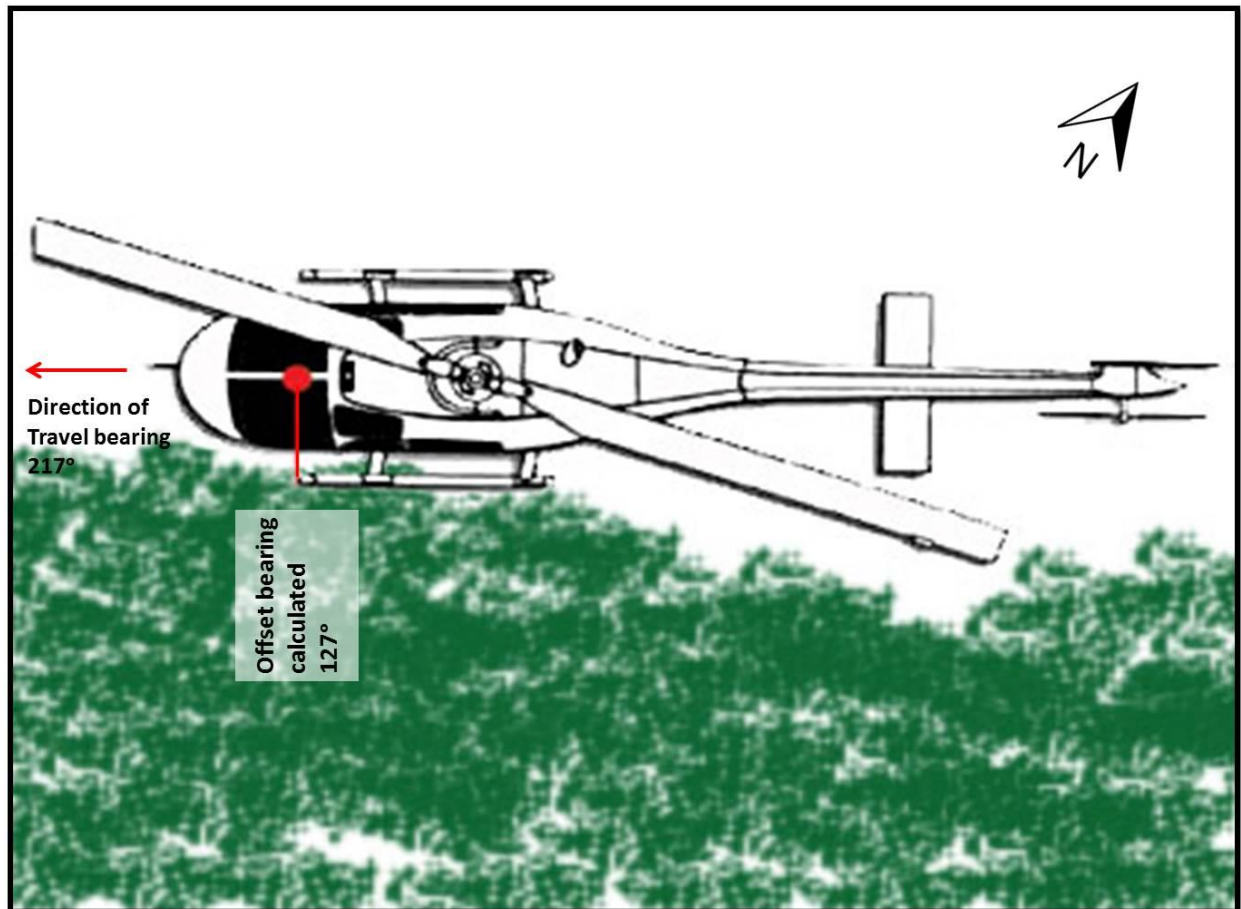


**Figure SOP 5-2.** A rendering of a hovering helicopter performing a GPS point data collection. The GPS antenna mount (red dot) is located on the center dashboard of the aircraft. For a Bell 206 BIII the distance between the GPS antenna and the end of the skid is 1.05 meters (3.4 ft) and the offset angle is exactly 90° degrees. In this rendering the aircraft has a direction of travel bearing of 217° (red arrow) hence the offset bearing is 127° ( $217^\circ - 90^\circ = 127^\circ$ ) with an offset distance of 1.05 meters. The crewmember in the co-pilot seat directs the pilot; visually lining up the outside of the skid with the mangrove ecotonal edge below; then directs the pilot to hover in place while acquiring a GPS location. In this rendering, the wind is from 217° steady at 10 mph. A similar approach was used when collecting position data for the accuracy test.

### Collecting Vegetation Data at Marker Points

Vegetation cover is the absolute percent area occupied by vegetation regardless of species. Tree cover is the absolute percent area occupied by trees, regardless of species. Absolute percent cover of an individual species is evaluated as the total cover of the species, ignoring the presence of other species. Cover is estimated as canopy cover, defined for a species as “the percentage of ground covered by the vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings within the canopy are included” (Anderson 1986). We have chosen to use canopy cover instead of foliar cover based on the recommendation of Anderson. “Canopy cover is best suited as a practical field procedure for documenting a plant community” (Anderson 1986).

### Specific steps:

1. On the mangrove side of the ecotone estimate the absolute total percent vegetated cover to the nearest 5%.
2. Estimate absolute percent cover for trees, shrubs, and herbs to the nearest 1%. Note that the total of % tree + % shrub + % herbs can be greater than 100%, although this is uncommon in these communities.
3. Estimate the absolute percent cover of each tree species, shrub species, and herb species to the nearest 1%. The purpose is to provide a rapid assessment of the vegetation community, and an exhaustive search and recording of species with less than 5% cover is not expected or assumed. Note that the sum of the absolute percent cover of each individual tree species can be greater than the total absolute cover for trees recorded in step 2, and similarly for shrub species and herbaceous species, as species canopies can overlap. This is uncommon in these communities.
4. Repeat steps 1–3 for the marsh side of the ecotone.

Data collected via helicopter hovering is restricted to a two-dimensional view from above and the ability to estimate absolute cover in thick highly overlapping canopies is problematic. However, the communities being investigated in this protocol tend to have limited overlapping structure and the difference in estimates between hovering and ground is expected to be minimal and to still provide useful information with respect to what vegetation communities are on either side of the ecotone. Researchers estimating via helicopter are instructed to record absolute percent cover to the best of their ability as well as ensure the method of collection “hover” is recorded.

### Ground Method

After the location of the ecotone point has been determined, evaluate a 5 × 5 meter (16.4 × 16.4 ft) area on the mangrove side of the ecotone and a 5 × 5 meter area on the marsh side. The front side of the datasheet (Figure SOP 5-2) is where data are recorded, and the reverse side of the datasheet provides a map of the surrounding area where the marker point is located. Vegetation data are estimated by standing at the marker point and filling out the data form based on an estimated 5 meter × 5 meter square on the marsh side and then the mangrove side of the ecotone marker. A series of nine photos are taken at each marker point. Start by taking a photo of the datasheet to identify the marker point. Then take four photos of the marsh side of the ecotone, followed by four photos of the mangrove side to create a panorama. More photos can be taken to document rare plants or for further documentation of the field site.

### Helicopter Method

If arriving by helicopter where landing is not possible, vegetation data are collected from a hovering helicopter at a height approximately 2 meters (6.6 ft) above the canopy in forested mangrove communities and 10 meters (32.8 ft) above the canopy in dwarf mangrove communities. The overall goal is stay at least 10 meters above the ground surface to maintain a safe operating altitude.

Canopy height is estimated using the helicopter altimeter. Take a reading of the altimeter and subtract the estimated distance from the helicopter skid to the top of the plot canopy. Marsh side vegetation strata and species are identified and percent cover estimated after instructing the pilot to position the helicopter so the passenger side of the helicopter is facing the marsh component of the ecotone. The pilot is then instructed to rotate the helicopter 180° so the passenger side of the helicopter is facing the mangrove component of the ecotone. During this helicopter rotation the pilot is to only perform this action if it can be accomplished safely. The mangrove side vegetation strata and species are identified and percent cover estimated (see Figure SOP 5-2 as to placement of helicopter when recording mangrove side vegetation data). While the project leader (usually the SFCN botanist) records the vegetation data, a second biologist sitting in the back passenger side seat takes pictures of the habitat. The first picture is of the datasheet to identify the marker point being surveyed and then four pictures of the habitat are taken on each side of the ecotone.

# SFCN Mangrove-Marsh Ecotone Monitoring Marker Point Datasheet

Location \_\_\_\_\_ Date \_\_\_\_\_

Travel Method: ☐ Airboat ☐ Helicopter ☐ Hike ☐ Other

Recording Method: ☐ Ground ☐ Hover

Side Visited First: ☐ Mangrove ☐ Marsh

Observers: \_\_\_\_\_

First Initial and Last Name

Field Check ☐ \_\_\_\_\_

DB Entry ☐ \_\_\_\_\_

DB Check ☐ \_\_\_\_\_

Ecotone Point:

Trimble File Name \_\_\_\_\_ GPS Mark # \_\_\_\_\_ GPS Unit # \_\_\_\_\_

Photo Order:

(1) Datasheet, (2) Down the Ecotone to the Left, (3) (4) (5) First Side, (6) Down the Ecotone to the Right, (7) (8) (9) Second Side

Overall Absolute % Cover \_\_\_\_\_%

**Mangrove Side**

Absolute % Cover by Stratum

|              |         |
|--------------|---------|
| Tree Stratum | _____ % |
| Tree Species | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |

|               |         |
|---------------|---------|
| Shrub Stratum | _____ % |
| Shrub Species | _____ % |
| _____         | _____ % |
| _____         | _____ % |
| _____         | _____ % |
| _____         | _____ % |
| _____         | _____ % |

|              |         |
|--------------|---------|
| Herb Stratum | _____ % |
| Herb Species | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |

Canopy Height

Tree \_\_\_\_\_ (m)

Shrub \_\_\_\_\_ (m)

Herb \_\_\_\_\_ (m)

Overall Absolute % Cover \_\_\_\_\_%

**Marsh Side**

Absolute % Cover by Stratum

|              |         |
|--------------|---------|
| Tree Stratum | _____ % |
| Tree Species | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |

|               |         |
|---------------|---------|
| Shrub Stratum | _____ % |
| Shrub Species | _____ % |
| _____         | _____ % |
| _____         | _____ % |
| _____         | _____ % |
| _____         | _____ % |
| _____         | _____ % |

|              |         |
|--------------|---------|
| Herb Stratum | _____ % |
| Herb Species | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |
| _____        | _____ % |

Canopy Height

Tree \_\_\_\_\_ (m)

Shrub \_\_\_\_\_ (m)

Herb \_\_\_\_\_ (m)

Comments:

Figure SOP 5-2. Example of the field data sheet to record vegetation data for each marker point.

### Field Data Sheet Instructions:

- **Location**—this will be the unique ID derived from the segment number and marker point number separated by an underscore (ex. 10\_1, segment 10, and marker point 1).
- **Date**—the date of the assessment of each marker point.
- **Travel Method**—the method used to get to the marker point, such as helicopter, airboat, or hiking.
- **Recording Method**—the set of methods (i.e. ground or helicopter) that are used to record data and take photos.
- **Side Visited First**—the side of the ecotone (i.e. mangrove or marsh) that the observers are facing when they start their data and photo collection.
- **Observers**—the first initial and last names of the field crew collecting data at this marker point.

### Ecotone Point

- **Trimble File Name:** Record the marker file name entered into the Trimble Geo7X unit.
- **GPS Mark #:** The GPS mark number assigned to the marker point, usually collected on site by a handheld GPS unit, and automatically chosen by the unit.
- **GPS Unit #:** The GPS unit number itself. In the SFCN office, we have multiple handheld GPS units and each one is assigned a unique identifying number (such as 1, 2, 3...). If you do not have an assigned unit number, use the GPS model number (such as Garmin 60Cxs, 62s, etc.) instead.
- **Photo Order:** Photographer must stand with back towards mangroves and facing marsh. The first photo taken at a specific marker point is of the field sheet (showing the unique marker point identification number). The next photos are taken clockwise starting with one down the left side of the ecotone, then at 45° intervals, three more marsh side photos, one down the right side of the ecotone, and then at 45° intervals, three more mangrove side photos (Figure SOP 5-3). Have camera settings without flash, in portrait mode, and in the macro setting. For photos taken on the ground have camera parallel to the ground and shoot picture straight ahead at shoulder height (approximately 5 feet [1.5 m] from ground). For photos taken from the helicopter the camera is aimed down towards the vegetation.
- **Overall Absolute % Cover:** Record an overall absolute cover estimate to the nearest 5%, taking into account all strata together to come up with an absolute cover estimate for each side of the ecotone. In most cases this value will be a high percentage 80 to 100 % unless there is a large amount of open water or bare mud or ground.

- **Absolute % Cover by Stratum:** This is the percent of the vegetated cover by stratum (does not include non-vegetated cover). Record the estimated absolute percent cover of tree (greater than or equal to 5 meters [16.4 ft] in height), shrub (less than 5 meters in height and woody), and herb (non-woody plants) strata in the plot area to the nearest 1%. In the spaces provided under this heading, record the estimated absolute percent cover of all easily observable species found within each respective strata to the nearest 1%. Enter the six-letter species code of the species encountered on the mangrove side of the ecotone marker, and then the marsh side. The six-letter code consists of the first three letters of the genus and the first three letters of the specific epithet to come up with the species code. For example, *Rhizophora mangle* (Red Mangrove), would have a species code of RHIMAN.
- **Canopy Height:** Record the estimated canopy height in meters of tree (**greater than or equal to 5 meters [16.4 ft] in height**), shrub (**less than 5 meters in height and woody**), and herb (**non-woody plants**) strata for each 5 × 5 meter (16.4 × 16.4 ft) plot. Height estimations for each stratum are recorded separately—the height of trees will not be averaged with the height of shrubs or herbs, and so forth. These values represent the average of each of the three strata. Note: the height of a tree is measured from the ground up to the top of the tree. Canopy height is estimated by using a telescoping height pole or a previously measured person. For example, the field helper is 1.8 meters (5.9 ft) in height and the shrub height is one and a half times taller than the field helper, arriving at an estimated height of 2.7 meters (8.9 ft). In many cases, when doing fieldwork, the helicopter has no other option than to land close to where field measurements are made, rendering the use of a telescoping height pole too risky. The telescoping height pole is used when fieldwork is done by airboat or walk-in sites. Height estimations from a helicopter are made using the helicopter altimeter and subtracting the height above the canopy.
- **Comments:** Any important or interesting features such as structures, trails, hurricane damage, water cover and soil cover.



**Figure SOP 5-3.** Photo of ecotone edge between red mangrove shrubs and cattail/spikerush freshwater marsh.

## Literature Cited

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- Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring and monitoring plant populations. Bureau of Land Management, Denver, CO. BLM/RS/ST-98/005+1730.
- Moser, J., R. B. Shamblin, T. A. Fotinos, A. J. Atkinson, J. L. Chandler, M. Londoño, J. M. Patterson, and K. R. T. Whelan. 2019. South Florida/Caribbean Network mangrove-marsh ecotone monitoring: Protocol narrative. Natural Resource Report NPS/SFCN/NRR—2019/1923. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2260295> (last accessed May 2019).
- USDA 2004. Field instructions for the annual inventory of California, Oregon, and Washington 2004: US Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forest Inventory and Analysis Program. 373 p.



**National Park Service**  
**Inventory and Monitoring Division**

[illegible]

# Pre-Data Entry Processing

## Downloading Trimble Geo7X GPS Units

To download Trimble Geo7X GPS Units, see SOP 10 *Using Trimble Geo 7X GPS Unit—Version 1.0*.

## Downloading Garmin Handheld GPS Units

GPS point (plot) and trackline files should be downloaded into the folder (Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\spatial\_info) in the subfolder named “GPS”. Each GPS point and trackline file should be renamed using the following naming convention “YYYYMMDD\_point” or “YYYYMMDD\_trackline” (example “20140908\_trackline”).

To download Garmin handheld GPS Units, see SOP 9 *Using Garmin Handheld GPS Units—Version 1.0*.

## Scanning Datasheets

Before returning from the field, all datasheets are reviewed for any errors or blank fields. Afterward, scan all datasheets in pdf format with the naming convention “YYYYMMDD\_Field\_Datasheets” (example “20140908\_Field\_Datasheets.pdf”) and put in the scanned datasheets folder (Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\data\scanned\_datasheets).

## Downloading Photos and Photo Renaming

Photos are downloaded into the folder: Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\images.

After returning from a field day, the photographs from the camera are downloaded before going back into the field. Below are detailed instructions for downloading photographs from an Olympus Stylus Tough-8000 camera. If another model of camera is used in the future, follow the instructions provided for the particular camera:

- Attach the Olympus Stylus Tough-8000 camera download cable to a USB port on the computer and then attach the camera to the other end of the download cable.
- When the camera is attached to the download cable, it will automatically turn on and reveal a list of four choices on the camera screen. These choices are PC, Easy Print, Custom Print and Exit. At the right of the PC box, there will be a right facing arrow. To activate this arrow, hit the lightning bolt key on the camera menu. This will take you to a new screen on the camera with two choices—Storage, and MTP. Hit the down button on the camera (of the camera menu buttons, it will show a clock on the button) to highlight the MTP choice.
- Press the OK button on the camera. On the computer screen, this will bring up the Scanner and Camera Wizard. Click Next. This will take you to a new screen on the computer where you can choose pictures to copy. Pictures with a green arrow in the upper right hand corner will be the pictures that will be copied. Click Next.

- A new screen will appear on the computer. This will be the Picture Name and Destination page. In “Type a name for this group of pictures”, follow this naming convention: “YYYYMMDD” (e.g. 20140908). Then choose the correct folder for the group of pictures to be saved. When choosing a place to save the group of pictures, you would choose the following destination: Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\images\.
- It is recommended that you delete the pictures from the camera after copying them. This can be done by clicking the box next to “Delete pictures from my device after copying them.” Click Next.
- The pictures will then be copied to the specified destination. A new screen on the computer will appear with other options. At this point you are finished downloading the pictures. Make sure the “Nothing. I’m finished working with these pictures” is checked and then hit “Next” and “Finish.” You can now disconnect the camera from the computer and put away the download cable and camera.
- Once the photos have been downloaded they can be renamed. Use a program such as IrfanView or Adobe Bridge set to the following naming convention: YYYYMMDD\_segment code and point\_direction (e.g. 20171127\_10\_2\_marsh.jpg).

## Data Entry of Field Datasheets into Access Database

Data from completed field data sheets are entered into the Mangrove-Marsh Ecotone monitoring database as soon as possible after returning from the field, while details from the field are still vivid in the mind of the researchers. The Mangrove-Marsh Ecotone monitoring database is located in Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\data\SFCN\_Mangrove\_Marsh\_Ecotone.mdb. The Mangrove-Marsh Ecotone monitoring database is designed to resemble field datasheets in order to simplify data entry.

It is **important** to consult with the data management personnel tasked with providing support for the Mangrove-Marsh Ecotone Access database **prior to entering data for a new assessment** in order to verify that the appropriate assessment and locations are established before time and effort are put into data entry.

### Marker Point Field Datasheet Entry

If entering data for the first time:

- Upon opening the Mangrove-Marsh Ecotone monitoring database (Figure SOP 6-1), click “Add Marker Visit” under the “Marker Visits” section in the “SFCN Ecotone Database” navigation.
- The “Marker Data Entry” form (Figure SOP 6-2) will open.

Fill out all fields as follows:

- **Assessment:** Use the dropdown menu to select the proper assessment. If it was the initial assessment, the number 1 is selected. If data collected are from the second round of assessments, select 2 and so on.
- **Date:** Enter the date that the fieldwork was completed. There is a calendar icon located to the right of the date entry box. By clicking on this box, a calendar will appear with the current date highlighted. Click on the date that fieldwork occurred and that date appears in the Date entry box.
- **Location:** Use the dropdown menu to choose the appropriate marker location.
- **Photos:** Enter the number of pictures taken that corresponds to the marker.
- **Observers:** Enter the initials of the individuals that took part in the survey. There is a dropdown menu located at the upper right of this data field, and by clicking on it, a list of the names of people who were on past surveys will appear. Click on the name or initials appearing in the dropdown menu and they will appear in the data entry field.
- **GPS Mark:** Enter the GPS mark taken at the marker post location.
- **GPS Unit #:** Enter the number given to the GPS unit that was used in gathering field marks. Each of the handheld GPS units owned by the South Florida/Caribbean Network has been given a number that is written in multiple places with a Sharpie on the unit itself. Sometimes, however, the number will get rubbed off the outer casing of the GPS unit. When this happens, open the cover to the battery storage area of the GPS unit, and the unit number will also be written there.
- **Travel Type:** Enter the type of transit used to arrive at the site. There is a dropdown menu to the right of the data field box. By clicking it, a list of the travel types appears. Click on the method that describes the travel type.
- **Comments:** Enter any comments, remarks or notes taken in the field. This may include site descriptions, observations or any item of interest pertaining to the survey area.
- **Mangrove Cover:** Enter the overall absolute percent cover of vegetation on the mangrove side of the ecotone marker.
- **Mangrove Tree Stratum % Cover:** Enter the estimated absolute percent cover of the tree stratum on the mangrove side.
- **Mangrove Tree Canopy Height:** Enter the average estimated tree canopy height in meters on the mangrove side of the ecotone marker.
- **Mangrove Tree Species:** Enter the six-letter species code of the tree species encountered on the mangrove side of the ecotone marker. The six-letter code consists of the first three letters of the genus and the first three letters of the specific epithet to come up with the species code.

For example, *Rhizophora mangle* (Red Mangrove), would have a species code of RHIMAN. When a species code is entered in this data field, a new Species line will appear below the line where the data are being entered, in anticipation of the next species. If the species you enter is not in the database, it will ask you if you are sure the spelling is correct and if you want to add the species to the database.

- **Mangrove Tree Species % Cover:** Enter the estimated absolute percent cover of each species found within the tree stratum on the mangrove side of the ecotone marker.
- **Mangrove Shrub Stratum % Cover:** Enter the estimated absolute percent cover of the shrub stratum on the mangrove side.
- **Mangrove Shrub Canopy Height:** Enter the average estimated shrub canopy height in meters on the mangrove side of the ecotone marker.
- **Mangrove Shrub Species:** Enter the six-letter species code of the shrub species encountered on the mangrove side of the ecotone marker.
- **Mangrove Shrub Species % Cover:** Enter the estimated absolute percent cover of each species found within the shrub stratum on the mangrove side of the ecotone marker.
- **Mangrove Herb Stratum % Cover:** Enter the estimated absolute percent cover of the herb stratum on the mangrove side.
- **Mangrove Herb Canopy Height:** Enter the estimated herb canopy height in meters on the mangrove side of the ecotone marker.
- **Mangrove Herb Species:** Enter the six-letter species code of the herb species encountered on the mangrove side of the ecotone marker.
- **Mangrove Herb Species % Cover:** Enter the estimated absolute percent cover of each species found within the herb stratum on the mangrove side of the ecotone marker.
- **Marsh Cover:** Enter the overall absolute percent cover of vegetation on the marsh side of the ecotone marker.
- **Marsh Tree Stratum % Cover:** Enter the estimated absolute percent cover of the tree stratum on the marsh side.
- **Marsh Tree Canopy Height:** Enter the estimated tree canopy height in meters on the marsh side of the ecotone marker.
- **Marsh Tree Species:** Enter the six-letter species code of the tree species encountered on the marsh side of the ecotone marker. The six-letter code consists of the first three letters of the genus and the first three letters of the specific epithet to come up with the species code. For example, *Rhizophora mangle* (Red Mangrove), would have a species code of RHIMAN.

When a species code is entered in this data field, a new Species line will appear below the line where the data is being entered, in anticipation of the next species. If the species you enter is not in the database, it will ask you if you are sure the spelling is correct and if you want to add the species to the database.

- **Marsh Tree Species % Cover:** Enter the estimated absolute percent cover of each species found within the tree stratum on the marsh side of the ecotone marker.
- **Marsh Shrub Stratum % Cover:** Enter the estimated absolute percent cover of the shrub stratum on the marsh side.
- **Marsh Shrub Canopy Height:** Enter the estimated shrub canopy height in meters on the marsh side of the ecotone marker.
- **Marsh Shrub Species:** Enter the six-letter species code of the shrub species encountered on the marsh side of the ecotone marker. The six-letter code consists of the first three letters of the genus and the first three letters of the specific epithet to come up with the species code. For example, *Rhizophora mangle* (Red Mangrove), would have a species code of RHIMAN. When a species code is entered in this data field, a new Species line will appear below the line where the data are being entered, in anticipation of the next species. If the species you enter is not in the database, it will ask you if you are sure the spelling is correct and if you want to add the species to the database.
- **Marsh Shrub Species % Cover:** Enter the estimated absolute percent cover of each species found within the shrub stratum on the marsh side of the ecotone marker.
- **Marsh Herb Stratum % Cover:** Enter the estimated absolute percent cover of the herb stratum on the marsh side.
- **Marsh Herb Canopy Height:** Enter the estimated herb canopy height in meters on the marsh side of the ecotone marker.
- **Marsh Herb Species:** Enter the six-letter species code of the herb species encountered on the marsh side of the ecotone marker. The six-letter code consists of the first three letters of the genus and the first three letters of the specific epithet to come up with the species code. For example, *Cladium jamaicense* (Sawgrass) would have a species code of CLAJAM. When a species code is entered in this data field, a new Species line will appear below the line where the data is being entered, in anticipation of the next species. If the species you enter is not in the database, it will ask you if you are sure the spelling is correct and if you want to add the species to the database.
- **Marsh Herb Species % Cover:** Enter the estimated absolute percent cover of each species found within the herb stratum on the marsh side of the ecotone marker.

- **Entered By:** Use the dropdown menu or enter the first initial and last name of the person entering the data into the database.
- **Checked By:** Use the dropdown menu or enter the first initial and last name of the person checking the data.

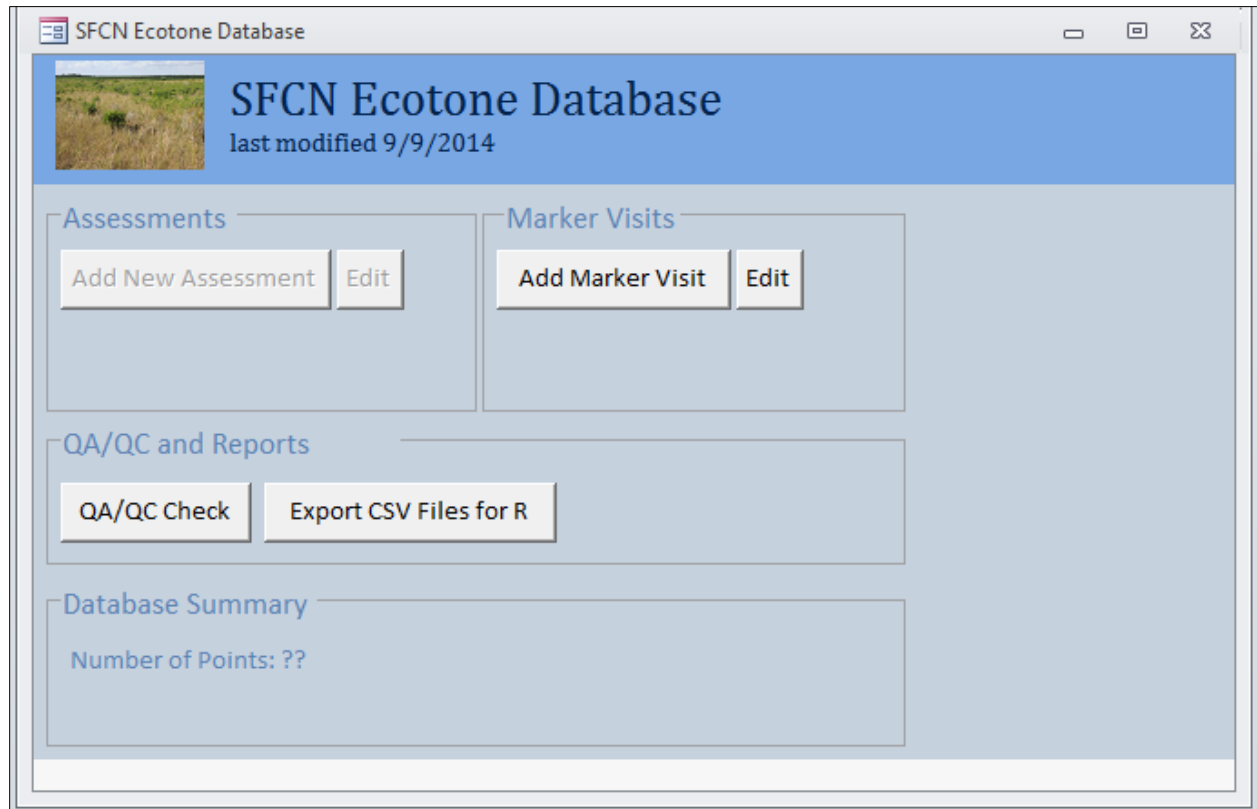


**Figure SOP 6-1.** SFCN Ecotone Database navigation of the Mangrove-Marsh Ecotone Access database.

Data Entry

**Marker Data Entry**

**Mangrove Side**  %

**Trees**  %  
 Canopy Height (m)

**Shrubs**  %  
 Canopy Height (m)

**Herbs**  %  
 Canopy Height (m)

| Species | % | Cover |
|---------|---|-------|
| *       |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |

| Species | % | Cover |
|---------|---|-------|
| *       |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
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|         |   |       |

| Species | % | Cover |
|---------|---|-------|
| *       |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |

**Nearest Distance to Digitized Line**

Distance (m)   
 Method   
 Comments   
 Entered By:

**Marsh Side**  %

**Trees**  %  
 Canopy Height (m)

**Shrubs**  %  
 Canopy Height (m)

**Herbs**  %  
 Canopy Height (m)

| Species | % | Cover |
|---------|---|-------|
| *       |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |

| Species | % | Cover |
|---------|---|-------|
| *       |   |       |
|         |   |       |
|         |   |       |
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|         |   |       |
|         |   |       |

| Species | % | Cover |
|---------|---|-------|
| *       |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |
|         |   |       |

Entered By:

Checked By:   
 Checked Date:

**Figure SOP 6-2.** Marker Data Entry form of the Mangrove-Marsh Ecotone Access database when entering data for the first time. Entry of nearest distance to digitized line occurs in SOP-7.

### ***If Editing or Checking Data already Entered in the Database***

- Upon opening the Mangrove-Marsh Ecotone monitoring database (Figure SOP 6-1), click “Edit” under the “Marker Visits” section in the “SFCN Ecotone Database” navigation.
- The “Edit/View Marker Data” navigation (Figure SOP 6-3) will open.
- Select the appropriate assessment that you want to edit or check under the “Assessment” section.
- The “Ecotone” section will populate with all markers that have some amount of data entered/stored.
- Select the appropriate marker, labeled as “marker number.”
- The “Marker Data Entry” form will open.
- Verify all fields are filled out correctly as previously described in “If entering data for the first time” section of Marker Post Field Datasheet Entry.

**Edit/View Marker Data** Close

Click the marker visit that you would like to view or edit. Use the filters at the top of the list to limit the possible visits.

| Assessment                      | Ecotone / Transect |
|---------------------------------|--------------------|
| Visit 1 (8/26/2010 - 5/27/2014) | 1_1                |
| Visit 2 (7/13/2016 - )          | 1_2                |
| Visit 3 ( - )                   | 1_3                |
| Visit 4 ( - )                   | 1_4                |
| Visit 5 ( - )                   | 10_1               |
|                                 | 10_2               |
|                                 | 10_3               |
|                                 | 10_4               |
|                                 | 11_1               |
|                                 | 11_2               |
|                                 | 11_3               |
|                                 | 11_4               |
|                                 | 12_1               |
|                                 | 12_2               |
|                                 | 12_3               |
|                                 | 12_4               |
|                                 | 13_1               |
|                                 | 13_2               |
|                                 | 13_3               |

**Figure SOP 6-3.** Edit/View Marker Data navigation of the Mangrove-Marsh Ecotone Access database when editing/checking data. Example from pilot study data.



**National Park Service**  
**Inventory and Monitoring Division**



*Mangrove-Marsh Ecotone Data Quality Assurance and  
Quality Control Procedures—Version 1.0*

Careful, accurate collection of data, as directed in this protocol, is critical to the success of mangrove-marsh ecotone monitoring. This standard operating procedure (SOP) describes quality assurance/quality control (QA/QC) procedures for accurate data collection, transcription and stewardship, and assessment of data quality. The network will use standardized datasheets for data collection. This SOP details the steps taken to perform quality assurance/quality control (QA/QC) evaluations on the data contained within the Mangrove-Marsh Monitoring Database. These data are collected on data sheets and verified by a single person (the data entrant) or multiple persons.

## Revision Log

[illegible]

## Quality Assurance/Quality Control of Digitized Line

Before collection of field marker point data, the following checks of the digitized lines occur. The initial check will occur when the digitizer finishes digitizing one segment. If the digitizer's line work is accepted, then the digitizer will continue digitizing other segments. The QA/QC checks will occur for each segment's digitized line.

- The primary digitizer reviews the lines, looking for issues such as misplaced vertices and whether the lines follow the digitizing criteria (e.g., treats open water, gaps, and tree islands correctly).
- Checks of digitized lines are conducted by the botanist (if not the primary digitizer) or the community ecologist during the digitizing process until the lines are completed. The purpose of these checks is to determine if the digitizer is following SOP rules and whether the ecotone boundary has been interpreted correctly. If errors are found, the digitizer receives further training and all or part of the digitized line work will need to be redone.

The GPS locations of the marker points are used to QA/QC digitized lines relative to the field determination. The shortest distances between the new digitized lines and the field marker points are measured and used to estimate the overall accuracy of line work. The steps below are conducted by someone other than the digitizer, (e.g., by the community ecologist, data manager, or assistant data manager).

Bring locations of marker points (field points) into the ArcMap project together with the digitized lines and imagery used.

- Use the "Measurement Tool" to measure the straight-line difference from each marker point to the nearest point on the digitized line. Open up the Marker Data Entry form in the database and enter the distance (Figure SOP 6-2). If the marker point is downslope (mangrove side) of the digitized line, the data are entered as a negative distance. If the marker point is upslope of the digitized line, the data are entered as a positive distance.
- Examine each marker point in relationship to the digitized line for obvious differences that are likely correctable through training or clarification, e.g., digitization is on the shadow edge rather than on the vegetation edge, or the 3-meter (9.8-feet [ft]) gap rule is not being applied correctly.
- Add notes or comments if there is an obvious reason for large differences.
- Calculate the mean, median, minimum, maximum and root square mean error (RSME) for the differences for the four marker points of each line segment, and determine if the differences are significantly different from zero using a t-test. This is done to calculate the differences for each segment and for all segments together.

- If the t-test shows the differences between the line and marker point locations are significantly different from zero, then examine why (e.g., line is systematically placed too far into the marsh). If a fire or hurricane has occurred between digitizing and marker point determination, it may be impossible to re-digitize the line and the bias must be reported with use of the line.
- Examine differences for patterns, large differences, and reasons for differences.
- Digitized line work is redrawn when average differences are greater than 7 meters [23 ft] or show a systematic bias where changes are not attributable to a fire or hurricane occurring between imagery acquisition and marker point determination. Locations of marker points are not shown to the digitizer but types and sizes of errors may be shared.
- Both original lines and updated lines are maintained in the geodatabase.

## **Datasheets**

When using paper datasheets, the field crew will use datasheets copied onto Rite-in-Rain paper. After paper datasheets have been filled out in their entirety, a complete set of working copies will be made (see Data Stewardship section below). Post-field collection data entry notes and remarks shall be made only on the copies, not on the original datasheets. Post-field collection remarks (e.g., unknown species identifications) must be written using a different colored pencil or pen. All network staff members (including the field crew) who make modifications to the datasheet shall indicate their identity (first initial and last name), date of modifications, purpose of their review, and the color used to provide comments or make changes.

## **Field Data Transcribed to Paper Datasheets**

Datasheets must be protected and carefully stowed when traveling to avoid loss. All information added to a datasheet must be printed using pencil and clearly legible. While manually recording data, the crewmember entering the data will verbally double check all field values for accuracy and completeness with the crew member collecting or announcing the data. All discrepancies will be corrected prior to moving to the next data field. Upon completing data collection at each site, original datasheets are reviewed and checked for legibility and completeness. The crew member responsible for completing this field verification must initial the datasheet in the upper right-hand corner.

## **Field Data Transcribed to Computer**

Data quality and verification involve checking the accuracy of field data at each stage that it is transcribed from its original source. To minimize the possibility of carrying entry errors forward into analysis, the data quality and verification process for this protocol involves multiple checks.

The database has automated checks built-in such as a restricted list of species codes that pop-up a message if the species is not on the list. It is then possible to either correct the code or proceed to a

form to add a new species. Lookup lists for assessments, marker point names, and other fields are used where appropriate. During the process of transcribing data from paper datasheets into the database, the technician will double check all entries and correct discrepancies prior to advancing to the next datasheet.

Following data entry into the computer, a crew member reviews 100% of the records entered to ensure that values on field forms are accurately and completely transcribed into digital form. The person who conducts the 100% verification check will be different from the person who originally entered the data. Notes or changes made to the datasheets may only be made on the complete set of copies made for this purpose. After computerized data are verified to accurately reflect the original field data (i.e., the entered data match the collected data), the paper forms will be archived and remaining data processing will be done in the database.

## **Field Data Validation**

Records are reviewed by the community ecologist after data verification. The community ecologist, botanist, and network program manager are the authorities on the methodologies and species involved. Although data may be correctly transcribed from the original field forms, their values may not always be accurate or logical. As often as possible, components of the data validation process have been built into the database (e.g., value range restrictions, separate species pick-lists for trees and shrubs). Although many validation problems can be addressed by a well-designed database, the community ecologist or network program manager must also review and validate the data after verification is complete.

Additional checks on field data include:

- Confirm plant species are reasonable, based upon area of the park and species seen previously during field data collection for this protocol.
- Confirm mangrove and marsh data are not interchanged.
- Confirm that cover estimates are consistent with an ecotone edge, e.g., mangrove cover should be greater than 50% cover on the mangrove side.
- Confirm height estimates are reasonable, e.g., sawgrass heights greater than 3 meters (9.8 ft) would be suspect.

If field data fail one or more of these checks, then, based on the severity of the concern and the difficulty of recollecting field data, a decision will be made to (a) keep the data but flag them with a message, (b) mark the data as invalid with an explanation, or (c) recollect on a future mission.

## GPS Data Validation

Checks on GPS points during Trimble file download include:

- Confirm that all marker points are in the Universal Transverse Mercator (UTM) zone 17N coordinate system with a datum of NAD83, or its most modern successor. Note: NAD83 will be replaced in 2022 and all marker points will need to be modernized in advance of that switch according to guidance from the National Geodetic Survey.
- Confirm that all marker point visits have corresponding marker point coordinates.
- Confirm that all marker point coordinates collected on the ground are comprised of at least 100 averaged positions, and all those collected while hovering in a helicopter have at least 30 averaged positions.
- Confirm that all marker point coordinates have a horizontal accuracy of less than 1.5 meters (4.9 ft).
- Confirm that all marker points, when displayed in ArcGIS on imagery, appear on the ecotone and are not offset from the expected location.

If coordinates fail one or more of these checks, they are brought to the attention of the data manager and community ecologist. Based on the severity of the concern and the difficulty of recollecting those coordinates, a decision will be made to keep the coordinates but flag them with a message, drop the coordinates, or recollect on a future mission.

## Data Stewardship

Clear and consistent data-stewardship practices play a critical role in long-term data security and help prevent irretrievable loss of information. Datasheets are checked to ensure that all original data are present and legible and are scanned within one week of collection. Scanned datasheets are archived in Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\data\scanned\_datasheets. Once produced, photocopies of the datasheets are affixed as coversheets to their corresponding originals and used for all computer data entry and verification procedures. All post-field corrections and remarks must be recorded on the copies. All post-field corrections and remarks must be annotated with the date and initials of the person making the changes.

Once the computerized data are verified as accurately reflecting the original field data and validation is complete, the paper field datasheets (both the original unaltered datasheets and the annotated copies) are stored in the mangrove-marsh ecotone binder in the SFCN conference room. The electronic version of the data is used for all subsequent data activities.

## **Certification**

Data certification starts once the Botanist, Community Ecologist, and the Data Manager have affirmed that the appropriate QA/QC procedures for the current year's data are complete and the data set is ready to be used in analysis and reporting. At this point, the Data Manager updates the certification level of the data. If a Quality Assurance Plan (QAP) exists, then the data are set to "certified." If no QAP exists, then the data are set to "accepted."

## **Quality Control Data**

As a QA/QC check during the course of the sampling season, one segment will be randomly selected and all four marker points will be re-visited (7% of field sampling effort), with estimates of the ecotone location and vegetation cover sampled as described above. The choice to revisit marker points on a single randomly chosen segment was made to minimize helicopter costs.

The QA/QC field crew can consist of several combinations of network staff, park staff or other contractors. The QA/QC team must include a botanist capable of identifying all woody and herbaceous plants at each marker point, and at least one network staff member well versed on the Mangrove-Marsh Ecotone protocol.

The community ecologist and botanist will review the QA/QC data to determine if the original data are valid or need to be recollected. The QA/QC data will be used to generate basic estimates of the variance in marker point placement and vegetation estimates.

**National Park Service**  
**Inventory and Monitoring Division**

| Revision Date | Author | Changes Made | Reason for Change | New Version # |
|---------------|--------|--------------|-------------------|---------------|
|               |        |              |                   |               |
|               |        |              |                   |               |
|               |        |              |                   |               |
|               |        |              |                   |               |
|               |        |              |                   |               |

## Introduction

The following is a general description of how to calculate the basic metrics, conduct the analyses, and generate reports. Automated scripts and templates will be developed at a later date. However, the basic metrics below are generated from ArcGIS and then analyzed with any basic statistical software (e.g., SAS or R) to generate basic t-statistics.

## Basic Metrics Reported

The basic summary metrics reported for the mangrove-marsh ecotone include:

- Maps: Maps showing location of the ecotonal lines through time.
- Accuracy of linework: Accuracy of linework vs. ground marker points and documentation of any areas of mapped line that required adjustment.
- Vegetation data: Species composition data, including absolute percent cover by tree, shrub, and herb strata (marsh side; mangrove side) at marker points. Vegetation data are collected to document composition of vegetation communities on both the “mangrove” and “marsh” sides of the ecotone.

### Maps

- Maps are generated using ArcGIS for each segment (Figure SOP 8-1 and 8-2). For the second and subsequent digitization efforts, the map will show both the original and subsequent digitized lines and marker points.

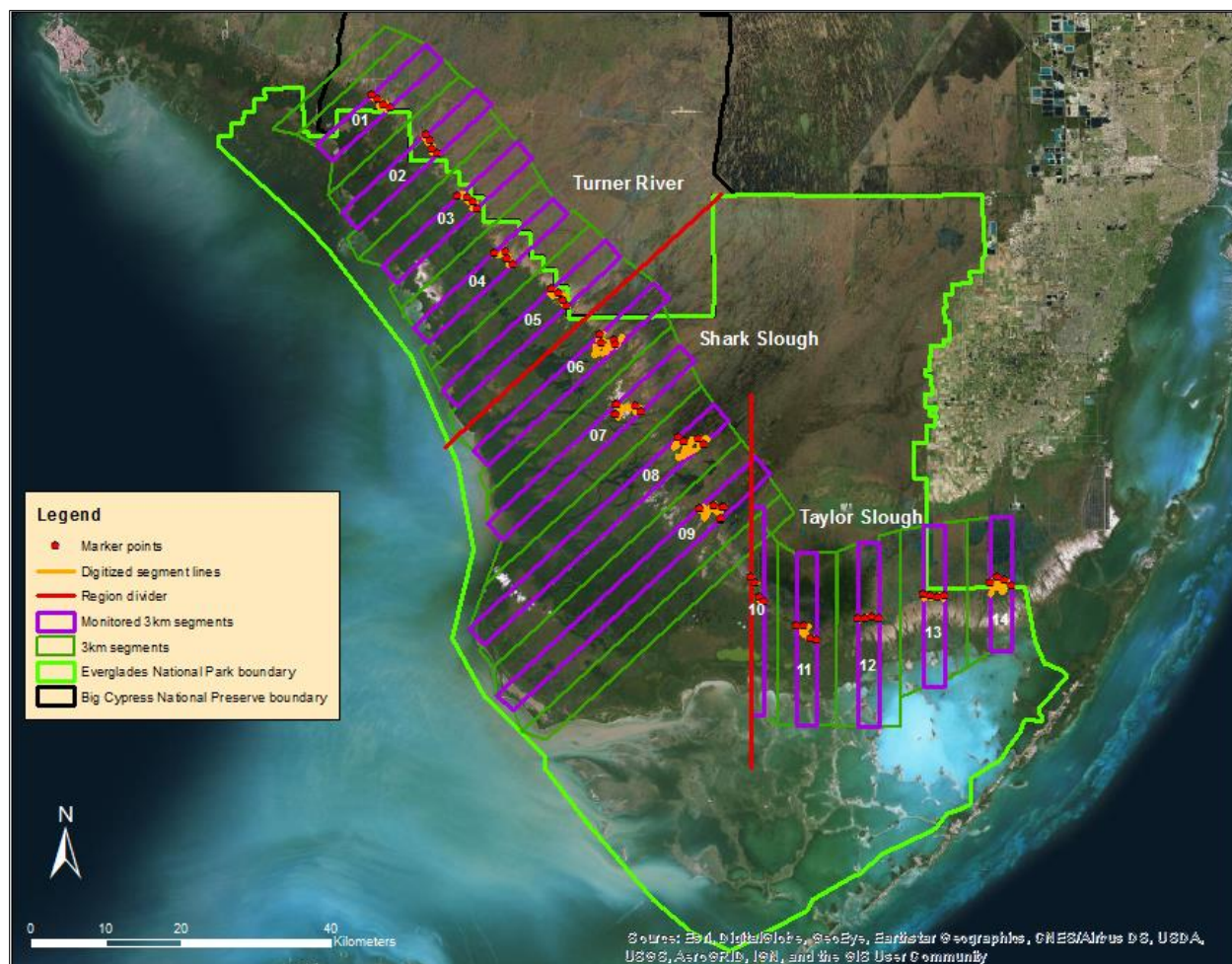


Figure SOP 8-1. Map displaying all digitized ecotone lines together with marker points.

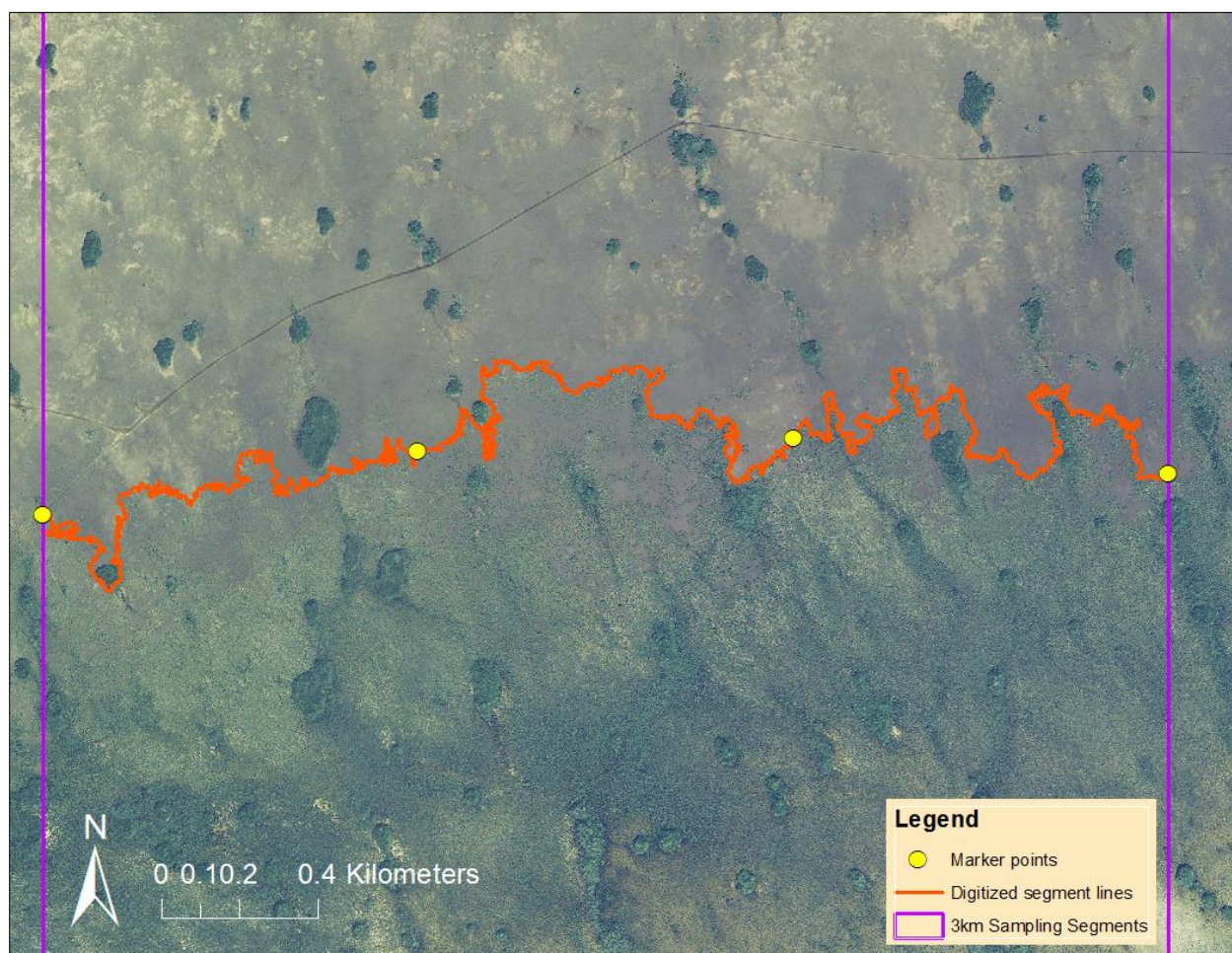


**Figure SOP 8-2.** A digitized ecotone segment (12) in Taylor Slough shown in orange. Marker points are shown as yellow dots on or near the line. Upslope orientation guidelines are shown in purple.

### Accuracy of Linework

- Distances between the marker points and the ecotone line are calculated according to SOP 7 *Mangrove-Marsh Ecotone Data Quality Assurance and Quality Control Procedures—Version 1.0*. These distances are averaged across all marker points along the line, a standard error is calculated, and a 95% confidence interval of the mean is calculated. This provides the expected average error of the digitized line in relation to the ground-based estimate of the ecotone location.
- The average distance and 95% confidence limits for the region and ecotone are calculated using the average accuracy for each segment rather than the individual differences, and the sample size is based upon the number of segments and assumes a finite sample universe of 42 segments (Table SOP 8-1).

**Table SOP 8-1.** Example of reporting marker point data. Example data are adapted from Ochopée pilot data.

| REGION          | SEGMENT | AVERAGE<br>DISTANCE<br>(M) | STANDARD<br>ERROR | LOWER 95%<br>CONFIDENCE<br>LIMIT | UPPER 95%<br>CONFIDENCE<br>LIMIT | MAXIMUM<br>UPSLOPE<br>DIFFERENCE | MAXIMUM<br>DOWNSLOPE<br>DIFFERENCE |
|-----------------|---------|----------------------------|-------------------|----------------------------------|----------------------------------|----------------------------------|------------------------------------|
| Turner<br>River | A       | -0.28                      | 1.30              | -4.42                            | 3.86                             | 3.23                             | -2.76                              |
|                 | B       | 4.93                       | 5.23              | -11.71                           | 21.57                            | 20.54                            | -1.50                              |
|                 | C       | 0.75                       | 0.66              | -1.35                            | 2.85                             | 2.51                             | -0.53                              |
|                 | D       | -0.17                      | 0.56              | -1.95                            | 1.61                             | 0.92                             | -1.32                              |
|                 | Region  | 1.31                       | 1.11              | -2.22                            | 4.84                             | 20.54                            | -2.76                              |

### Vegetation data

Vegetation data are reported and graphed as absolute percent cover by herb, shrub, and tree, in the marsh side and mangrove side of the plots (Figure SOP 8-3). Vegetation species composition data are reported by marker point using absolute percent cover. The purpose of the vegetation data is to provide ancillary, descriptive data about the composition of the “mangrove” and “marsh” sides of the ecotone, which in turn may inform management about the hydrology and water quality at the interface. Field data documenting vegetation community composition of the “mangrove” and “marsh” portions of the ecotone may also increase understanding of which marsh communities are susceptible to rapid mangrove expansion (Smith et.al. 2013). For example, the data could document a pattern of association between high-density red mangroves adjacent to very low-density spikerush (*Eleocharis* spp.) in areas that subsequently experience rapid mangrove ecotonal expansion in the next time interval. As another example, if the vegetation community were indicative of freshwater hydrology instead of brackish, this in turn could inform which management actions (such as controlled burns or increased freshwater inputs) are more likely to successfully slow mangrove encroachment.



**Figure SOP 8-3.** Marker point stratum percentages from the sample marker points from four segments. Similar graphs would be developed for the status and trends report.

**Table SOP 8-2.** Example table reporting marker point vegetation species composition using absolute percent cover within each stratum. This table is an example and not actual results from Segments 10, 06, and 01.

| Side     | Strata | Scientific Name             | 10_1 | 10_2 | 10_3 | 10_4 | 06_1 | 06_2 | 06_3 | 06_4 | 01_1 | 01_2 | 01_3 | 01_4 |
|----------|--------|-----------------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Mangrove | Herb   | <i>Cladium jamaicense</i>   | 23   | –    | 15   | 6    | –    | 1    | –    | 3    | –    | 9    | –    | 10   |
|          | Herb   | <i>Eleocharis cellulosa</i> | 1    | 15   | 15   | 2    | –    | 15   | –    | 22   | –    | 21   | –    | 10   |
|          | Herb   | <i>Utricularia purpurea</i> | –    | 15   | –    | –    | –    | –    | –    | –    | –    | –    | –    | –    |
|          | Shrub  | <i>Rhizophora mangle</i>    | 56   | 55   | 55   | 72   | 90   | 64   | 100  | 56   | 100  | 55   | 90   | 100  |
| Marsh    | Herb   | <i>Chara</i> sp.            | –    | –    | 3    | –    | –    | 1    | –    | –    | 60   | –    | –    | –    |
|          | Herb   | <i>Cladium jamaicense</i>   | 38   | 5    | –    | –    | 20   | 12   | 25   | 20   | 20   | 18   | –    | –    |
|          | Herb   | <i>Eleocharis cellulosa</i> | 2    | 20   | 18   | 12   | 40   | 14   | 25   | 40   | 20   | 42   | –    | 72   |
|          | Herb   | <i>Utricularia purpurea</i> | –    | 5    | 7    | 12   | 10   | –    | –    | –    | –    | –    | 20   | 7    |
|          | Shrub  | <i>Rhizophora mangle</i>    | 40   | 3    | 3    | 1    | 8    | 20   | –    | 14   | 4    | –    | –    | 8    |

## Metrics for analyzing change over time

Additional metrics are calculated after two or more visits by segment, region, and entire ecotone:

- Polygons of Change: Area and number of polygons of change upslope, area and number of polygons of change downslope, and total area of change (upslope change – downslope change)
- Nearest Neighbor Distance: Mean, minimum, maximum, standard deviation and standard error of distance of change (always positive) between the two digitized lines.
- Nearest Neighbor Distance with Directionality: Mean, minimum, maximum, standard deviation and standard error of directional distance of change (upslope being positive and downslope being negative) between the two digitized lines.

### Polygons of Change

Use SOP 4 *Analysis of Area between Two Digitized Lines—Version 1.0* to calculate polygons. Polygons showing a mangrove increase (upslope change) will be given a positive (+) area and polygons showing a marsh increase (downslope change) will be given a negative (-) area. Total area of change and total area of positive and negative polygons are calculated for all segments. The total area of change is averaged within a region and across the ecotone, and standard error is calculated for a finite sampling universe of 42 segments. A 95% confidence interval using a t-statistic is calculated by region and for the overall ecotone. If the confidence interval does not contain zero (0), then the change is significantly different from zero. If the assumptions of a t-statistic cannot be met, then non-parametric statistical approaches, like a sign-rank test, will be used.

### Nearest Neighbor Distance

Use SOP 3 *Analysis of Distance between Two Digitized Lines—Version 1.0* to calculate the Nearest Neighbor differences between the two lines using equal interval points along both lines. For each point the Near tool calculates a positive (+) number that represents the distance to the closest point on the second line.

### Nearest Neighbor Distance with Directionality

Use SOP 3 *Analysis of Distance between Two Digitized Lines—Version 1.0* to calculate the Nearest Neighbor differences between the two lines using equal interval points along both lines. For each point the Near tool calculates a distance to the closest point on the second line. A positive (+) or negative (-) sign is then assigned based on whether the distance is measured within a mangrove increase or marsh increase polygon respectively.

# Change Analysis

## Individual Segment

*Sample unit:* Nearest neighbor directional distance measurements within a single segment

*Analysis:* Testing the null hypothesis of no change occurring within an individual segment involves the creation of a 95% confidence interval of the mean difference. If the confidence interval contains zero this suggests there is no movement of the ecotone (i.e., a one-sample t-test for whether the mean is zero). An effective sample size of  $n=30$  will be used in the tests as the nearest neighbor method generates greater than 1,000 points and errors from points close in space are likely correlated, i.e. the average distance and variance of the distances is calculated based upon the 1,000 plus distance measurements, but the degrees of freedom used to calculate the confidence interval are based upon 30 sample points ( $df = 30 - 1 = 29$ ). The reduced sample size assumes that errors from points approximately 100 m apart are uncorrelated.

## Region

*Sample units:* Segment average nearest neighbor directional distance and segment polygon area change.

*Sample size:* Sample size ( $n$ ) for Turner River Region is 5 segments from a finite sample universe of 16 segments. Sample size for Shark Slough Region is 4 segments out of 13 segments. Sample size for Taylor Slough is 5 out of 13 segments.

*Analysis:* Testing the null hypothesis of no change occurring within a region involves treating the average distance (or area of change) from each segment within the region as the data points. A 95% confidence interval is created of the mean of the mean distance or area using a  $t$ -statistic. Standard error is calculated assuming a finite sampling universe, as there are a limited number of line segments possible. If the confidence interval does not contain zero, the null hypothesis that no change has occurred in the ecotone line within the region can be rejected.

## Ecotone

*Sample units:* Segment average nearest neighbor directional distance and segment polygon area change.

*Sample size:* Sample size ( $n$ ) is 14 segments from a finite sample universe of 42 segments.

*Analysis:* Testing the null hypothesis of no change occurring across the entire ecotone is calculated similar to that for a region, but uses data from all segments within the ecotone.

# Create Status and Trends Report

Routine status and trends reports are produced every 10 years in the National Park Service's Natural Resource Report Series (NRR). The mangrove-marsh ecotone monitoring status and trends reports will focus on:

- A summary of the data collected during a sampling event.
- Updating multi-year maps.
- Change analysis results from initiation of monitoring or from previous stress events (e.g., hurricanes).
- Interpreting changes in the light of ancillary data and information such as hurricane impacts, sea-level rise, hydrological inputs, restoration activities, fires, and related research.

The report will need to go through appropriate peer review.

## NRR Template and Section 508 Compliance

Once the first status and trends report is created, for subsequent monitoring cycles, the contents of the most recent status and trends report will need to be cut and pasted into the current NRR template and updated.

1. Locate the latest status and trends template (NRR) by checking [NPS I&M Report Templates](#).
2. Copy and paste the report sections into the template and update the report methods with specific sample dates, personnel, and any specific changes from that year. Provide new tables and figures and accompanying text.
3. Once NRR has received its report number, the report will be uploaded to the [Integrated Resource Management Applications portal](#) (IRMA.nps.gov), linked to from the [SFCN webpage](#), and an associated resource brief will be updated.

The South Florida/Caribbean Network will send the report to an editor to ensure compliance with the requirements of Section 508 of the United States Workforce Rehabilitation Act of 1973. However, SFCN staff can facilitate the review by using the latest NRR template and following the self-contained instructions, which will meet most of these requirements. In addition:

- Tables must be in Microsoft Word table format. They cannot be images of a table, or still in Microsoft Excel or SigmaPlot, or set-up using "typewriter techniques," e.g., using spaces and tabs on a regular line of text to create "columns."
- Tables cannot be wider than the page margins.
- Images must have alternate text.

- Images and text boxes must also stay within the existing page margins.

For additional details on adding alternate text or formatting tables, please see the guidance in:

Z:\SFCN\_Publications\ReportGuidelines\508\_Compliance\IM\_PDF\_Accessibility\_Using\_MSWord.pdf.

Or any more recent guidance at: [NPS I&M Natural Resource Publication Series](#).

## Literature Cited

Rehabilitation Act of 1973. Enacted September 26, 1973. U.S. Equal Employment Opportunity Commission.

Smith, T. J., III, A. M. Foster, G. Tiling-Range, J. W. Jones. 2013. Dynamics of mangrove-marsh ecotones in subtropical coastal wetlands: fire, sea-level rise, and water levels. *Fire Ecology* 9(1): 66–77.



## Standard Operating Procedure 9

## Purpose

## Revision Log

[illegible]

# Using the GPS Unit in the Field

## Navigating to Waypoint

1. To navigate to a waypoint, press the Find button.
2. Select Waypoints and press Enter.
3. Scroll to the waypoint you want to navigate to. Press Enter -> Go To, and press Enter again.
4. The GPS will now provide guidance and alert you when you are arriving at the point.
5. To stop Navigating, when in the map view press Menu -> Stop Navigation, and press Enter. On newer units such as the 62s or 64s, press Find > Stop Navigation.

## Uploading Waypoints

1. Turn your GPS unit **ON**.
2. Connect the Garmin unit to the computer using a USB cable.
3. Open **DNR GPS** software. Your GPS unit should be automatically detected by **DNR GPS**. On the lower left hand corner it should say "Connected." If it does not say "Connected," do the following:
  - a. Make sure GPS unit is turned **ON**.
  - b. Select GPS -> Set Port -> USB.
4. Be sure the correct Projection is displaying on the bottom left hand side of the window:
  - i. NAD83, UTM Zone 17N for Florida.
5. If the projection is incorrect or not showing, it needs to be set.
  - a. Select File -> Set projection.
  - b. Under the projections window, Select the appropriate projection for the shapefile.
    - i. NAD83, UTM Zone 17N for Florida.
  - c. Click on the **Load PRJ** button to load the projection file. Scroll to Z:\GIS\Tools\Coordinate Systems\Projected Coordinate Systems\UTM\NAD 1983\ Select the projection. See above to location projections. Click on **Open**. Then click **OK**.
6. Select **File -> Load From -> File ->** Choose appropriate file.
  - a. Make sure the file type reads ESRI Shapefile (2D or 3D) (\*.shp).

7. Choose a field from the shapefile that will display as the ident (waypoint name) and comment (waypoint comment).
8. “File was loaded successfully” message will be shown.
9. Select Waypoint -> Upload.
10. You will see a **Transfer Complete** window. Look for the Waypoints you loaded in the GPS unit to make sure they show up in the correct area.

## Downloading Waypoints and Tracklines

1. Turn your GPS unit **ON**.
2. Connect the Garmin unit to the computer using a USB cable.
3. Open **DNR GPS** software. Your GPS unit should be automatically detected by **DNR GPS**. On the lower left-hand corner it should say “Connected.” If it does not say “Connected,” do the following:
  - a. Make sure GPS unit is turned **ON**.
  - b. Select GPS -> Set Port -> USB.
4. Be sure the correct Projection is displaying on the bottom left hand side of the window:
  - i. NAD83, UTM Zone 17N for Florida.
5. If the projection is incorrect or not showing, it needs to be set.
  - a. Select File -> Set projection.
  - b. Under the projections window, Select the appropriate projection for the shapefile.
    - i. NAD83, UTM Zone 17N for Florida.
  - c. Click on the **Load PRJ** button to load the projection file. Scroll to Z:\GIS\Tools\Coordinate Systems\Projected Coordinate Systems\UTM\NAD 1983\ Select the correct projection. Click on **Open**. Then click **OK**.
6. Select Waypoint -> Download or Tracklines -> Download.
7. Select **File -> Save To -> File ->**
8. The shapefile should be saved to two folders on the server. The first folder to save to is the main GPS folder: Save the file under Z:\GIS\GPS\Garmin\_60CSx\<your GPS unit number>.shp.

9. Name your file using the established system with the unit number and the date the data were downloaded (year/month/day), then identify the file as waypoints, trackpoints or tracklines (Ex. Garmin60Unit1\_20141024\_Waypoints.shp. In **Save as type:** Choose **ESRI Shapefile (2D or 3D)(\*.shp)**. When saving **Tracklines** an **Output Shape** window appears after you click **Save**.
10. The second folder to save the shapefile to is your working vital sign spatial\_info folder.  
Example: Save the file under Z:\SFCN\Vital\_Signs\ Mangrove\_Marsh\_Ecotone\spatial\_info\.
11. Name your file using the date the data was collected (year/month/day), the segment number, and either waypoints or tracklines at the end. Example: 20141024\_10\_Waypoints.shp. In **Save as type:** Choose **ESRI Shapefile (2D or 3D)(\*.shp)**. When saving **Tracklines** an **Output Shape** window appears after you click **Save**.
12. Choose the **Line** option and then **OK**. If you want to save the data as **Trackpoints**, choose **Point** instead of **Line**.

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## Standard Operating Procedure 10

*Using Trimble Geo7X GPS Unit—Version 1.0*

## Purpose

This standard operating procedure (SOP) outlines the procedures for using a Trimble Geo7X GPS sub-meter GNSS unit. If using the Trimble unit for the first time or after an extended time of inactivity, consult with data management personnel before collecting coordinates.

## Revision Log

[illegible]

# Introduction

Collection of marker point coordinates is completed with a Global Navigation Satellite System (GNSS) receiver capable of horizontal accuracies of less than 1 meter (3.3 feet [ft]). A GNSS receiver is capable of calculating coordinates from GPS, GLONASS, Galileo, Beidou, and other regional satellite navigation systems. Many receivers exist that meet these specifications, including the Trimble Geo7X and the EOS Arrow series. The Trimble Geo7X sub-meter GPS unit has a factory specification of up to 0.25 meter (0.82 feet [ft]) horizontal accuracy after post-processing/differential correction. The following steps focus on a Trimble Geo7X, but can be adapted to work with other units as necessary.

## Procedure

### Steps for Field Point Data Collection

For each time the GPS is taken out of sleep mode, it is good practice to perform steps 1–5 a few minutes before proceeding to step 6. Two to three minutes of GPS warm-up time improves coordinate accuracy.

1. Set up antenna at 2 meters (6.5 ft).
2. Turn Unit On (press power button).
  - a. Tap anywhere on the screen to activate.
3. Tap “Start.”
  - a. Tap “TerraSync.”
4. Select dropdown menu (first row, top left).
  - a. Select “Data.”
5. At beginning of each field day, type in the file name using the date created and “\_ecotone” (ex. 04152018\_ecotone).
6. Hit “Create” (upper right corner of screen).
7. Confirm antenna height.
  - a. If the “Sensor 1 Failed to Open” warning pops up, simply click “OK.”
8. Hit “Create.”
  - a. Hold the antenna level and avoid moving it.
  - b. Keep in mind that small movements at the base of the antenna translate into larger swings (10–20 centimeters [3.9–7.8 inches {in}]) at the top.

9. Fill in Point Number (i.e. 10\_2 for Segment 10 and marker point 2).
10. Allow to average for 100 points (upper right corner).
11. Select “Ok” when done.
12. Hit power when finished with each marker (doing so will put the unit into sleep mode).
13. When finished with last marker, hit “Close” (upper right).
  - a. Hit “Yes.”
14. Hit “X” (upper right).
  - a. Hit “Yes.”

### ***Connecting the Geo7X to the Computer***

1. Connect the Trimble Geo7X to the computer using the Trimble-supplied or other compatible USB cable.
2. Turn on the Geo7X.
  - a. The Windows Mobile Device Center software on the computer should detect the connection. The computer may not have Windows Mobile Device Center installed. If not, download software from Microsoft’s webpage and install software. For computers with 32-bit operating systems, the webpage to download the software is <https://www.microsoft.com/en-us/download/details.aspx?id=14>. For computers with 64-bit operating systems, the webpage to download the software is <https://www.microsoft.com/en-us/download/details.aspx?id=3182>.
  - b. You can cancel out the “Windows Mobile Device Center” screen that appears once the Trimble unit is connected; you will use the Trimble software to connect to the GPS unit.
3. Open the GPS Pathfinder Office software (on the computer). The software should be located inside the Trimble folder in the “All Programs” list of the Start Up window.
4. The Select Project window should appear immediately after opening the program. Click on the “Modify” text box.
  - a. The Project Folders window should now appear. For the Project Folder section, click on the “Browse” text box.
  - b. The Browse For Folder window should appear. Select the Folder “Trimble\_Geo7X\_RAW” located under Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\spatial\_info\marker\_points\Submeter\_GNSS\Trimble\_Geo7X\Export. Click ‘Ok’ on the Project Folders window.

- c. A small window will appear stating that the folder already exists and asking if you want to continue. Click “Yes.”
  - d. Another window will appear stating the project folder has changed. Click “Ok.”
  - e. Now click “Ok” on the Select Project window. This window should now close.
5. In the GPS Pathfinder Office main page click “Utilities” and then “Data Transfer.”
6. The Trimble GPS unit should be connected, and you will see a green checkmark and text “Connected to GEO5436443999” in the Data transfer window.
  - a. If this does not occur, ensure that “GIS Datalogger on Windows Mobile” is selected under Device dropdown.

#### ***Downloading File(s) from the Geo7X***

1. Follow steps within “Steps for Field Point Data Collection” to connect the GPS unit.
2. In the Data transfer window, check that you are in the “Receive” tab. Click “Add” and then click “Data File.”
3. Now select the file(s) that you would like to transfer to your computer; hold the CTRL key down to select more than one file and click “Open.”
4. Click “Transfer All” and the file will be sent to the Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\spatial\_info\marker\_points\Submeter\_GNSS\Trimble\_Geo7X\Export. The Transfer Completed window should appear afterwards, confirming a successful transfer.

#### ***Uploading File(s) to the Geo7X***

1. Open the GPS Pathfinder Office software (on the computer).
2. Click the “Utilities” menu and then “Import.” The Import window should appear.
3. Under “Input Files,” browse for the shapefile that you want to transfer to the Geo7X.
4. Under “Output File,” click “Browse” to select the preferred output file location and provide a filename. Remember this information.
5. Under “Choose an Import Setup,” select “Sample ESRI Shapefile Setup.”
6. Ensure that the proper GIS Coordinate System has been selected.
  - a. Edit this coordinate system under “Properties...” if necessary.
7. Click “Ok” and the shapefile (shp) will be converted to an import (imp) file.
8. Follow steps within Section 1 to connect the GPS unit.

9. Check that you are in the “Send” tab and then click “Add” and “Data File.”
10. Now select the file(s) that you would like to transfer to the GPS unit; hold the ctrl key down to select more than one file and click “Open.”
11. Click “Transfer All” and the file will be sent to the GPS unit.

### ***Differential Correction***

**Note:** These instructions assume a standard configuration of GPS Pathfinder where base station files are saved to ‘Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\spatial\_info\marker\_points\Submeter\_GNSS\Trimble\_Geo7X\Base’. Please adjust accordingly if the settings on your computer are different.

1. Open Windows Explorer and navigate to the base station folder for the current project, which with the default configuration will be: ‘Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\spatial\_info\marker\_points\Submeter\_GNSS\Trimble\_Geo7X\Base.’
  - a. An empty “Base” folder is helpful for the next steps.
  - b. If there are any files in this folder (from previous differential correction attempts), place them in a subfolder named “Archive.”
2. In GPS Pathfinder Office, click ‘Utilities’ and then “Differential Correction...”
3. Select the file(s) to be corrected under “Select SSF files to correct.” If not, locate the file using the browse button . Click Next. For Processing Type, select “Automatic Carrier and Code Processing (Recommended).” Click Next. The Correct Settings are displayed. Click Next.
4. Under “Base Data,” click on the “Base Provider Search” button and click “Select.” The Select Base Provider window appears and allows choosing a base data provider from a station close to the coordinates collected. The distance in kilometers and integrity index are shown for each base data provider. Click the “Update List” button. The Downloading base providers window should appear. Wait for the downloading progress to finish. Then select the provider that is the closest continuously operation reference station (CORS) and has highest integrity index value. Click “Ok.” Selecting the closest CORS with a question mark for the integrity value may also be appropriate.
5. The Differential Correction Wizard window will show the selected base data provider for both the “Base Provider Search” and “Reference Position” sections. Under “Reference Position” select the “Use position from downloaded base files” button. Make sure that the “Confirm base data and position before processing” check box is checked. Click “Next.”
6. Under Output Folder, select the “Use the project folder” button. Under Output Filename, select the “Create a unique filename based on the input filename” button. Click “Start.”

7. The Differential Correction Wizard should now display the base data details and the coordinates from the National Geodetic Survey (NGS).
  - a. Open an internet browser and go to the [CORS webpage](#). Enter the four-letter station ID of the CORS (Continuously Operating Reference Stations) used as the base data provider in the empty text box next to the “Enter SiteID” button. Click the “Enter SiteID” button. A new webpage tab should open displaying links to information for the CORS site. Click on the “Coordinates” link. The webpage display will change. Now click on the “Position and Velocity” link. The webpage display changes again. Scroll down to the “L1 Phase Center of the current GPS antenna: ...” section. Take note of latitude, longitude, and ellipsoid height under the “NAD\_83 (2011) POSITION (EPOCH 2010.0)” section.
  - b. Compare the base data details and coordinates from the Differential Correction Wizard window and the [NGS NOAA CORS webpage](#) output outlined in the previous step. The values should match exactly or be within 0.0001–0.00001 meters for the latitude and longitude and 0.01 meters (.03 ft) for the ellipsoid height. Do not use selected CORS if the discrepancies between the values are greater than the aforementioned limits.
  - c. In the Differential Correction Wizard, look at the “total coverage” percentage under the Coverage Details section. If the “Coverage” is less than 100%, consider selecting a different CORS. If none of the nearby CORS stations provide complete coverage, use the one that maximizes this percentage.
  - d. Click “Confirm” to continue.
  - e. The Differential Correction Summary output will now show in the Differential Correction Wizard. Check to see that at least 90% of the file was code corrected.
8. Click “Close” on the Differential Correction Wizard window. The corrected points can be exported by following the steps in step 5 with this “cor” file selected.

### ***Exporting Shapefiles***

1. Open the GPS Pathfinder Office software.
2. Click the ‘Utilities’ tab and then “Export...”
3. Ensure that the file(s) to be exported are listed under “Selected Files”. If not, locate the file(s) using the “Browse” button.
4. From the “Choose an Export Setup” section, choose “Sample ESRI Shapefile Setup” from the dropdown box.
5. Click “Properties...” Here are suggested settings for South Florida. Make the necessary changes.

- a. Attributes tab.
    - i. All Feature Types: check all items.
    - ii. Point Features: check all items.
  - b. Position Filter tab.
    - i. Minimum Geometry: 3D (4 or more measurements) or 2D (3 or more measurements) when dealing with severe GPS conditions like heavy canopy.
    - ii. Check the “Uncorrected” check box if differential correction was less than 100%.
    - iii. Make sure “Include Non-GNSS Positions” check box is unchecked.
  - c. Coordinate System tab.
    - i. Click “Change...”
    - ii. System = UTM.
    - iii. Zone = 17N
    - iv. Datum = NAD 1983 (Conus).
    - v. Altitude Measured From = Mean Sea Level.
    - vi. Coordinate Units = Meters.
    - vii. Altitude Units = Meters.
    - viii. In the Projection File section click “Browse.” Then in the “Select Projection File” window navigate to “Z:\GIS\Tools\Coordinate Systems\Projected Coordinate Systems\UTM\NAD 1983” and select the “NAD 1983 UTM Zone17N.prj” file. Click “Open.”
6. Click “Ok” in the Export window. The Export status window will appear, followed by the Export Completed window, which provides a summary of shapefile export.

### **Troubleshooting**

Occasionally the Geo7X will not connect to the internal GPS receiver after being turned on. When this occurs, you will notice a blinking icon (two disconnected cables) near the top of the screen within TerraSync. To fix this issue, you will need to reboot Microsoft Windows CE. Press and hold the “Power” button for 10 seconds. Release the button and the unit should reboot. This process usually takes a couple minutes. When you return to the opening screen, tap it once to dismiss the Owner Information. Tap GPS in the lower right to launch the TerraSync software.



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**Table SOP 11-1.** File types and method of archiving.

| File Type                                      | SFCN Conference Room | SFCN Server | IRMA Data Store |
|------------------------------------------------|----------------------|-------------|-----------------|
| Datasheets                                     | X                    | X           | X               |
| Aerial Imagery                                 | –                    | X           | X               |
| Photos                                         | –                    | X           | X               |
| Shapefiles (digitized lines and marker points) | –                    | X           | X               |
| Database                                       | –                    | X           | X               |
| Protocol                                       | –                    | X           | X               |
| Analysis scripts                               | –                    | X           | X               |
| Status and trends reports                      | –                    | X           | X               |

## Archiving Datasheets

Physical datasheets are stored in the SFCN conference room in 3-ring binders on the Mangrove-Marsh Ecotones shelf. The scanned copies of the datasheets will be zipped and uploaded to NPS Integrated Resource Management Applications (IRMA) Data Store. For details of uploading files to IRMA, please see: [IRMA Portal Data Store Help Topics](#).

## Archiving Aerial Imagery

The aerial imagery used on each round of analysis will be zipped and uploaded to the IRMA Data Store. If the imagery used does not have a distribution license that allows for sharing with the general public, it may need to be set to internal NPS only.

## Archiving Photos

Datasheet and directional marker point photos taken at each marker point are archived by zipping the photographs and uploading them to IRMA Data Store. These files are located on the network server: Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\images.

## Archiving Shapefiles

Geospatial marker points and ecotone lines are zipped and uploaded to IRMA Data Store.

## Archiving the Database

Archiving for these files starts once the Community Ecologist, Botanist and the Data Manager all have affirmed that the appropriate QA/QC procedures for a calendar year's data are complete, the

data set is certified, and the Mangrove\_Marsh\_Ecotone.mdb database is ready for archiving. Archiving will correspond to the same year in which monitoring is conducted.

The Metadata is updated within the database. This includes updating any new field descriptions, table descriptions, query descriptions and form descriptions.

At this point, the Data Manager uploads a copy of the database to [IRMA Data Store](#). Once the data are archived, any changes made to the databases must be documented in an edit log.

## Archiving Protocol

The active version of the protocol must always be available on IRMA Data Store, along with previous versions. If changes were made to the protocol that year, but are not yet included in the formal document, these are described in an accompanying readme file in the same folder. The readme is named:

- Z:\SFCN\Vital\_Signs\Mangrove\_Marsh\_Ecotone\documents\protocol\Mangrove\_Marsh\_Ecotone\_Protocol\_Readme\_YYYY.docx

The readme documents do not need to be formal, but need to be read by someone else in the SFCN office to make sure they are understandable and contain no obvious errors.

## Archiving Analysis Scripts

Analysis scripts (R, SAS, or Microsoft Excel Worksheets) used during the year must be uploaded to IRMA Data Store.

## Archiving Status and Trends Reports

Status and trends reports are archived on IRMA Data Store when they are published in the Natural Resource Report Series and their report numbers received. The [SFCN web page](#) and the SFCN product tracking database are updated:

- Z:\SFCN\SFCNProductTracking.mdb

## Server Archive

Backup copies of the folders containing data and archives on the SFCN server are maintained at the South Florida office and are sent quarterly to the National Park Service's I&M Division's Washington support office (WASO) in Fort Collins, Colorado.



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## Procedures

The *South Florida/Caribbean Network Mangrove-Marsh Ecotone Monitoring: Protocol Narrative* (Moser et.al. 2019) and associated SOPs can only be modified through a versioning system with the following guidance.

1. Protocol edits and versioning are tracked in the Revision History Log attached to the beginning of the entire protocol and at the beginning of each SOP. Major changes result in an update by whole numbers (e.g., version 1.0, version 2.0, etc.) and minor changes by hundredths (e.g., version 1.01, version 1.02,). Record the new version number, date of revision, author of the revision, describe the change, and provide a rationale for the change. The version number used for the narrative and the SOPs will not stay synchronized.
2. All major changes must first be approved by appropriate network and park staff, including the network program manager, community ecologist, and data manager and then sent to the regional program manager with a summary of changes and recommendation for whether additional scientific review is needed. The regional program manager will determine if additional external scientific review is necessary. In general, minor changes to the protocol will only require in-house review by network staff (e.g., editing, formatting, switch to new software or comparable technology changes that do not affect sampling design, data quality, or data interpretation) followed by submission to the regional program manager for approval. Major changes in the protocol may require external review by subject matter experts (e.g., fundamental changes in sampling design, field methods).
3. Once approved for publication, the narrative, if revised, is submitted to the National Inventory and Monitoring (I&M) publication manager for formatting review and a new report number. The SOPs can be published to IRMA without obtaining a report number.
4. The data manager is informed about the protocol changes so the new version numbers can be incorporated in the database, metadata, and reports. The data manager may need to edit the database if the changes affect the database structure.
5. The new protocol version is posted on the [SFCN website](#) and [IRMA Data Store](#), the National Inventory and Monitoring Program protocol database is updated, and copies are forwarded to the parks and everyone else known to be working with the previous version of the protocol.

## Literature Cited

Moser, J., R. B. Shamblin, T. A. Fotinos, A. J. Atkinson, J. L. Chandler, M. Londoño, J. M. Patterson, and K. R. T. Whelan. 2019. South Florida/Caribbean Network mangrove-marsh ecotone monitoring: Protocol narrative. Natural Resource Report NPS/SFCN/NRR—2019/1923. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2260295> (last accessed May 2019).

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# *Methods for Testing Accuracy of Coordinates Taken from a Hovering Helicopter—Version 1.0*

This standard operating procedure (SOP) outlines the methods for testing the accuracy of a Trimble Geo7x GPS with external antenna, mounted in a hovering helicopter. We also present results of a 2016 test that serves as an accuracy estimate of these methods. The helicopter hover method was requested as the main method of data collection by the Everglades National Park Wilderness Committee; however the Everglades National Park Unit Aviation Manager prefers landing at each marker point based on safety concerns of hovering at low altitudes above a point. Our main method of collecting data is to land and walk to marker points, but in some situations there may not be an adequate area to land a helicopter (vegetation is too dense or deep muddy substrate). In these situations, the only way to collect marker point data is by hovering over the point.

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## Procedures

The following procedures will need to be performed every 10 years before the start of fieldwork utilizing a helicopter. The rationale is that there will be some sort of change from the previous sampling event. Examples of changes include different GPS unit being used, new pilot and field personnel, or another make of helicopter that may have different dimensions.

1. Take an on-ground GPS point with a Trimble GPS (see Trimble TerraSync Pocket Guide) at a number of points (greater than or equal to 3) in an area around the helicopter landing pad at locations that are easily recognizable (e.g. signpost, intersection of two lines on the tarmac) and located at a safe distance from parked aircraft and buildings (Fig SOP 13-1).



**Figure SOP 13-1.** Locations selected for hover method test are circled in red. Base map imagery is from ESRI.

2. Attach the Trimble GPS unit to the external antenna and attach the antenna to the two metal hooks on the dashboard of the helicopter using the two magnets on the antenna. Use a piece of tape to secure the antenna at a third point.
3. Measure the shortest horizontal distance from the middle of the GPS antenna on the dashboard of the helicopter to the outside of the passenger's side skid of the helicopter. For a Bell 206 BIII helicopter this distance is measured at 1.05 meters (3.4 feet [ft]). Record the angle between the front of the helicopter (the direction of travel) and the skid relative to the GPS antenna, to the nearest degree; this is used in generating the proper offset for recorded coordinates. On the Bell 206 BIII this is 90° (Fig SOP 13-2).

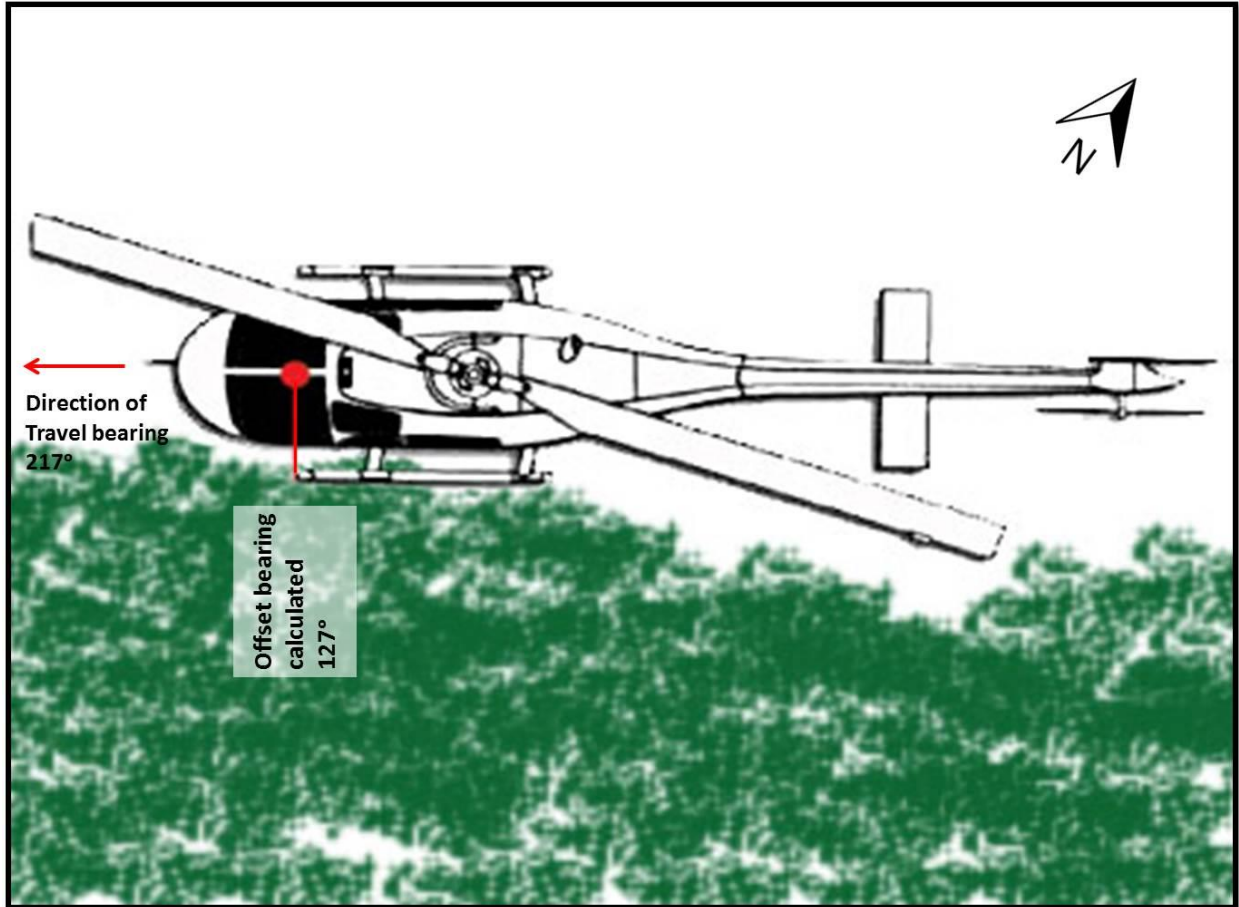


**Figure SOP 13-2.** A rendering of a hovering helicopter performing a GPS point data collection. The GPS antenna mount (red dot) is located on the center dashboard of the aircraft. For a Bell 206 BIII the distance between the GPS antenna and the end of the skid is 1.05 meters (3.4 ft) and the offset angle is exactly 90° degrees. In this rendering the aircraft has a direction of travel bearing of 217° (red arrow), hence the offset bearing is 127° ( $217^\circ - 90^\circ = 127^\circ$ ) with an offset distance of 1.05 meters. The crew member in the co-pilot seat directs the pilot; visually lining up the end of the skid with the mangrove ecotonal edge below; then directs the pilot to hover in place while acquiring a GPS location. In this rendering the wind is from 217° steady at 10 mph. A similar approach was used when collecting position data for the accuracy test.

4. Once in the air, instruct the pilot to hover over a selected GPS location (a GPS unit with the marker points is also mounted on the helicopter dashboard for pilot guidance) as close to the ground as safely possible without contacting vegetation. Example points were taken at approximately 6 meters (19.7 ft) off the ground, but future tests will be conducted from at least 10 meters (32.8 ft) off the ground to match the field data collection procedures. Give the pilot directions to help align the passenger's side helicopter skid with the selected point or the ecotone edge.
5. Begin collecting the GPS point with the Trimble once the helicopter is aligned with the point. Let the Trimble collect positions for 30 seconds before tapping "DONE" on the Trimble.

Record the direction of travel of aircraft (heading) while taking the GPS point, to the nearest 5°.

6. Proceed to the next selected location.
7. After all points have been collected and the coordinates differentially corrected, add the shapefile with the corrected coordinates to ArcMap (Figure SOP 13-3). Offset the hover points by the bearing and distance between the GPS unit and the helicopter skid point used to mark the ecotone location (Figure SOP 13-2). The offset bearing will be the direction of travel of the helicopter recorded in step 5, minus the correction angle recorded in step 3. Use the ArcMap Measure tool to find the distance between the ground and corrected hover point at each sampled location (Table SOP 13-1).



**Figure SOP 13-3.** Two test points taken with the Trimble GPS on the ground (yellow circles), hovering in a helicopter (red circles), and corrected for the antenna offset (blue circles).

8. Summary statistics of the differential between the ground and hover points can then be calculated (Table 13-1).

**Table SOP 13-1.** Results from three helicopter hover method test points in an open airport area setting in 2016. All three points were collected with the helicopter facing east (heading of 90°).

| Test Point         | Distance between Ground and Hover Coordinates (m) | Distance after correcting for antenna offset (m) |
|--------------------|---------------------------------------------------|--------------------------------------------------|
| 1                  | 1.93                                              | 1.13                                             |
| 2                  | 1.14                                              | 0.24                                             |
| 3                  | 1.83                                              | 1.48                                             |
| Mean               | 1.63                                              | 0.95                                             |
| Standard Deviation | —                                                 | 0.64                                             |



# Standard Operating Procedure 14

## Purpose

## Revision Log

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## Introduction

The South Florida/Caribbean Network Mangrove-Marsh Ecotone Monitoring protocol (Moser et al. 2019) monitors ecotonal movement of mangroves and upslope freshwater marshes in Everglades National Park (EVER) and Big Cypress National Preserve (BICY). Tracking the position of ecotones can indicate the long-term trajectory of these plant communities. Changes in the ecotone can be indicative of changing environmental drivers. The mangrove to freshwater marsh ecotones are expected to move, for example, in response to changes in water management, sea-level rise, storms, and fire, some of which can be manipulated to alter the rate of change. Ecotonal movement of vegetation communities across the landscape is indicative of large-scale processes affecting the park.

Remote sensing approaches are used to delineate the physical location of the ecotone between mangroves and freshwater marsh. Fourteen 3-kilometer (1.9-mile [mi]) segments are systematically placed across the ecotone within the two parks. New aerial imagery is used to digitize the mangrove-marsh ecotone in each segment and must be one meter or better resolution and have positional accuracy of  $\pm 3$  meters (9.8 feet [ft.]) or better. Four ground-truth field point locations (marker points) are established systematically along the ecotone boundary of each segment to provide field-based measurements and ground-truthing of the digitized line.

The specific objectives of the Mangrove-Marsh Ecotone Monitoring Protocol are:

- Determine the spatial and temporal movement of the mangrove-marsh ecotone at systematically selected segments.
- Document the composition of vegetation communities at field verification locations. Collect vegetation data, e.g., composition, percent cover and canopy height of dominant species within herbaceous, shrub, and forest strata, to document composition of vegetation communities on both the “mangrove” and “marsh” sides of the ecotone.

Monitoring is repeated approximately once every 10 years as new imagery becomes available. The monitoring duties for the Mangrove-Marsh Ecotone Monitoring Protocol will be completed by South Florida/Caribbean Network staff and the information collected used to support the management of natural resources in Everglades National Park and Big Cypress National Preserve.

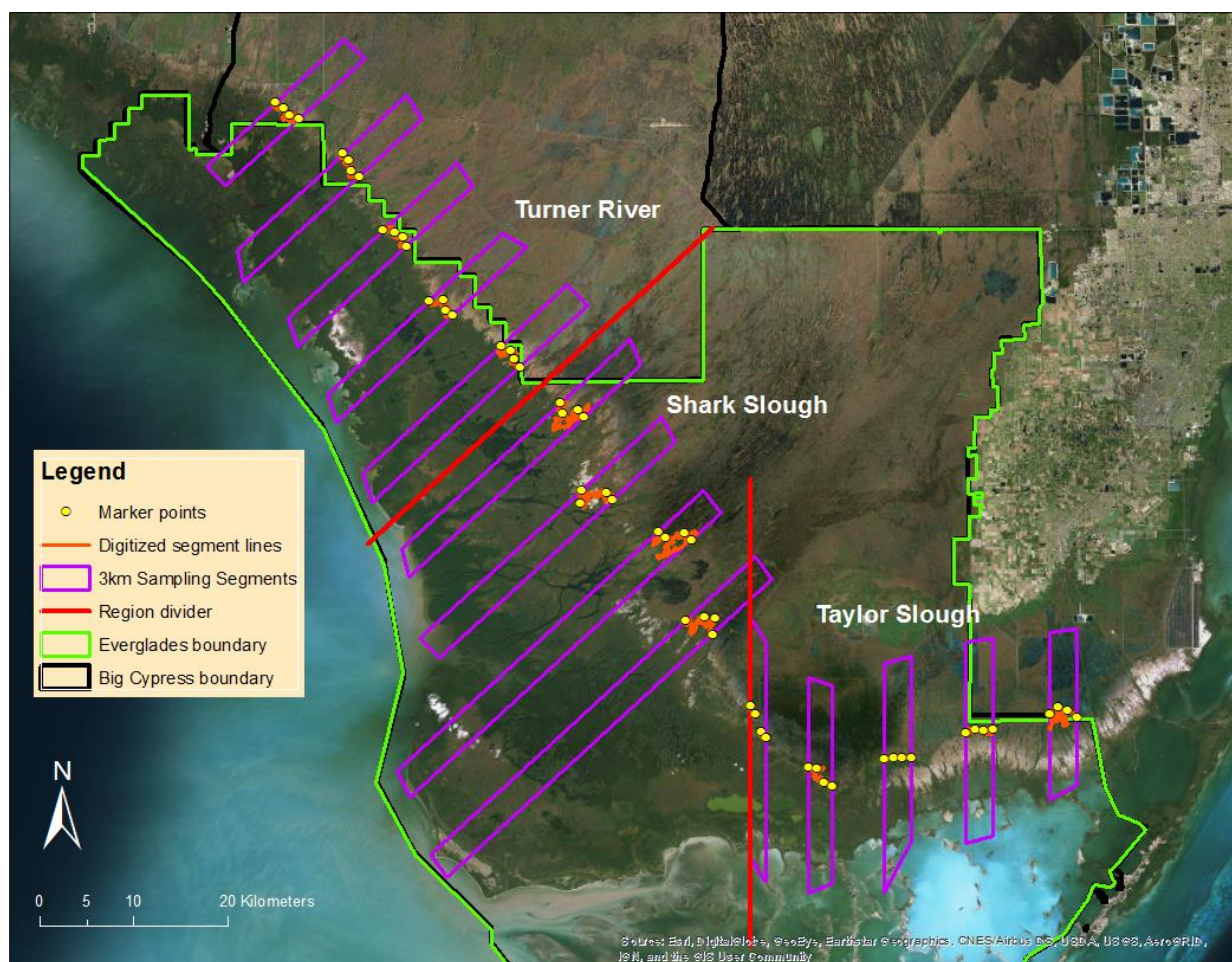


**Figure SOP 14-1.** Map of 3-kilometer (1.9-mi) ecotone segments (purple outlines), digitized lines (orange), and marker points (yellow dots).

## Methods

Ecotonal movement is monitored with aerial imagery, with a set of ground points evaluated to provide quality assurance and quality control, and with vegetation data. The future monitoring schedule for ecotonal movement will be approximately every 10 years. The schedule may vary depending on the availability of aerial imagery of sufficient quality (less than 1 meter [3.2-ft] resolution and better than  $\pm 3$  meters [9.8-ft] positional accuracy). Digitizing the mangrove-marsh ecotonal boundary using new aerial imagery is the first stage of the monitoring process and therefore cannot begin until imagery is produced and released. The frequency of reassessment for this project reflects the time scale over which vegetation communities are expected to move based on our examination of historical imagery and similar work done by others (Krauss et al. 2011).

Access to marker points requires travel by helicopter, airboat, or on foot. The marker points are spread across the southern and western coast of Everglades National Park and the southwest corner of Big Cypress National Preserve to maximize the spatial extent of mangrove-marsh ecotone monitoring. The number of marker points will always be four per 3-kilometer (1.9-mi) segment,

spaced approximately 1 kilometer (0.62 mi) apart to demarcate three 1-kilometer segments. For a full explanation of mangrove-marsh ecotone monitoring and the pilot work that was done to determine methods and monitoring areas, see Moser et al. 2019 – *South Florida/Caribbean Network Mangrove-Marsh Ecotone Monitoring*. Marker point monitoring is optimized using a two-person crew, one being a trained botanist from the South Florida/Caribbean Network (SFCN). Complete methods are described in SOP 5 *Mangrove-Marsh Ecotone Field Methods—Version 1.0*.

Ecotone lines are digitized based on <year> imagery (Table SOP 14-1) with multiple field visits required to monitor all field sites. Marker points and associated data are collected within one to two years of aerial imagery acquisition.

**Table SOP 14-1.** Segment digitizing metadata for the <ordinal number> mangrove-marsh ecotone assessment. *Data presented here based on pilot study at index sites.*

| Region / Segment | Imagery Name | Imagery Year | Imagery Resolution | Digitizing Year | Field Visit Dates                |
|------------------|--------------|--------------|--------------------|-----------------|----------------------------------|
| Mahogany Hammock | CERP         | 2009         | 30 cm              | 2014            | March 2014                       |
| Ochopee          | FDOR         | 2012         | 60 cm              | 2012            | November 2012                    |
| Spreader Canal   | CERP         | 2009         | 30 cm              | 2012            | August 2012                      |
| Shark Slough     | CERP         | 2009         | 30 cm              | 2013            | December 2013–January 2014       |
| Taylor Slough    | CERP         | 2009         | 30 cm              | 2011            | September 2011 and February 2014 |

Compile, as feasible, relevant ancillary data and information such as hurricane impacts, sea-level rise, hydrological inputs, restoration activities, fires, and related research to assist interpreting the spatial and temporal pattern of ecotone change.

## Results and Discussion

### Summary

Report summary of results and anything unusual that managers should be made aware of. If results are interpretive beyond what is specified in this protocol, then the report should shift to Natural Resource Report Series with peer review.

1. Appendix 14-A contains maps of the ecotonal lines and error statistics based on comparison with ground marker points.
2. Appendix 14-B contains marker point strata % cover figures by region.
3. Appendix 14-C contains marker point species % cover tables by region.
4. Appendix 14-D contains species list tables for each marker point by region.

5. Appendix 14-E contains changes in area and distance between <Time 1> and <Time 2>.

### **Discussion of results**

Discuss results in light of relevant ancillary data and information such as hurricane impacts, sea level rise, hydrological inputs, restoration activities, fires, and related research to assist interpreting the spatial and temporal pattern of ecotone change.

### **Assessment issues and improvements**

Include anything that should be noted for future assessments, including difficulty with access and low water.

## **Literature Cited**

- Krauss, K. W., A. S. From, T. W. Doyle, T. J. Doyle, and M. J. Barry. 2011. Sea-level rise and landscape change influence mangrove encroachment onto marsh in the Ten Thousand Islands region of Florida, USA. *Journal of Coastal Conservation* 15(4):629–638.
- Moser, J., R. B. Shamblin, T. A. Fotinos, A. J. Atkinson, J. L. Chandler, M. Londoño, J. M. Patterson, and K. R. T. Whelan. 2019. South Florida/Caribbean Network Mangrove-Marsh Ecotone Monitoring: protocol narrative—version 1.0 Natural Resource Report. Natural Resource Report NPS/SFCN/NRR—2019/1923. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2260295> (last accessed May 2019).

## Appendix SOP 14-A. Three-kilometer Segment with Ecotone Line, Marker Points and Calculated Accuracy of Digitized Line

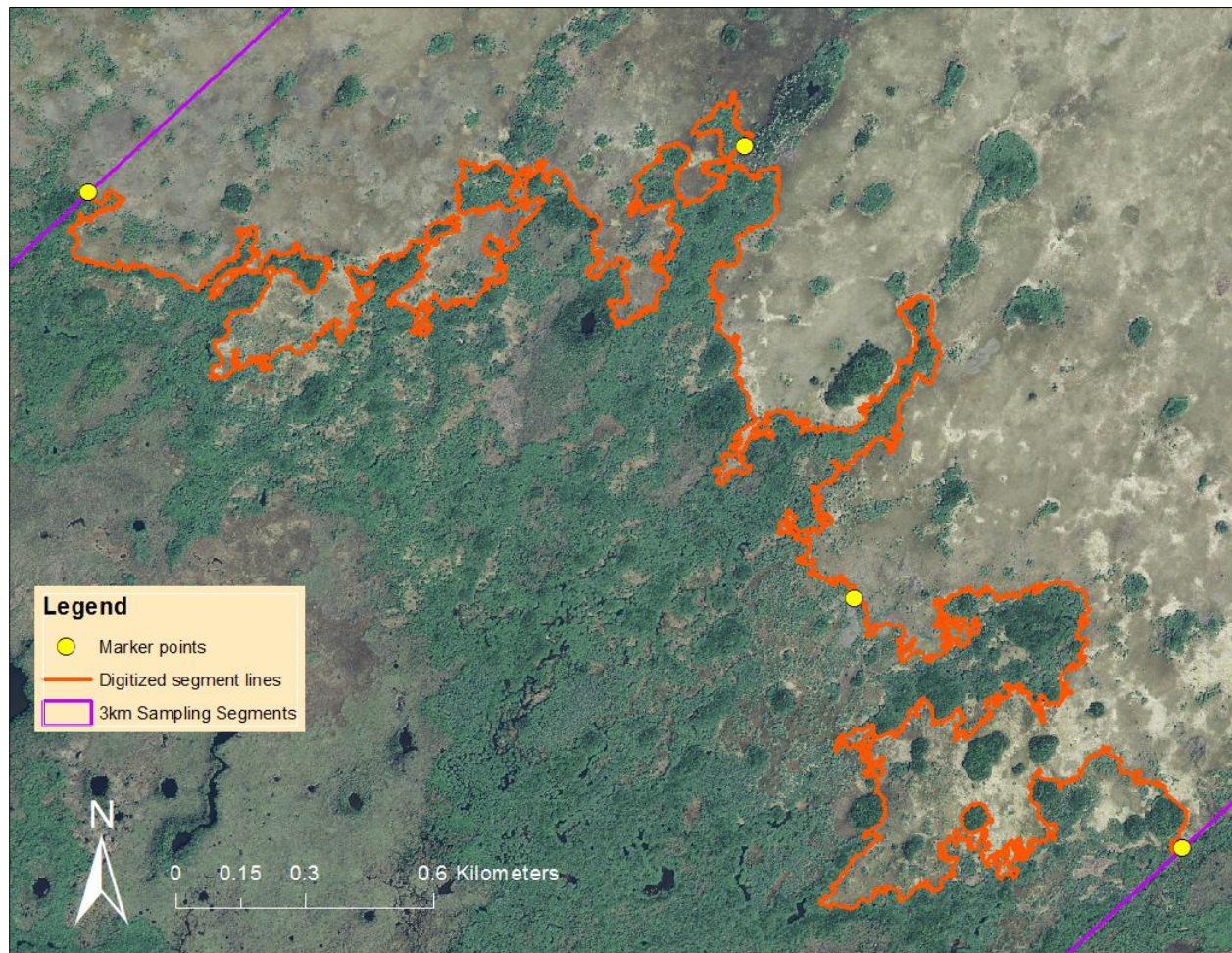


**Figure SOP 14-A-1.** Digitized ecotone line (orange line) during <ordinal number> assessment (<year line digitalized>) of segment <X>. Yellow circles represent marker points and purple lines represent 3-kilometer segment guidelines.

**Table SOP 14-A-1.** Mean and range of differences between digitized ecotone lines and marker points. Differences where the line is to the marsh side of the marker points are recorded as negative whereas differences where the line is to the mangrove side are positive. A t-statistic is calculated to test the probability that the average of the difference is different from zero (i.e., whether the line is systematically biased to one side of the marker points).

| Segment | N | Mean | Median | Min | Max | RSME | t value | Prob =0 |
|---------|---|------|--------|-----|-----|------|---------|---------|
| NA      | – | –    | –      | –   | –   | –    | –       | –       |
| NA      | – | –    | –      | –   | –   | –    | –       | –       |
| NA      | – | –    | –      | –   | –   | –    | –       | –       |
| NA      | – | –    | –      | –   | –   | –    | –       | –       |
| NA      | – | –    | –      | –   | –   | –    | –       | –       |

## Appendix SOP 14-B. Monitoring and Vegetation Data Collection Date Tables for each 3-Kilometer Segment

**Table SOP 14-B-1.** Monitoring and vegetation data collection field date's during <ordinal number> mangrove-marsh ecotone assessment (<year>-<year>) for each 3-kilometer segment.

| Segment | Latitude | Longitude | Marker Point Date |
|---------|----------|-----------|-------------------|
| A       | –        | –         | March 2018        |

## Appendix SOP 14-C. Segment Marker Point Strata Absolute % Cover Figures



**Figure SOP 14-C-1.** Segment marker point strata absolute percent cover during &ltordinal number> assessment (&ltyear>-&ltyear>). Data presented here based on pilot study.

## Appendix SOP 14-D. Segment Species Absolute % Cover Tables

**Table SOP 14-D-1.** Species absolute % cover at <segment ID> during <ordinal number> assessment (<year>-<year>).

| Side     | Strata | Scientific Name             | 1  | 2  | 3  | 4  |
|----------|--------|-----------------------------|----|----|----|----|
| Mangrove | Herb   | <i>Cladium jamaicense</i>   | 10 | -- | 10 | 10 |
|          |        | <i>Eleocharis cellulosa</i> | 5  | 10 | 20 | 10 |
|          |        | <i>Utricularia purpurea</i> | 5  | 10 | -- | -- |
|          | Shrub  | <i>Rhizophora mangle</i>    | 75 | 80 | 70 | 85 |
| Marsh    | Herb   | <i>Chara</i> sp.            | -- | -- | -- | -- |
|          |        | <i>Cladium jamaicense</i>   | 80 | 5  | 5  | 10 |
|          |        | <i>Eleocharis cellulosa</i> | 20 | 40 | 50 | 50 |
|          |        | <i>Utricularia purpurea</i> | -- | 20 | -- | -- |
|          | Shrub  | <i>Rhizophora mangle</i>    | 20 | 10 | 10 | 15 |

## Appendix SOP 14-E. Project Species List Tables

**Table SOP 14-E-1.** Species list during <ordinal number> assessment (<year>-<year>).

| Scientific Name              | Common Name                | Family           | Native |
|------------------------------|----------------------------|------------------|--------|
| <i>Catopsis berteroniana</i> | Powdery Strap Airplant     | Bromeliaceae     | Yes    |
| <i>Chara</i> sp.             | Musk Grass                 | Characeae        | Yes    |
| <i>Cladium jamaicense</i>    | Jamaica Swamp Sawgrass     | Cyperaceae       | Yes    |
| <i>Crinum americanum</i>     | Seven Sisters              | Amaryllidaceae   | Yes    |
| <i>Eleocharis cellulosa</i>  | Gulf Coast Spikerush       | Cyperaceae       | Yes    |
| <i>Panicum virgatum</i>      | Switchgrass                | Poaceae          | Yes    |
| <i>Rhizophora mangle</i>     | Red Mangrove               | Rhizophoraceae   | Yes    |
| <i>Tillandsia paucifolia</i> | Potbelly Airplant          | Bromeliaceae     | Yes    |
| <i>Tillandsia</i> sp.        | Airplant                   | Bromeliaceae     | Yes    |
| <i>Tillandsia utriculata</i> | Giant Airplant             | Bromeliaceae     | Yes    |
| <i>Utricularia purpurea</i>  | Eastern Purple Bladderwort | Lentibulariaceae | Yes    |

## Appendix SOP 14-F. Changes in Area and Distance between <Time 1> and <Time 2>

**Table SOP 14-F-1.** Distance change between digitized ecotone lines between <Time 1> and <Time 2>. Upslope is positive. Downslope is negative. Effective sample size within a segment is N=30.

| Segment | Mean Difference | Median Difference | Maximum Positive Difference | Maximum Negative Difference | Standard Deviation | Standard Error | t value | Prob mean = zero |
|---------|-----------------|-------------------|-----------------------------|-----------------------------|--------------------|----------------|---------|------------------|
| -       | -               | -                 | -                           | -                           | -                  | -              | -       | -                |
| -       | -               | -                 | -                           | -                           | -                  | -              | -       | -                |
| -       | --              | -                 | -                           | -                           | -                  | -              | -       | -                |
| -       | --              | -                 | -                           | -                           | -                  | -              | -       | -                |
| -       | -               | -                 | -                           | -                           | -                  | -              | -       | -                |

**Table SOP 14-F-2.** Area change between digitized ecotone lines between <Time 1> and <Time 2>.

| Segment | Total Area Change | Upslope Area Change | Downslope Area Change |
|---------|-------------------|---------------------|-----------------------|
| -       | -                 | -                   | -                     |
| -       | -                 | -                   | -                     |
| -       | --                | -                   | -                     |
| -       | --                | -                   | -                     |
| -       | -                 | -                   | -                     |



**National Park Service**  
**Inventory and Monitoring Division**

| Revision Date | Author | Changes Made | Reason for Change | New Version # |
|---------------|--------|--------------|-------------------|---------------|
|               |        |              |                   |               |
|               |        |              |                   |               |
|               |        |              |                   |               |
|               |        |              |                   |               |
|               |        |              |                   |               |

## Procedures

When accessing wilderness areas of Big Cypress National Preserve, the following forms must be filled out and sent by email to Big Cypress National Preserve resource management. All forms can be filled out and sent at the same time. A phone call will be necessary beforehand to fill out the Visiting Employee Checklist form. Allow at least two weeks before planned fieldwork for these forms to be processed. These forms include;

1. The Request for Off-Trail ORV Administrative Access (Figure SOP 15-1). This one page form is not solely for ORV (Off-road vehicles), but also is filled out for airboat access and helicopter landings in wilderness areas.
2. Application for Off-Trail ORV Access (Figure SOP 15-2). This form consists of three pages and may include a Minimum Requirements Analysis (MRA).
3. Backcountry Travel Plan (Figure SOP 15-3). This one page form includes information such as names of field crew, contact information, vehicle and/or vessel information, itinerary, and a list of equipment. A map with proposed sampling sites also needs to accompany this form.
4. Visiting Employee Checklist (Figure SOP 15-4). This one page form is a checklist for use in supervision of visiting employees (e.g. SFCN employees visiting Big Cypress National Preserve). This checklist form makes sure that the visiting employees have their trainings up to date, have filled out all the necessary forms (Request for Off-Trail ORV Administrative Access, Application for Off-Trail ORV Access, and Backcountry Travel Plan), have received park emergency communication procedures, and have a clear chain of command in place. Prior to filling out this form, call resource management to set up check in/check out procedures, park emergency communication procedures, and identify a park point of contact.

## REQUEST FOR OFF-TRAIL ORV ADMINISTRATIVE ACCESS

This form is to be used by any person employed by, under contract with, or otherwise affiliated with the National Park Service at Big Cypress National Preserve desiring to use an ORV off of the designated trail system. The requester must complete Part 1 and submit this form to the superintendent's office through the appropriate Division chief at least one week prior to the desired date of access.

### Part 1. Requester Supplied Information

Requester \_\_\_\_\_ Date of request \_\_\_\_\_

BICY Division \_\_\_\_\_ Phone \_\_\_\_\_ Email \_\_\_\_\_

Address, if non-BICY \_\_\_\_\_

Dates for which access is requested \_\_\_\_\_

Specific locations where access is requested, including points of entry \_\_\_\_\_

\_\_\_\_\_

Purpose of access \_\_\_\_\_

\_\_\_\_\_

Vehicle descriptions \_\_\_\_\_

Names of all individuals traveling \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Why off-trail access is necessary; i.e., why other routes or other means of non-ORV access cannot be used

\_\_\_\_\_

\_\_\_\_\_

I agree to enter only the off-trail areas approved on this form and to comply with any conditions stated in the "Remarks" space below. I agree to document all off-trail travel and to forward copies of all electronic files or maps to the Environmental Protection Specialist at the completion of the approved access.

Requester's signature \_\_\_\_\_ Date \_\_\_\_\_

### Part 2. Concurrence and Approval:

Division Chief \_\_\_\_\_ Date \_\_\_\_\_

Environmental Protection Specialist \_\_\_\_\_ Date \_\_\_\_\_

Superintendent approval \_\_\_\_\_ Date \_\_\_\_\_

Non-approval \_\_\_\_\_ Date \_\_\_\_\_

Remarks:

8/4/11  
version

Figure SOP 15-1. Request form for access to wilderness area within Big Cypress National Preserve.

**BIG CYPRESS NATIONAL PRESERVE  
APPLICATION FOR OFF-TRAIL ORV ACCESS**

You must submit this application if you are employed by, under contract with, or otherwise affiliated with the National Park Service (NPS) at Big Cypress National Preserve (BICY) and desire to use an off-road vehicle (ORV) off of the designated ORV trail system for nonemergency purposes. You are highly encouraged to modify your proposed activity, if possible, to either (1) not require the use of ORVs or (2) accomplish your activity with ORVs on designated trails only (go to <http://www.nps.gov/bicy/planyourvisit/designated-trail-implementation.htm> for the current maps). In either case, completion and submission of this application is not required, but other NPS and/or BICY requirements may apply. Otherwise, you must complete Part I and submit this application to the Superintendent's Office through the appropriate Division Chief, if applicable, at least two weeks prior to the desired date of access.

**Part I. Applicant-supplied Information—Attach Extra Sheets if Necessary**

Subpart A. Please provide the following:

Name \_\_\_\_\_ Date of Request \_\_\_\_\_  
BICY Division, if applicable \_\_\_\_\_ Resource Management \_\_\_\_\_ Phone 305-252-0347  
Email address \_\_\_\_\_  
Address, if non-BICY 18001 Old Cutler rd., Suite 419, Palmetto Bay, FL 33157  
Dates for which access is requested \_\_\_\_\_  
Specific locations where access is requested, including points of entry: Please attach map  
Purpose of access \_\_\_\_\_  
Vehicle descriptions \_\_\_\_\_  
Names of all individuals travelling \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
ORV operator certification: Please attach documentation supporting the qualifications of all proposed ORV operators  
Proposed actions to minimize ORV impacts \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

By signing and dating below, I agree to enter only the off-trail areas approved by this application and to comply with any conditions stated in the "BICY Remarks" space in Part II below. I agree to document the locations of all off-trail travel and forward copies of electronic files or maps of such locations to the Environmental Protection Specialist ([damon\\_doumlele@nps.gov](mailto:damon_doumlele@nps.gov)) within three weeks after completion of the approved access. I realize that failure to adhere to these requirements may constitute cause for non-approval of future off-trail ORV applications.

Applicant's signature \_\_\_\_\_ Date \_\_\_\_\_

**Figure SOP 15-2.** Application form for Off-Trail ORV Access to wilderness area within Big Cypress National Preserve (page 1 of 3).

Subpart B. Please answer the following:

1. Can all parts of the activity involving ORVs or other motorized equipment take place outside of proposed or eligible wilderness as shown on pages 83 and 119 of the 2010 BICY *Addition General Management Plan/Wilderness Study/Off-Road Vehicle Management Plan/Environmental Impact Statement* (<http://www.nps.gov/bicy/parkmgmt/addition-lands-gmp.htm>)?

☐ Yes.

☐ No, at least some of the ORV and/or other motorized activity will take place in proposed wilderness.

Complete a Minimum Requirements Analysis (MRA)

(<http://www.wilderness.net/index.cfm?fuse=MRDG#>) and attach it to this application (note: the MRA requires separate Superintendent approval and will add some delay to processing the off-trail application). If the MRA concludes that motorized activity is not appropriate, you must (a) withdraw your application, (b) modify your proposal to eliminate all motorized activity, or (c) modify your proposal to conduct all motorized activity outside of proposed wilderness.

☐ No, at least some of the ORV and/or other motorized activity will take place in eligible but not proposed wilderness.

Describe the measures you will take to prevent or minimize degrading, even temporarily, the wilderness qualities of untrammeled, natural, undeveloped, or offering solitude or a primitive and unconfined recreation (go to [http://www.wilderness.net/toolboxes/documents/WC/Presentation%20\(with%20notes\)%20preserving%20wilderness%20character.pdf](http://www.wilderness.net/toolboxes/documents/WC/Presentation%20(with%20notes)%20preserving%20wilderness%20character.pdf) for explanation of these terms).

2. Can the ORV activity take place during dry conditions, normally late winter/spring?

☐ Yes.

☐ Yes, but not practical or feasible for the following reasons:

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☐ No, or partially, for the following reasons:

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**Figure SOP 15-3.** Application form for Off-Trail ORV Access to wilderness area within Big Cypress National Preserve (page 2 of 3).

3. Can the ORV activity take place in areas or habitat less sensitive to ORV use, such as pinelands and disturbed areas, as opposed to sensitive areas or habitat, such as marl prairies, marshes, cultural sites, and endangered/threatened species nesting or denning sites?

☐ Yes.

☐ Yes, but not practical or feasible for the following reasons:

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☐ No, or partially, for the following reasons:

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4. Can the ORV activity be conducted such that impacts on visitors will be minimal?

☐ Yes.

☐ Yes, but not practical or feasible for the following reasons:

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☐ No, or partially, for the following reasons:

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**Part II. Concurrence and Approval—To Be Completed by BICY Staff**

Division Chief \_\_\_\_\_ Date \_\_\_\_\_

Environmental Protection Specialist \_\_\_\_\_ Date \_\_\_\_\_

Superintendent approval \_\_\_\_\_ Date \_\_\_\_\_

Non-approval \_\_\_\_\_ Date \_\_\_\_\_

BICY Remarks: \_\_\_\_\_

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**Figure SOP 15-4.** Application form for Off-Trail ORV Access to wilderness area within Big Cypress National Preserve (page 3 of 3).

| <b>Big Cypress National Preserve</b><br><b><u>BACKCOUNTRY TRAVEL PLAN</u></b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |        |                                                                              |                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------------------------------------------------------------------------|----------------------|
| <u>Date/Time Start:</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |        | <u>Date End:</u>                                                             |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |        | <u>Group:</u> <input type="checkbox"/> <u>Solo:</u> <input type="checkbox"/> |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |        | <u>Estimated Return Time:</u>                                                |                      |
| <u>ENTRY PT.</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |        | <u>EXIT PT.</u>                                                              |                      |
| Leader:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Radio# | Clothing Description:                                                        | Pack Color:          |
| Name:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Radio# | Clothing Description:                                                        | Pack Color:          |
| Name:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Radio# | Clothing Description:                                                        | Pack Color:          |
| Name:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Radio# | Clothing Description:                                                        | Pack Color:          |
| <u>Re-contact phone#</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        | <u>Supervisor:</u>                                                           | <u>Supvr. Phone#</u> |
| <u>Communications Devices:</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |        | <u>CELL PHONE#</u>                                                           | <u>RADIO CALL #</u>  |
| <u>Travel By:</u> (check all that apply)            Foot: <input type="checkbox"/> Airboat <input type="checkbox"/> Buggy <input type="checkbox"/> ATV <input type="checkbox"/> 4X4 <input type="checkbox"/> Other <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |        |                                                                              |                      |
| <u>Vehicle(s):</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |        |                                                                              |                      |
| Make/Model:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Color: | License Plate/State:                                                         | Parked at:           |
| Make/Model:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Color: | License Plate/State:                                                         | Parked at:           |
| <u>Detailed Itinerary:</u> List travel plan (trails, routes) for each day and where you plan to stay each night. Please be detailed. Use an additional sheet if necessary.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |        |                                                                              |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |        |                                                                              |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |        |                                                                              |                      |
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |        |                                                                              |                      |
| <u>Risk Management Considerations</u> (Examples: water travel, solo travel, high/low water travel, weather forecast) :                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |        |                                                                              |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |        |                                                                              |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |        |                                                                              |                      |
| <u>Equipment:</u> <input type="checkbox"/> Compass <input type="checkbox"/> Map <input type="checkbox"/> GPS <input type="checkbox"/> Signal Mirror <input type="checkbox"/> Flare <input type="checkbox"/> Whistle <input type="checkbox"/> Flashlight/Headlamp<br>(check in all <input type="checkbox"/> First Aid Kit <input type="checkbox"/> Reflective Marker <input type="checkbox"/> Space Blanket <input type="checkbox"/> Personal Locator Beacon<br><u>applicable</u> ) <input type="checkbox"/> Come Along <input type="checkbox"/> Shelter/Bivy Gear <input type="checkbox"/> Fence Jack <input type="checkbox"/> Food <input type="checkbox"/> Shovel <input type="checkbox"/> Rope <input type="checkbox"/> Water |        |                                                                              |                      |
| <u>Weapon(s) (specify):</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |        | <u>Other(specify):</u>                                                       |                      |
| <u>Equipment Identifiers:</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |        |                                                                              |                      |
| <u>Tent Color(s):</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        | <u>Tent Fly Color(s):</u>                                                    |                      |
| <u>Please describe any known or suspected problems with radio contact that you anticipate:</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |        |                                                                              |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |        |                                                                              |                      |
| <u>Additional information:</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |        |                                                                              |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |        |                                                                              |                      |
| rev. 1/19/2007                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |        |                                                                              |                      |

**Figure SOP 15-5.** Backcountry Travel Plan form, for use when accessing wilderness area within Big Cypress National Preserve.



National Park Service

U.S. Department of the Interior

Recommended Checklist for Use in Supervision of Visiting Employees

| Employee's Supervisor of Record                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Employee                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Receiving Park/Organization                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <input type="checkbox"/> Has attended Operational Leadership Training.*<br><input type="checkbox"/> Clear safety standards established with employees.<br><input type="checkbox"/> Established Point of Contact for receiving park/organization.<br><input type="checkbox"/> Defined check in/check out protocols with receiving park/organization.<br><input type="checkbox"/> Provided employee with appropriate Personal Protective Equipment and commensurate training.<br><input type="checkbox"/> Clear chain of command in place.<br><input type="checkbox"/> Emergency communication procedures for receiving park are known and understood. | <input type="checkbox"/> Has attended Operational Leadership Training.*<br><input type="checkbox"/> Contacted receiving park point of contact in advance and confirmed project itinerary.<br><input type="checkbox"/> Follow check in/check out protocols for receiving park/organization.<br><input type="checkbox"/> More than one communication mechanism is in place.<br><input type="checkbox"/> Receiving park emergency communication procedures are known and understood.<br><input type="checkbox"/> All required safety certification/trainings for job and receiving park/organization completed. | <input type="checkbox"/> Backcountry Travel Procedures or other check in/check out protocols are up to date and provided to incoming resources.<br><input type="checkbox"/> Provided park/organization specific safety training expectations ahead of time to incoming employee's supervisor.<br><input type="checkbox"/> Local point of contact has attended Operational Leadership training.*<br><input type="checkbox"/> Risk management assessments have been performed and provided to the employee.<br><input type="checkbox"/> Emergency communication procedures are given to, and understood by, incoming resources. |
| <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

\*Completion of Operational Leadership training is not mandatory but the lack thereof may cause the receiving unit to have a heightened sense of concern.

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Local additions encouraged in the space provided.

**Figure SOP 15-6.** Visiting Employee Checklist form is completed to ensure that the field crew has had the proper training and has set up park contact and check in/check out procedures. A phone call to park resource management setting up these procedures prior to fieldwork will be necessary.