AOS PROTOCOL AND PROCEDURE:
RIPARIAN MAPPING IN LAKES AND NON-WADEABLE STREAMS

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See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	05/12/2014	ECO-01128	Initial release
B	01/22/2015	ECO-02632	Migration to new protocol template
C	06/25/2015	ECO-02725	Minor updates including the removal of LWD sampling, adding a meter stick for clinometer measurements, and removing datasheets from the Appendix.

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1 OVERVIEW

1.1 Background

Riparian areas are ecosystems adjacent to streams, rivers, lakes, wetlands, and floodplains that form complex and interrelated hydrological systems (Verry et al., 2000) (Figure 1). While riparian areas are determined by hydrologic conditions and topographic relief, they are mapped independently from either wetlands or uplands. Riparian ecosystems are transition zones between aquatic and terrestrial systems and are, hence, unique in their high biological diversity. These areas are characterized by the presence of plant communities contiguous to and affected by surface or ground water of perennial or ephemeral water bodies. Riparian areas lack the amount or duration of water usually present in wetlands, yet display wetter conditions than adjacent uplands (US Fish and Wildlife Service, 2009). These areas have distinctly different vegetation than adjacent areas or have species similar to surrounding areas that exhibit a more vigorous or robust growth form (Cowardin et al., 1979). High habitat complexity and variability and ecologically diverse communities are formed as a result of frequent disturbances related to, for example, water movement, ice abrasion and sediment transport (Verry et al., 2000).

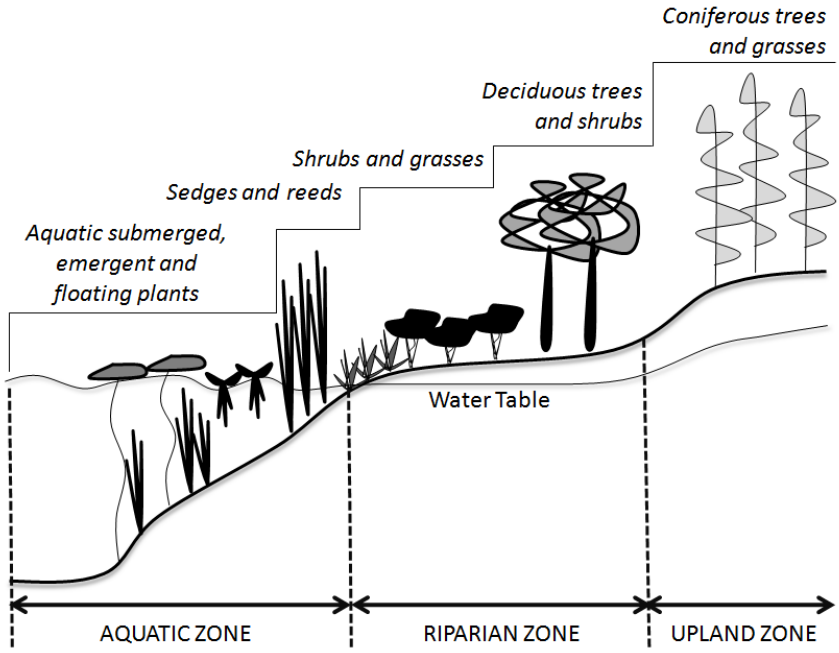

Figure 1. The riparian zone represents the land closest to the shoreline

Water level fluctuations results in the establishment and presence of vegetation able to withstand wet and dry conditions. It is an important buffer between the aquatic and terrestrial ecosystems. The riparian zone is characterized by vegetation comprising trees, shrubs, wildflowers, grasses, and other plants.

Riparian areas play a critical role in water quality by filtering or absorbing contaminants from the upland landscape or from floodwaters, through the provision of shade in shorelines that keeps water temperatures low, as a carbon source to streams through litterfall, for creating soil stability and sediment control, and by supporting wildlife habitat and food for fish. These areas also provide nearshore habitat structural elements, such as large woody debris, that create ideal conditions for shelter for many land and aquatic organisms and are a sink for sediments. Through infiltration, absorption, uptake, filtering, and deposition processes, riparian zones significantly reduce the amount of runoff and pollutants that reach both surface and underground water sources (Narumalani et al., 1997).

The overall objective of riparian habitat mapping is to provide accurate and up-to-date data of riparian cover composition, distribution, and interspersion of riparian habitats within the study area and enable identification of potential change over time. Since the remote sensing images, light detection and ranging (LIDAR), and other imagery available for interpretation may be dated and disturbances in the watershed can be rapid, it is important to consistently verify and update the riparian maps through annual site visits. Lake riparian mapping will take place once per year preferably during stable conditions and during times of maximum canopy cover. The approach follows the U.S. Environmental Protection Agency's EMAP protocol (Kaufmann, 2001), employing a randomized, systematic spatial sampling design that minimizes bias in the placement of measurements. This approach is met by making measurements at pre-defined areas that are spaced equidistant around the lake. Data for the riparian canopy cover extent and bank structure at lakes and non-wadeable streams are recorded across 10 equaly spaced locations and up to 50 m into the riparian zone within the permitted boundaries.

1.2 Scope

This document provides a change-controlled version of Observatory protocols and procedures. Documentation of content changes (i.e. changes in particular tasks or safety practices) will occur via this change-controlled document, not through field manuals or training materials.

1.2.1 NEON Science Requirements and Data Products

This protocol fulfills Observatory science requirements that reside in NEON's Dynamic Object-Oriented Requirements System (DOORS). Copies of approved science requirements have been exported from DOORS and are available in NEON's document repository, or upon request.

Execution of this protocol procures samples and/or generates raw data satisfying NEON Observatory scientific requirements. These data and samples are used to create NEON data products, and are documented in the NEON Scientific Data Products Catalog (RD[03]).

1.3 Acknowledgments

This protocol is based on modified versions of the U.S. Environmental Protection Agency (2008), U.S. Environmental Protection Agency (2008, 2007), and U.S. Fish and Wildlife Service (2009).

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

Applicable documents contain higher-level information that is implemented in the current document. Examples include designs, plans, or standards.

AD[01]	NEON.DOC.004300	EHS Safety Policy and Program Manual
AD[02]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD[03]	NEON.DOC.000724	Domain Chemical Hygiene Plan and Biosafety Manual
AD[04]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[05]	NEON.DOC.014051	Field Audit Plan
AD[06]	NEON.DOC.000824	Data and Data Product Quality Assurance and Control Plan

2.2 Reference Documents

Reference documents contain information that supports or complements the current document. Examples include related protocols, datasheets, or general-information references.

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms
RD[03]	NEON.DOC.005003	NEON Scientific Data Products Catalog
RD[04]	NEON.DOC.001271	NEON Protocol and Procedure: Manual Data Transcription
RD[05]	NEON.DOC.001646	General AQU Field Metadata Sheet
RD[06]	NEON.DOC.001152	NEON Aquatic Sample Strategy Document
RD[07]	NEON.DOC.001154	AOS Protocol and Procedure: Aquatic Decontamination
RD[08]	NEON.DOC.001863	NEON Lake Outline Sketch
RD[09]	NEON.DOC.001864	NEON Non-Wadeable Streams Outline Sketch
RD[10]	NEON.DOC.002494	Datasheets for AOS Sample Shipping Inventory
RD[11]	NEON.DOC.002764	Datasheets for Riparian Mapping in Lakes and Non-Wadeable Streams
RD[12]	NEON.DOC.001717	TOS Standard Operating Procedure TruPulse Rangefinder Use and Calibration

2.3 Acronyms

Acronym	Definition
DBH	Diameter at Breast Height
EMAP	Environmental Monitoring and Assessment Plan (US EPA)
EPA	Environmental Protection Agency
GDD	Growing Degree Days
USDA NRCS	United States Department of Agriculture Natural Resource Conservation Service
USGS	United States Geological Survey

2.4 Definitions

Dominant: The principal vegetative species prevalent in the area. Typically considered >30% coverage.

Emergent: Growing above the water's surface. Rooted with an herbaceous stem.

Forested: Woody vegetation more than 6 meters in height.

Growth form: Pertaining to the health, compactness, crowding and/or number of individuals.

Hydric Soil: Soils that are sufficiently wet in the upper part to develop anaerobic conditions during the growing season.

Intermittent: An area where moisture is only prevalent for part of the year, or where substrate is exposed. No detectable seasonal pattern in surface water.

Lentic: Biotic and/or abiotic interactions in standing water.

Lotic: Biotic and/or abiotic interactions in moving water.

Orthoimagery: A raster image that has been geometrically corrected ("orthorectified") to remove distortion caused by camera optics, camera tilt, and differences in elevation. Source is either satellite or airborne sensors. Data is orthorectified to achieve an accuracy commensurate with a given topographic map equivalent.

Perennial: Present in all seasons of the year and usually over multiple years.

Revetment: Structures built to preserve the existing uses of the shoreline, to protect the slope, and act as defense against erosion.

Riparian: Transitional areas between terrestrial and aquatic ecosystems, distinguished by gradients in biophysical conditions, ecological processes, and biota.

Scrub/Shrub: Woody vegetation <6 meters in height.

Wetland: Areas transitional between terrestrial and aquatic environments where the water table is usually at or near the surface or the land is covered by shallow water.

3 METHOD

Digitized maps delineating riparian habitats and vegetation, derived from aerial photographs and orthoimagery available through the USGS site (http://seamless.usgs.gov/website/seamless/viewer.htm), are provided as a baseline. For sites which prove to be inaccessible, this mapping component will prove critical for following long term changes in the habitat cover type and density. Where possible, ground truthing is used to verify the accuracy of the riparian maps (Figure 2).

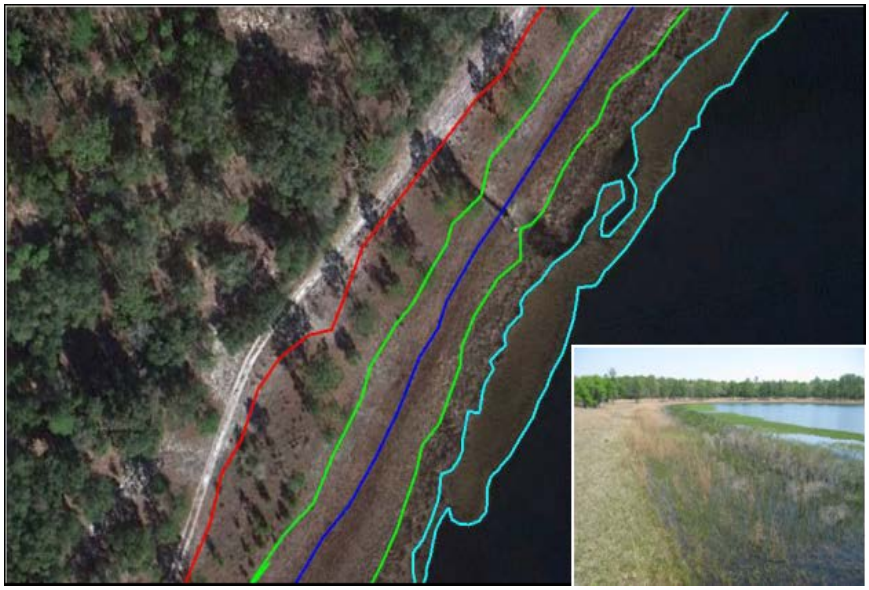

Figure 2. Example of digitized polygons representing littoral and riparian vegetation zoning. An example of emergent aquatic vegetation is pictured in the inset window.

The dark blue line represents the division between the littoral and riparian regions (as defined by the high water line). Above this line an area of grasses and shrubs is denoted below the green line followed by an area of sparse coniferous big tree (>0.3 DBH) coverage underlain by grasses (above the green line). Uplands are indicated above the red line. Below the dark blue line, the littoral habitat is delineated by an area of seasonally submerged sedges (green line) followed by an area of emergent shrubs and finally of floating emergent grasses below the light blue line (as seen in the inset photo).

Field ground truthing undertaken as part of this protocol consists of the following steps:

1. Walk around the site within the permitted boundaries and observe the vegetation and note differences to the mapped vegetation directly on the map at specified GPS locations within the riparian zone.
2. Conduct lake/non-wadeable nearshore observations.

On arrival in the field, technicians, where possible and permitted, walk around the perimeter of the lake or non-wadeable stream and make observations of the vegetation and bank structures following the guidelines outlined in this protocol, noting discrepancies in the maps and recording observations where necessary. These observations could include new areas of vegetation disturbance (landslides, erosion, or human disturbances). The observations are made within a boundary from the shoreline where permitted. Should the shore not be accessible, general observations are made from the boat.

Lake and non-wadeable stream based riparian mapping occurs by identifying 10 primary equidistant stations around the perimeter of the lake (Figure 3a) or 5 stations on either shore of the non-wadeable stream (Figure 3b). The approximate locations of the 5 or 10 stations are determined prior to the

mapping visit and marked on the *Lake Outline Sketch/ Non-Wadeable Streams Outline Sketch* (Appendix F). The US EPA selected the number of survey locations using a probability based survey design (U.S. Environmental Protection Agency, 2007). Once on the water, technicians travel to an identified station and establish the dimensions of the survey plot. Riparian mapping surveys are conducted off shore using a boat. The survey begins by estimating an observation location 10 m (perpendicular) from the shoreline within the littoral zone or shoreline. This spot may be marked with a GPS waypoint and is the vantage point from which technicians record riparian observations, and is also the point that separates the open water from the littoral area.

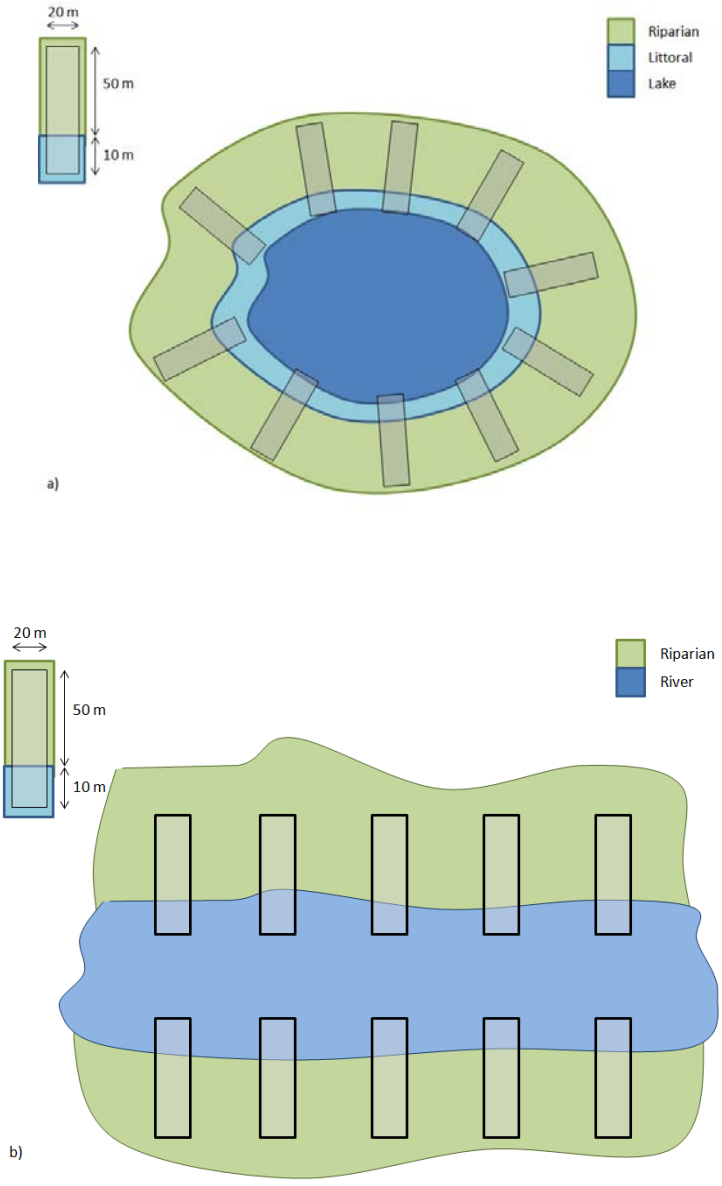

Figure 3. Sketch of riparian habitat mapping set-up and scheme for a) lakes; and b) non-wadeable streams.

The riparian portion of the plot extends up to 50 m from the shoreline towards the terrestrial systems and 20 m (10 m each side of central point) along the shoreline. The dimensions of the plots (20 m alongshore to up to 50 m inland) are determined using a compass and angle referencing clinometer (Figure 4). In this zone, technicians record information about the vegetation type, the height, and areal coverage of trees, shrubs, and grasses. In addition, observations of shoreline substratum (e.g., gravel, sand), the high-water mark, and bank slope characteristics are noted on the appropriate Field Datasheets. Anthropogenic activities and other features (e.g., buildings, land use, docks, trash, vegetation disturbances) are noted and any striking features seen adjacent to the plot. A photo is taken at each transect location for future reference and archived appropriately.

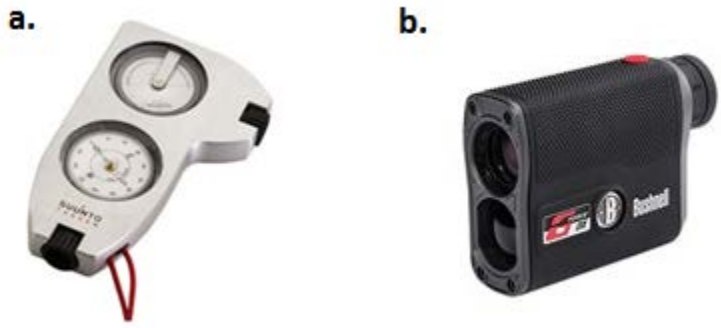

Figure 4. An example of **a)** a tandem clinometer that is both as a compass and used for measuring angles and **b)** a laser rangefinder which uses a laser beam to determine the distance to an object and a clinometer for determining height.

The activities outlined in this protocol are based on modified versions of the U.S. Environmental Protection Agency (2008, 2007) and U.S. Fish and Wildlife Service (2009).

The following modifications have been made:

- The perimeter of the lakes and the determination of the mapping locations in this protocol are chosen and delineated using Google Earth and GIS approaches, instead of using 1:100,000 topographic maps and the use of a string.
- The determination of the 20 meter horizontal widths of the riparian areas in the field are determined using a compass and angle referencing clinometer rather than by estimation.
- The distance into the riparian zone used as the identification area has been extended to 50 m.
- The determination of distance and height can be made using a laser rangefinder.

Standard Operating Procedures (SOPs), in Section 7 of this document, provide detailed step-by-step directions, contingency plans, sampling tips, and best practices for implementing this sampling procedure. For more details on how to operate the laser rangefinder refer to the NEON Rangefinder protocol (NEON.DOC.001717). To properly collect data, field technicians **must** follow the protocol and

associated SOPs. Use NEON's problem reporting system to resolve any field issues associated with implementing this protocol.

The value of NEON data hinges on consistent implementation of this protocol across all NEON domains, for the life of the project. It is therefore essential that field personnel carry out this protocol as outlined in this document. In the event that local conditions create uncertainty about carrying out these steps, it is critical that technicians document the problem and enter it in NEON's problem tracking system.

The procedures described in this protocol will be audited according to the Field Audit Plan (AD[05]). Additional quality assurance will be performed on data collected via these procedures according to the NEON Data and Data Product Quality Assurance and Control Plan (AD[06]).

4 SAMPLING SCHEDULE

4.1 Sampling Frequency and Timing

Sampling for riparian canopy cover measurements in lakes and non-wadeable streams shall occur once per year. Sampling timing is provided annually by Science Operations and shall be outlined in the NEON Aquatic Sampling Strategy Document (RD[06]). Sampling for Riparian canopy cover measurements in lakes and non-wadeable streams shall take place within +/- 2 weeks of time of maximum vegetation cover during stable conditions.

4.2 Criteria for Determining Onset and Cessation of Sampling

Sampling for lake and non-wadeable stream riparian habitat occurs during stable conditions and time of maximum vegetation cover. Maximum vegetation cover date ranges are determined using Moderate-resolution Imaging Spectroradiometer (MODIS) data and growing degree days (GDD).The specific times are determined using multivariate statistics and site specific historical information (see RD[06]).

4.3 Timing for Laboratory Processing and Analysis

There is no domain lab processing for this protocol.

4.4 Sampling Timing Contingencies

Table 1. Contingent decisions

Delay/ Situation	Action	Outcome for Data Products
Hours	If equipment stops functioning during sampling continue from where the sampling left off as soon as possible or restart if more than one week has passed.	No adverse outcome.
	If there is no access to the shore (due to safety issues, dense vegetation, unsafe ground conditions or because part of the segment is in private property), flag the field data sheet and comment on the conditions. Drive around the lake or non-wadeable stream perimeter with the boat and make observations where possible.	No adverse outcome.
	If the edge of the lake or non- wadeable stream is not accessible within 10 meters for the spot location sampling due to, for example, thick emergent aquatic vegetation, estimate the closest distance to the lake shore, and recalculate the sampling area to fit a 20 x 50 m meter grid. Then continue as detailed in the protocol.	No adverse outcome.
Days	If weather turns bad and creates unsafe conditions during sampling, stop sampling and resume as soon as is safe or restart if more than one week has passed.	No adverse outcome.

5 SAFETY

This document identifies procedure-specific safety hazards and associated safety requirements. It does not describe general safety practices or site-specific safety practices.

Personnel working at a NEON site must be compliant with safe field work practices as outlined in the Operations Field Safety and Security Plan (AD[02]) and EHS Safety Policy and Program Manual (AD[01]). Additional safety issues associated with this field procedure are outlined below. The Field Operations Manager and the Lead Field Technician have primary authority to stop work activities based on unsafe field conditions; however, all employees have the responsibility and right to stop their work in unsafe conditions.

In addition, the following safety guidelines are provided:

1. Due to site-specific hazards that may be encountered in accessing the shoreline technicians may complete observations without dismounting from the vessel. In addition, the technicians are required not to put hands and feet in waters where alligators are present and to make sure a safe distance from hazards is maintained.
2. All personnel must be wearing a personal flotation device (PFD) prior to entering and while in the boat.
3. All employees shall have access to a form of communication with other team members such as a two-way radio.
4. Technicians should be aware of any site-specific hazards and to the waters of that particular location (i.e. current status, tidal charts, etc.)

6 PERSONNEL AND EQUIPMENT

6.1 Equipment

The following equipment is needed to implement the procedures in this document. Equipment lists are organized by task. They do not include standard field and laboratory supplies such as charging stations, first aid kits, drying ovens, ultra-low refrigerators, etc.

Table 2. Equipment list – Lake riparian mapping procedure

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable items					
	R	Meter stick (1 m)	Use with clinometer to measure bank angle	1	N
	R	Suunto Clinometer	Determining shoreline bank angle	1	N
	R	Lake Outline Sketch	Navigating to sampling locations	1	N
	R	Quick reference field operations handbook	References	1	N
	R	Camera	Photographing riparian locations	1	N
	R	Sonar with GPS antenna	Navigating to sampling locations	1	N
	R	Memory card	For camera and sonar	3	N
	R	Handheld GPS unit	Navigating to sampling locations	1	N

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Consumable items					
	R	Physical Habitat Characterization Forms	Recording physical habitat characterization data	12	N
	R	Field notebook	Recording field notes	2	N
	R	12 V small batteries	For GPS unit	1	N

R/S=Required/Suggested

Table 3. Equipment list – General boating equipment

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable items					
	R	Boat		1	Y
	R	Anchor with rope		1	N
	R	Oars		2	N
	R	Trolling Electric Motor		1	Y

Item No.	R/S	Description	Purpose	Quantity	Special Handling
	R	Battery (12 volt)		1	Y
	R	Safety kit for boat (e.g., flares, bailer, float with rope)		1	Y
	R	First Aid Kit		1	N
	R	Personal Flotation Devices (PFDs)		1 per person	N
Consumable items					
		(none)			

R/S=Required/Suggested

6.2 Training Requirements

All technicians must complete required safety training and technicians must complete protocol-specific training for safety and implementation of this protocol as required in Field Operations Job Instruction Training Plan (AD[04]).

All personnel required to operate a boat shall be trained through an approved program. All others shall be aware of boating safety procedures.

Personnel are to be trained in lake and non-wadeable stream riparian mapping measurements and safe working practices for lake work.

6.3 Specialized Skills

Where applicable, personnel will be licensed to operate a boat and able to safely handle a motor and drive a boat safely.

Personnel should be able to use a clinometer to compute angles and distances.

6.4 Estimated Time

The time required to implement a protocol will vary depending on a number of factors, such as skill level, system diversity, environmental conditions, and distance between sample plots. The timeframe provided below is an estimate based on completion of a task by a skilled two-person team (i.e., not the time it takes at the beginning of the field season). Use this estimate as framework for assessing progress. If a task is taking significantly longer than the estimated time, a problem ticket should be submitted.

We estimate lake and non-wadeable stream riparian mapping sampling requires 2 technicians for 3 hours each sampling day plus travel to and from the site and 1-2 hours of laboratory work at the Domain Support Facility.

7 STANDARD OPERATING PROCEDURES

SOP A Preparing for Sampling

(Modified from U.S. EPA 2007)

1. Ensure memory cards are blank. If files are present, confirm data and photos have been uploaded prior to deleting.
2. Verify all equipment is available and functioning properly.
3. Fully charge all batteries and electronic equipment. DO NOT assume that batteries are fully charged even if new.
4. Ensure all equipment is decontaminated with bleach (see NEON Aquatic Decontamination Protocol RD[07]).
5. Print out 12 Physical Habitat Characterization Datasheets.
6. Prepare a *Lake Outline Sketch* or *Non-Wadeable Streams Outline Sketch* for the scheduled site.
   a. Open the *Lake Outline Sketch* or *Non-Wadeable Streams Outline Sketch* from the NEON document repository (RD[08] or RD[09]).
   b. Enter the selected locations and GPS positions, identified in Google Earth, on the *Lake Outline Sketch* or *Non-Wadeable Streams Outline Sketch* (Figure 5).
   c. Save and print this sketch. This will become the field document. (see example Appendix F)

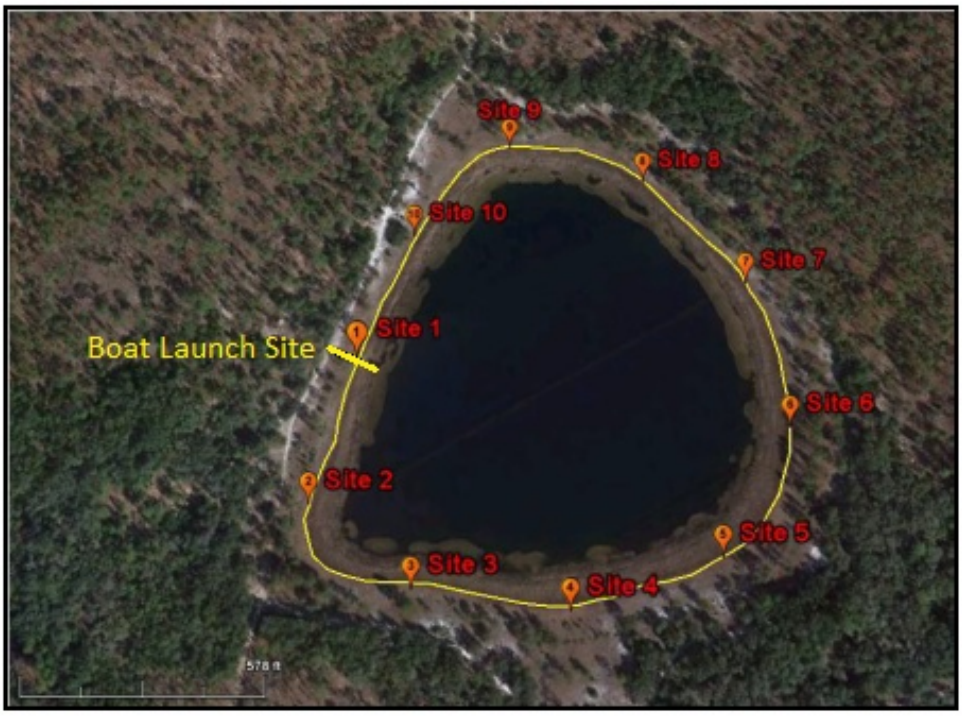

Figure 5. Example of Google Earth image with selected equidistant sample locations.

7. Familiarize yourself with the most common species of plants in your domain/sites.

a. Resources available include provided reference guides and the USDA NRCS online guide 'Plants Database' found at http://plants.usda.gov/java/
   1) "**See list of the plants in my state**" under the '*I want to…*' tab
   2) "**Learn about all the endangered plants of the U.S**." under the '*I want to*…' tab

8. Familiarize yourself with the clinometers. Refer to the Forestry-Suppliers Technical Bulletin M0003 Appendix H(http://www.forestry-suppliers.com/t01_pages/pdfs/M0003.pdf).

SOP B Field Sampling

B.1 Riparian Vegetation Mapping

1. Starting at the nearest boat access point, proceed by boat around the lake or non-wadeable stream near the shore, observing bank, shoreline, emergent, and subsurface characteristics.
   a. Record observations on the site-specific *Lake Outline Sketch/Non-Wadeable Streams Outline Sketch*. The focus of the riparian vegetation mapping is to record observations of riparian habitat; do not record littoral vegetation observations.
2. Once back at the boat access point locate and proceed to the first sampling location.
3. Position the boat at a distance of 10 m (~30 ft., offshore), anchor if necessary. Drop the float overboard in the spot where sampling is occurring. Use this as a mid-point marker for the 20 m horizontal distance for measuring the littoral areas and the perpendicular point from the shoreline, from where to delineate the littoral and riparian habitats (Figure 6 and Figure 7).
4. Estimates of riparian vegetation cover structure and composition include observations at three levels: the canopy layer (> 5 m high), understory (0.5 – 5.0 m high), and the ground cover layer (< 0.5 m high). Additionally, observations of human land use activities and disturbances shall be recorded.
   a. For each of the upper two vegetation layers, record the type of woody vegetation that occur within the canopy and understory be indicating the presence of Deciduous (D), Coniferous (C), Broadleaf Evergreen (E), Mixed (M), or None (N). A mixed vegetation layer is considered mixed if the more than 10% of the areal coverage is composed of an alternate vegetation type. Record the semi-quantitative (observational) measurements on the *Physical Habitat Characterization Datasheet*, for each of the three vegetation layers and human influences.
   b. Layers of Riparian Vegetation:
      1) **Canopy** **>5 m height**
         a) Big Trees >0.3m DBH
         b) Small Trees < 0.3m DBH
      2) **Understory** **0.5 to 5 m height**
         a) Woody shrubs and saplings
         b) Tall herbs, grasses and forbs
      3) **Ground Shrubs** **<0.5 m height**
         a) Woody shrubs
         b) Herbs, grasses and forbs
         c) Standing water and inundated vegetation
         d) Barren, duff, paved or built
      4) **Human**
         a) Buildings, roads, ramps, lawns, agricultural, industrial, cleared lot, pavement, and trash.
   c. Categorization of Cover:
      1) Absent = 0%

2) Sparse > 0 - < 10 %
3) Moderate > 10 - < 40 %
4) Heavy > 40 - < 75 %
5) Very Heavy > 75 %

d. Complete a separate *Physical Habitat Characterization Datasheet* for <u>each</u> station.

5. Record other observations made regarding areas that are *adjacent* to the 20 m stretch being sampled. This is particularly important where human disturbance is evident (i.e. house, road, boat ramp, lawn, power lines, garbage etc.). The adjacent sections should be each approximately 15 m wide (Figure 7).
   a. Make every reasonable attempt to record physical habitat observations and measurements for all 5 stations if sampling a non-wadeable stream or 10 stations if sampling a lake. Where this is impossible, flag the data in the field on the *Physical Habitat Characterization Datasheets*) to clearly indicate that no observations could be made for that feature at that particular station. (EPA 2007; Field Operations Manual).

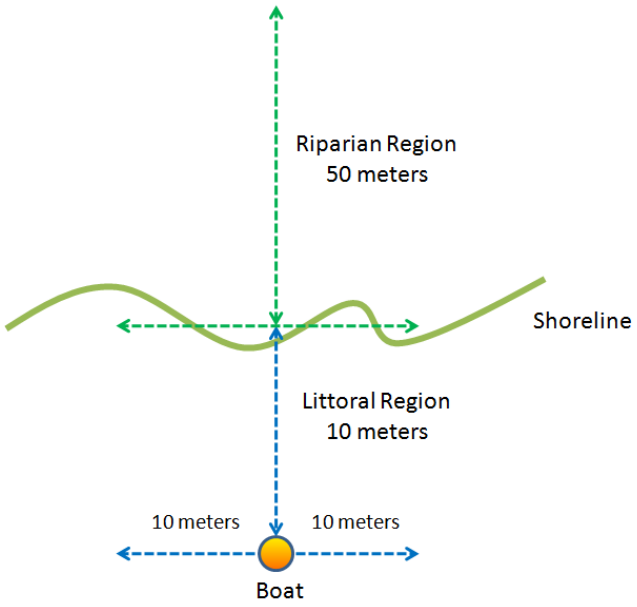

Figure 6. Positioning of boat/buoy for sampling at each location. The distance to the shoreline and the approximate location size of the riparian zone are also shown.

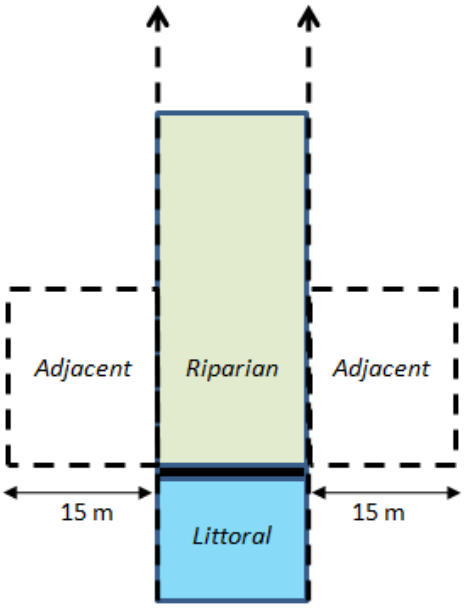

Figure 7. Location of adjacent areas around riparian mapping zone.

6. If unsure of or unable to determine the plant canopy cover type, take a photo of the site and specimen and note this in your field books.

B.2 Riparian Bank Characteristics

1. Using the clinometer and the meter stick, determine and record the (approximate) *Shoreline Bank Angle* in Part C 1st box of the *Physical Habitat Characterization Datasheet*.
   Lay the meter ruler against the bank with one end towards the water. Half of the meter stick (0.5 m) should be resting on the bank to determine the angle. Place the clinometer on the meter stick; read and record the bank angle in degrees. There may be a variety of angles. If two predominate, tick both and estimate which one is dominant. If a boulder or log is present along the bank being measured, record a bank angle from an adjacent and representative slope.
   a. Vertical >75° vertical understory
   b. Steep 30 – 75°
   c. Gradual <30°

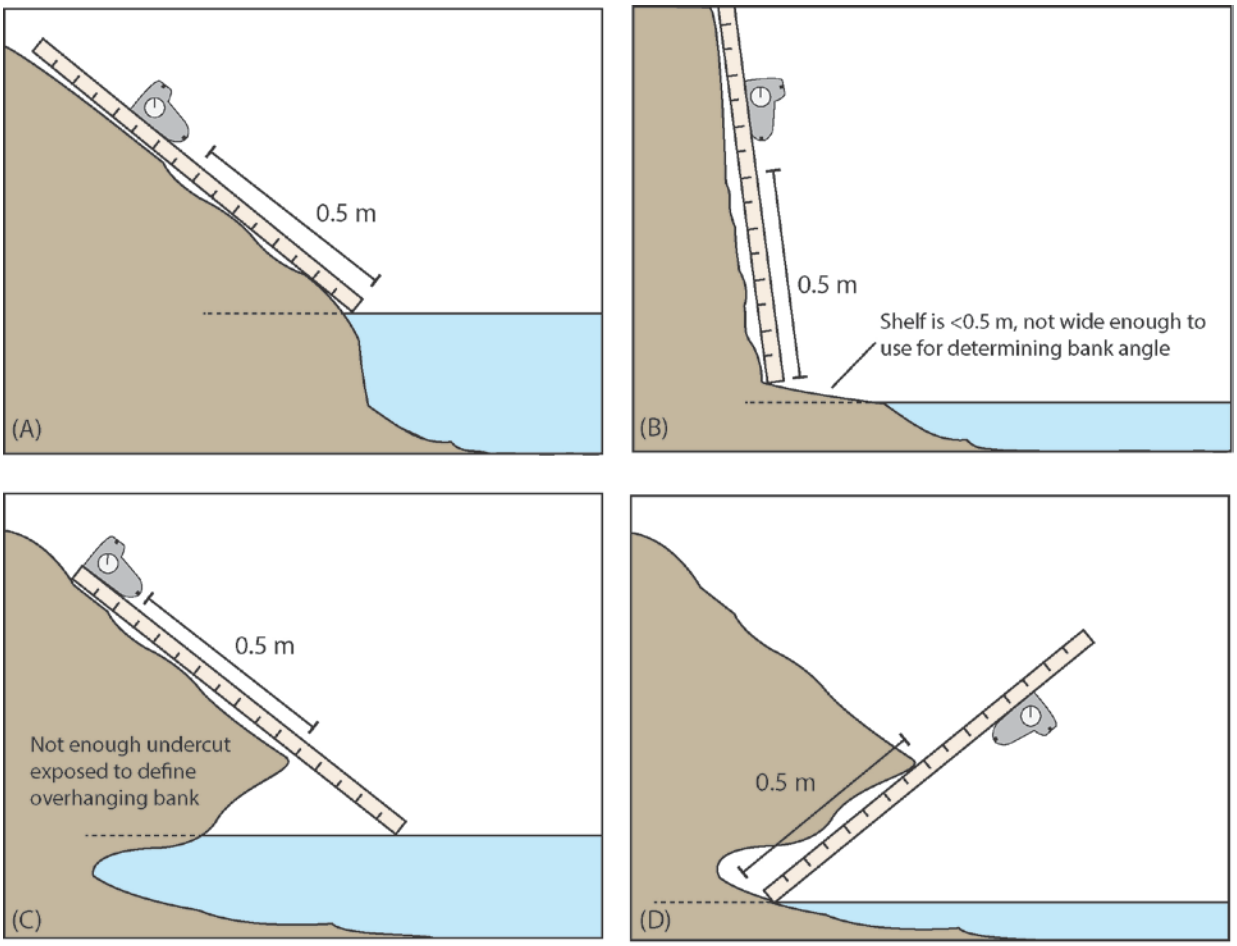

Figure 8. Determining shoreline bank angle for different bank types using a meter stick and clinometer. (A) Typical shoreline, (B) incised channel, (C) undercut stream bank, and (D) overhanging stream bank.

2. Determine the *Bank Revetment* (artificial bank reinforcement structures) through observations and record in Part C 2nd box of the *Physical Habitat Characterization Datasheet*.
   a. Rip-rap – Blanket of rock covering the bank, usually large angular boulders
   b. Hard Bank – Walls of large rocks, concrete blocks or rectangular gabion wire baskets
   c. Other – Tree or other vanes intended to stop erosion
   d. None
3. Determine the *Bank Texture* through observations and record in Part C 3rd box of the *Physical Habitat Characterization Datasheet*.
   a. Bedrock – very resistant to erosion
   b. Boulder/Cobble – boulders >10”/cobbles 2.5 to 10”. Moderate resistance to erosion
   c. Gravel – 0.08-2.5 “. Moderate to high erodibility when dominant component.
   d. Sand – 0.004 – 0.08”. High bank erodibility when dominant component
   e. Silt – 0.00008 – 0.004 “. Non-cohesive with high to very high erodibility
   f. Clay – < 0.00008”. Cohesive clays are relatively resistant to erosion
   g. Mix – Variety of particle sizes. i.e. glacial till

4. Estimate and record the vertical distance between present water level and the high water level (Figure 9). Also, record the water level on the permanent staff gage and record this in Part C 4th box of the *Physical Habitat Characterization Datasheet.* The current level may be the same as the high water level. If sampling during extreme low water conditions (i.e., drought) record the lower bank water level relative to the staff gage if visible. To facilitate the identification of fluctuating water levels, look for shoreline marks (debris line on shore) or markings on trees close to the apparent shoreline (Figure 9).
5. Take photos at all locations and record the photo numbers on the *Physical Habitat Characterization Datasheet*.

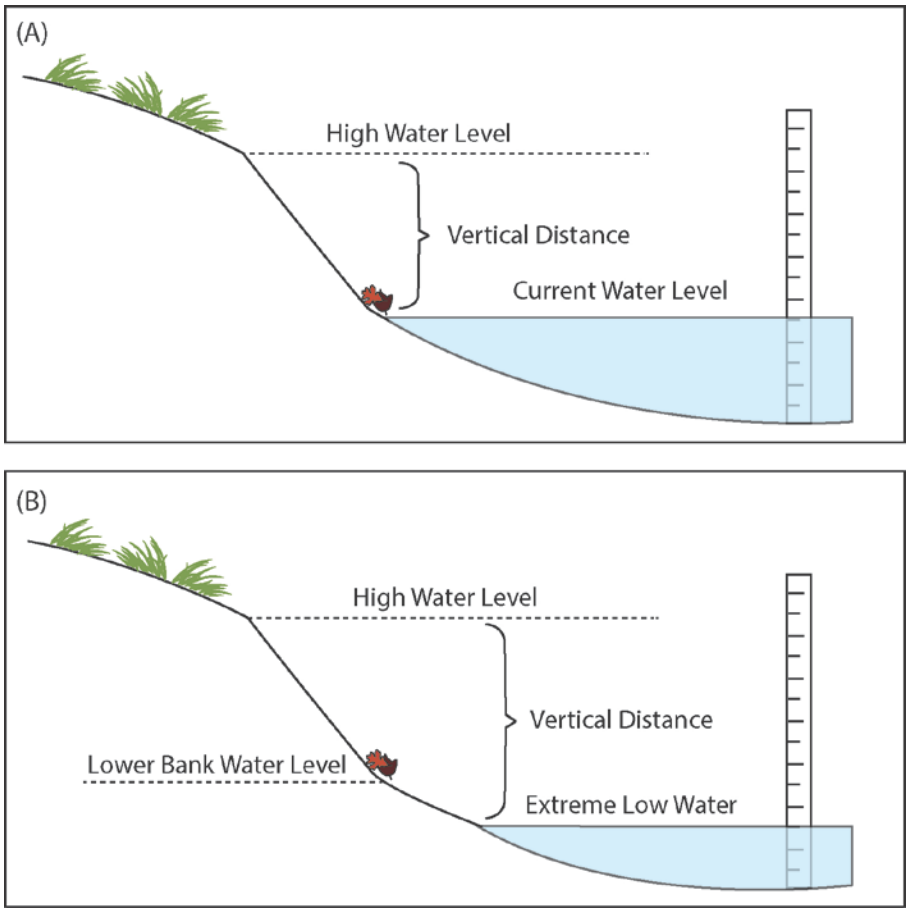

Figure 9. Illustration of measuring (A) the current and high water level marks in relation to the staff gage and (B) measuring the current water level during low water period. Note that the current level may be at the high water level mark.

B.3 Ending the Sampling Day

1. Equipment maintenance, cleaning and storage
   a. Recharge all batteries.
   b. Ensure all equipment is properly decontaminated and dry prior to storage.

SOP C Data Entry and Verification

As a best practice, field data collected on paper datasheets should be digitally transcribed within 7 days of collection or the end of a sampling bout (where applicable). However, given logistical constraints, the maximum timeline for entering data is within 14 days of collection or the end of a sampling bout (where applicable). See RD[04] for complete instructions regarding manual data transcription.

Transcribe all manually recorded data into an excel file name "*yyyymmdd_lakename_Riparian*".

SOP D Sample Shipment

There is no sample shipment for this protocol.

8 REFERENCES

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Appendix A DATASHEETS

The following datasheets are associated with this protocol:

Table 4. Datasheets associated with this protocol

NEON Doc. #	Title
NEON.DOC.001646	General AQU Field Metadata Sheet
NEON.DOC.002494	Datasheets for AOS Sample Shipping Inventory
NEON.DOC.002764	Datasheets for Riparian Mapping in Lakes and Non-Wadeable Streams

These datasheets can be found in Agile or the NEON Document Warehouse.

Appendix B QUICK REFERENCES

B.1 Steps for Riparian Mapping

Step 1 – Check the riparian mapping kit to make sure all supplies are packed.

1. Print out 12 Physical Habitat Characterization Datasheets.
2. Prepare a *Lake Outline Sketch* or *Non-Wadeable Streams Outline Sketch* for the scheduled site.

Step 2 – Ensure the General AQU Field Metadata Sheet (RD[05]) is completed per field site visit.

Step 3 – Starting at the nearest boat access point, proceed by boat around the lake or non-wadeable stream near the shore, observing bank, shoreline, emergent, and subsurface characteristics.

Step 4 – After returning to the boat access point, navigate to the first sampling location.

Step 5 – Riparian Vegetation Mapping:

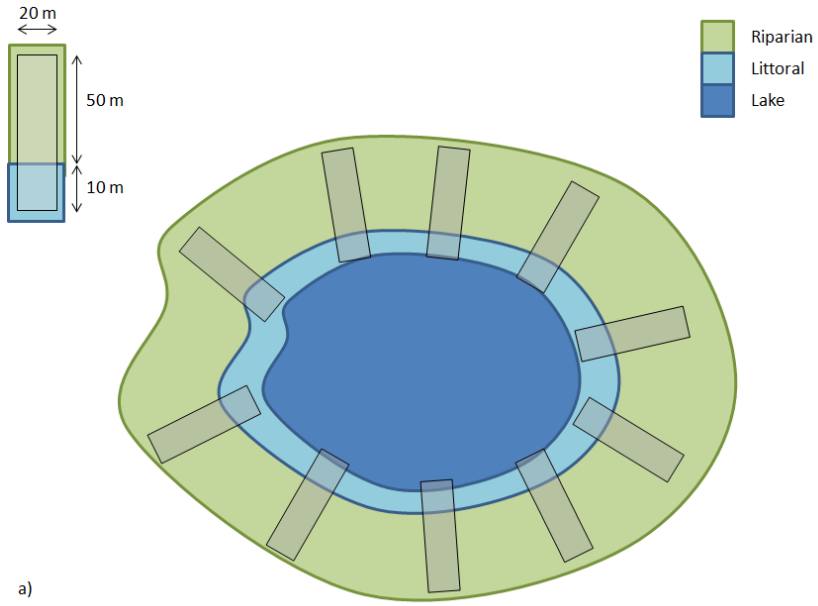
1. Use the clinometer to record the semi-quantitative (observational) measurements
   a. Layers of Riparian Vegetation
   b. Categorization of Cover

Step 6 – Riparian Bank Characteristics:

1. Shoreline Bank Angle
2. Bank Revetment
3. Bank Texture
4. Estimate and record the vertical distance between present water level and the high water mark
5. Take photos at all locations

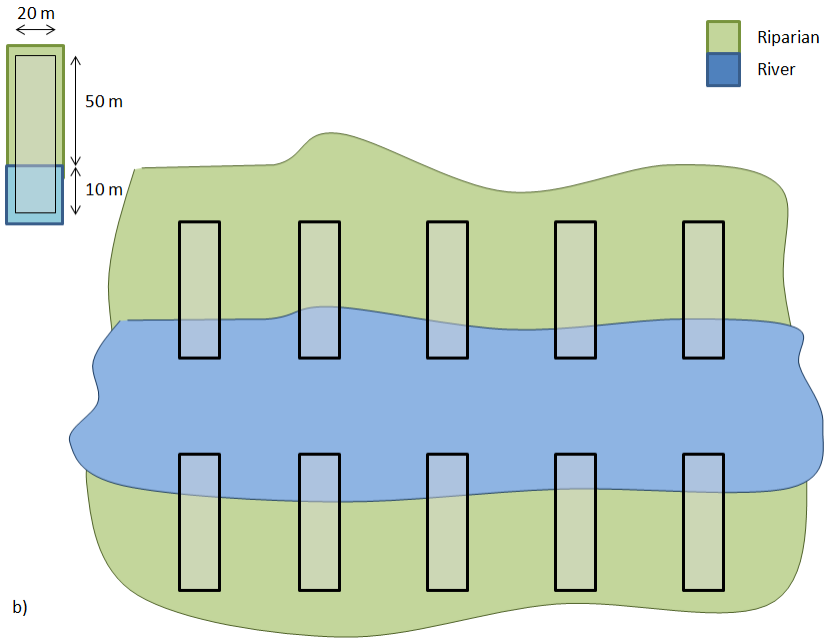
B.2 Locations for Riparian Mapping

1. Lakes



a)

2. Non-Wadeable Streams



b)

Appendix C REMINDERS

Before heading into the field: Make sure you…

- ☑ Collect and prepare all equipment and ensure batteries are full.
- ☑ Pre-print *Physical Habitat Characterization Datasheets* and Lake Outline Sketch or Non-Wadeable Streams Outline Sketch.
- ☑ Familiarize yourself with the most common species of plants in your domain/sites.

Sample collection: Be sure to…

- ☑ Position the boat at a distance of 10 m (~30 ft., offshore), anchor if necessary.
- ☑ Drop the float overboard in the spot where sampling is occurring. Use this as a mid-point marker for the 20 m horizontal distance for measuring the littoral areas and the perpendicular point from the shoreline, from where to delineate the littoral and riparian habitats.
- ☑ Complete a separate *Physical Habitat Characterization Datasheet* for <u>each</u> station.
- ☑ If unsure of or unable to determine the plant canopy cover type, take a photo of the site and specimen and note this in your field books.

Ending the day: Be sure to…

- ☑ Recharge all batteries.
- ☑ Ensure all equipment is properly decontaminated and dry prior to storage.

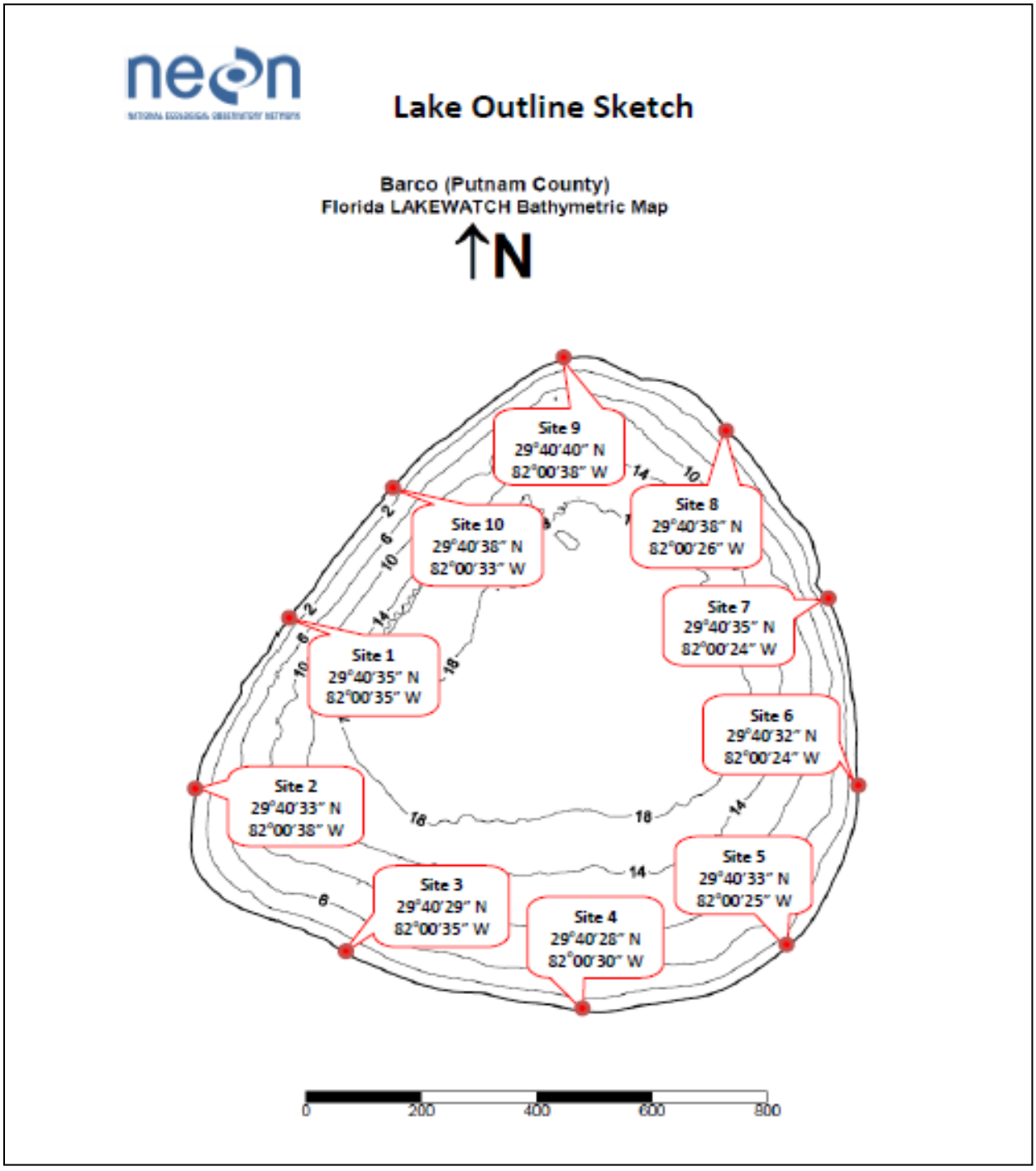
Appendix D ESTIMATED DATES FOR ONSET AND CESSATION OF SAMPLING

See the Site Specific Sampling Strategy Document on AQU's NEON intranet site.

Appendix E SITE-SPECIFIC INFORMATION

See the Site Specific Sampling Strategy Document on AQU's NEON intranet site.

Appendix F EXAMPLE OF LAKE OUTLINE SKETCH DATASHEET



Appendix G RIPARIAN CLASSIFICATION SYSTEM

Hierarchical Determination for Dominant System

This classification follows the USFWS (2009) "A system for mapping riparian areas in the western United States" and incorporates the plant identification system developed by the USDA PLANTS Database (2015).

1) **System** A single unit category - riparian vegetation (**Rp**)
2) **Subsystem** Defines two categories reflecting the water source for the riparian area
   a) lotic – stream (moving water)
   b) lentic – lake (standing water)
3) **Class** Describes the dominant non-hydrophytic life form of riparian vegetation.
   a) (**FO**) forested - woody vegetation usually >6 m in height
   b) (**SS**) scrub/shrub - woody vegetation usually < 6 m in height
   c) (**EM**) emergent - erect, rooted vegetation with herbaceous stems
4) **Subclass** Further describes the Class as either:
   a) deciduous – losing leaves seasonally
   b) evergreen – retaining leaves through all seasons
   c) mixed deciduous/evergreen
5) **Dominance Type** Refers to vegetative species within the mapping unit. The description for the dominant species type will follow the USDA PLANTS Database (2015; (http://plants.usda.gov) plant symbology, e.g.:
   a) (**PODE3**) *Populus deltoids* W. Eastern cottonwood
   b) (**ALRU2**) *Alnus rubra* Bong. Red alder

For instance, **Rp1FO6PODE3** is interpreted as (Table 5):

Table 5. Example of notation for hierarchical determination for dominant system.

System	**Rp**	Riparian
Subsystem	**1**	Lotic
Class	**FO**	Forested
Subclass	**6**	Deciduous
Dominance Type	**PODE3**	Eastern cottonwood
*For Mixed Dominance Types add second USDA plant ID	**ALRU2**	Red alder

Refer to for the determination of the dominant vegetation system.

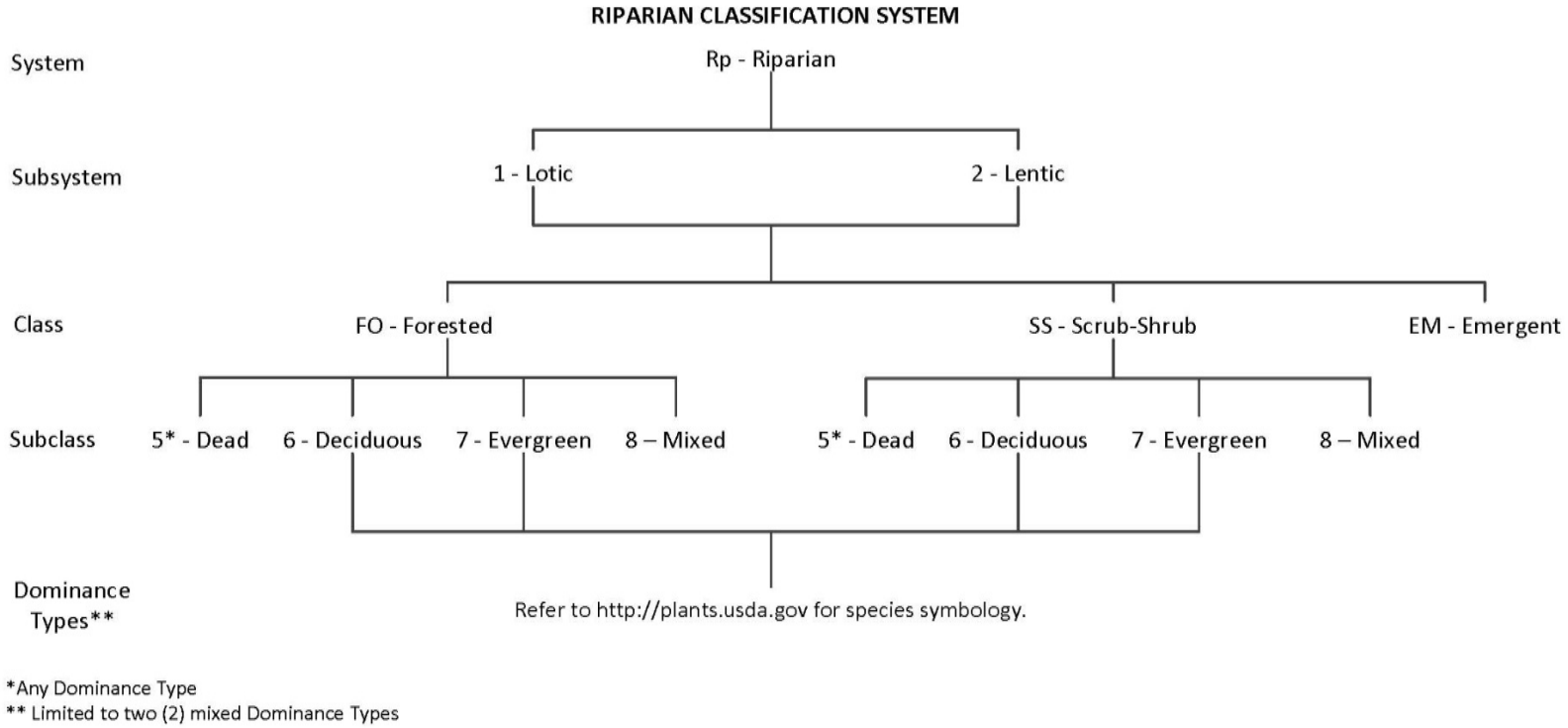


Figure 10. Example of riparian classification system from USFWS (2009) Hierarchical Riparian Mapping and Classification System with the USDA PLANTS Database (2015).

Classification of Riparian Vegetation

1) Layers of Riparian Vegetation:
   a) **Canopy** **>5 m height**
      i) Big Trees >0.3m DBH
      ii) Small Trees < 0.3m DBH
   b) **Understory** **0.5 to 5 m height**
      i) Woody shrubs and saplings
      ii) Tall herbs, grasses and forbs
   c) **Ground Shrubs** **<0.5 m height**
      i) Woody shrubs
      ii) Herbs, grasses and forbs
      iii) Standing water and inundated vegetation
      iv) Barren, duff, paved or built
   d) **Human**
      i) Buildings, roads, ramps, lawns, agricultural, industrial etc.
2) Categorization of Cover:
   a) Absent = 0%
   b) Sparse > 0 - < 10 %
   c) Moderate > 10 - < 40 %
   d) Heavy > 40 - < 75 %
   e) Very Heavy > 75 %

Bank Features

1) Bank angle
   a) Steep >75^{o} vertical understory
   b) Moderate 30 – 75^{o}
   c) Shallow <30^{o}
2) Bank Revetment
   a) Rip-rap – Blanket of rock covering the bank, usually large angular boulders
   b) Hard Bank – Walls of large rocks, concrete blocks or rectangular gabion wire baskets
   c) Other – Tree or other vanes intended to stop erosion
   d) None
3) Bank Texture
   a) Bedrock – very resistant to erosion
   b) Boulder/Coble – boulders >10”/cobbles 2.5 to 10”. Moderate resistance to erosion
   c) Gravel – 0.08-2.5 “. Moderate to high erodibility when dominant component.
   d) Sand – 0.004 – 0.08”. High bank erodibility when dominant component
   e) Silt – 0.00008 – 0.004 “. Non-cohesive with high to very high erodibility
   f) Clay – < 0.00008”. Cohesive clays are relatively resistant to erosion
   g) Mix – Variety of particle sizes. i.e. glacial till

4) Water Level Fluctuations
    a) High mark
    b) Low mark

Appendix H REFERENCE DOCUMENTATION FOR CALIBRATION

Rangefinder: Bushnell G Force DX1300 http://www.bushnell.com/getmedia/f60765d9-7efb-43b3-af01-bfe30112273c/202460_202461_GForceDX1300_6LIM_111313_web.pdf?ext=.pdf

Clinometer: Forestry-Suppliers Technical Bulletin M0003 http://www.forestry-suppliers.com/t01_pages/pdfs/M0003.pdf