AOS PROTOCOL AND PROCEDURE:
RIP - Riparian Habitat Assessment

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See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	09/15/2016	ECO-03994	Initial release, merging streams and lakes Riparian Habitat Assessment P&Ps (NEON.DOC.001195 and NEON.DOC.001196).
B	04/10/2017	ECO-04424	CM updated with new template and changes based on feedback from FOPS. Changes reflect improved estimation techniques for more rapid riparian observations Included improved descriptions of observations perspective.
C	02/09/2018	ECO-05457	Updated equipment list. Required the use of GPS with decimeter accuracy (Trimble) for navigating to transect locations. Removed monopod. Revised densiometer reading technique. Clarified the observation areal extent for Part A and Part B. Big tree, small tree that forks or have multiple branches DBH clarification. Recommend developing site-specific training materials for common riparian and upland plant species identification. Bank angle and undercut documentation revised. Mixed Vegetation Type definition emphasized. Added rule for distinguishing between Vegetation Composition densities. Included storage instructions for digital photographs. Emphasized that only one field ecologist shall provide the observations. Updated equipment list.
D	09/25/2018	ECO-05970	Definitions have been updated. Methods section include a statement that the data provided through this protocol should be applied to detect change at the reach-scale not at the transect-level. Removed references to JIRA. Updated plot figures. Provided a new figure of an example riparian photo; also included photo file saving structure and naming convention recommendations. Clarified Part A instructions in Appendix E for recording dominant and sub-dominant species. Updated the field datasheets Part A to clarify when to record dominant and sub-dominant species. Updated all occurrences of field operations technician to field ecologist. Clarified the description of transects and plots. Added sampling impractical and reach condition fields.
E	06/02/2020	ECO-06245	Modify transect size to be consistent with EPA NRSA, 10 x 10m at streams, 10 x 15m at rivers, and 10 x 15m

			above the high-water line at lakes. Added collection of densiometer readings at river sites. Require a field ecologist with the ability and the skill set to identify dominant riparian species at the site in question. Assist with identifying riparian dominant and subdominant species. Defining dominant species as aerial coverage dominance.

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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 hydrologic 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 (U.S. Fish and Wildlife Service, 1997 & 2009). These areas are characterized by vegetation comprising trees, shrubs, wildflowers, grasses, and other plants, but 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 diverse biological communities are formed as a result of frequent disturbances related to, for example, water movement and fluctuation, ice abrasion and sediment transport (Verry et al., 2000). As a continental scale Observatory with sites in 20 different eco-climatic regions, NEON sites represent a broad range of riparian communities (**Figure 2**).

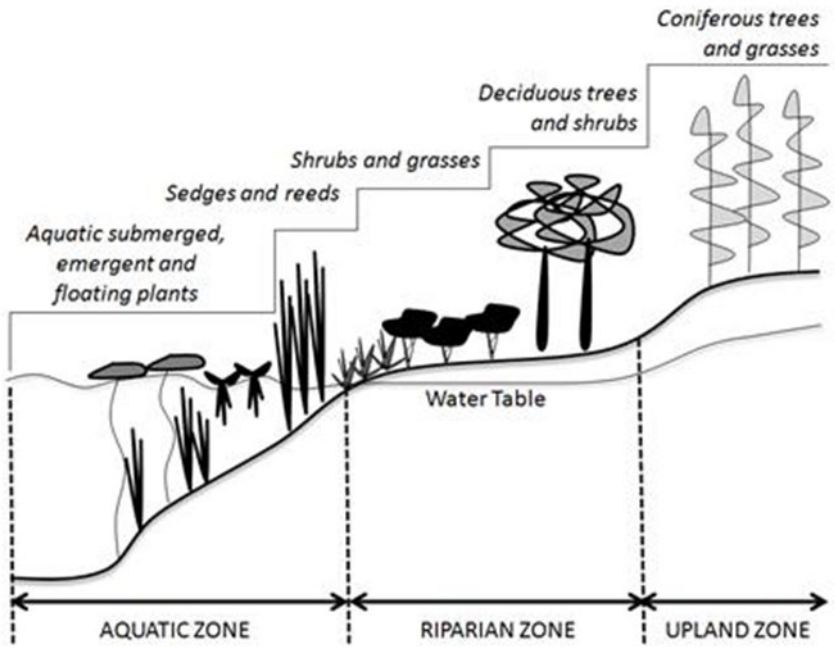

Figure 1. The riparian zone represents the land closest to the shoreline.

Figure 2. Examples of riparian habitats in different eco-climatic regions. a) NEON Domain 10: Central Plains; b) NEON Domain 18: Tundra; c) NEON Domain 11: Southern Plains; and d) NEON Domain 13: Southern Rockies

Riparian habitat provides an important buffer between the aquatic and terrestrial ecosystems. Fluctuations in water level result in the establishment and presence of vegetation able to withstand both wet and dry conditions. Riparian areas play a critical role in water quality by filtering or absorbing contaminants from the upland landscape. Riparian vegetation provides shade in shorelines that keep water temperatures low, serves as a carbon source to streams via litterfall, creates soil stability and sediment control, and supports wildlife habitat and food for fish and other aquatic organisms. These areas also provide nearshore habitat structural elements, such as snags or large woody debris (LWD), that create ideal conditions for shelter for many land and aquatic organisms and are a sink for sediment. 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).

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, 1997)

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.001155	NEON Training Plan
AD[05]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[06]	NEON.DOC.004104	NEON Science Data Quality 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.002652	NEON Level 1, Level 2, and Level 3 Data Products Catalog
RD[04]	NEON.DOC.001271	AOS/TOS Protocol and Procedure: Data Management
RD[05]	NEON.DOC.001646	General AQU Field Metadata Sheet
RD[06]	NEON.DOC.003282	NEON Site Management and Disturbance Data Collection
RD[07]	NEON.DOC.001154	AOS Protocol and Procedure: Aquatic Decontamination
RD[08]	NEON.DOC.003162	AOS Protocol and Procedure: Wadeable Stream Morphology
RD[09]	NEON.DOC.001197	AOS Protocol and Procedure: Bathymetry and Morphology of Lakes and Non-Wadeable Streams

RD[10]	NEON.DOC.003156	Datasheets for AOS Protocol and Procedure: Riparian Habitat Assessment in Wadeable Streams
RD[11]	NEON.DOC.002764	Datasheets for AOS Protocol and Procedure: Riparian Habitat Assessment in Lakes and Non-Wadeable Streams
RD[12]	NEON.DOC.002186	AOP Determination of Peak Greenness Plan

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
LWD	Large Woody Debris
MODIS	Moderate Resolution Imaging Spectroradiometer
OHWM	Ordinary High-Water Mark
SOP	Standard Operating Procedure
USDA NRCS	United States Department of Agriculture Natural Resource Conservation Service

2.4 Definitions

Aerial Coverage: "The proportion of each species at the uppermost surface of the vegetation (e.g. the aerial view)" (Fehmi 2010).

Bankfull: The primary channel that when filled, just begins to flow on to the floodplain.

Canopy: The forest overstory that consists or leaves, branches, and stems that cover the riparian zone when viewed from above.

Dominant species: The principal vegetative species most prevalent in the area. Considered >30 % of the vegetative composition, as determined by aerial coverage.

Sub-dominant Species: At plots with more than one dominant species (>30% aerial cover), the other species that meet the criteria. Plots can have no more than 3 species that meet the criteria.

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

Forbs: An annual, biennial, or perennial vascular flowering plant without woody tissue above or at the ground level.

Gabion wire basket: A wire basket or cage filled with rocks used to stabilize stream and riverbanks to prevent erosion.

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

Hydrophytes: Plants that have adapted to live completely or partly submerged in water including wetlands and aquatic systems or wet habitats.

Mid-point: The middle point along wadeable stream riparian transects, where center densiometer readings are collected. This point is calculated by dividing the wetted width by two.

Ordinary High-Water Mark The line along the lakeshore established by the highest water level maintained for a long enough time period to leave evidence on the shore; lake banks, beachline, exposed boulder lines, water stains (Scherek and Yakel 1993).

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

Peak Greenness: The site-specific period of phenology marking the start of the plant growing season, from spring "green-up" to end of the season plant senescence.

Revetment: Structures built to preserve the existing uses of the shoreline, to protect the slope, and act as defense against erosion. These include rocks, concrete, trees, and in-stream structures such as vanes or J hooks to modify streamflow.

Rip-rap: Rock, boulders, concrete, or other hard substrate used to armor the shorelines of streams, lakes, and rivers to prevent erosion.

Scrub/Shrub: Woody vegetation <5m in height.

Thalweg: The line that connects the deepest part of the active channel.

3 METHOD

This protocol provides methods for conducting a site-level rapid estimate of riparian shading, riparian vegetation structure and composition, human impacts, and bank characteristics of the areas that buffer the permitted banks of NEON wadeable stream, river, and lake sites. The objective of the protocol is to provide data to detect and quantify trends in riparian habitat at the reach scale (as opposed to the transect/plot-scale). If a site has not established riparian transects and plots, contact NEON Aquatic Science for guidance on how to re/establish riparian sample locations.

Riparian habitat sampling can be conducted by a team of two. Field data collection consists of the following components at each site:

1. Wadeable stream sites:
    a. Measurements are collected on foot.
    b. Ten permanent transects are established throughout the monitoring reach that extend across the channel.
        1) At each transect, measure and record:

1) Wetted width and thalweg depth.
2) Canopy cover at the center of the stream and on the right and left banks.
3) Bank angle, revetment, and texture.

c. Twenty permanently- paired 10 x 10m riparian vegetation plots are located throughout the monitoring reach.
   1) Ten plots each are located on each side of the channel.
   2) Plots begin at the top of the bank where the transect defines the middle of the plot width (5m upstream and 5m downstream).
   3) At each plot, measure and record:
      1) Physical habitat
      2) Vegetation structure
      3) Dominant species
      4) Riparian composition
      5) Human activities

d. At each transect collect a photo that depicts the riparian habitat along each bank.

2. River sites:
   a. Measurements are collected from a boat.
   b. Ten permanently–paired 10 x 15m riparian vegetation plots are located throughout the monitoring reach.
      1) Five plots are located on each side of the channel.
      2) Plots begin at the top of the bank.
      3) At five of the ten paired plots (one plot of each pair that is located closest to the thalweg), measure and record:
         1) Canopy cover at 0.3m into the river from the edge of water.
      4) At all ten plots, measure and record:
         1) Physical habitat
         2) Vegetation structure
         3) Riparian composition
         4) Human activities
         5) Bank angle, revetment, and texture

c. At each plot collect a photo that depicts the riparian habitat along the bank.

3. Lake sites:

   a. Measurements are collected from a boat.

   b. Ten permanent 10 x 15m riparian plots are located at equidistant intervals around the lake.

      1) At each plot, determine the Ordinary High-Water Mark (OHWM) line, this serves as the near-water boundary of the riparian habitat plot.

      2) At each plot, measure and record:

         1) Physical habitat

         2) Vegetation structure

         3) Riparian composition

         4) Human activities

         5) Bank angle, revetment, and texture

   c. At each plot collect a photo that depicts the riparian habitat along the bank.

This document includes Standard Operating Procedures (SOPs) (**Section** 7) that provide detailed step-by-step directions, contingency plans, data collecting and recording tips, and best practices for implementing riparian habitat data collection procedures. To properly collect data, field ecologists **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 field ecologists document the problem and enter it in NEON's problem tracking system, in order to get feedback from science staff at headquarters.

The procedures described in this protocol will be audited according to the NEON Science Data Quality Plan (AD[06]).

3.1 Transect and Plot Distribution and Dimension

At wadeable stream and river sites, riparian transect locations were determined by NEON Science staff prior to site establishment. Transects were established at equidistant interval spacing and evenly distributed throughout the monitoring reach. Transects are delineated by a single permanent marker located on the bank at a known GPS location. Riparian plots do not contain permanent markers at wadeable stream sites, but the dimensions are based around each of the permanently established

transects. At lake sites (which do not contain transects), riparian plots are permanently established with plot markers.

Prior to sampling, submit an incident ticket to Science if:

1. Permanent transects are not established at a given wadeable stream or river site.
2. Permanent plots have not been established at a given lake site.
3. Transect or plot re-establishment is required due to natural or anthropogenic disturbance.

Transect and plot distributions and dimensions are as follows:

1. Wadeable streams sites:
    a. Wadeable stream sites contain ten transects (**Figure 3**).
        1) Transects are spaced equally throughout the monitoring reach.
        2) The first transect begins 50m upstream from the downstream reach boundary.
        3) Transect spacing is ~100m.
        4) The final transect is located 50m downstream from the upstream reach boundary.
    b. Wadeable stream sites contain twenty paired riparian plots **(Figure 4**).
        1) Each plot extends 5m upstream and 5m downstream of each transect and 10m into the uplands from the top of the bank.
            1) Each plot is 10m long and 10m wide.
        2) Each plot must be paired with another plot located on the opposite bank, directly across the stream

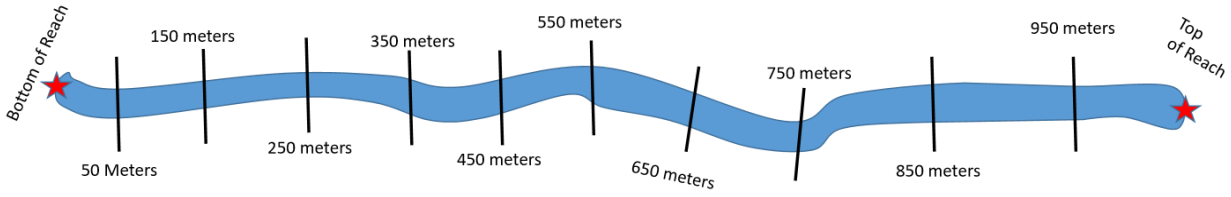

Figure 3. Conceptual diagram of sampling transect distribution at wadeable stream sites.

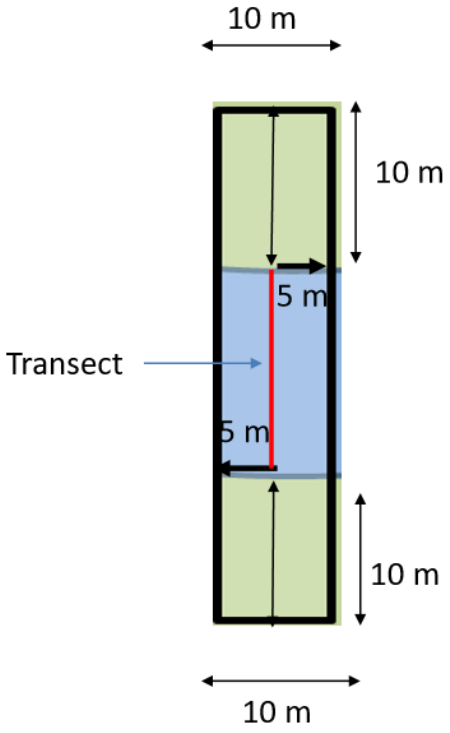

Figure 4. Conceptual diagram of paired riparian plot dimensions at wadeable stream sites.

2. River sites:

   a. River sites contain ten riparian vegetation plots (**Figure 5**).

      1) Plots are spaced equally throughout the monitoring reach.

      2) Each plot is 10m wide and runs 15m long into the uplands.

      3) Each plot must be paired with another plot located on the opposite bank, directly across the river.

   b. Each riparian plot begins at the edge of water and extends 15 m inland.

      1) The exact delineation of each riparian plot varies based on river stage.

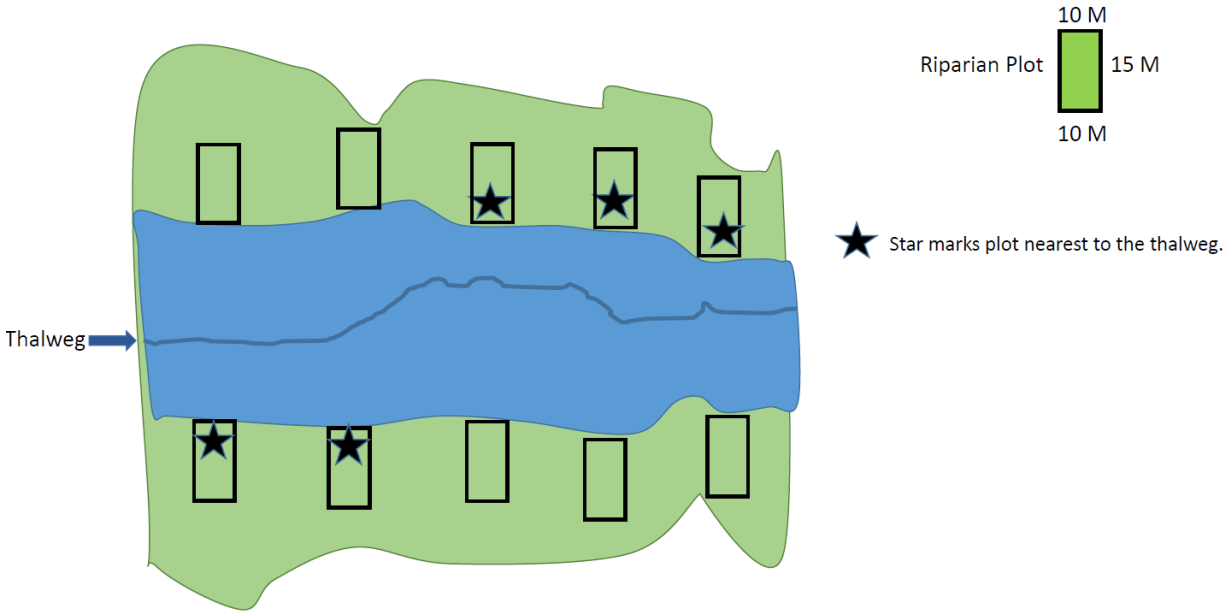

Figure 5. Conceptual diagram of riparian plots at river sites. The thin blue line represents the river thalweg. Stars indicate the paired plot that is located closest to the thalweg - this is the paired plot where riparian vegetation canopy cover is measured.

3. Lake sites:

    a. Lake sites contain ten riparian vegetation plots (**Figure 6**).

        1) Plots are spaced equally around the lake, beginning at the Ordinary High Water Mark (OHWM).

        2) Each plot is 10m wide (from the OHWM)) and 15m long (into the uplands).

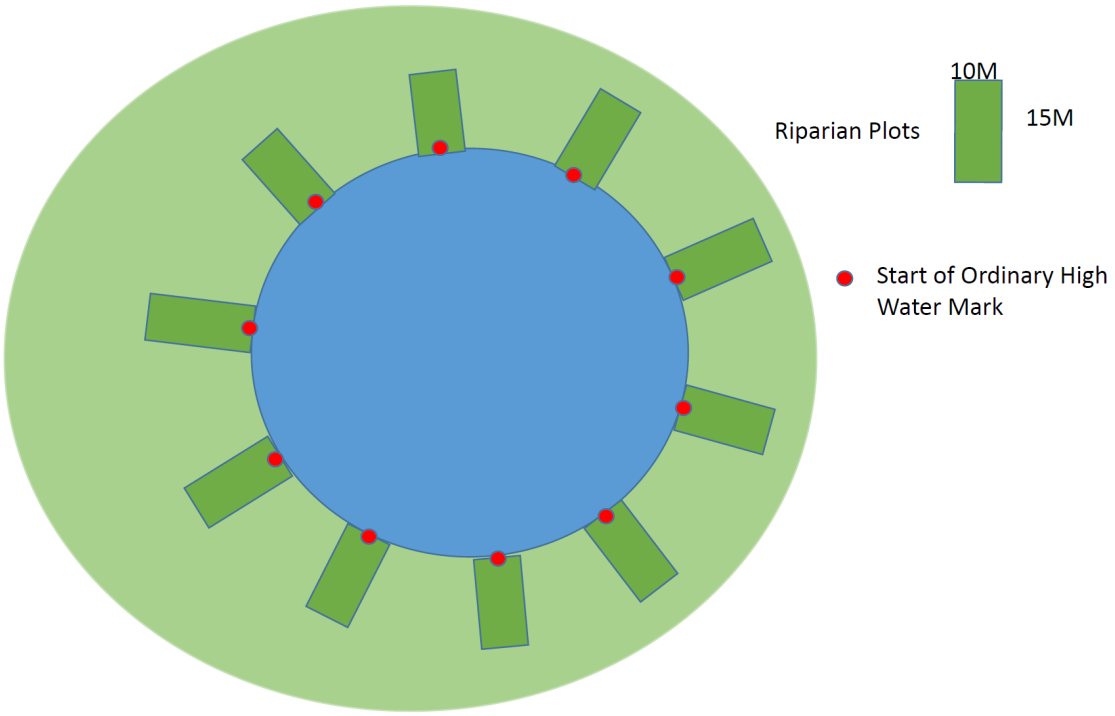

Figure 6. Conceptual diagram of riparian plots at lake sites. Plots boundaries begin at the ordinary high-water mark (red dot).

4 SAMPLING SCHEDULE

4.1 Sampling Frequency and Timing

The time window for performing the riparian habitat assessment was chosen to, when possible, match the window for AOP flights over NEON aquatic sites.

Riparian habitat sampling must occur during:

1. Safe sampling conditions (**Section 5**)
2. Peak greenness
    a. Conducting the protocol during the peak greenness window ensures repeatable interannual comparison of data and accurate measurements of riparian vegetation.
    b. Sampling is cancelled if the peak greenness widow is missed (**Table 2**).

Riparian habitat sampling shall occur once per year at every NEON aquatic site. Refer to Domain-specific Sampling Strategy documents for data collection timelines (**Appendix C**).

Table 1. Sampling frequency for Riparian Habitat Assessment procedures on a per-SOP/per-site basis.

SOP	Plot Type	Plot Number	Bout Duration	Bouts Per Year	Bout Interval	Yearly Interval	Remarks
SOP B	Wadeable stream, River, Lake	All	1 day	1X sampling per year	NA	Annual	Sampling occurs during peak greenness

4.2 Criteria for Determining Onset and Cessation of Sampling

At all sites, every effort must be made to carry out riparian sampling during the peak greenness window (**Appendix C**). AOP flights are scheduled to occur during periods of peak greenness to allow for a direct comparison of AOS sampling and AOP remote sensing data. Note that riparian habitat sampling is not dependent on whether or not an AOP flight is conducted over a given aquatic site during the peak greenness window.

4.3 Timing for Laboratory Processing and Analysis

There is no Domain lab processing component of the Riparian Habitat protocol, except when dominant plant species cannot be identified in the field and need to be identified in the lab. Dominant plant species lab identification must be carried out within two weeks of sample collection.

4.4 Sampling Timing Contingencies

Table 2. Contingency decisions for Riparian Habitat Sampling .

Delay/ Situation	Action	Outcome for Data Products
Sampling is delayed hours	If the sampling delay occurs **within** a single plot or transect, plot and/or transect needs to be redone in entirety.	No adverse outcome.
Sampling is delayed 1-14 days	If the sampling delay occurs **between** plots or transects, resume sampling ASAP.	No adverse outcome.
Sampling is delayed >14 days	If the sampling delay occurs **between** plots or transects, resume sampling ASAP.	Potentially reduced data quality
Sampling cannot be completed within peak greenness	If sample is interrupted and cannot be rescheduled within the peak greenness window, cancel sampling and create an incident ticket to Science.	Missed data for this sampling season.

4.5 Missed or Incomplete Sampling

Sampling according to the schedule is not always possible. Multiple factors may result in missed sampling during a given bout (**Figure 7**). For example:

- Logistics – e.g., insufficient staff or equipment
- Environment – e.g., deep snow, flooding, inclement weather, or
- External site management activities – e.g., controlled burns, pesticide application

Instances such as those listed above must be documented for scheduling, tracking long-term plot suitability, and informing end users of NEON data availability. Some types of missed sampling are due to events that should be recorded in the Site Management App. Refer to the Site Management and Event Reporting Protocol for more detail (RD[06]).

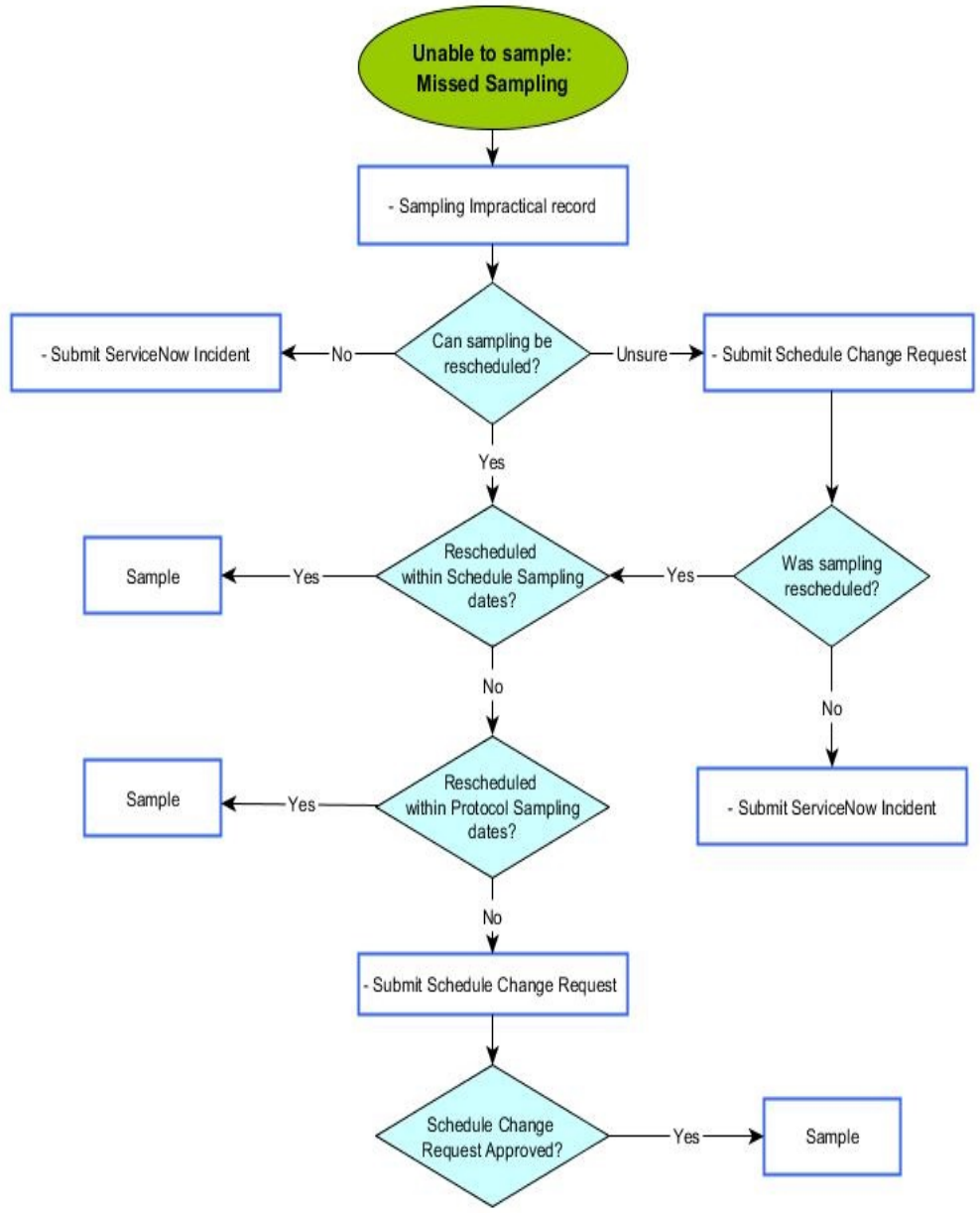

Figure 7. Flowchart that outlines Missed Sampling reporting procedures for the Riparian Habitat Assessment protocol.

Missed or Incomplete Sampling Terms

Terms that inform Missed or Incomplete Sampling include:

- **Protocol Sampling Dates**: Bout-specific sampling dates.
- **Scheduled Sampling Dates**: Bout-specific sampling dates scheduled by Field Science and approved by Science. These dates coincide with or are a subset of the Protocol Sampling Dates.

- **Missed Sampling**: Incidence of *scheduled sampling* that did not occur. Missed Sampling is recorded at the same resolution as data that are ordinarily recorded.
- **Sampling Impractical**: The field name associated with a controlled list of values that is included in the data product to explain a Missed Sampling event – i.e., why sampling did not occur.
- **Rescheduled**: Missed Sampling is rescheduled for another time within the *protocol sampling dates*, resulting in no change to the total number of sampling events per year.

The documentation that must accompany missed sampling depends on the timing, subsequent action, and the audience appropriate for numerous scenarios.

To Report Missed or Incomplete Sampling:

1. Missed or Incomplete Sampling must be communicated to Science by a Service Now Incident.
    a. For Missed Sampling that is rescheduled, there are some cases that require approval by Science and Operations.
    b. The lead Field Ecologist should consult the Delayed or Cancelled Activities table to best determine when reporting is required.
2. Create a Fulcrum record for each Missed Sampling event in the field. That is, if data are recorded in the field at the plot/transect level, a record must be made for each plot/transect missed.
3. For each Missed Sampling record, the **Sampling Impractical** field must be populated in the mobile collection device.

4.6 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. Use this estimate as framework for assessing progress. If a task is taking significantly longer than the estimated time, an incident ticket should be submitted. Please note that if sampling at particular locations requires significantly more time than expected, Science may propose to move these sampling locations.

Table 3. Estimated staff and labor hours required for implementation of the riparian habitat survey.

SOP	Estimated time	Suggested staff	Total person hours
SOP A.1: Preparing for Data Capture	1.5 hours	2	1.5 hours
SOP B: Field Data Collection – Measuring Canopy Cover and Characterizing Riparian Habitat at Wadeable Stream Sites	Navigate to transect (10 min); characterize riparian habitat at 20 plots (10 min/plot); collect six canopy cover measurements at ten plots (15min/transect)	2	7.5 hours
SOP B: Field Data Collection – Measuring Canopy Cover and Characterizing Riparian Habitat at River Sites	Navigate to ten plots (15 min/plot); characterize riparian habitat at ten plots (10 min/plot); collect four canopy cover measurements at five plots (10 min/plot)	2	6 hours
SOP B: Field Data Collection – Characterizing Riparian Habitat at Lake Sites	Navigate to ten plots (10 min/plot); characterize riparian habitat at ten plots (10 min/plot)	2	3.3 hours
SOP D: Data Entry and Verification	Species identification, QAQC data (1.5 hours/bout)	1	1.5 hours

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.

1. Activities in wadeable streams should only be performed when flow conditions are safe. Do not attempt to wade a stream where velocity x depth is ≥ 10 ft2 /s .
2. In lakes and rivers, site-specific hazards may be encountered that necessitate sampling from the boat, without dismounting from the vessel. In addition, use extra caution in waters where alligators are present and maintain a safe distance from hazards.
3. All personnel must be wearing a personal flotation device (PFD) prior to entering a boat.
4. All personnel shall have access to a form of communication with other team members such as a two-way radio. Be aware of any site-specific hazards and to the waters of that particular location (i.e. current status, tidal charts, water release from dams, etc.).

6 PERSONNEL

6.1 Training Requirements

All technicians must complete required safety training as defined in the NEON Training Plan (AD[04]). Additionally, technicians must complete protocol-specific training for safety and implementation of this protocol as required in Field Operations Job Instruction Training Plan (AD[05]).

It is mandatory that one technician has experience with the identification of plants, (preferably in the identification of plants found in riparian and wetland habitats found at the site where observations are made), be able to use a dichotomous key, and have experience identifying plant specimens in the lab with a dissecting microscope and associated tools. At each site this technician must be able to identify most of the dominant plants to the lowest taxonomic level. Reference **Appendix D** for examples on utilizing USDA PLANT Database codes.

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 stream riparian habitat assessment measurements and safe working practices for stream work, to include use of waders and PFDs, where applicable.

6.2 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.

7 STANDARD OPERATING PROCEDURES

SOP Overview

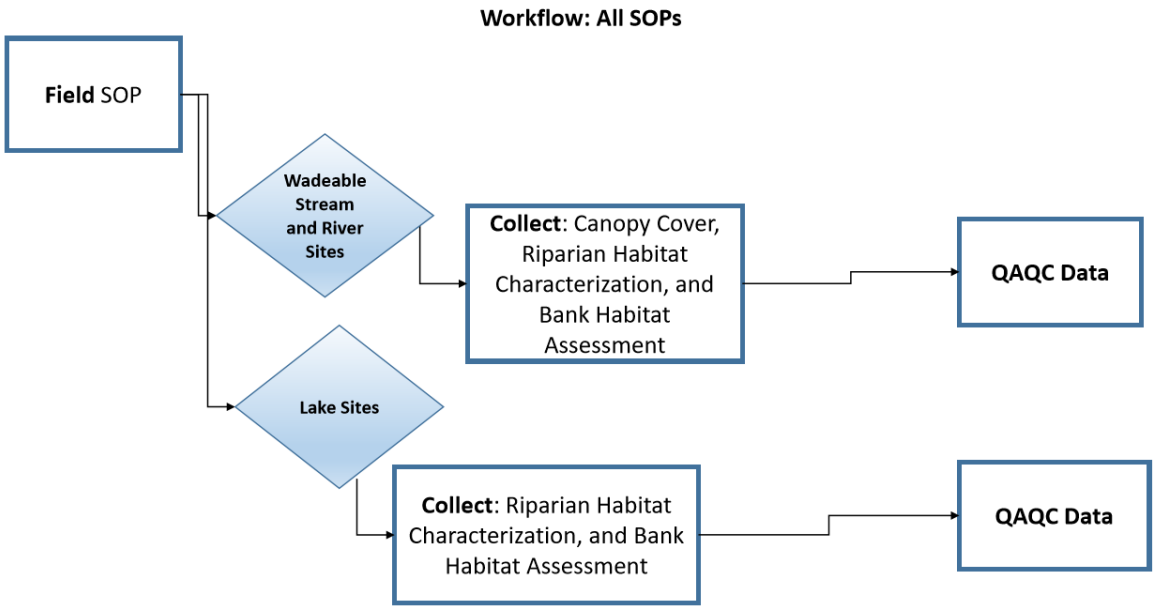

Figure 8. Riparian habitat workflow.

SOP A Preparing for Sampling

A.1 Preparing for Data Capture

Surveys are conducted as a team of two. If working in a team, only one field ecologist shall provide the field observations and the second field ecologist shall record the data.

1. Verify all equipment is available and functioning properly (**Table 5**, **Table 6**, **Table 7**).
2. Decontaminate equipment following the AOS Protocol and Procedure: Aquatic Decontamination Protocol (RD[07]).

When sampling at wadeable stream and river sites, prepare the densiometer prior to leaving the office by modifying the field of view using the following steps:

1. Using a piece of tape, create a “V” shape over the bottom two-thirds of the densitometer (**Figure 9**).
    a. This will help constrain measurement readings to the upper one-third of the densiometer.
2. With a black permanent marker, add 17 dots where the lines intersect on the convex densiometer, in the area above the tape (**Figure 9**).
    a. This allows for quick readings in the field, as you count the number of black dots that are covered by riparian cover.
    b. Values range between 0 (canopy is completely open) and 17 (canopy is completely closed).
3. Attach a 0.3m piece of line or flagging to the densiometer.
    a. This is used to maintain the height of the densiometer above the water when collecting data.
4. Only collect data once the bubble on the densiometer is level.

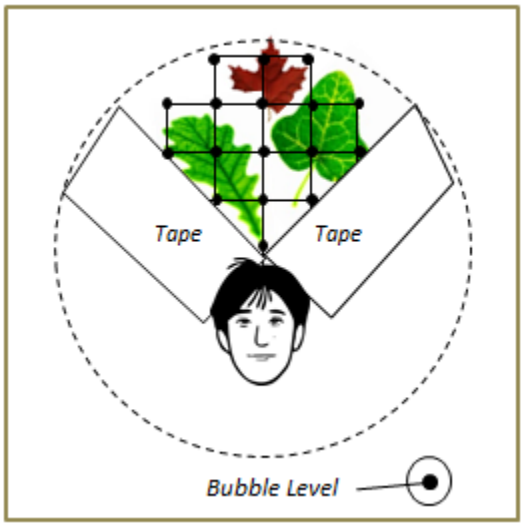

Figure 9. Illustration of the modified convex densiometer used to measure canopy cover at wadeable stream and river sites.

SOP B Field Sampling

B.1 Measuring Canopy Cover at Wadeable Stream and River Sites

Canopy cover measurements are only conducted at wadeable stream and river sites. A modified convex densiometer is used to measure the amount of riparian vegetation shade at a given point in the channel.

To measure riparian canopy cover at wadeable stream sites:

1. Canopy cover is measured at each of the ten riparian vegetation transects.
    a. To maximize efficiency, canopy cover measurements should be performed in conjunction with riparian vegetation plot characterization and bank assessment at each plot/transect.
2. Navigate to the first transect.
3. Affix a meter tape to the permanent transect markers so that it spans the channel perpendicular to the streamflow.
    a. A laser range finder can also be used but a meter tape is preferred.
    b. The permanent plot marker must be used to ensure interannual repeatability.
4. Record the wetted width of the transect.
5. Record the depth of thalweg.
    a. Be sure to measure thalweg depth on the transect line and not upstream or downstream of this location.
6. Delineate the mid-point of the wetted width.
    a. This is the exact center of the wetted width where mid-point densitometer measurements are collected.
7. Measure canopy cover in four directions at the mid-point, all measurements must be collected with the densiometer over the transect line (**Figure 10**).
    a. Level the densiometer 0.3m above the water surface directly over the transect line.
    b. Record the number of densiometer points (0-17) covered by riparian vegetation while facing upstream.
    c. Record the number of densiometer points (0-17) covered by riparian vegetation while facing downstream.
    d. Record the number of densiometer points that (0-17) covered by riparian vegetation while facing the left bank.
    e. Record the number of densiometer points that (0-17) covered by riparian vegetation while facing the right bank.

8. Measure canopy cover over the left bank (**Figure 11**).
    a. Stand 0.3m into the stream from the wetted edge of the left bank and face the left bank.
    b. Level the densiometer 0.3m above the water surface and centered on the transect line .
    c. Record the number of densiometer points that are covered by riparian vegetation.
9. Measure canopy cover over the right bank (**Figure 11**).
    a. Stand 0.3m into the stream from the wetted edge of the right bank and face the right bank.
    b. Level the densiometer 0.3m above the water surface and centered in the transect.
    c. Record the number of densiometer points that are covered by riparian vegetation.
10. Repeat the above steps at each of the remaining nine transects.
    a. Record any notes that describe notable sampling observations/conditions in the comments section of the app.

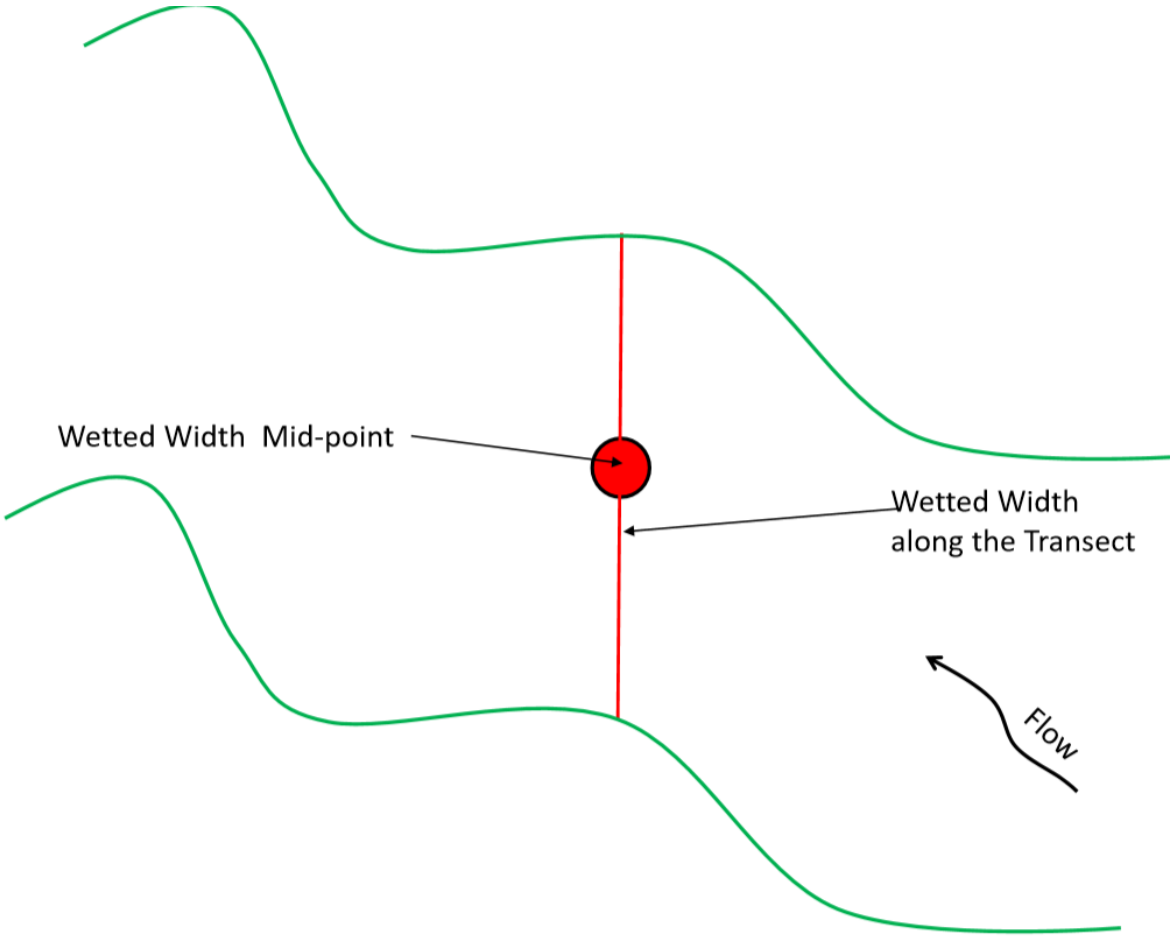

Figure 10. Illustration depicting mid-point canopy measurement locations at wadeable stream sites, this point is located at the mid-point of the wetted width as it falls on the transect line; measure canopy cover facing upstream, toward the left bank, right bank, and downstream.

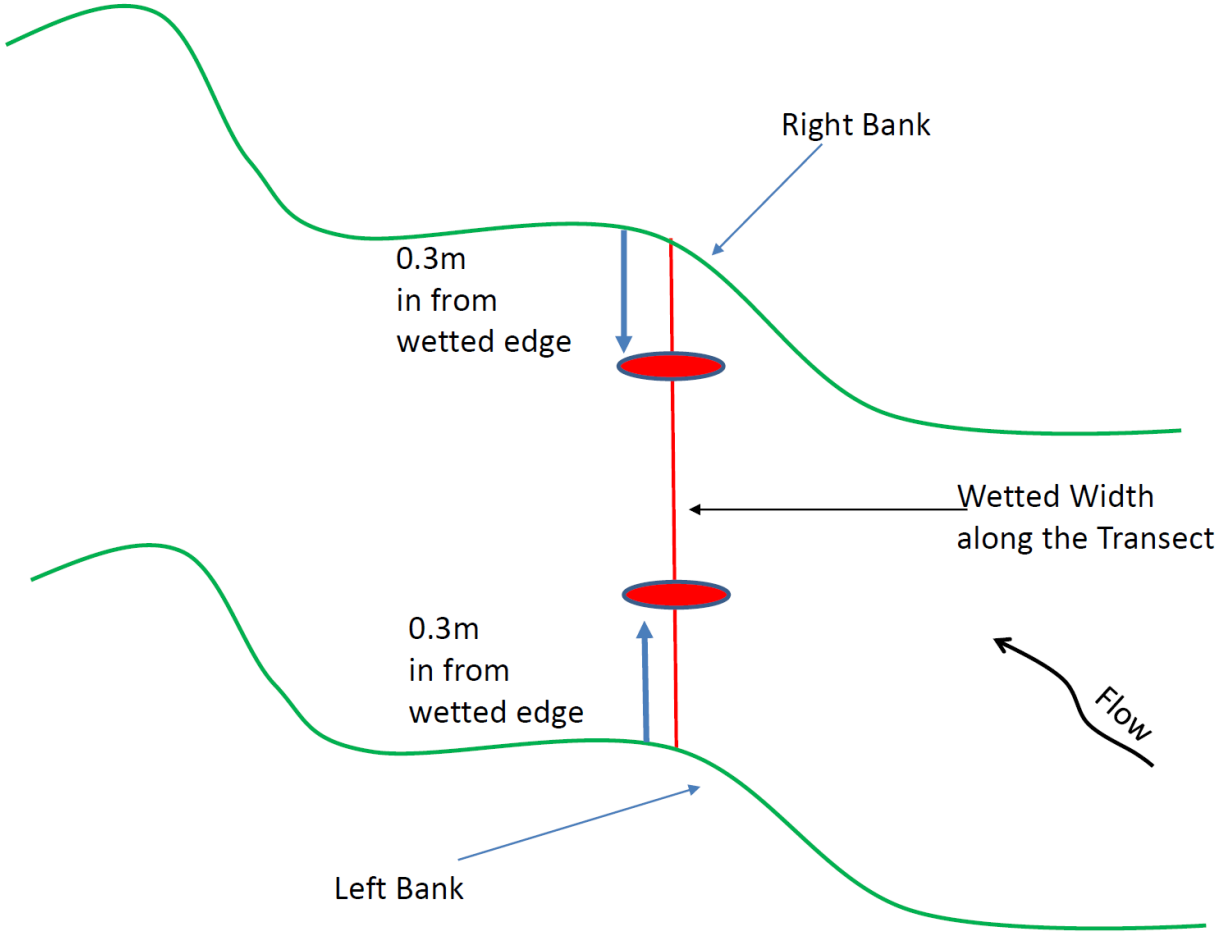

Figure 11. Illustration depicting left and right bank canopy measurement locations at wadeable stream site

To measure riparian canopy cover at river sites:

1. Canopy cover is measured at five of the ten riparian plots.
2. Navigate to the most downstream paired plots.
    a. Measurements are to occur at plots working downstream to upstream.
3. Measure canopy cover at the paired plot that is closest to the river thalweg (**Figure 5**).
    a. Record which bank (left or right, facing downstream) canopy cover is collected.

b. Navigate the boat into the plot mid-point (i.e. 5m upstream and 5m downstream of the plot boundaries) and 0.3m into the river from the wetted edge (**Figure 12**.).

    1) This may be difficult given the stage and/or velocity conditions present at the time of sampling. Attempt to get into the closest position allowable in the safest manner possible. Record in the remarks the distance from the shore observations were made if entering 0.3m from the wetted edge is not possible.

c. Level the densiometer 0.3m above the water surface.

d. Record the number of densiometer points (0-17) covered by riparian vegetation facing upstream.

e. Record the number of densiometer points (0-17) covered by riparian vegetation facing toward the bank closest to the thalweg (river left/right bank).

f. Record the number of densiometer points (0-17) covered by riparian vegetation facing toward the opposite (river left/right) bank.

g. Record the number of densiometer points (0-17) covered by riparian vegetation facing downstream.

4. Repeat the above steps at each of the remaining four transects, working in an upstream direction.

    a. Record any notes that describe notable sampling observations/conditions in the comments section of the app.

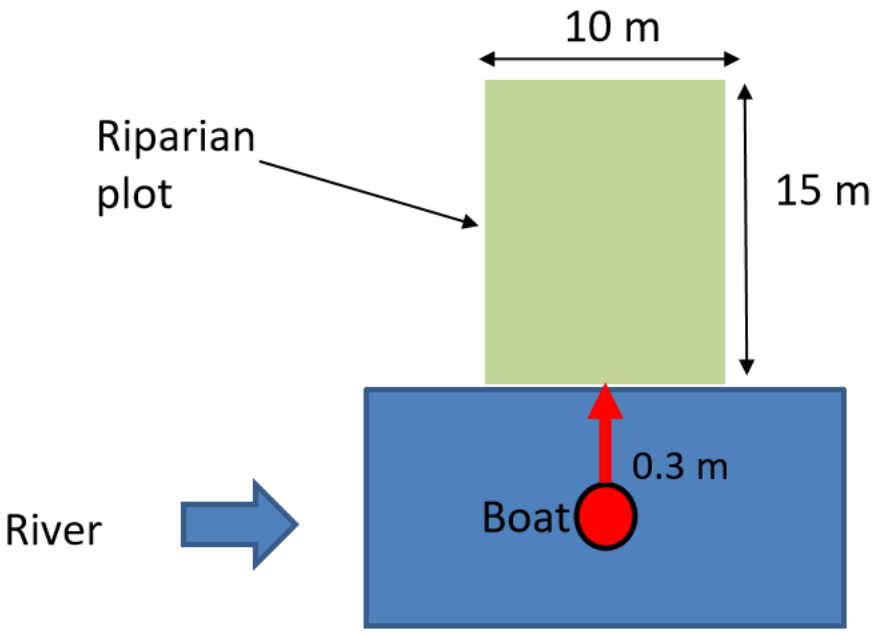

Figure 12. Illustration depicting canopy measurement locations at river sites. Note that the boat is located at the plot mid-point and 0.3m offshore.

B.3 Photographing riparian plots

Riparian plot photos are a source of qualitative data that add context to changes observed in the quantitative data collected during habitat sampling (i.e. changes due to natural disturbance) (**Figure 13**). The camera function in the mobile device used for data entry is to be used for all pictures. If mobile device camera is not functional, a photograph should not be taken. Document such instances in the remarks section of the app and submit and incident ticket to Science. Complete the following steps to collect riparian photographs at each of the ten riparian plots:

1. The following requirements apply to all site types:

    a. Make every effort to take each photograph at of the same location at each plot during every riparian habitat sampling bout.

    b. Each photograph should contain the riparian vegetation, the edge of water, and the bankfull edge.

    c. Each photograph must be documented in the app Metadata table.

        1) Select the number of photos taken at each location.

            a) Note that the app automatically assigns filenames for each photograph that is taken.

        2) Enter any notes that pertain to each photograph that is taken.

2. At wadeable stream sites:

   a. Stand at the mid-point of the transect that bisects the riparian plot (delineated in **SOP B.2**).

      1) The mid-point is the location where the canopy cover mid-point measurements are collected.

   b. Take a photo facing the bank that includes the riparian vegetation, the edge of water and the bankfull edge (**Figure 14**).

3. At river and lake sites:

   a. Anchor the boat so that it is situated 10m offshore so that boat is lined up with the middle of the plot (5m upstream and 5m downstream).

      1) Center the photograph so that the plot is evenly divided in the picture (5m upstream, 5m downstream) the picture must include; riparian vegetation, the edge of water and the bankfull edge (**Figure 14**).

      2) If the boat cannot be anchored, hold the position of the boat in this location using the motor.

   b. Take a photo facing the bank that includes the riparian vegetation, the edge of water and the bankfull edge.

Figure 13. Left: Riparian plot photo taken at Transect 4 at D04 GUIL in 2016, prior to Hurricane Maria; Right: Riparian plot photo taken at the same location in 2017 following the hurricane.

Figure 14. Example photograph of a riparian plot at a wadeable stream site. Note that the photo is centered at the transect mid-point and the wetted edge, bankfull edge and riparian vegetation are contained in the frame.

B.4 Characterizing physical habitat in riparian plots

Riparian physical habitat characterization provides a semi-quantitative dataset describing the structure and composition of riparian vegetation throughout the monitoring reach.

Complete the following steps to characterize physical habitat at each wadeable stream, river, and lake site's riparian plots.

1. Stand (or navigate the boat) in a position that affords the best view of as much of the riparian plot that can be safely and accurately assessed.
    a. Staff can locate themselves anywhere within the permitted reach in order to get the best view of each riparian plot.
    b. Record the amount of the plot that can be observed: 1m to 10m at wadeable stream sites, or 1m to 15m at river and lake sites. If < 1m into the plot can be observed, move until a location where >1m into the plot can be observed before collecting data.

2. At river and lake sites only, record the distance from the measurement location to the nearest plot boundary.
3. Record the dominant systems within the riparian plot.
    a. Reference **Appendix D** for a detailed description of the dominant systems (sub-system, class, and sub-class).
4. Record the riparian plot's dominant plant species to the lowest taxonomic level possible.
    a. "Dominant plant species" are defined as the individual species or vegetative community that comprise ≥ 30% of the aerial coverage within the plot.
        1) "Aerial coverage" is defined as the proportion of each species at the uppermost surface of the vegetation (e.g., the aerial view).
    b. Plants that contain stems outside of the plot, but with canopy overhanging the plot should be counted in the estimate of dominant species.
    c. At select sites the dominant species may not be an individual species, but rather vegetative communities comprised of a number of difficult to identify but similar species. Recording these communities is more informative than parsing out dominance to any individual species.
        1) Currently there are only two communities this is allowed for:
            1) Riparian willows: plots are dominated by shrubs and small trees from the genus *Salix*.
            2) Grass/sedge: plots where aerial dominance is controlled by an assortment of grass and sedge species.
    d. If a taxon ID update is required, submit a "Taxon list additions and updates " request form for the AOS Plant List for Riparian Assessment in Service Now .
5. Enter sub-dominant species within the riparian plot (if applicable).
    a. Enter a sub-dominant species only if:
        1) The class = "forested" or "scrub/shrub", the species comprises ≥30% of the aerial cover of the plot and the sub-class = "mixed".
        2) The class = "unconsolidated bottom", the species comprises ≥30% of the aerial cover of the plot and the sub-class = "vegetated".

B.5 Characterizing Vegetation Structure and Riparian Composition at Wadeable Stream, River, and Lake Sites

Vegetation structure and composition is characterized at each riparian plot through estimates of areal cover (shade from direct overhead sun) provided by the following three vegetation layers (**Figure 15**):

- Canopy: > 5m high

- Understory: 0.5-5.0m high
- Ground cover: <0.5m high

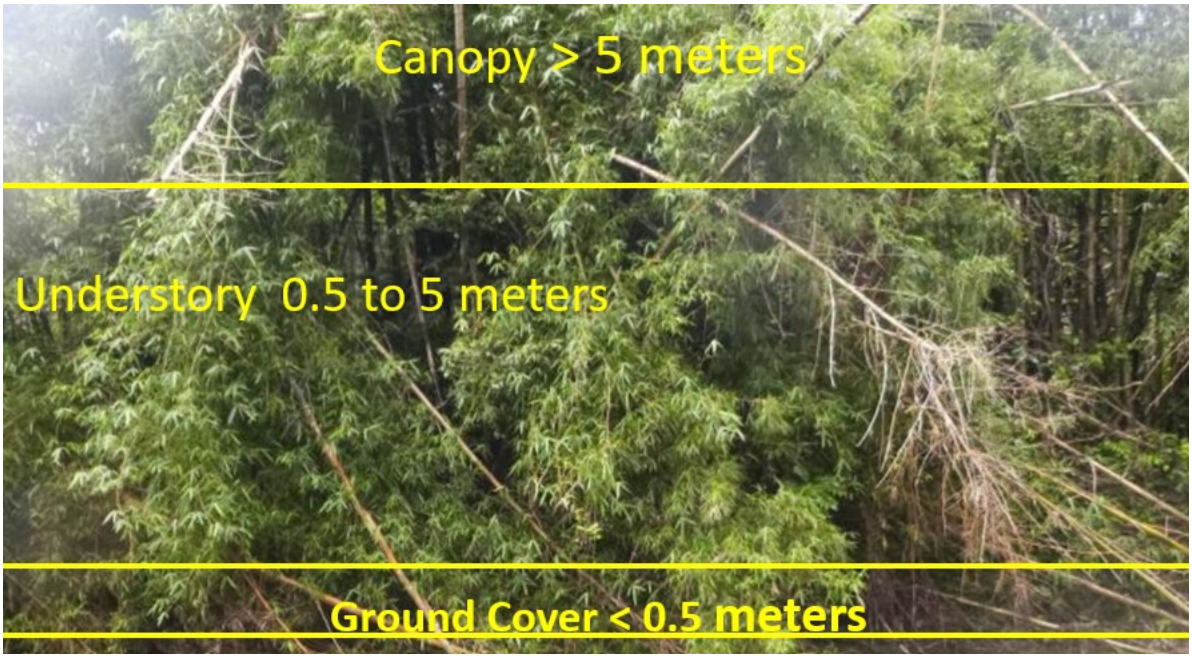

Figure 15. Photo illustration of the three vegetation layers measured in each riparian plot: canopy (>5m), understory (0.5 – 5m), and ground cover (<0.5m).

At each riparian plot, the percentage of the plot shaded by each of the three vegetation layers is recorded along with the vegetation types. Determine the vegetation type (e.g. conifer, deciduous), for each woody vegetation layer (big trees, small trees, woody shrubs and samplings) . To estimate the percentage of the plot shaded imagine that the plot has the sun shining directly above it. For each vegetation type, assess the percentage of shade contributed by that vegetation type and record the appropriate percentage. Each canopy layer and vegetation type can equal up to 100% coverage for a particular plot, so that the total percentage for canopy, understory, and ground cover can equal up to 300%. Reference **Appendix D** for details on classification of riparian vegetation.

<u>For each vegetation layer record the following characteristics:</u>

1. Canopy (vegetation >5.0m high)
    a. Record the “Big Tree” (≥0.3m DBH) vegetation type.
        1) Choose “Mix” if >10% of the Big Tree areal coverage is composed of alternative vegetation types.
    b. Estimate and record the % of “Big Tree Density” in the plot.
    c. Record the “Small Tree Type” vegetation type.

1) Choose “Mix” if >10% of the small tree areal coverage is composed of alternative vegetation types.

d. Estimate and record the % of “Small Tree Density” in the plot.

2. Understory (vegetation 0.5 -5.0m high)

a. Estimate and record the “Woody Shrubs and Saplings” vegetation type.

1) Choose “Mix” if >10% of the woody shrub and sapling areal coverage is composed of alternative vegetation types.

b. Estimate and record the % “Woody Shrubs and Saplings Density” understory in the plot.

c. Estimate and record the % “Tall Herbs, Grasses and Forbes Density” understory in the plot.

3. Ground cover (vegetation < 0.5m high)

a. Estimate and record the % “Woody Shrubs and Saplings Density” ground cover in the plot.

b. Estimate and record the % “Short Herbs, Grasses and Forbes Density” ground cover in the plot.

c. Estimate and record the % of “Standing water/Inundated Vegetation Density” in the plot.

d. Estimate and record the % “Base Dirt or Duff Density” in the plot.

If the density category is difficult to distinguish (e.g., is it sparse or moderate?) choose the greater of the two options. In this example, “moderate” would be recorded.

B.6 Characterizing Human Influence at Wadeable Stream, River, and Lake Sites

The presence of human activities is characterized at each riparian plot by completing the following steps:

1. Select “Yes” or “No” to each human activity listed in the app.

a. Select “Yes” if the human activity is present inside or adjacent to the plot.

1) If the activity is present adjacent to the plot, record whether the activity is to the left (downstream) bank or right (upstream) bank of the transect and include any general remarks.

b. Select “No” if the activity is not present with or adjacent to the plot.

B.7 Characterizing Bank Structure at Wadeable Stream, River, and Lake Sites

Shoreline bank angle, bank revetment, and bank texture are assessed on each transect for wadeable stream sites and at the shoreline for each riparian plot at river and lake sites. River and lake sites measure bank characteristics at the perpendicular line of the shoreline that marks the estimated middle of the riparian plot (5m upstream and 5m downstream).

Banks are characterized by completing the following steps:

1. Measure the Shoreline Bank Angle.
    a. The shoreline bank angle is measured between the wetted edge and the apex of the bankfull height.
    b. Shoreline bank angle must be measured perpendicular to the shore and should include approximately 1.0m of the bank perpendicular to the edge of water.
    c. Measure and record the Dominant Bank Angle (>50°) using a clinometer and meter stick (**Figure 16**).
        1) Lay the meter ruler against the bank with one end in the water.
        2) Half or more of the meter stick (> 0.5m) should be resting on the bank to determine the Dominant Bank Angle.
        3) Place the clinometer on the meter stick.
        4) Read the clinometer and choose the appropriate bank angle range from the dropdown list in the app.
    d. Measure and record the Sub-dominant Bank Angle (< 50°) using a clinometer and meter stick (**Figure 16**).
        1) Lay the meter ruler against the bank with one end in the water.
        2) Half or more of the meter stick (< 0.5m) should be resting on the bank to determine the Sub-dominant Bank Angle.
        3) Place the clinometer on the meter stick.
        4) Read the clinometer and choose the appropriate bank angle range from the dropdown list in the app.
    e. Select whether or not the bank is undercut (**Figure 16**).
        1) "Undercut" is defined by the presence of a space >0.15m beneath the bank.
    f. Potential challenges related to collecting Shoreline Bank Angle measurements:
        1) If it is difficult to determine the Dominant Bank Angle from the Sub-dominant Bank Angle.

1) The longest section of the bank is considered the Dominant Bank Angle.

2) The shortest section of the bank is considered the Sub-dominant Bank Angle (< 0.5m).

2) A boulder or log is present along the bank.

1) Record the Shoreline Bank Angle from an adjacent and representative slope.

3) The bank is obscured by vegetation and no adjacent/representative options are available.

1) Estimate the Dominant and Sub-dominant Bank Angles.

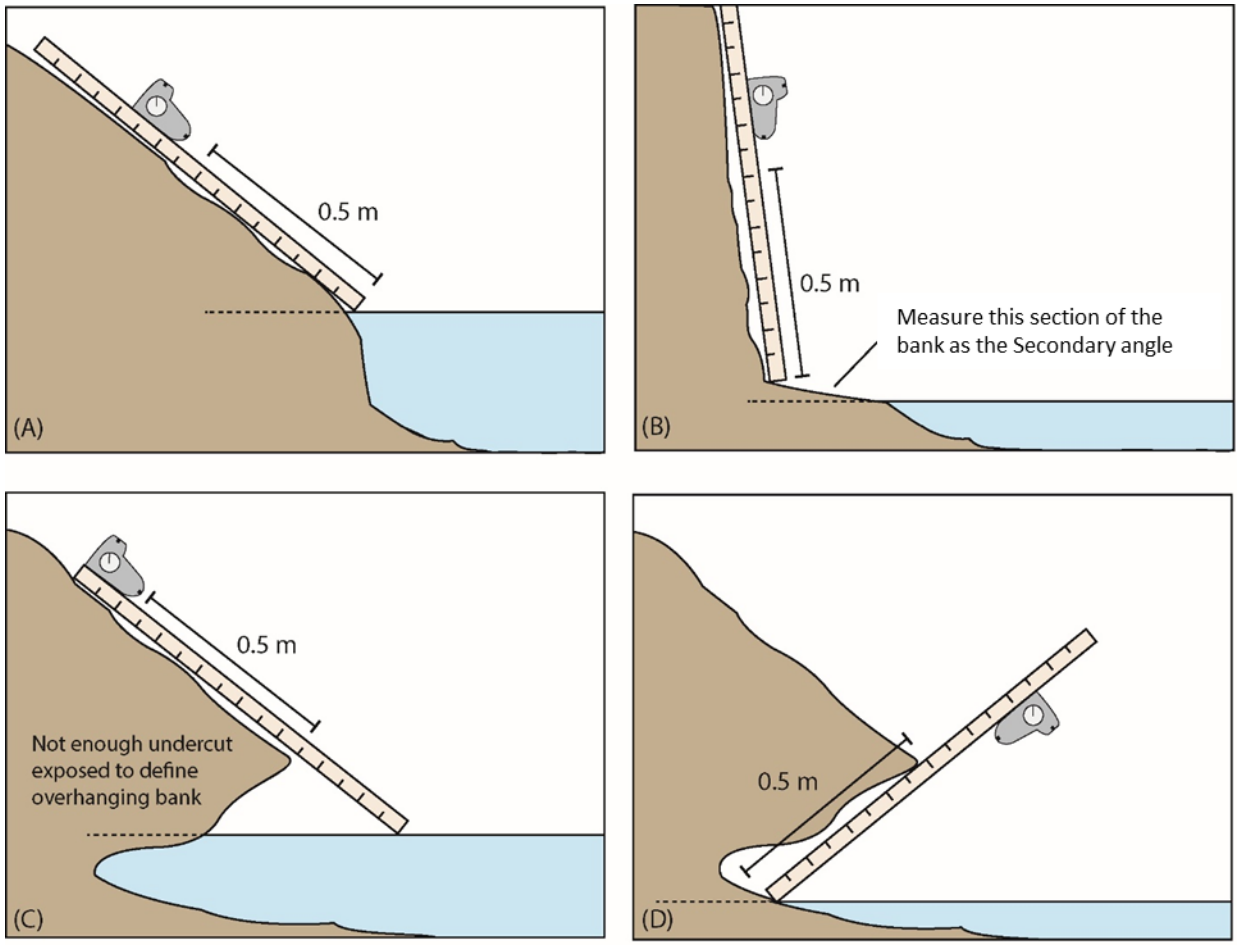

Figure 16. Bank angle using meter stick/clinometer. (A) Gradual shoreline (primary), (B) vertical bank (primary) incised channel (secondary), (C) gradual bank (primary) undercut stream

2. Quantify and record Bank Revetment on Dominant and Sub-dominant banks (**Figure 17**).

a. "Bank Revetment" refers to structure or materials placed on banks to mitigate erosion.

b. Choose from the following options to describe the presence of bank revetment on Dominant and Sub-dominant banks.

1) "Hard Bank"

a) Rip-rap or rock covering the bank, usually composed of large angular boulders, concrete blocks or rectangular gabion wire baskets.

2) "In-Stream"

a) Human-placed LWD, rock vanes, or J-hooks placed in the channel or water body that are intended to modify flow.

3) "Other": other structures cannot be defined by "Hard Bank" or "In-Stream" options.

a) "Other" could include soft armoring of the shore using planted trees, shrubs, and/or human-placed logs that are intended to mitigate erosion.

4) "None": no bank revetment is present.

Figure 17. Examples of bank revetments. A) rip-rap with rock; B) gabion baskets filled with rock; C) soft armoring using root wads and logs; D) in-stream rock J-hook for modifying flow.

3. Characterize Bank Texture on Dominant and Sub-dominant banks.
    a. Closely examine the composition of the substrate that composes the Dominant and Sub-dominant banks.
    b. Choose from the following options to describe the texture of Dominant and Sub-dominant banks.
        1) "Bedrock"
            a) Hard rock material that is very resistant to erosion.
        2) Boulder/Cobble
            a) Substrate with diameters ranging from 65 - >250mm.
            b) If banks are predominantly composed of boulders or cobble, they are moderately resistant to erosion.

3) Gravel
    a) Substrate with diameters ranging from 2 – 65mm.
    b) If banks are predominantly composed of gravel, they are moderately to highly susceptible to erosion.
4) Sand
    a) Substrate with diameters ranging from 0.10 – 2mm.
    b) If banks are predominantly composed of sand, they are highly susceptible to erosion.
5) Silt
    a) Substrate with diameters ranging from 0.02 – 0.10mm.
    b) If banks are predominantly composed of silt, they are non-cohesive and highly susceptible to erosion.
6) Clay
    a) Substrate with diameters < 0.02mm.
    b) If banks are predominantly composed of clay, they are cohesive and relatively resistant to erosion.
7) Mix:
    a) Banks that are composed of a variety of particle sizes or texture types (i.e. glacial till).

SOP C Post-Field Sampling Tasks

C.1 Document Incomplete Sampling Within a Site

Riparian Habitat sampling is scheduled to occur at all prescribed sampling locations according to the frequency and timing described in **Section 4** and **Appendix C**. Ideally, sampling will occur at these sampling locations for the lifetime of the Observatory (core sites) or the duration of the site's affiliation with the NEON project (relocatable sites). However, sampling may be shifted from one location to another when sampling is compromised. In general, a sampling location is compromised when sampling becomes so limited that data quality is significantly reduced.

There are two main pathways by which sampling can be compromised. First, sampling locations can become inappropriately suited to answer meaningful biological questions – e.g., a stream moves after a flood and the location is no longer within the stream channel). Second, sampling locations may be located in areas that are logistically impossible to sample on a schedule that that is biologically meaningful.

Riparian habitat sampling should always be rescheduled, unless the peak greenness window has been missed. Submit an incident to Science if:

1. Plots or transects need to be moved or re-established.
2. Sampling is canceled because the peak greenness window is missed, as outlined in the site-specific Aquatic Sampling Strategy documentation, (**Appendix C**).

To document locations not sampled during a riparian habitat sampling bout:

1. Review mobile application records to determine which locations were required for sampling but were not sampled.
2. Create an incident with the following naming convention to document the missed sampling: 'AOS/TOS Sampling Incomplete: MOD – [Root Cause Description]'
    a. Example: 'AOS Sampling Incomplete: RIP– Could not access plot due to permanently closed road.'
    b. Staff scientists review incident tickets periodically to determine whether a sampling location is compromised.

SOP D Data Entry and Verification

Mobile applications are the preferred mechanism for data entry. Data should be entered into the protocol-specific application as they are being collected, whenever possible, to minimize data transcription and improve data quality. Mobile devices should be synced at the end of each field day, where possible; alternatively, devices should be synced immediately upon return to the Domain Support Facility.

However, given the potential for mobile devices to fail under field conditions, it is imperative that paper datasheets are always available to record data. Paper datasheets should be carried along with the mobile devices to sampling locations at all times. 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. Review app data at the end of each day.

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APPENDIX A QUICK REFERENCES

A.1 Steps for Riparian Habitat Assessment

Step 1 – Check the riparian habitat assessment field kit to make sure all supplies are packed.

Step 2 – Charge and update hand held data capturing device. Print out the *Canopy Cover* (streams) and *Physical Habitat Characterization Datasheet*s (RD[10] and RD[11]).

Step 3 – Place tape over the bottom 2/3 of the convex spherical densiometer with 17 exposed points. Attach a 0.3m length of flagging to the bottom of densiometer for a height reference.

Step 4 – Ensure the General AQU Field Metadata and Gauge Height App is completed at each field site visit.

Step 5 – (All sites) Navigate to the first riparian assessment location with a handheld GPS.

Step 6 – Collect data.

a. Wadeable stream sites: Collect canopy cover, thalweg and wetted width at all 10 transects, characterize all 20 riparian vegetation plots and banks.
b. Rivers: At all 10 plots at river sites, characterize riparian vegetation plots and characterize bank.
    1. At the 5 co-located riparian plots closest to the thalweg collect canopy cover.
c. Lakes: At all 10 plots at lake sites: characterize riparian vegetation plots and bank.

APPENDIX B REMINDERS

Before heading into the field: Make sure you…

- ☑ Collect and prepare all equipment and ensure batteries are charged.
- ☑ Charge and up-load the latest App version of the Riparian Assessment App and Pre-print the *Canopy Cover* and *Physical Habitat Characterization Datasheets* and the Riparian Locations map from the AOS Site Specific Sampling Strategies document.
- ☑ Familiarize yourself with the most common species of plants present at the site.

While collecting data: Be sure to…

- ☑ Measure canopy cover at wadeable stream sites.
  - Using a convex spherical densiometer collect six measurements at each transect Four total measurements facing four directions from the mid-point (upstream, left bank, downstream, and right bank)
  - Collect one measurement from the left bank (looking away from the stream into the terrestrial portion of the riparian transect)
  - Collect one measurement from the right bank (looking away from the stream into the terrestrial portion of the riparian transect) for a total of six measurements.
  - **REMINDER** left and right banks are defined while looking downstream.
- ☑ Measure canopy cover at non-wadeable river sites.
  - Using a convex spherical densiometer collect four measurements at the transect closest to the thalweg: four total measurements facing four directions (upstream, towards thalweg, downstream, and towards bank).
  - **REMINDER** left and right banks are defined while looking downstream.
- ☑ Hold the densiometer 0.3m above the water surface.
- ☑ At all sites complete a separate *Physical Habitat Characterization* using the mobile application for each transect.
- ☑ If you are unable to determine the dominant species cover type, collect a specimen for lab identification and enter a remark into the app.

Ending the day: Be sure to…

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

APPENDIX C ESTIMATED DATES FOR ONSET AND CESSATION OF SAMPLING

Guidelines for the timing of sample collection for each domain are contained in Aquatic Site Sampling Design documentation (**Table 4**). Date ranges for riparian habitat sampling are based on peak greenness windows. Periods of peak greenness may, however, vary during a given year relative to the dates listed. It is thus essential that Field Science staff monitor annual conditions to determine the onset and cessation of sampling.

Table 4. NEON Aquatic Site Sampling Design documents.

Domain Number	Document Number	Document Name
01	NEON.DOC.003600	Aquatic Site Sampling Design – NEON Domain 01
02	NEON.DOC.003601	Aquatic Site Sampling Design – NEON Domain 02
03	NEON.DOC.003602	Aquatic Site Sampling Design – NEON Domain 03
04	NEON.DOC.003603	Aquatic Site Sampling Design – NEON Domain 04
05	NEON.DOC.003604	Aquatic Site Sampling Design – NEON Domain 05
06	NEON.DOC.003605	Aquatic Site Sampling Design – NEON Domain 06
07	NEON.DOC.003606	Aquatic Site Sampling Design – NEON Domain 07
08	NEON.DOC.003607	Aquatic Site Sampling Design – NEON Domain 08
09	NEON.DOC.003608	Aquatic Site Sampling Design – NEON Domain 09
10	NEON.DOC.003609	Aquatic Site Sampling Design – NEON Domain 10
11	NEON.DOC.003610	Aquatic Site Sampling Design – NEON Domain 11
12	NEON.DOC.003611	Aquatic Site Sampling Design – NEON Domain 12
13	NEON.DOC.003612	Aquatic Site Sampling Design – NEON Domain 13
14	NEON.DOC.003613	Aquatic Site Sampling Design – NEON Domain 14
15	NEON.DOC.003614	Aquatic Site Sampling Design – NEON Domain 15
16	NEON.DOC.003615	Aquatic Site Sampling Design – NEON Domain 16
17	NEON.DOC.003616	Aquatic Site Sampling Design – NEON Domain 17
18	NEON.DOC.003617	Aquatic Site Sampling Design – NEON Domain 18
19	NEON.DOC.003618	Aquatic Site Sampling Design – NEON Domain 19

APPENDIX D SITE-SPECIFIC INFORMATION

D.1 Hierarchical Determination of 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. **Subsystem**: Define the NEON aquatic site type data is being collected at
    a. Wadeable stream
    b. River
    c. Lake
2. **Class**: Describes the habitat including substrate and the dominant life form of the riparian plot. Below in bold is a description of class type.
3. **Subclass**: Further describes the Class, defined under each applicable class. Below in italics is a description of subclass type.
    a. **Rock Bottom** - The Class Rock Bottom includes habitats with substrates having an aerial cover of stones, boulders, or bedrock that is 75% or greater and vegetative cover of less than 30%.
        1) *Bedrock* - Where bedrock is covering 75% or more of the surface and less than 30 % areal coverage of macrophytes.
        2) *Rubble* - Where there is less than 75% areal cover of bedrock, but stones and boulders alone or in combination with bedrock cover 75% or more of the area. The areal coverage of macrophytes is less than 30%.
    b. **Unconsolidated Bottom** - The Class Unconsolidated Bottom includes habitats with at least 25 % cover of rock particles smaller than stones and vegetative cover.
        1) *Cobble-Gravel* - The unconsolidated particles smaller than stones are predominantly cobbles and gravel. Shell fragments, sand, and silt often fill the spaces between the larger particles.
        2) *Sand* - The unconsolidated particles smaller than stones are predominantly sand, although finer or coarser sediments may be intermixed.
        3) *Mud* - The unconsolidated particles smaller than stones are predominantly silt and clay, although coarser sediments or organic material may be intermixed.

4) *Organic* - The unconsolidated material smaller than stones is predominantly organic: there is no minimum depth requirement. The organic material is dead plant tissue in varying stages of decomposition.

5) *Vegetated* – (Greater than 30%) Some streambeds are exposed long enough to be colonized by pioneer plants that, unlike Emergent Wetland plants or Scrub-Shrub Wetland plants, are usually killed by rising water levels.

c. **Aquatic Bed** -The Class Aquatic Bed includes habitats where plants and algae grow principally on or below the surface of the water (i.e., surface plants or submergents) are the uppermost life form layer with at least 30 % areal coverage. Applicable water conditions include irregularly exposed, regularly flooded, permanently flooded, intermittently exposed, semi-permanently flooded, and seasonally flooded.

1) *Algal* - In these Aquatic Beds, algae have the greatest areal coverage. Algal Beds are widespread and diverse in the Marine and Estuarine Systems, where they occupy substrates characterized by a wide range of sediment depths and textures.

2) *Aquatic Moss* - In this Subclass, aquatic mosses have the greatest areal coverage, which are far less common than algae or vascular plants and occur primarily in the Riverine System and Permanently Flooded systems.

3) *Rooted Vascular* - In this Subclass, rooted vascular plants have the greatest areal coverage, they are referred to by others as temperate grass flats.

4) *Floating Vascular* - In this Subclass, vascular plants that float freely on or below the water surface have the greatest areal coverage. Floating Vascular Beds occur mainly in the Lacustrine, Palustrine, and Riverine Systems.

d. **Moss Lichen** - The Moss-Lichen Class includes areas where mosses or lichens cover at least 30 % of substrates other than rock and where emergent, shrubs, or trees alone or in combination cover less than 30%.

1) *Moss* - The areal coverage of mosses exceeds that of lichens; Moss dominated wetlands are most abundant in the far northern boreal forests and Arctic tundra.

2) *Lichen* - The areal coverage of lichens exceeds that of mosses. Lichen Wetlands also are a Northern Subclass.

e. **Forested** - woody vegetation usually > 6 m in height with at least 30% areal coverage.

1) *Broad-leaved Deciduous* - In this Subclass, broad-leaved deciduous species have the greatest areal coverage in the tree layer.

2) *Needle-leaved Deciduous* - In this Subclass, needle-leaved deciduous species have the greatest areal coverage in the tree layer.

3) *Broad-leaved Evergreen* - In this Subclass, broad-leaved evergreen species have the greatest areal coverage in the tree layer.

4) *Needle-leaved Evergreen* - In this Subclass, needle-leaved evergreen species have the greatest areal coverage in the tree layer.

5) *Mixed* – In this Subclass, the forested vegetation type is composed of two or more species.

6) *Dead* - This Subclass includes stands of dead woody plants 6 m in height or taller, regardless of their density, with less than 30% cover of living vegetation.

f. **Scrub/Shrub** - woody vegetation usually < 6 m in height with at least 30% areal coverage

1) *Broad-leaved Deciduous* - In this Subclass, the dominate species is a broad-leaved deciduous species have the greatest areal coverage in the scrub/shrub layer.

2) *Needle-leaved Deciduous* - In this Subclass, the dominate species is a needle-leaved deciduous species have the greatest areal coverage in the scrub/shrub layer.

3) *Broad-leaved Evergreen* - In this Subclass, the dominate species is a broad-leaved evergreen species have the greatest areal coverage in the scrub/shrub layer.

4) *Needle-leaved Evergreen* - In this Subclass, the dominate species is a needle-leaved evergreen species have the greatest areal coverage in the scrub/shrub layer.

5) *Mixed* – In this Subclass, the scrub/shrub vegetation type is composed of two or more species.

6) *Dead* - This Subclass includes stands of dead woody plants < 6 m in height or taller, regardless of their density, with less than 30% cover of living vegetation.

g. **Emergent** – wetland erect, rooted vegetation with herbaceous stems with at least 30% areal coverage. Applicable water conditions include regularly flooded, permanently flooded, intermittently exposed, semi-permanently flooded, and seasonally flooded.

1) *Persistent* - Persistent emergents are hydrophytes with stems and leaves that are evident all year above the surface of the water or above the soil surface if water is absent.

2) *Nonpersistent* - Nonpersistent emergents are emergent hydrophytes whose stems and leaves are evident above the water surface or above the soil surface if surface water is absent, only during the growing season or shortly thereafter.

3) *Phragmites australis* - Wetlands in this subclass are dominated by common reed (*Phragmites australis*).

4. **Dominant Type:** Refers to vegetative species within the mapping unit. Enter the dominant species type that represents >30% species composition. If the class is “forested” or

"scrub/shrub" and the sub-class is "mixed", enter the dominant and sub-dominant species types. Follow the USDA PLANTS Database (2015) plant symbology, e.g.:

a. (**PODE3**) *Populus deltoides* W. Eastern cottonwood

b. (**ALRU2**) *Alnus rubra* Bong. Red alder

D.2 Classification of Riparian Vegetation

1. Estimate the areal coverage for each of the upper two vegetation layers (canopy and understory only), record the vegetation type (including trees, shrubs, herbs, grasses, and forbs) that occurs by indicating the presence of Broad-leaved Evergreen (E), Needle-leaved Evergreen (NE), Broad-leaved Deciduous (BD), Needle-leaved Deciduous (ND), Mixed (M), Other (O), Dead (DD), or None (N).

    a. ***Note:*** *A vegetation layer is considered "mixed" if more than 10% of the areal coverage is composed of an alternate vegetation type.*

2. Record the semi-quantitative (categorical) measurements on the mobile device or on the *Physical Habitat Characterization Datasheet*, for each of the three vegetation layers and human influences. Trees with a DBH > 0.3 m are considered "big"; < 0.3m DBH are "small." If the tree forks at breast height or has multiple stems, the widest diameter, either below the fork or of the widest branch should be considered when classifying the canopy forming trees (USFS 2005).

3. **Layers of Riparian Vegetation**:

    a. **Canopy (> 5m height)**

        1) Big Trees (≥ 0.3m DBH)

        2) Small Trees (< 0.3m DBH)

    b. **Understory (0.5 to 5m height)**

        1) Woody shrubs and saplings

        2) Tall herbs, grasses and forbs

    c. **Ground Shrubs (< 0.5m height)**

        1) Woody shrubs

        2) Herbs, grasses and forbs

        3) Standing water and inundated vegetation (temporarily flooded)

        4) Bare dirt or duff

    d. **Human Activities**

        1) Buildings, roads, ramps, lawns, agricultural, industrial etc.

4. **Categorization of Cover:**
    a. Absent (0%)
    b. Sparse (> 0-10%)
    c. Moderate (>10-40%)
    d. Heavy (>40-75%)
    e. Very Heavy (>75%)
    f. ***Note:*** *If the cover category is difficult to distinguish (e.g., is it sparse or moderate?) choose the greater of the two. In this example, "moderate" would be recorded.*
5. **Bank Features:**
    a. Bank angle
        1) Vertical/Undercut (>75° vertical)
        2) Steep (30–75°)
        3) Gradual (< 30°)
        4) Bank undercut? (Yes or No)

APPENDIX E 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.

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 5. Equipment list for riparian habitat sampling at wadeable stream sites.

Item No.	Exact Brand?	Description	Purpose	Quan-tity
MX111388	N	Mobile field data recording device (Tablet)	Recording data	1
	N	Personal flotation devices	Safe wading	1 per person
MX102549	N	GPS receiver, decimeter accuracy (Trimble GEO XH 6000 or 7000)	Navigating to sampling locations and establishing transects	1
MX104369	N	Surveyor's tape measure 50 m or 100 m	Establishing transects	1
	N	Permanent transect marker rods	Establishing transects	22
MX102980	N	Sunto Clinometer	Determining shoreline bank angle	1
MX100348	Y	Spherical Densiometer	Determining canopy cover	1
MX104742 MX100322	N	Rangefinder (shared with FSU)	Determining angles, distance and height (alternate to using the clinometer)	1
MX105823	N	Folding meter stick	Measuring stream water depth	1

Item No.	Exact Brand?	Description	Purpose	Quan -tity
	N	Stream base map	Navigating to sampling locations	1
	Y	Quick Reference Guide	Protocol field reference	1
MX107144	N	Camera	Photographing riparian locations	1
	N	Field guide to local plants and riparian vegetation	Reference for field identification of plants	1
	N	Calculator	Calculating stream cover density	1
MX102603	N	First aid kit	Safety	1
MX100491 MX100494 MX107505	N	Waders	Safe wading	1 per person
	Y	Canopy Cover Datasheets	Recording data	1
	Y	Physical Habitat Characterization Datasheets	Recording data	10
	N	Field notebook	Recording field notes	1 per person

Table 6. Equipment list for riparian habitat sampling at river and lake sites.

Item No.	Exact Brand?	Description	Purpose	Quan-tity
MX105823	N	Meter stick (1m)	Use with clinometer to measure bank angle	1
MX100348	Y	Spherical Densiometer	River sites only: Determining canopy cover	1
MX102980	N	Sunto Clinometer	Determining shoreline bank angle	1
	N	Lake or Non-wadeable stream map	Navigating to sampling locations	1
	Y	Quick reference field operations handbook	References	1
MX107144	N	Camera	Photographing riparian locations	1
	N	Field guide to local plants and riparian vegetation	Reference for field identification of plants	1
MX102549	Y	GPS receiver – recreational grade (Garmin etc.)	Navigating to sampling locations	1
	N	Memory card	For camera	3
	Y	Physical Habitat Characterization Forms	Recording physical habitat characterization data	10
	N	Field notebook	Recording field notes	1 per person

Table 7. Equipment list for riparian habitat sampling from a boat.

Item No.	Exact Brand?	Description	Purpose	Quan-tity
MX107097	N	Boat	Navigating to sampling locations at river sites	1
MX100457	N	Anchor with rope	Maintaining boat position	1
	N	Oars	Boat operation	2
MX100899	N	Boat motor (electric at most sites; gas at some sites)	Boat operation	1
MX102603	N	Battery (12 volt)	Boat operation	1
	N	First Aid Kit	Safety	1
MX100274	N	Personal Flotation Devices (PFDs)	Safety	1 per person
	N	Fire extinguisher (if using gas motor or otherwise required by state/local law)	Safety	1
	N	Boat identification/Registration	Safety	1
	N	Sound producing device (whistle or air horn)	Safety	1 per person