AOS PROTOCOL AND PROCEDURE: RIPARIAN HABITAT ASSESSMENT

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See configuration management system for approval history.

The National Ecological Observatory Network is a project solely funded by the National Science Foundation and managed under cooperative agreement by Battelle. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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.

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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; Figure 1). 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; Figure 2).

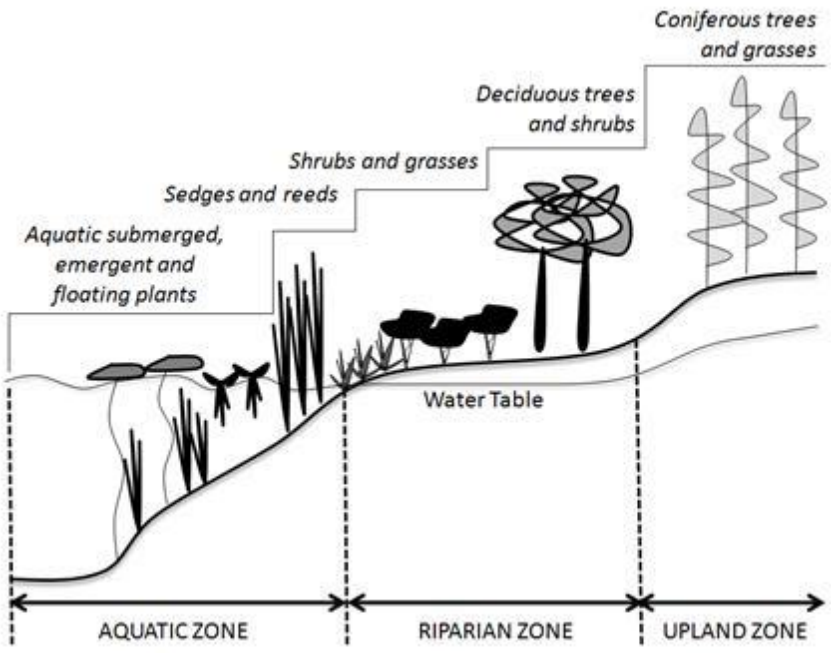

Figure 1. The riparian zone represents the land closest to the shoreline.

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 03 Southeast.

Riparian habitat provides an important buffer between the aquatic and terrestrial ecosystems. Water level fluctuations result in the establishment and presence of vegetation able to withstand wet and dry conditions. Riparian areas play a critical role in water quality by filtering or absorbing contaminants from the upland landscape, or from floodwaters. Riparian vegetation provides shade in shorelines that keeps water temperatures low, is a carbon source to streams through 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 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).

1.2 Scope

The overall objective of riparian habitat assessment 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. Disturbances in the watershed can be rapid, and exisiting remote sensing images, light detection and ranging (LIDAR), and other imagery available for interpretation may be dated. Annual implementation of this protocol will provide a regular record of changes in riparian conditions at a site and will provide a method to ground-truth NEON Airborne Observation Platform (AOP) flights.

NEON AOP flights are timed to coincide with peak greenness at NEON terrestrial sites within a domain, defined as the range of dates where Moderate-resolution Imaging Spectroradiometer (MODIS) normalized difference vegetation index (NDVI) is within 90% (RD[12]) of the site maximum. In addition, growing degree days (GDD) are included in the peak greenness ranges. The riparian habitat assessment will will take place once per year at all sites, concurrent with the NEON Airborne Observation Platform (AOP) flights over most aquatic sites. For the 10 aquatic sites not specifically co-located with a terrestrial site, there may be a slight mismatch with the actual peak greenness window at these aquatic sites and the AOP flights. For the 3 aquatic sites that are too far away from a terrestrial site to be flown by AOP, peak greenness was determined for the aquatic site directly using MODIS data. For specific peak greenness temporal windows, see the Domain-specific sampling strategy documents referenced in RD[06].

The riparian habitat assessment is a modified version of the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Plan (EMAP) protocol (Kaufmann, 2001), employing a randomized, systematic spatial sampling design that minimizes bias in the placement of measurements. This is accomplished by making measurements at pre-defined areas that are spaced equidistant along a stream/river corridor or around a lake. Data for the riparian canopy cover extent as well as the vegetation composition and physical habitat observations are recorded at 10 equally spaced lateral transects across the channel and up to 50 m into the riparian zone.

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.

1.3 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 generates raw data satisfying NEON Observatory scientific requirements. These data are used to create NEON data products, and are documented in the NEON Scientific Data Products Catalog (RD[03]).

1.4 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	Chemical Hygiene Plan and Biosafety Manual
AD[04]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[05]	NEON.DOC.004104	NEON Science Performance QA/QC 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.001152	NEON Aquatic Sample Strategy Document
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
SOP	Standard Operating Procedure
USDA NRCS	United States Department of Agriculture Natural Resource Conservation Service
USGS	United States Geological Survey

2.4 Definitions

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. Usually considered >30 % of the vegetative composition.

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.

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. These include rocks, concrete, trees, and in-stream structures such as vanes or J hooks to modify stream flow.

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 <6 meters in height.

Thalweg: Deepest portion of a stream or river channel that carries the greatest volume of water flow.

3 METHOD

This protocol is intended to provide a rapid estimate of the riparian vegetation, human impacts, and bank characteristics of the areas that buffer the permitted banks of lakes, rivers, and streams.

Note: *This protocol provides data collected to analyze and detect changes to riparian habitat at the reach-scale not at the transect-level.*

Surveys are conducted either by an individual making and recording the observations or 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.

Field data collection undertaken as part of this protocol consists of the following steps at each transect:

1. Walk or boat around the site within the permitted boundaries and conduct vegetation cover and composition observations at specified transect locations.
2. Record human activities that are present in the riparian and adjacent areas.
3. Conduct lake, river, or stream bank observations.
4. At stream sites, collect canopy density measurements using a densiometer.
5. Collect a representative photo of the riparian habitat

There are riparian habitat transects that are surveyed at non-wadeable streams, lakes, and wadeable streams. The approximate locations of the 10 transects are determined prior to the riparian assessment visit and marked on the Site-Specific Riparian Locations figure in the Domain-specific Aquatic Site Sampling Strategy document (RD[06]). At lake and non-wadeable (river) sites, riparian habitat assessments are conducted offshore using a boat; at wadeable streams the observations are collected from the center of the channel. Lake (**Error! Reference source not found.**) and non-wadeable stream (**Error! Reference source not found.**) based riparian habitat assessment occurs by identifying 10 primary equidistant transects around the perimeter of the lake or 5 transects on both shores (left and right banks) of the non-wadeable stream for a total of 10 transects. Wadeable stream riparian habitat assessment occurs by identifying 10 transects spread equally throughout the aquatic sampling reach (**Error! Reference source not found.**). Provide a reasonable estimate of all surveyed parameters when recording observations at each transect. Any observations of the riparian areas outside of the specified Riparian Assessment locations should be recorded in the General AQU Field Metadata Sheet (RD[05]).

At each transect, observations are collected from a plot which extends up to 50 m from the shoreline/bank towards the terrestrial systems (less if the plot is visibly obstructed) and 20 m (10 m each side of central point) along the shoreline. The dimensions of the plot (up to 50 m inland by 20 m parallel to shore) are determined using a compass and angle referencing clinometer by estimation, they are not measured. Two plots are established at wadeable stream sites; one on the left bank and one on the right bank. A single plot is established at each transect for non-wadeable streams and lake sites which extend into the riparian vegetation. In each plot, field ecologists record information about the vegetation type and the height and areal coverage of trees, shrubs, and grasses using an inclinometer or rangefinder

(**Figure 6**). Observations in sloping or undulating terrain are recorded as if looking down on the 50 m by 20 m plot from an aerial view. Where interpretation of the riparian area is obscured by vegetation or topography, estimate the composition of the habitat. In addition, observations of shoreline substratum (e.g., gravel, sand), the high-water mark, and bank slope characteristics are noted on the appropriate field in the mobile device or the datasheets (RD[10] and RD[11]). 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.

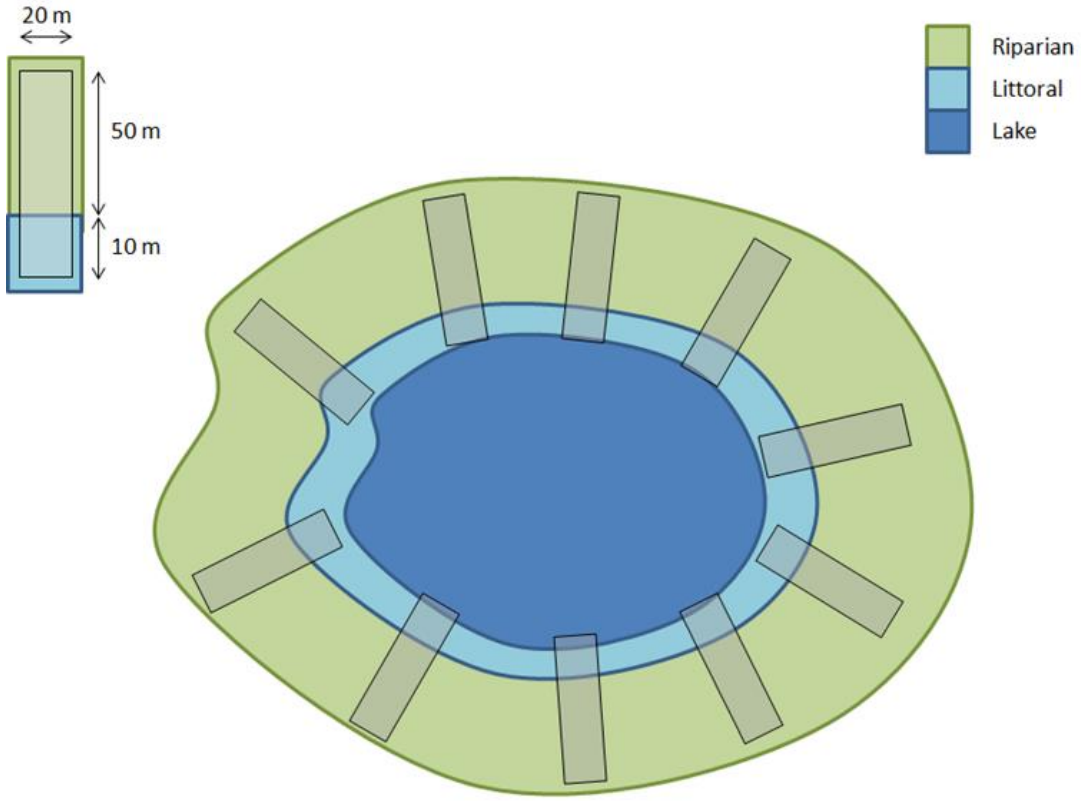

Figure 3. Conceptual illustration of the riparian habitat assessment plots at lake sites. The riparian zone is in green, near shore littoral zone in light blue, and the lake is in dark blue. Ten plots are equally distributed around the lake.

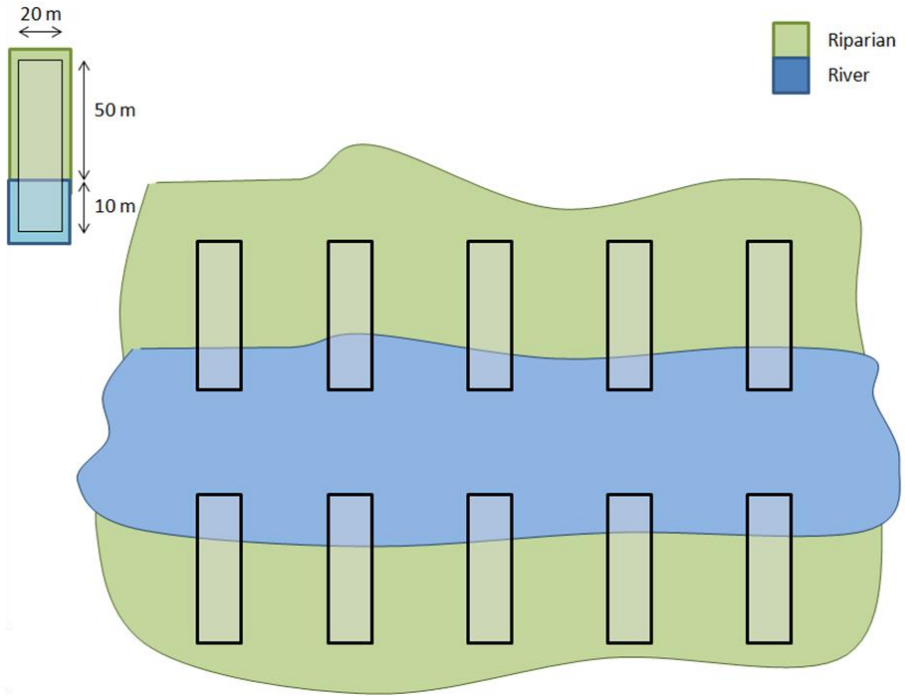

Figure 4. Conceptual illustration of the riparian habitat assessment plots at non-wadeable stream (river) sites. The riparian zone is in green and the river is in dark blue. Five plots are equally distributed on the right bank and the left bank for a total of ten plots.

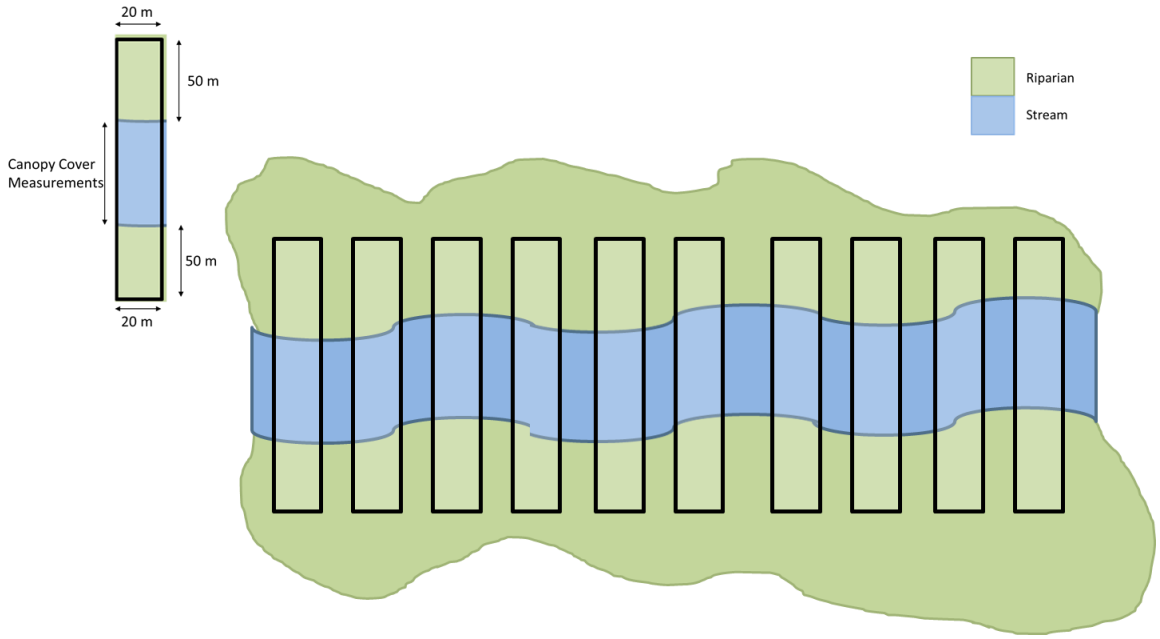

Figure 5. Conceptual illustration of the riparian habitat assessment plots at wadeable stream sites. The riparian zone is in green and the stream is in dark blue. Ten plots are equally distributed throughout the wadeable stream reach.

Figure 6. An example of (a) a tandem clinometer used both as a compass and 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; and (c) a convex spherical densiometer used for determining % canopy cover.

The activities outlined in this protocol are based on modified methods developed by the U.S. Environmental Protection Agency (2008) and U.S. Fish and Wildlife Service (1997, 2009).

The following modifications have been made:

- The determination of the 20 meter horizontal widths of the riparian areas in the field are determined by estimation. It may be helpful to use a tape measure set to 20 m parallel to the stream bank or a rangefinder to calibrate your estimate of the riparian plot width.
- This method follows Ode (2007) which uses the Strickler modification (17-point) of a convex spherical densiometer (**Figure**) to correct for overestimation of canopy density (thickness and consistency of plant foliage) that occurs with unmodified readings (Strickler, 1959).
- The maximum distance into the riparian zone that may be used as the identification area has been extended to 50 m to enable more representative identification in areas with large floodplains and shallow terrains.
- 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, data collecting and recording tips, and best practices for implementing this data collection 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 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.

The procedures described in this protocol will be audited according to the Field and Lab Procedures Quality Assurance Plan (AD[05]).

4 DATA COLLECTION SCHEDULE

4.1 Frequency and Timing

The time window for performing the riparian habitat assessment was chosen to match the window for AOP flights of the aquatic sites when possible. AOP flight schedules are determined by the time window of peak greenness for the closest terrestrial NEON site. Riparian habitat field data collection occurs during the:

1. Period of maximum vegetation cover or "peak greenness"
2. During safe wading conditions (see Section 5 Safety)

Refer to the Site Specific Sampling Strategy Document for the data collection timeline (Appendix D and E). The riparian habitat assessment shall occur once per year at every aquatic site. Data collection timing is outlined in the Site-Specific NEON Aquatic Site Sampling Design documents.

4.2 Criteria for Determining Onset and Cessation of Field Data Collection

Peak greenness date ranges are determined using MODIS data and growing degree days. The specific times are determined using multivariate statistics and site specific historical information (see RD[06]). Peak greenness dates are defined as the range of dates where MODIS NDVI is within 90% of the site maximum. Most aquatic sites are co-located with terrestrial NEON sites, therefore the peak greenness dates for these aquatic sites should match exactly with the co-located terrestrial site and the flight time window. However, there are several aquatic sites that are not co-located with terrestrial sites, so by matching with the flight time window of the closest terrestrial site, there may be a slight mismatch with the actual peak greenness window at these aquatic sites (HOPB, CUPE, GUIL, MCDI, ARIK, PRIN, WLOU, REDB, BIGC, and OKSR). In addition, there are three aquatic sites that are too far away from a terrestrial site to be flown by AOP. For these three sites (BLUE, SYCA and MCRA), peak greenness was determined using the same algorithm for the aquatic site directly.

4.3 Timing for Laboratory Processing and Analysis

There is no domain lab processing for this protocol.

4.4 Data Collection Timing Contingencies

Table 1. Contingent decisions

Delay/ Situation	Action	Outcome for Data Products
Hours	If equipment stops functioning during data collection, continue from where the data collection 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 shoreline (due to safety issues, dense vegetation, sensitive ecosystem, unsafe ground conditions or because part of the segment is on private property), record conditions and comments on the field data sheet. Proceed by walking, driving, or boating along the edge of the water body and make observations where possible.	No adverse outcome.
	If the observation point (center of the stream for wadeable streams, 10 m offshore for non-wadeable streams and lakes) is inaccessible due to unsafe wading conditions or dense vegetation, adjust observation position accordingly, estimate and record the distance to shore and proceed with collecting data as detailed in the protocol.	No adverse outcome.
Days	If the weather, current, or other unsafe conditions prohibit in-water work (wading or boating) field activities, stop and resume as soon as safe conditions are met. Unless physical change or more than one week has passed because of the change in weather and flow (i.e. bank erosion, movement of LWD etc.) data collection should resume from where it was left off and completed within the window provided for the Riparian Habitat Assessment protocol.	No adverse outcome.
7 Days or More	Restart assessment if 7 or more days have passed since the previous measurements were started.	No adverse outcome. However, if the vegetation cover has changed significantly or if the restart time occurs outside of the peak greenness window submit a trouble ticket and contact the protocol author.

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 Ecologist 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.

Activities in streams should only be performed when flow conditions are safe. Do not attempt to wade a stream where velocity x depth is ≥ 10 ft^2/s (0.93 m^2/s).

In addition, the following safety guidelines are provided:

1. Due to site-specific hazards that may be encountered in accessing the shoreline field ecologists may complete observations without dismounting from the vessel.
2. Field ecologists are required not to put hands and feet in waters where alligators or other submerged wildlife dangers are present and to make sure a safe distance of 20 m from hazards is maintained.
3. All personnel must be wearing a personal flotation device (PFD) prior to entering and while in the boat.
4. Personnel in wadeable streams shall work in teams of 2, at a minimum, and shall wear personal flotation devices (PFDs) when wading where velocity, depth or obstructions may create a hazardous work environment (e.g. stream is fast moving, the depth is greater than knee-high in slow moving stream, or the stream may present slip or fall hazards).
5. All employees shall have access to a form of communication with other team members such as a two-way radio.
6. Field ecologists should be aware of any site-specific hazards and the waters of that particular location (i.e. status, tidal charts, etc.)

6 PERSONNEL AND EQUIPMENT

6.1 Equipment

The following equipment is used 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 – Field equipment for wadeable stream riparian habitat assessment

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
Durable items							
MX111388	CDW-G	4452963	R	Mobile field data recording device (Tablet)	Recording data	1	N
			S	Personal flotation devices	Safe wading	1 per person	N
MX102549	Compass Tools Inc.	88180-04	R	GPS receiver, decimeter accuracy (Trimble GEO XH 6000 or 7000)	Navigating to sampling locations and establishing transects	1	N
MX104369	Ben Meadows Co., Inc. Forestry Suppliers, Inc.	213379 37184	R	Surveyor's tape measure 50 m or 100 m	Establishing transects	1	N
			R	Permanent transect marker rods	Establishing transects	22	N
MX102980	Ben Meadows Co., Inc.	225434	R	Suunto Clinometer	Determining shoreline bank angle	1	N
MX100348	Ben Meadows Co., Inc. Forestry Suppliers, Inc.	102165 43887	R	Spherical Densiometer	Determining canopy cover	1	N

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
MX104742 MX100322	B&H Photo Corp Forestry Suppliers, Inc.	SISOK12601 91567	S	Rangefinder (shared with FSU)	Determining angles, distance and height (alternate to using the clinometer)	1	N
MX105823	Forestry Suppliers, Inc.	71112	R	Folding meter stick	Measuring stream water depth	1	N
			R	Stream base map	Navigating to sampling locations	1	N
			R	Quick References (Appendix B)	Protocol field reference	1	N
MX107144	B&H Photo Corp	PADMCTS30BL	R	Camera	Photographing riparian locations	1	N
			R	Field guide to local plants and riparian vegetation	Reference for field identification of plants	1	N
			R	Calculator	Calculating stream cover density	1	N
MX102603	Grainger, W.W.	11C657	R	First aid kit		1	N
MX100491 MX100494 MX107505	Ben Meadows Co., Inc. Grainger, W.W. Forestry Suppliers, Inc. Cabela's		R	Waders	Safe wading	1 per person	N
Consumable items							
			R	Canopy Cover Datasheets	Recording data	1	N

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
			R	Physical Habitat Characterization Datasheets	Recording data	10	N
			S	Field notebook	Recording field notes	1 per person	N

R/S=Required/Suggested

Table 3. Equipment list – Lake and non-wadeable riparian habitat assessment procedure

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
Durable items							
MX105823	Forestry Suppliers, Inc.	71112	R	Meter stick (1 m)	Use with clinometer to measure bank angle	1	N
MX102980	Ben Meadows Co., Inc.	225434	R	Suunto Clinometer	Determining shoreline bank angle	1	N
			R	Lake or Non-wadeable stream map		1	N
			R	Quick reference field operations handbook	References	1	N
MX107144	B&H Photo Corp	PADMCTS30BL	R	Camera	Photographing riparian locations	1	N
			R	Field guide to local plants and riparian vegetation	Reference for field identification of plants	1	N
MX102549	Compass Tools Inc.	88180-04	R	GPS receiver – recreational grade (Garmin etc.)	Navigating to sampling locations	1	N
			R	Memory card	For camera	3	N
Consumable items							
			R	Physical Habitat Characterization Forms	Recording physical habitat characterization data	10	N

			S	Field notebook	Recording field notes	1 per person	N

R/S=Required/Suggested

Table 4. Equipment list – General boating equipment

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
Durable items							
			R	Boat		1	Y
MX107097	Amazon Capital Services Inc.	B003ZZG5EM	R	Anchor with rope		1	N
MX100457			R	Oars		2	N
			R	Boat motor (electric at most sites; gas at some sites)		1	Y
MX100899	Grainger, W.W.	2UKJ5	R	Battery (12 volt)		1	Y
MX102603	Grainger, W.W.	11C657	R	First Aid Kit		1	N
			R	Personal Flotation Devices (PFDs)		1 per person	N
MX100274	Grainger, W.W.	3YWN1 6AJW7	S	Fire extinguisher (if using gas motor or otherwise required by state/local law)		1	Y

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
			R	Boat identification/Registration		1	N
			R	Sound producing device (whistle or air horn)			
Consumable items							
				(none)			

R/S=Required/Suggested

6.2 Training Requirements

All field ecologists must complete required safety training and 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 stream riparian habitat assessment measurements and safe working practices for stream work, to include use of waders and PFDs, where applicable.

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 measurement locations. 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 that riparian habitat assessment for all transects at a site requires two field ecologists for 6-8 hours plus travel to and from the site.

7 STANDARD OPERATING PROCEDURES:

See Appendix B for Quick References and Appendix C for Reminders.

SOP A Preparing for Sampling

A.1 Preparing for Data Capture

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 error and improve data quality. For detailed instructions on protocol-specific data entry into mobile devices, see the NEON Internal Sampling Support Library (SSL). 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.

Surveys are conducted either by an individual making and recording the observations or 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.

(Modified from U.S. EPA 2007)

1. Ensure memory cards in the digital camera are blank. If files are present, confirm data and photos have been uploaded prior to deleting files.
2. Verify all equipment is available and functioning properly.
3. Ensure all batteries and electronic equipment are fully charged, even if new.
4. Decontaminate equipment following the AOS Protocol and Procedure: Aquatic Decontamination Protocol (RD[07]).
5. Print applicable Datasheets (1 *Canopy Cover Datasheet* for streams sites and 10 *Physical Habitat Characterization Form* for all types of sites).
6. Ten transect locations are equally distributed throughout the stream or river reach and circumferentially at lake sites as described in Section 3. Initial transect locations are provided by the AOS team at headquarters (**Error! Reference source not found.**, **Error! Reference source not found.**, **Figure**). Field science then sets the permanent transect locations, records the location with a GPS unit (decimeter accuracy) and establishes the monument markers where allowed.
7. Before heading out to the field, confirm the location of each riparian transect. Ten cross-section transects are placed at equal intervals along the aquatic sampling reach at wadeable stream sites. Stream transects are set less than 100 m apart within a 1 km NEON aquatic reach. At river sites, transects are set at less than 200 m apart within a 1 km reach. For lake sites, the transects are spaced as evenly as possible around the lake perimeter. These transects shall not be located on the same transects as the biological sampling transects. Install and monument the transect

locations with the permanent monument markers on either the right or left bank above the high water mark.

8. **For stream sites** (For lake and non-wadeable stream sites, skip to step 8), a spherical convex densiometer is used to measure the amount of stream habitat that is shaded by riparian vegetation.
   a. Prepare the densiometer before heading out into the field (**Figure 7**). Place tape over the bottom 2/3 of the densiometer. A "V" shape is outlined to help constrain readings in the upper 1/3 of the densiometer that are otherwise representative of reflection of the vegetation to the side as well as directly above. This increases accuracy of readings to vegetation density only directly above the viewer (**Figure 7**). Seventeen dots should be added with a permanent marker where the lines intersect on the **convex** densiometer.
   b. Attach a 30 cm piece of line or flagging to the densiometer to maintain the height of the densiometer above the water in the center of the stream, or water/ground surface when taking measurements at either bank. Reading from the densiometer 30 cm above the water and in conjunction with the bubble level, will allow for the field ecologist to maintain the densiometer position as they move around it to face all four directions.

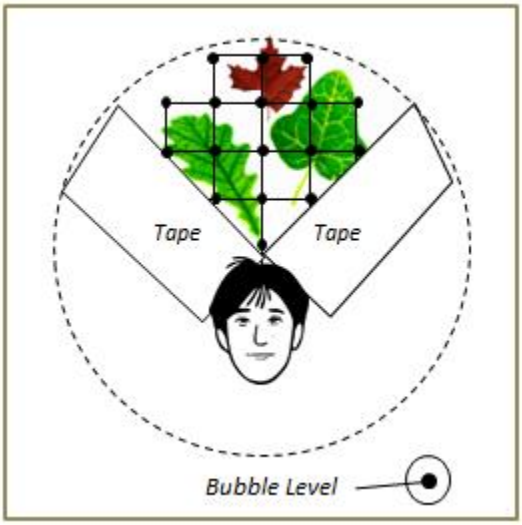

Figure 7. Preparing and reading a densiometer

9. Familiarize yourself with the most common species of plants in your domain/sites.
   a. Resources available include reference guides and the USDA NRCS online guide "The PLANTS Database."
      1) Under the 'I want to…' tab, select "**See list of the plants in my state.**"
      2) Under the 'I want to…' tab, select "**Learn about all the endangered plants of the U.S**."
10. Familiarize yourself with the clinometer, rangefinder, and spherical densiometer, if applicable (Appendix G). Refer to the Forestry-Suppliers Technical Bulletin M0003 Appendix F.

SOP B Field Data Collection

B.1 Data Collected per Date

Each day that riparian assessment field measurements are made the stage of the stream, lake, or river should be recorded. This is done by reading the level of water on a staff gauge. Enter the staff gauge height on the metadata application (mobile device) or the field datasheet in the *Physical Habitat Characterization Form* (SOP B.4, RD[10], and RD[11]).

B.2 Data Collected per Transect

For each stream or river transect, indicate whether the measurements are being recorded for the left or right bank facing downstream. On the *Physical Habitat Characterization Form,* estimate and record the Observed Transect Distance in 10 m increments. This estimate is the distance from the point of observation to the edge of the riparian plot that can be seen (up to 50 m). This distance is recorded at each transect including the left and right bank at wadeable stream sites.

This allows for a more accurate estimate of the areal extent of the riparian features observed.

B.3 Stream Canopy Cover

Canopy cover measurements are only collected at wadeable stream sites. **If you are performing riparian assessment at a lake or river site, please proceed to SOP B.4 Physical Habitat Characterization.** This method is based on the Water Quality Monitoring Technical Guidebook from Oregon's Watershed Enhancement Board (OWEB 1999) and California Department of Pesticide Regulation (2004).

Densiometer Measurements

1. Canopy cover over the stream is measured at each of the 10 stream cross-section transects using a **modified convex** spherical densiometer. Six measurements are obtained at each transect: 4 measurements in the four directions (upstream, right bank, left bank, and downstream) from the mid-channel (stream center; equal distance from left and right wetted banks). Also, take 1 measurement from the left bank and 1 from the right bank, both bank measurements are made facing away from the stream, perpendicular to shore, into the canopy for a total of 6 measurements. Measure and record the number of points covered (of 17 points) on the densiometer positioned 0.3 m from the water's edge on the LEFT bank facing into the riparian habitat, back toward the stream. Repeat this step for the RIGHT bank canopy cover measurement. Take only one reading from each bank.
2. Using the *Canopy Cover* portion of the mobile application or the *Field Datasheet*, enter the appropriate header data (site ID, field ecologist ID, collection date, start time, protocol number, and revision number).
3. Begin at the farthest downstream location. Affix the tape measure along the 1st transect from the left to the right bank.

4. On the mobile device or datasheet, record the water depth in the thalweg where the transect crosses the stream.
5. Record the wetted channel width (m) then divide that number by 2 for the mid-channel distance. Record the mid-channel point (m). The channel width distance may include islands or parts of dry land between braided stream channels.
6. Stand in the 1st transect (**Figure 8**) at mid-channel facing upstream.

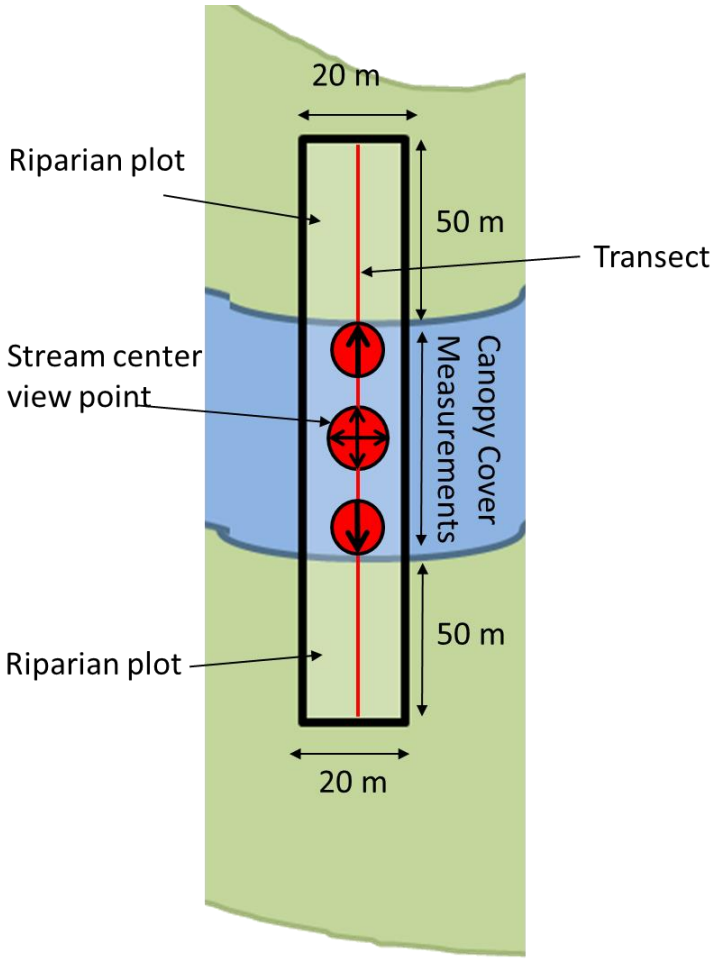

Figure 8. Conceptual illustration of transect and plot establishment at wadeable stream sites. Canopy cover measurements are collected at three locations within the stream. Riparian physical habitat assessment is conducted from the stream center (view point). Adjacent observations are made 15 m on either side (upstream and downstream) of the plot. (Modified from Kaufmann, 2001).

7. Measure and record overstory canopy cover from the stream center (mid-channel).

a. Hold the densiometer 0.3 m above the water surface.
b. Tilt the densiometer so that it is level using the bubble level indicator. Hold the densiometer so that the reflection of the top of your head just touches the point of the "V", as in (**Figure**).

c. Count the number of points covered by vegetation and enter this value in the mobile device or the *Canopy Cover Datasheet* under "# of points covered". Values will be between 0 for completely open and 17 for completely covered canopy.

d. Take four densiometer readings from the stream center at each of the 10 transects, one reading from the left bank, and one more from the right bank following the Densiometer Measurements procedures above.

e. Record the values on the mobile device or on the *Canopy Cover Datasheet* under "Center-Upstream", "Center-River Left", "Center-Downstream", "Center-River Right", "Left Bank-River Left", and Right Bank-River Right."

B.4 Physical Habitat Characterization

1. Using the mobile device or the *Physical Habitat Characterization Datasheet* (RD[10] and RD[11]), enter the appropriate header data (site ID, field ecologist ID, collection date and start time, and transect number). Record the Observed Transect Distance in 10 m increments for each bank.

   a. **Wadeable streams**

      1) Stand in the middle of the stream transect or where safe and both banks are in view. If the stream is composed of two or more channels, stand in the center between the furthest wetted widths. Make observations from this location; do not move to improve the viewing position unless there is a safety reason.

      2) Take a photo of the riparian zone facing toward the shoreline at each transect location; one facing the left bank and one facing the right bank. In the photo include the top of the current waterline and as much of the riparian habitat as possible (widest angle and in landscape orientation (**Figure 9**), record the photo number.

Figure 9. Example photograph of the riparian habitat with the waterline, bank and vegetation.

b. **Non-wadeable streams and lakes**

1) Position the boat at a distance of 10 m (~30 ft., offshore) and deploy anchor (required). If in-water obstructions prohibit observations from being made within 10 m from shore, position the boat as close as possible to the littoral zone.
2) Take a photo of the riparian zone facing toward the shoreline at each transect location. In the photo include the top of the current waterline and as much of the riparian habitat as possible (widest angle and in landscape orientation); record the photo number. Use the anchor location 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 10**).

c. If the transect location needs to be moved due to a recent morphological change or habitat disturbance, then document this request through the problem resolution system.

2. In **Part A** of the *Physical Habitat Characterization Datasheet* (RD[10] and RD[11]) or mobile device application, enter the full classification code following the Hierarchical Determination for Dominant System and USDA PLANTS symbol. Refer to **Appendix E, Riparian Classification System** for detailed instructions to properly document the dominant plants (species composition >30 %). Observations recorded for Part A include only the riparian habitat to whichever extent it occurs within the 50 m x 20 m plot (on each bank for wadeable stream sites).

Note: *It is important to be very familiar with the most common plant species that occur within the riparian zone and adjacent uplands. Include plant and tree field guides when preparing to conduct the riparian survey. Develop an informal presentation, domain-specific field guide, and training materials for common riparian plant species.*

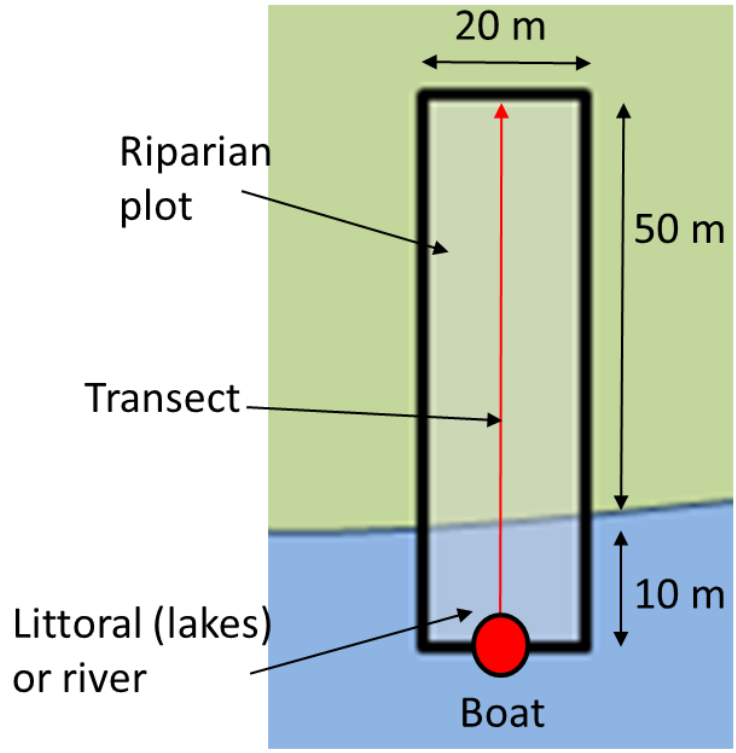

Figure 4. Position of the boat for riparian assessment at each lake or non-wadeable stream location. The distance to the shoreline and the approximate location and size of the riparian plot are also shown. Adjacent habitat observations are recorded from up to 15 m on either side of the plot.

3. Using **Part B** of the *Physical Habitat Characterization Datasheet* or mobile device application, record estimates of riparian vegetation structure and composition including upland habitat throughout the entire 50 m x 20 m plot. 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. Observations of riparian areal cover may total up to more than 100 %. For example, if each for cover type (canopy, understory, and ground cover) is recorded as ">75%" then the total cover type would be greater than 100%
   a. 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).

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

b. 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"; < 0.3 m 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).

c. 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 Cover** **<0.5 m height**
      a) Woody shrubs
      b) Herbs, grasses, and forbs
      c) Standing water and inundated vegetation (temporarily flooded)
      d) Bare dirt or duff

d. Indicate the areal cover (shaded area) by each riparian vegetative layer with the following cover categories:
   1) Absent = 0%
   2) Sparse > 0 - 10 %
   3) Moderate > 10 - 40 %
   4) Heavy > 40 - 75 %
   5) Very Heavy > 75 %

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. Also, the cover types can add up to greater than 100% as stated above.*

e. **Human**
   1) Record "Present" of "Absent" for human influences such as buildings, roads, boat ramps, lawns/parks, agriculture, industry, cleared lot/pavement, NEON infrastructure, trash (heap), or other.

4. Complete a separate *Physical Habitat Characterization* on the Datasheet or on the mobile device for <u>each</u> transect.
5. Record on the datasheet or mobile device other observations made regarding areas that are *adjacent* (15 m outside of the 10 m upstream and downstream transect) to the horizontal stretch being assessed. This is particularly important where human disturbance is evident (i.e. house, road, boat ramp, lawn, power lines, garbage etc.).
6. Make every reasonable attempt to record physical habitat observations and measurements for all 10 riparian transects.

a. Indicate if the reach is inaccessible by recording sampling impractical (dry, frozen, snow, other) and document if the reach condition could affect the data collection (normal flow, segmented pools, disconnected side channel, other low flow, high flow, heavy vegetation, skipped station, partially wetted sediments, other). If multiple reach conditions affect data collection, document the most impactful condition.
b. If you are unsure of or unable to determine the canopy cover type, take a photo of the site and specimen and note this in the field metadata sheet.

7. Using Part C of the Physical Habitat Characterization Datasheet or mobile device application, enter data from the following observations.
   a. Determine the Primary (>50%) and Secondary (<50%) *Bank Angle* in Part C (1st box) using the clinometer and the meter stick, record the information in the *Physical Habitat Characterization Datasheet* or on the mobile device application (Appendix A). The bank angle assessment is made along the transect line perpendicular to shore and should include approximately one meter of the bank perpendicular to the water's edge.
      1) Lay the meter ruler against the bank with one end towards the water. Half or more of the meter stick (>0.5 m) should be resting on the bank to determine the primary angle. Place the clinometer on the meter stick; read and select the appropriate bank angle range to record in degrees (**Error! Reference source not found.**).
   b. There may be a variety of angles. If two bank angles predominate, select both and estimate which one is the primary angle (>0.5 m). The longest section of the bank is considered primary; the shorter section is secondary (<0.5 m). If a boulder or log is present along the bank being measured, record a bank angle from an adjacent and representative slope. Additionally, indicate "yes" or "no" if the bank is undercut; this is defined as having a space >15 cm (0.5 feet) see **Figure 12C** and **Figure 12D**. Estimate the bank angle where it is obscured by vegetation.
   c. Bank angle
      1) Vertical (> 75^{o})
      2) Steep (30 – 75^{o})
      3) Gradual (<30^{o})
      4) Bank undercut? (Yes or No)

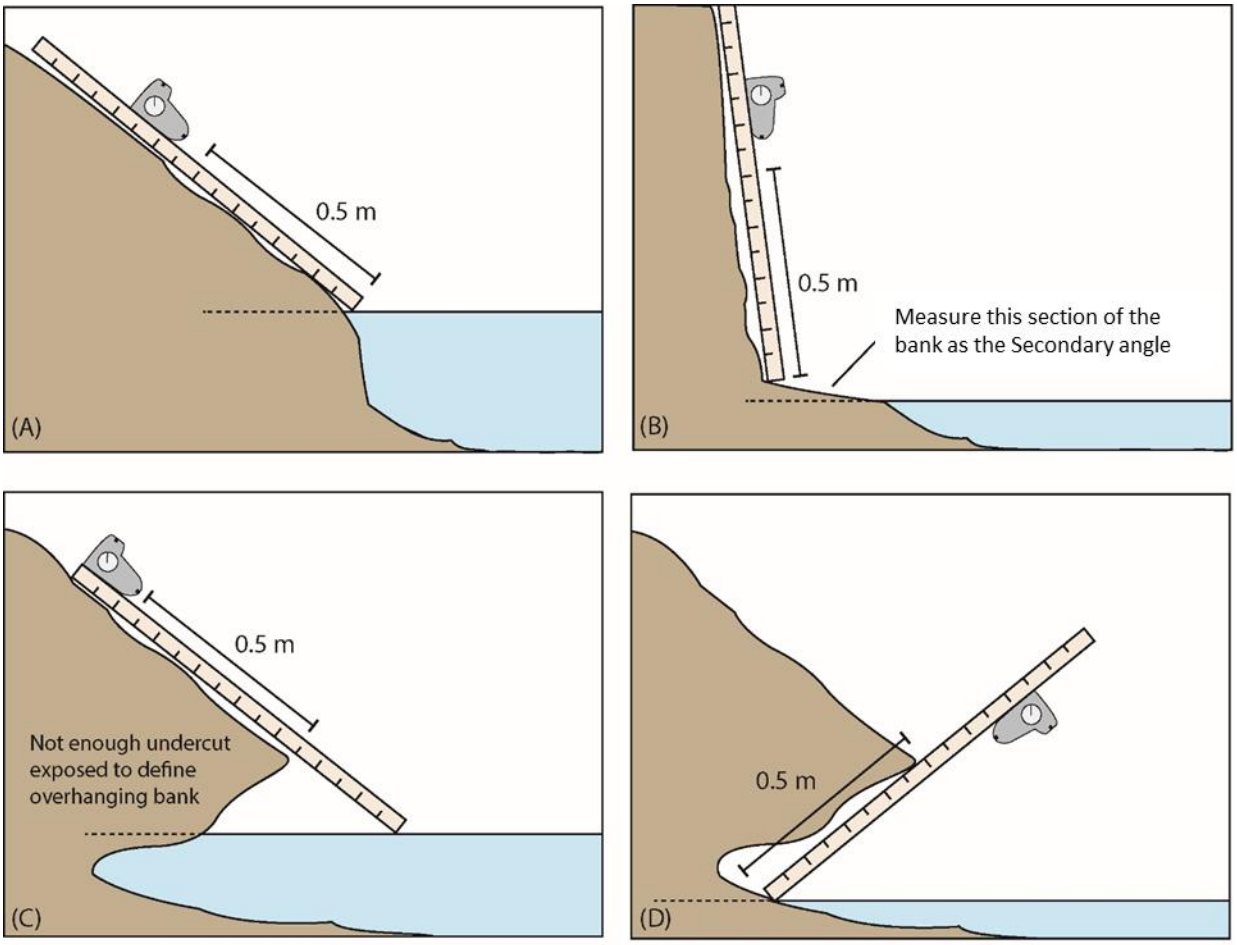

Figure 5. Determining shoreline bank angle for different bank types using a meter stick and clinometer. (A) Gradual shoreline (primary angle), (B) vertical bank (primary angle) incised channel (secondary angle), (C) gradual bank (primary angle) with an undercut stream bank (secondary angle), and (D) overhanging stream bank (primary angle).

8. Determine the Primary (> 50%) and Secondary (< 50%) *Bank Revetment* (artificial bank reinforcement structures, **Error! Reference source not found.**) through observations and record in Part C (2nd box) of the *Physical Habitat Characterization Datasheet* (Appendix A) or mobile device application.
    1) Hard Bank: Rip-rap, rock covering over the bank, usually large angular boulders, concrete blocks or rectangular gabion wire baskets
    2) In-Stream: Human-placed LWD, tree root wads , rock vanes, or J-hooks in the stream channel to modify flow
    3) Other: Soft armoring of the shore using planted trees, shrubs, and human-placed logs intended to stop erosion
    4) None

Figure 6. Examples of shoreline revetments a) rip-rap with rock, b) gabion baskets filled with rock, c) soft armoring using root wads and logs, and d) in-stream rock J-hook for modifying flow.

9. Determine the Primary (>30 %) and Secondary (10-30 %) *Bank Texture* through observations and note this in Part C (3rd box) of the *Physical Habitat Characterization Datasheet* (Appendix A) or with the mobile device application. The bank texture assessment is made along the transect line perpendicular to shore. While positioned at or near the bank, pick up or closely observe the composition of the bank substrate to estimate texture and classify using the following size categories:
   a. Bedrock: Very resistant to erosion
   b. Boulder/Cobble: Boulders >250 mm/cobbles 65 to 250 mm. Moderate resistance to erosion
   c. Gravel: 2 – 65 mm. Moderate to high erodibility when dominant component.
   d. Sand: 0.10 – 2 mm High bank erodibility when dominant component
   e. Silt: 0.02 – 0.10 mm. Non-cohesive with high to very high erodibility
   f. Clay: < 0.02 mm. Cohesive clays are relatively resistant to erosion

g. Mix: Variety of particle sizes (this is most appropriate for glacial till or where the bank texture is composed of several sizes of sediment and rock making it difficult to differentiate the dominant and subdominant components)

B.5 Ending the Riparian Assessment Day

Equipment maintenance, cleaning, and storage

a. Recharge all batteries.
b. Ensure all equipment is properly decontaminated and dry prior to storage according to the NEON Aquatic Decontamination Protocol (RD[07]).
c. Upload photos to the CI Dropbox by Domain. The following file structure is recommended:
   N:\DSF\CI Dropbox\DomainXX\AOS\YEAR\RiparianAssessmentPhotos\SITE.
   Example "N:\DSF\CI Dropbox\Domain 03\AOS\2018\Riparian Habitat Assessment Photos\BARC"
   Save each photo with the following file naming convention:
   SITE.DATE.Transect/Point#.Left/Right bank (streams). Example "HOPB.20180625.01.Left"

SOP C Data Entry and Verification

The importance of thorough, accurate data transcription cannot be overstated; the value of the efforts in the field is only manifested once the data are properly entered for delivery to NEON's end users. 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.

If paper datasheets are used, the procedure is as follows:

1. Enter data from field datasheets according to instructions in the NEON Protocol and Procedure: Manual Data Transcription (RD[04]).
2. Scan datasheets and save in PDF file format.
3. Save paper copy of datasheets.

SOP D **Sample Shipment**

There is no sample shipment for this protocol.

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APPENDIX A DATASHEETS

The following datasheets are associated with this protocol:

Table 5. Datasheets associated with this protocol

NEON Doc. #	Title
NEON.DOC.001646	General AQU Field Metadata Sheet
NEON.DOC.003156	Datasheets for AOS Protocol and Procedure: Riparian Habitat Assessment in Wadeable Streams
NEON.DOC.002764	Datasheets for AOS Protocol and Procedure: Riparian Habitat Assessment in Lakes and Non-Wadeable Streams

These datasheets are available in the NEON Document Warehouse.

APPENDIX B QUICK REFERENCES

B.1 Steps for Riparian Habitat Assessment

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

Step 2 – 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 0.3 m length of flagging to the bottom of densiometer for a height reference.

Step 4 – Ensure the General AQU Field Metadata Sheet (RD[06]) is completed on each field site visit.

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

Step 6 – At stream sites, measure Stream Canopy Cover Density at each of the 10 transects using the modified densiometer:

1. Measure the channel width at each transect and divide that number by 2 for the mid-channel distance.
2. While standing in the center of the stream (mid-channel), hold the densiometer level and 0.3 m above the water surface. Take four 17-point readings: a) facing upstream, b) left bank, c) downstream, and d) right bank. The observer remains at the center point in the stream, then pivots for each measurement.
3. Take 1 measurement from the left bank and right bank facing away from the stream into the terrestrial portion of the riparian transect for a total of 6 densiometer measurements per transects.

Step 7 – (All sites) Hierarchical Determination for Dominant System (See Appendix E):

1. Record the Subsystem and Class of the system
2. Record the Dominant Type of vegetation and the Sub-dominant species (if applicable)

Step 8 – (All sites) Riparian Vegetation Structure (See SOP B.4):

Stand in the center of the stream and make qualitative observations

1. Layers of Riparian Vegetation (Canopy, understory, ground cover)
2. Categorization of Cover (Type and Density)

Step 9 – (All Sites) Riparian Bank Characteristics (See SOP B.5):

1. Shoreline Bank Angle
2. Bank Revetment
3. Bank Texture

Step 10 – (All Sites) Take photos at all transect locations

1. Non-wadeable Streams and Lakes: collect a single photo at each transect.
2. Wadeable Streams: collect photos of the right and left bank at each transect
3. Record the photo number using the mobile device or datasheet

Step 11 – Navigate to the next riparian assessment location and repeat Steps 6-10 (wadeable streams) and Steps 7-10 (non-wadeable streams and lakes) until all 10 transects have been completed.

B.2 Locations for Riparian Habitat Assessment

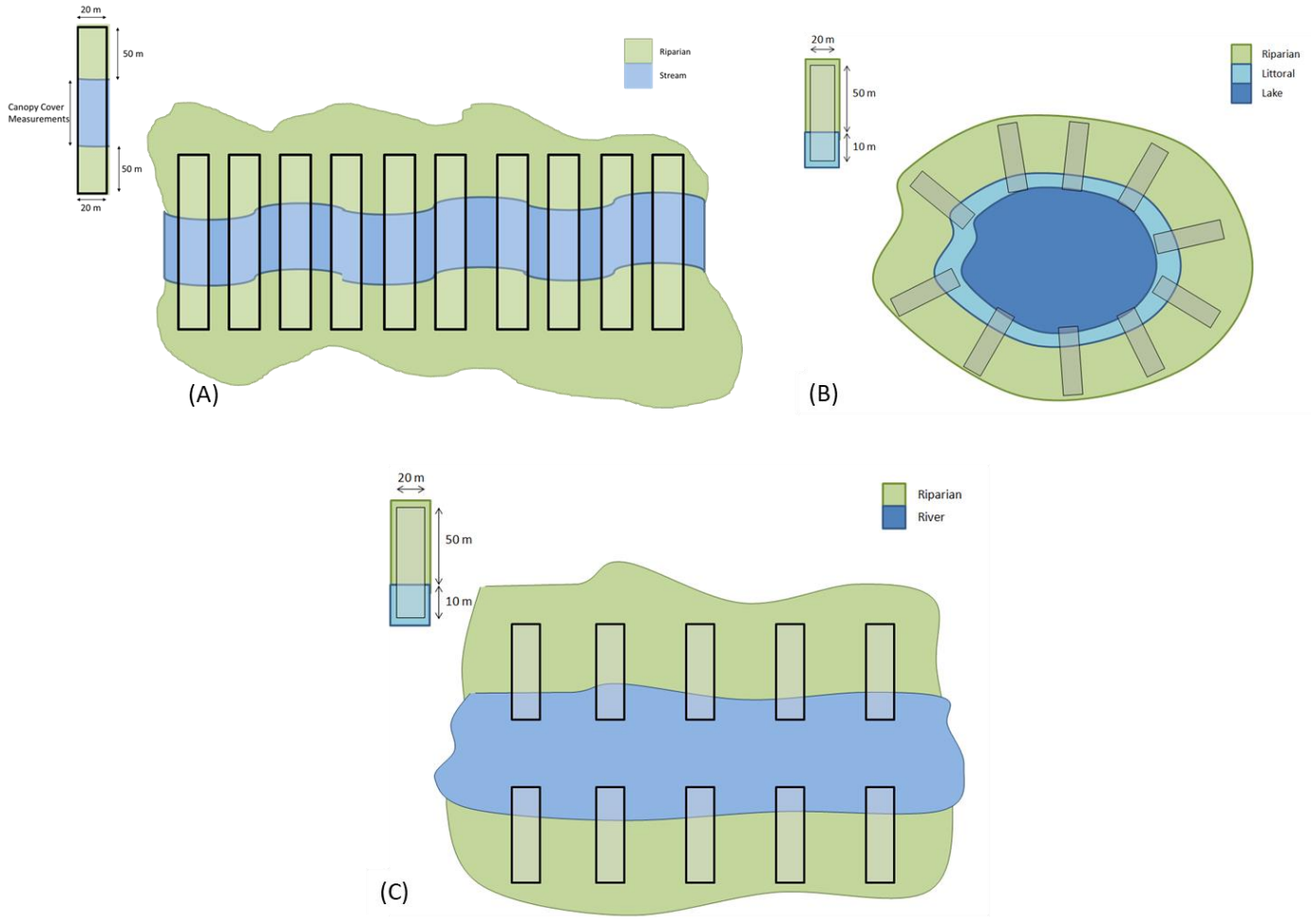

Figure 13. Riparian vegetation structure observation plots. (A) Wadeable streams, (B) lakes, and (C) non-wadeable streams (rivers).

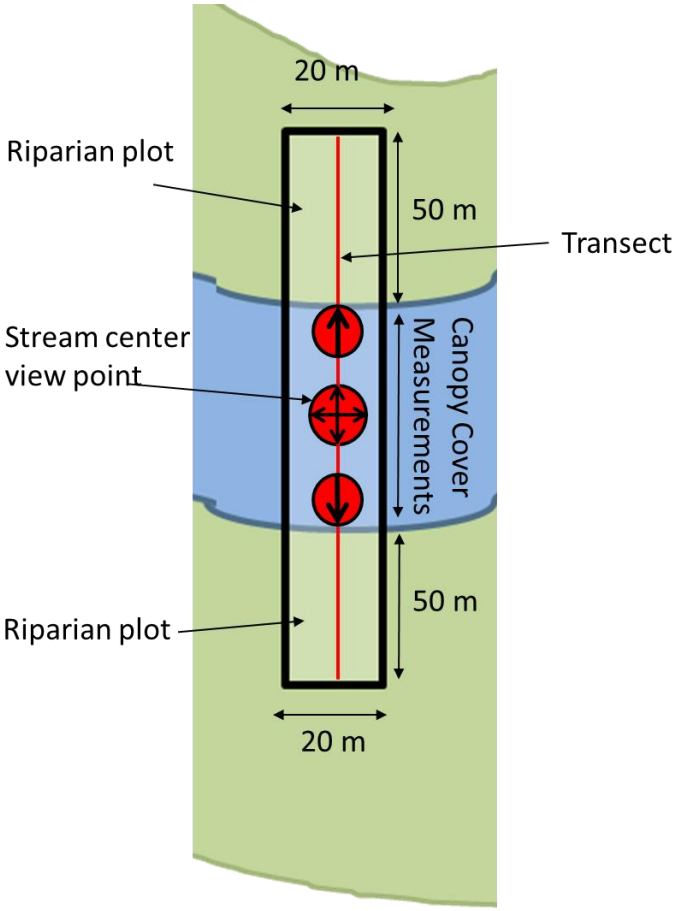

Figure 7. Conceptual illustration of transect and plot establishment at wadeable stream sites.

APPENDIX C REMINDERS

Before heading into the field: Make sure you…

- ☑ Collect and prepare all equipment and ensure batteries are charged.
- ☑ 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 and sensitive species of plants in your domain/sites.

While collecting data: Be sure to…

- ☑ Measure canopy cover at wadeable stream sites.
  - Using a convex spherical densiometer collect six measurements at each transect: 4 measurements in the four directions at mid-channel (upstream, left bank, downstream, and right bank)
  - Take 1 measurement from the left bank (looking away from the stream into the terrestrial portion of the riparian transect)
  - Take 1 measurement from the right bank (looking away from the stream into the terrestrial portion of the riparian transect) for a total of 6 measurements.
  - **REMINDER** left and right banks are defined while looking downstream.
- ☑ Hold the densiometer 0.3 meters above the water surface
- ☑ At all sites complete a separate *Physical Habitat Characterization* using the mobile application or the *Field Datasheet* for <u>each</u> transect.
- ☑ If unsure of or unable to determine the plant canopy cover type or encounter other issues, take a photo of the site and/or specimen and note this in the field metadata; include a comment on the *Physical Habitat Characterization* using the mobile application or the *Field Datasheet* as well.

Ending the day: Be sure to…

- ☑ Recharge all batteries.
- ☑ Ensure all equipment is properly decontaminated and dry prior to storage.
- ☑ Upload photos to the CI Dropbox by Domain and Site under “Riparian Assessment.”

APPENDIX D ESTIMATED DATES FOR ONSET AND CESSATION OF DATA COLLECTION

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

APPENDIX E RIPARIAN CLASSIFICATION SYSTEM

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**: Defines three categories reflecting the water source for the riparian area
   a) stream (moving water, shallow enough to safely wade)
   b) river (moving water, too deep of swift to safely wade)
   c) lake (standing water)
2) **Class**: Describes the habitat including substrate and the dominant life form of riparian vegetation. **Subclass**: Further describes the Class, defined under each applicable class.
   a) Rock Bottom - The Class Rock Bottom includes habitats with substrates having an areal cover of stones, boulders, or bedrock that is 75 % or greater and vegetative cover of less than 30 %
      i) Bedrock - Where bedrock is covering 75 % or more of the surface and less than 30 % areal coverage of macrophytes
      ii) 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
      i) 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
      ii) Sand - The unconsolidated particles smaller than stones are predominantly sand, although finer or coarser sediments may be intermixed
      iii) Mud - The unconsolidated particles smaller than stones are predominantly silt and clay, although coarser sediments or organic material may be intermixed
      iv) 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
      v) Vegetated – (Greater than 30% or less 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, semipermanently flooded, and seasonally flooded.

i) 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.

ii) 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

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

iv) 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 emergents, shrubs, or trees alone or in combination cover less than 30 %

i) 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

ii) 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

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

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

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

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

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

vi) 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

i) Broad-leaved Deciduous - In this Subclass, broad-leaved deciduous species have the greatest areal coverage in the scrub/shrub layer

ii) Needle-leaved Deciduous - In this Subclass, needle-leaved deciduous species have the greatest areal coverage in the scrub/shrub layer

iii) Broad-leaved Evergreen - In this Subclass, broad-leaved evergreen species have the greatest areal coverage in the scrub/shrub layer

iv) Needle-leaved Evergreen - In this Subclass, needle-leaved evergreen species have the greatest areal coverage in the scrub/shrub layer

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

vi) 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 - erect, rooted vegetation with herbaceous stems with at least 30 % areal coverage. Applicable water conditions include regularly flooded, permanently flooded, intermittently exposed, semipermanently flooded, and seasonally flooded.

i) 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

ii) 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

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

3) **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

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).
   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"; < 0.3 m 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** **> 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 (temporarily flooded)
iv) Bare dirt or duff

d) **Human**
i) 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 %

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.*

Bank Features

5. Bank angle
a) Vertical/Undercut >75° vertical
b) Steep 30 – 75°
c) Gradual <30°
d) Bank undercut? Yes or No
6. Bank Revetment
a) Hard Bank: Rock covering over the bank, usually large angular boulders, concrete blocks or rectangular gabion wire baskets
b) In-Stream: Human-placed LWD, tree root wads, rock vanes, or J-hooks in the stream channel to modify flow
c) Other: Soft armoring of the shore using planted trees, shrubs, and human-placed logs intended to stop erosion
d) None
7. Bank Texture
a) Bedrock: Very resistant to erosion
b) Boulder/Cobble: Boulders >250 mm/cobbles 65 to 250 mm. Moderate resistance to erosion
c) Gravel: 2 – 65 mm. Moderate to high erodibility when dominant component
d) Sand: 0.10 – 2 mm High bank erodibility when dominant component
e) Silt: 0.02 – 0.10 mm. Non-cohesive with high to very high erodibility
f) Clay: < 0.02 mm. Cohesive clays are relatively resistant to erosion

g) Mix: Variety of particle sizes (glacial till or where the bank texture is composed of several sizes of sediment and rock making it difficult to differentiate the dominant and subdominant components)

APPENDIX F EQUIPMENT MANUALS

Clinometer Manual (Forestry Suppliers 2006)

Laser Rangefinder Manual (Bushnell 2011)

Spherical Densiometer (Forestry Suppliers 2013)