AOS PROTOCOL AND PROCEDURE: RIPARIAN HABITAT ASSESSMENT

PREPARED BY	ORGANIZATION	DATE
Brandon Jensen	AQU	11/01/2016
Kaelin Cawley	AQU	06/01/2016
Charlotte Roehm	AQU	03/14/2013
Glenn Patterson	AQU	11/04/2011

APPROVALS	ORGANIZATION	APPROVAL DATE
Andrea Thorpe	SCI	04/10/2017
Mike Stewart	SE	04/05/2017

RELEASED BY	ORGANIZATION	RELEASE DATE
Jennifer DeNicholas	CM	04/10/2017

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.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

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).

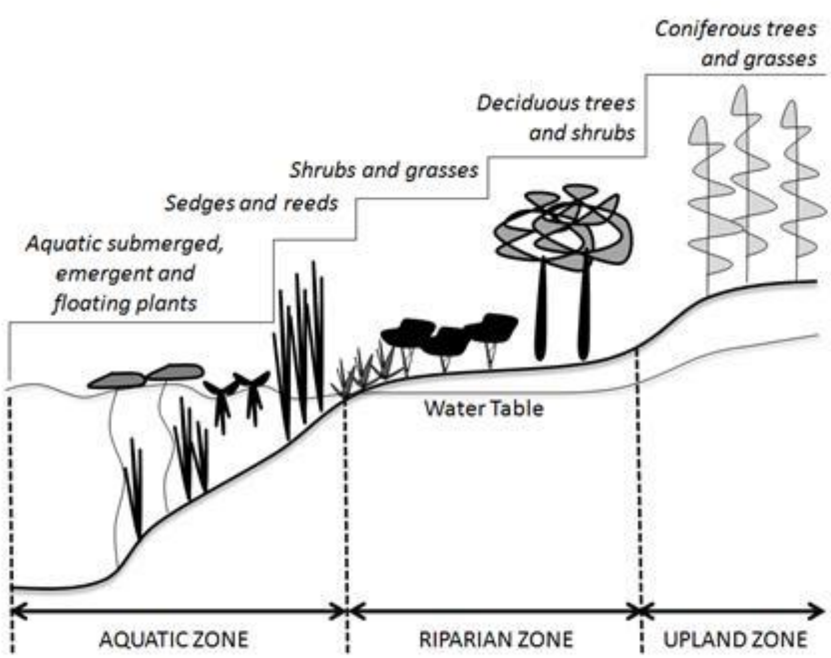

Figure 1. The riparian zone represents the land closest to the shoreline.

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 11Southern Plains; and d) NEON Domain 03 Southeast.

Water level fluctuations result in the establishment and presence of vegetation able to withstand wet and dry conditions and are an important buffer between the aquatic and terrestrial ecosystems.

Riparian areas play a critical role in water quality by filtering or absorbing contaminants from the upland landscape, or from floodwaters, through the provision of shade in shorelines that keeps water temperatures low, as a carbon source to streams through litterfall, for creating soil stability and sediment control, and by supporting wildlife habitat and food for fish 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. Exisiting remote sensing images, light detection and ranging (LIDAR), and other imagery available for interpretation may be dated and disturbances in the watershed can be rapid. Therefore, it is important to consistently verify and update the riparian assessments through annual site visits at the aquatic sites. The riparian habitat assessment will take place once per year during times of maximum canopy cover and coincide with the NEON Airborne Observation Platform (AOP) flights. Together, the remotely sensed data provided by the AOP will be ground-truthed via the riparain habitat assessment within the same time frame. The temporal window for performing the riparian habitat assessment was chosen to match the window for AOP flights of the aquatic sites, which were determined by the peak greenness for the closest terrestrial site. Peak greenness dates are 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. Most aquatic sites are co-located with terrestrial 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 10 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. In addition, there are three other aquatic sites that are too far away from a terrestrial site to be flown by AOP. For these sites, peak greenness was determined using the same algorithm for the aquatic site directly. For specific peak greenness temporal windows, see the Domain-specific sampling strategy documents referenced in RD[06]. The approach follows 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 approach is met 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	NEON Protocol and Procedure: Manual Data Transcription
RD[05]	NEON.DOC.001646	General AQU Field Metadata Sheet
RD[06]	NEON.DOC.001152	NEON Aquatic Sample Strategy Document
RD[07]	NEON.DOC.001154	AOS Protocol and Procedure: Aquatic Decontamination
RD[08]	NEON.DOC.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

Algal: In this subclass of 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.

Aquatic Bed: The Class Aquatic Bed includes habitats where plants and algae that 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.

Aquatic Moss: In this Subclass of Aquatic Beds, 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.

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

Bedrock: A cover class where bedrock is covering 75 % or more of the surface and less than 30 % areal coverage of macrophytes.

Canopy Closure: The amount of forest overstory measured with a densiometer from the center of the bankfull channel.

Cobble-Gravel: A cover class where the unconsolidated particles smaller than stones are predominantly cobbles and gravel. Shell fragments, sand, and silt often fill the spaces between the larger particles.

Dominant: The principal vegetative species prevalent in the area. Usually considered >30 % of the vegetative composition.

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

Floating Vascular: In this Subclass of Aquatic Beds, 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.

Forested: Woody vegetation more than 6 meters in height.

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

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

Hydrophytes: Plants that have adapted to live in water.

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

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

Lichen: The areal coverage of lichens exceeds that of mosses. Lichen Wetlands also are a Northern Subclass.

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

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 %.

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.

Mud: The unconsolidated particles smaller than stones are predominantly silt and clay, although coarser sediments or organic material may be intermixed.

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.

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.

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

Persistent: Persistent emergents are emergent hydrophytes whose stems and leaves are evident all year above the surface of the water or above the soil surface if water is absent.

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

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.

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

Rock Bottom: The Class Rock Bottom includes habitats with substrates having an areal cover of stones, boulders, or bedrock 75 % or greater and vegetative cover of less than 30 %.

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

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 %.

Sand: The unconsolidated particles smaller than stones are predominantly sand, although finer or coarser sediments may be intermixed.

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.

Unconsolidated Bottom: The Class Unconsolidated Bottom includes habitats with at least 25 % cover of particles smaller than stones and a vegetative cover less than 30 %.

Vegetated: Some Streambeds, with at least 30 % plant cover, 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.

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

3 METHOD

This protocol is intended to provide a rapid estimate of the riparian vegetation, human impacts, and bank characteristics, which buffer the permitted banks of lakes, rivers, and streams. Field data collection undertaken as part of this protocol consists of the following steps:

1. Walk or boat around the site within the permitted boundaries and conduct vegetation cover and composition observations at specified transect GPS 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.

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]). Provide a reasonable estimate of all surveyed parameters. Lake and non-wadeable stream 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 (**Figure 3**). Wadeable stream riparian habitat assessment occurs by identifying 10 transects spread equally throughout the aquatic sampling reach (**Figure 4**). 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]). Riparian habitat assessment surveys are conducted off shore using a boat at lakes and rivers or from the center of the channel in wadeable streams. A photo is taken at each transect location for future reference and archived appropriately.

The riparian portion of the plot 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. In this zone, technicians record information about the vegetation type and the height and areal coverage of trees, shrubs, and grasses using an inclinometer or rangefinder (**Figure 5**). 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 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.

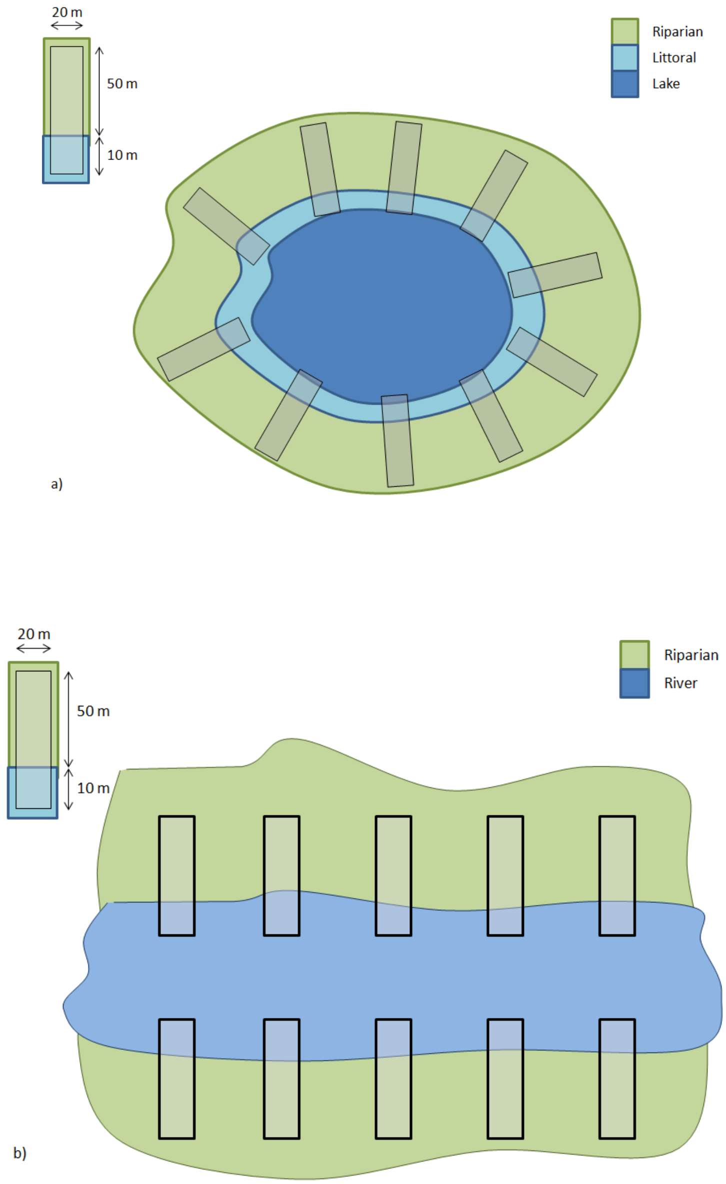

Figure 3. Sketch of riparian habitat assessment set-up and scheme for a) lakes; and b) non-wadeable streams.

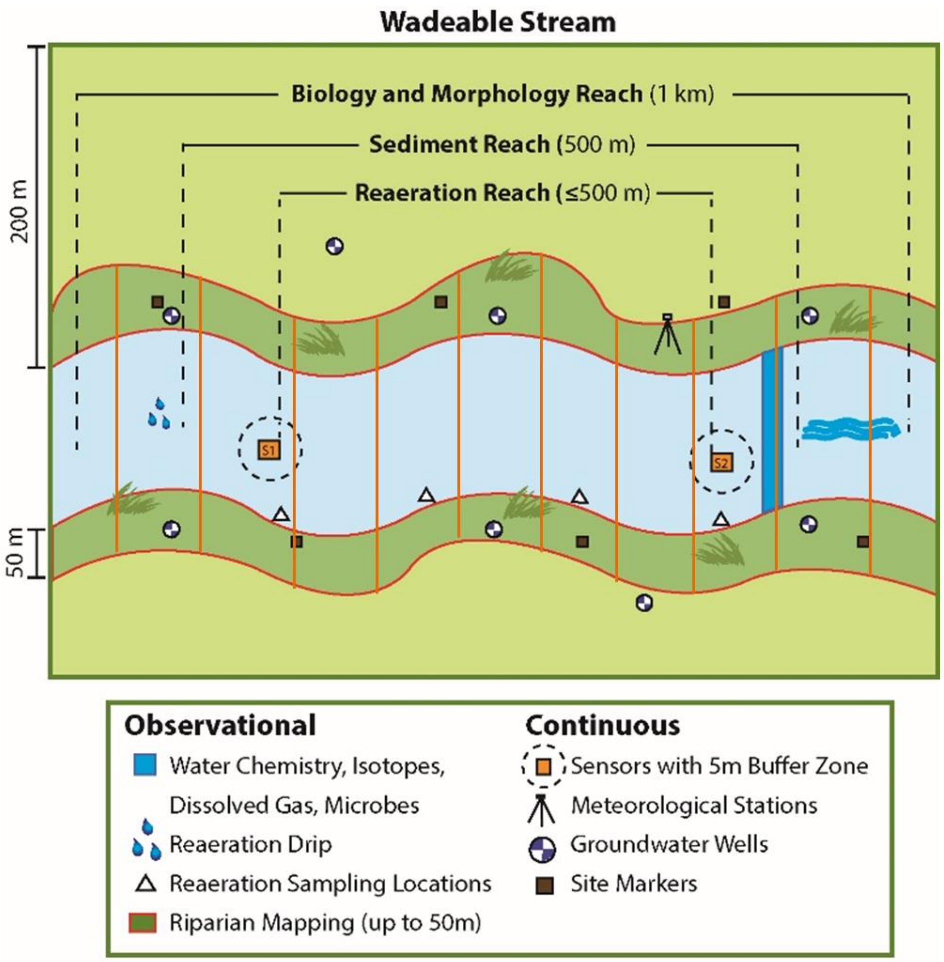

Figure 4. A generic wadeable stream site layout with riparian habitat assessment transect locations distributed throughout the 1 km biology and morphology sampling reach.

Figure 5. 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 transect width.
- This method follows Ode (2007) which uses the Strickler modification (17-point) of a convex spherical densiometer (**Figure 5**) 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 technicians **must** follow the protocol and associated SOPs. Use NEON's problem reporting system to resolve any field issues associated with implementing this protocol.

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

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

4 DATA COLLECTION SCHEDULE

4.1 Frequency and Timing

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. The time window for performing the riparian habitat assessment was chosen to match the window for AOP flights of the aquatic sites, which were determined by the time window of peak greenness for the closest terrestrial site. 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 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 3 aquatic sites that are too far away from a terrestrial site to be flown by AOP. For these 3 sites (BLUE, SYCA and MCRA), peak greenness was determined using the same algorithm for the aquatic site directly.

4.2 Criteria for Determining Onset and Cessation of Field Data Collection

Riparian habitat field data collection occurs during the period of maximum vegetation cover and 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). Maximum vegetation cover date ranges are determined using MODIS data and growing degree days (GDD). The specific times are determined using multivariate statistics and site specific historical information (see RD[06]).

4.3 Timing for Laboratory Processing and Analysis

There is no domain lab processing for this protocol.

4.4 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 lake shore (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	No adverse outcome.

Delay/ Situation	Action	Outcome for Data Products
	the field data sheet. Proceed by walking, driving, or boating along the edge of the water body and make observations where possible.	
	If the depth of water in the thalweg of the stream is too deep or the flow is too fast for safe wading, record conditions and comments on your field datasheet. If the edge of the lake or non- wadeable stream is not accessible within 10 meters for the riparian assessment due to, for example, thick emergent aquatic vegetation, estimate the closest distance to the lake shore. Then continue as detailed in the protocol.	No adverse outcome.
Days	If the weather, current, or other unsafe conditions prohibit in water work (wading) field activities, stop and resume as soon as safe conditions are met. Unless physical change or more than one week has passed as a result 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 or if the vegetation cover has changed significantly. Contact the protocol author if the restart time occurs outside of the peak greenness window.	No adverse outcome.

5 SAFETY

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

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

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 technicians may complete observations without dismounting from the vessel. In addition, the technicians are required not to put hands and feet in waters where alligators or other submerged wildlife dangers are present and to make sure a safe distance from hazards is maintained.
2. All personnel must be wearing a personal flotation device (PFD) prior to entering and while in the boat.
3. 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).
4. All employees shall have access to a form of communication with other team members such as a two-way radio.
5. Technicians should be aware of any site-specific hazards and the waters of that particular location (i.e. current 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.	R/S	Description	Purpose	Quantity	Special Handling
Durable items					
	S	Personal flotation devices	Safe wading	1 per person	N
	R	GPS unit	Navigating to sampling locations and establishing transects	1	N
	R	Surveyor's tape measure 50 m or 100 m	Establishing transects	1	N
	R	Permanent transect marker rods	Establishing transects	22	N
MX102980	R	Suunto Clinometer	Determining shoreline bank angle	1	N
MX100348	R	Spherical Densiometer	Determining canopy cover	1	N
	R	Monopod	Affixing the densiometer for consistent heights	1	N

Item No.	R/S	Description	Purpose	Quantity	Special Handling
MX104742	S	Rangefinder (shared with FSU)	Determining angles, distance and height (alternate to using the clinometer)	1	N
	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
	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
	R	First aid kit		1	N
	R	Waders	Safe wading	1 per person	N
Consumable items					
	R	Canopy Cover Datasheets	Recording data	1	N
	R	Physical Habitat Characterization Datasheets	Recording data	10	N

Item No.	R/S	Description	Purpose	Quantity	Special Handling
	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.	R/S	Description	Purpose	Quantity	Special Handling
Durable items					
	R	Meter stick (1 m)	Use with clinometer to measure bank angle	1	N
MX102980	R	Suunto Clinometer	Determining shoreline bank angle	1	N
	R	Lake or Non-wadeable stream map	Navigating to sampling locations	1	N
	R	Quick reference field operations handbook	References	1	N
	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	Sonar with GPS antenna	Navigating to sampling locations	1	N
	R	Memory card	For camera and sonar	3	N
	R	Handheld GPS unit	Navigating to sampling locations	1	N
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	12 V small batteries (1.5 v AA alkali)	For GPS unit	2	N

R/S=Required/Suggested

Table 4. Equipment list – General boating equipment

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable items					
	R	Boat		1	Y
	R	Anchor with rope		1	N
	R	Oars		2	N
	R	Trolling Electric Motor		1	Y
	R	Battery (12 volt)		1	Y
	R	Safety kit for boat (e.g., flares, bailer, float with rope)		1	Y
	R	First Aid Kit		1	N
	R	Personal Flotation Devices (PFDs)		1 per person	N
Consumable items					

Item No.	R/S	Description	Purpose	Quantity	Special Handling
		(none)			

R/S=Required/Suggested

6.2 Training Requirements

All technicians 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 2 technicians 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. Mobile devices should be fully charged at the beginning of each field day, whenever possible.

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.

(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. Fully charge all batteries and electronic equipment. IMPORTANT: Ensure all batteries and electronic equipment are fully charged, even if new.
4. Ensure all equipment that will touch the water is decontaminated with bleach (see 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. The cross-section transect locations will be established at NEON headquarters for lakes, river, and stream sites (**Figure 3**, **Figure 4**, **Figure 7**). Before heading out to the field, confirm the location of cross-section transects. Ten cross-section transects are placed at equal intervals along the aquatic sampling reach length, but not greater than 100 m apart within a 1 km NEON aquatic reach at stream and river sites. For lake sites the transects will be spaced as evenly as possible around the lake perimeter. These transects shall not be located on the same transects as the biological sampling cross-sections. Install and monument the transect locations with the permanent monument markers on either the right or left bank above the high water mark.
7. **For stream sites** (For lake sites, skip to step 8), where canopy cover will be estimated using a densiometer:
   a. Prepare the densiometer before heading out into the field (Figure 6). 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 6). Dots should be added with a permanent marker where the lines intersect on the **convex** densiometer.

b. The densiometer should be semi-permanently mounted to a monopod. When reading from the densiometer in the center of the stream the mono-pod, in conjunction with the bubble level, will allow for the technician to maintain the densiometer position as they move around it to face all four directions. The monopod can be marked to ensure a height of 30 cm above the water surface, when taking measurements in the center of the stream, or ground surface, when taking measurements at either bank.

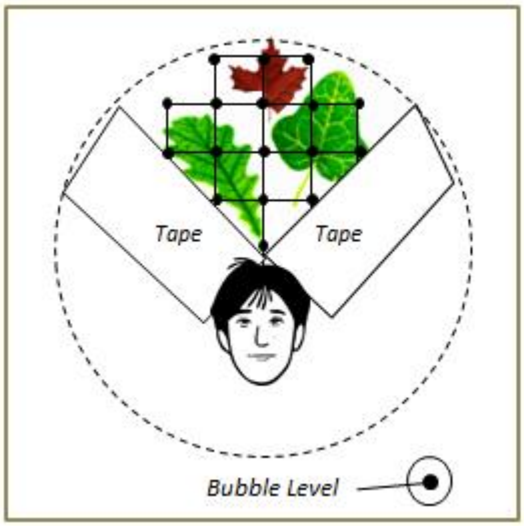

Figure 6. Preparing and reading a densiometer

8. 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**.”
9. 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 gage. Enter the staff gage height on 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 of right bank. On the *Physical Habitat Characterization Form* estimate and record the distance along the transect in 10 m increments that the riparian habitat observations include at each transect (left and right bank). 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).

Canopy cover over the stream is measured at each of the 10 stream cross-section transects using a monopod mounted **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 banks); 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.

1. Using the *Canopy Cover Datasheet*, enter the appropriate header data (site ID, technician ID, collection date, start time, protocol number, and revision number).
2. Begin at the farthest downstream location. Affix the tape measure along the 1st transect from the left to the right bank.
3. On the datasheet, record the water depth in the thalweg where the transect crosses the stream.
4. Record the wetted width (m) then divide that number by 2 for the mid-channel distance. Record the mid-channel point (m).
5. Stand in the 1st transect (Figure 7) at mid-channel facing upstream.

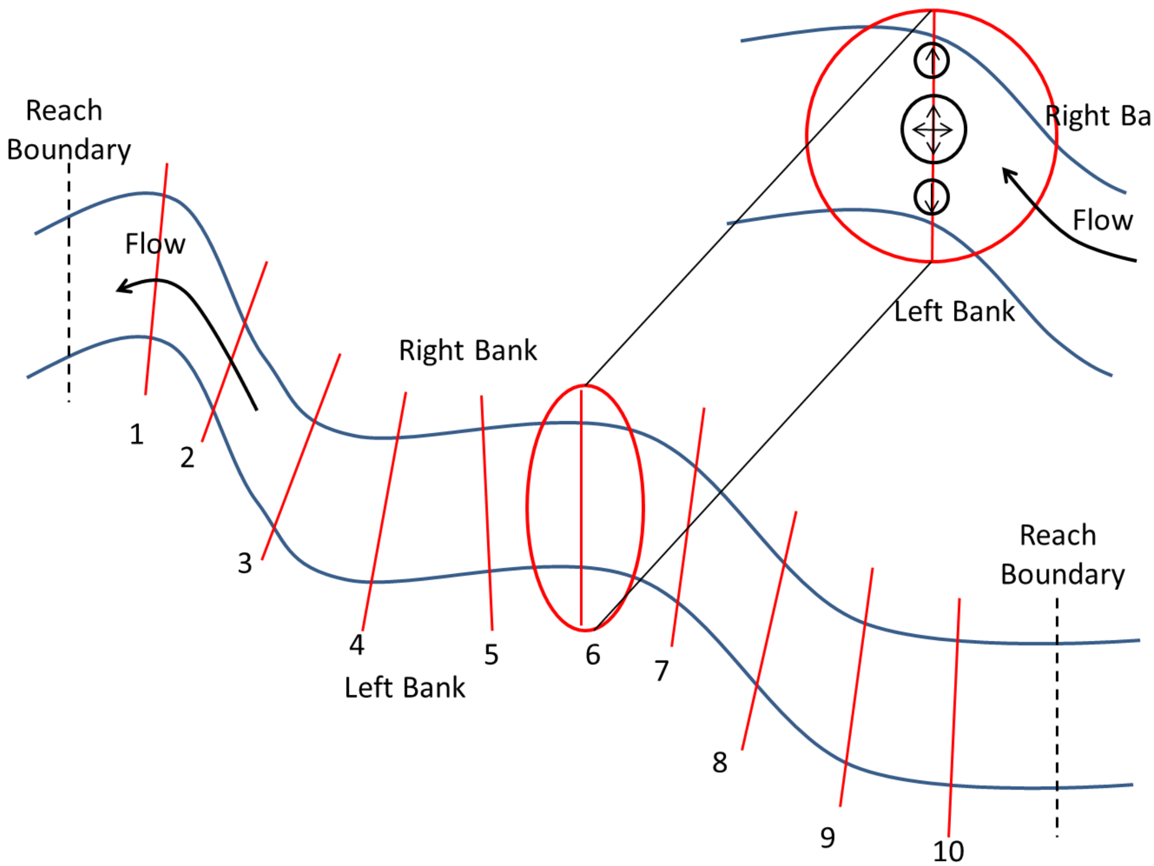

Figure 7. Location of 10 transects in the stream and sub-location of data collection points within each transect (Modified from Kaufmann, 2001).

6. Measure and record overstory canopy cover from the stream center (mid-channel).
   a. Affix the densiometer to the monopod at 0.3 meters above the water surface. This avoids errors stemming from people of different heights and water of varying depth.
   b. Tilt the monopod such that the densiometer is level, use the level bubble indicator and hold so the reflection of the top of your head just touches the point of the "V", as in (**Figure 6**).
   c. Count the number of points covered by vegetation and enter this value in 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 while pivoting around the monopod. Take a reading once each while facing upstream, left bank, downstream, and right bank.
   e. As you change direction be sure to keep the base of the monopod in the same location and pivot around the densiometer so that it does not change location. Be sure to read the densiometer when it is level after pivoting.
   f. Record the values on the *Canopy Cover Datasheet* under "Center-Upstream", "Center-River Left", "Center-Downstream", and "Center-River Right".

7. Measure and record the number of points covered (of 17 points) on the densiometer standing 0.3 m from the water's edge on the LEFT bank facing into the terrestrial portion of the riparian transect, away from the stream. Take only one reading at this bank. Set up the monopod such that the densiometer is 0.3 m above the land surface and it is level.
   a. Record the values on the *Canopy Cover Datasheet* under "Left Bank-River Left".
8. Measure and record the number of densiometer points covered standing 0.3 m from the water's edge on the RIGHT bank facing into the terrestrial portion of the riparian transect, away from the stream. Take only one reading at this bank. Set up the monopod such that the densiometer is 0.3 m above the land surface and it is level.
   a. Record the values on the *Canopy Cover Datasheet* under "Right Bank-River Right".

B.4 Physical Habitat Characterization

1. Using the *Physical Habitat Characterization Datasheet* (RD[10] and RD[11]), enter the appropriate header data (site ID, technician ID, collection date and start time, and transect number). Also, be sure to include the observed transect distance for each bank and ensure that the current gage height is recorded.
   a. The focus of this riparian vegetation habitat assessment is to record observations of riparian vegetation and habitat; do not record littoral vegetation observations.
2. **In streams**, stand in the middle of the stream (or where safe and both banks are in view) on the transect. Make observations from this location; do not move to improve the viewing position unless there is a safety reason. 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 (JIRA). 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); record the photo number.
3. **In lakes and rivers**, Position the boat at a distance of 10 m (~30 ft., offshore), anchor if necessary. 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. Note in the metadata the approximate distance from shore that the observations were made. 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 (JIRA). 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 9** and **Figure 10**).
4. In Part A of the *Physical Habitat Characterization Datasheet* (RD[10] and RD[11]), 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 %).

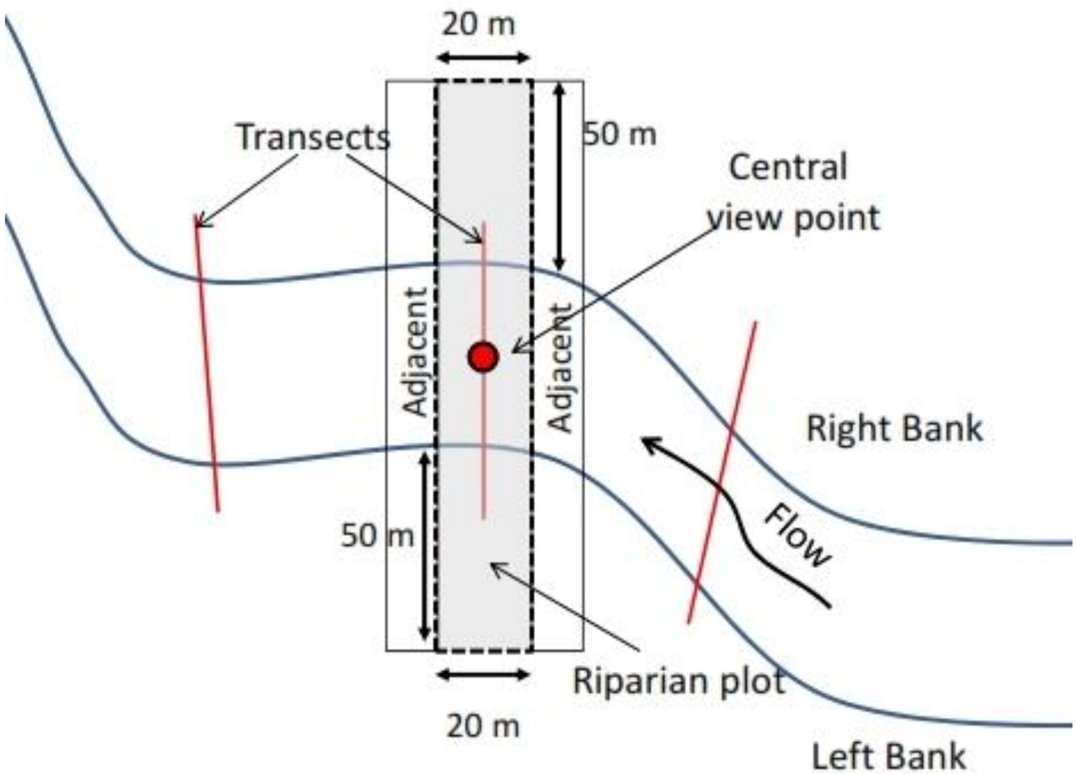

Figure 8. Determining the transects for riparian vegetation structure observations at each transect.

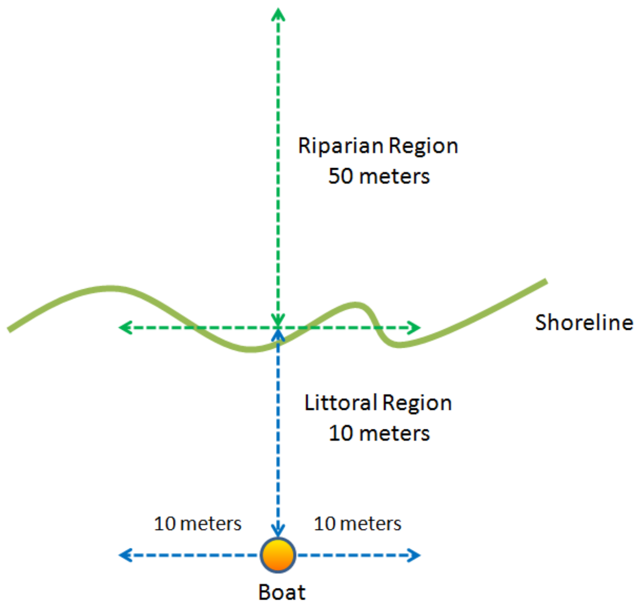

Figure 9. Positioning of boat for riparian assessment at each location. The distance to the shoreline and the approximate location size of the riparian zone are also shown.

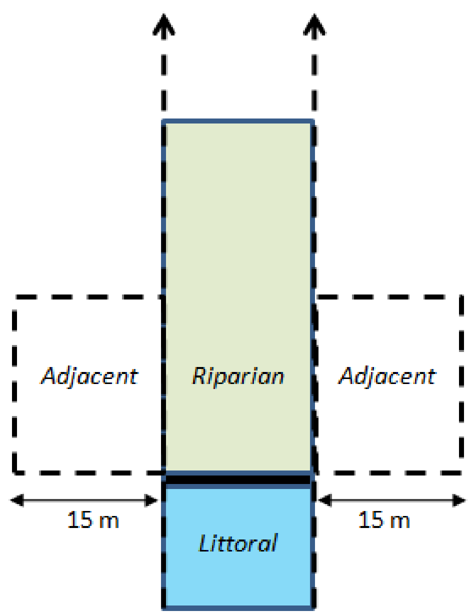

Figure 10. Location of adjacent areas around riparian assessment zone.

5. Using Part B of the *Physical Habitat Characterization Datasheet*, record estimates of riparian vegetation structure and composition. Include observations at three levels: the canopy layer (> 5 m high), understory (0.5 – 5.0 m high), and the ground cover layer (< 0.5 m high). Additionally, observations of human land use activities and disturbances shall be recorded. Observations of

riparian areal cover may total up to more than 100 % if each for cover type canopy, understory, and ground cover is recorded as ">75%."

6. Estimate the areal coverage for each of the upper two vegetation layers (canopy and understory only), record the type of vegetation (including trees, shrubs, herbs, grasses, and forbs) that occurs by indicating the presence of Deciduous (D), Coniferous (C), Broadleaf Evergreen (E), Mixed (M), or None (N). A mixed vegetation layer is considered mixed if the more than 10% of the areal coverage is composed of an alternate vegetation type.
7. Record the semi-quantitative (categorical) measurements on the *Physical Habitat Characterization Datasheet*, for each of the three vegetation layers and human influences.
   a. 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
      4) **Human**
         a) 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.
   b. Categorization of Cover:
      1) Absent = 0%
      2) Sparse > 0 - 10 %
      3) Moderate > 10 - 40 %
      4) Heavy > 40 - 75 %
      5) Very Heavy > 75 %
   c. Complete a separate *Physical Habitat Characterization Datasheet* for each transect.
8. Record on the datasheet 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 (Figure 10). This is particularly important where human disturbance is evident (i.e. house, road, boat ramp, lawn, power lines, garbage etc.).
9. Make every reasonable attempt to record physical habitat observations and measurements for all 10 riparian transects. Where this is impossible, indicate this information in the metadata and make a comment field on the *Physical Habitat Characterization Datasheet*, (RD[10] (streams) and RD[11] (lakes/non-wadeable streams)) to clearly indicate that no observations could be

made for a given feature at that particular riparian transect (EPA 2007; Field Operations Manual).

10. 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.

B.5 Riparian Bank Characteristics

1. Using Part C of the *Physical Habitat Characterization Datasheet* enter data from the following observations.
    a. Determine the Dominant (>50%) and Sub-dominant (<50%) *Bank Angle* in Part C (1st box) using the clinometer and the meter stick, record the information in the *Physical Habitat Characterization Datasheet* (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 dominant angle. Place the clinometer on the meter stick; read and select the appropriate bank angle range to record in degrees (**Figure 11**).
    b. There may be a variety of angles. If two bank angles predominate, tick both and estimate which one is dominant (>0.5 m). The longest section of the bank is considered dominant; the shorter section is sub-dominant (<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. Estimate the bank angle where it is obscured by vegetation.
        1) Vertical/undercut > 75°
        2) Steep 30 – 75°
        3) Gradual < 30°

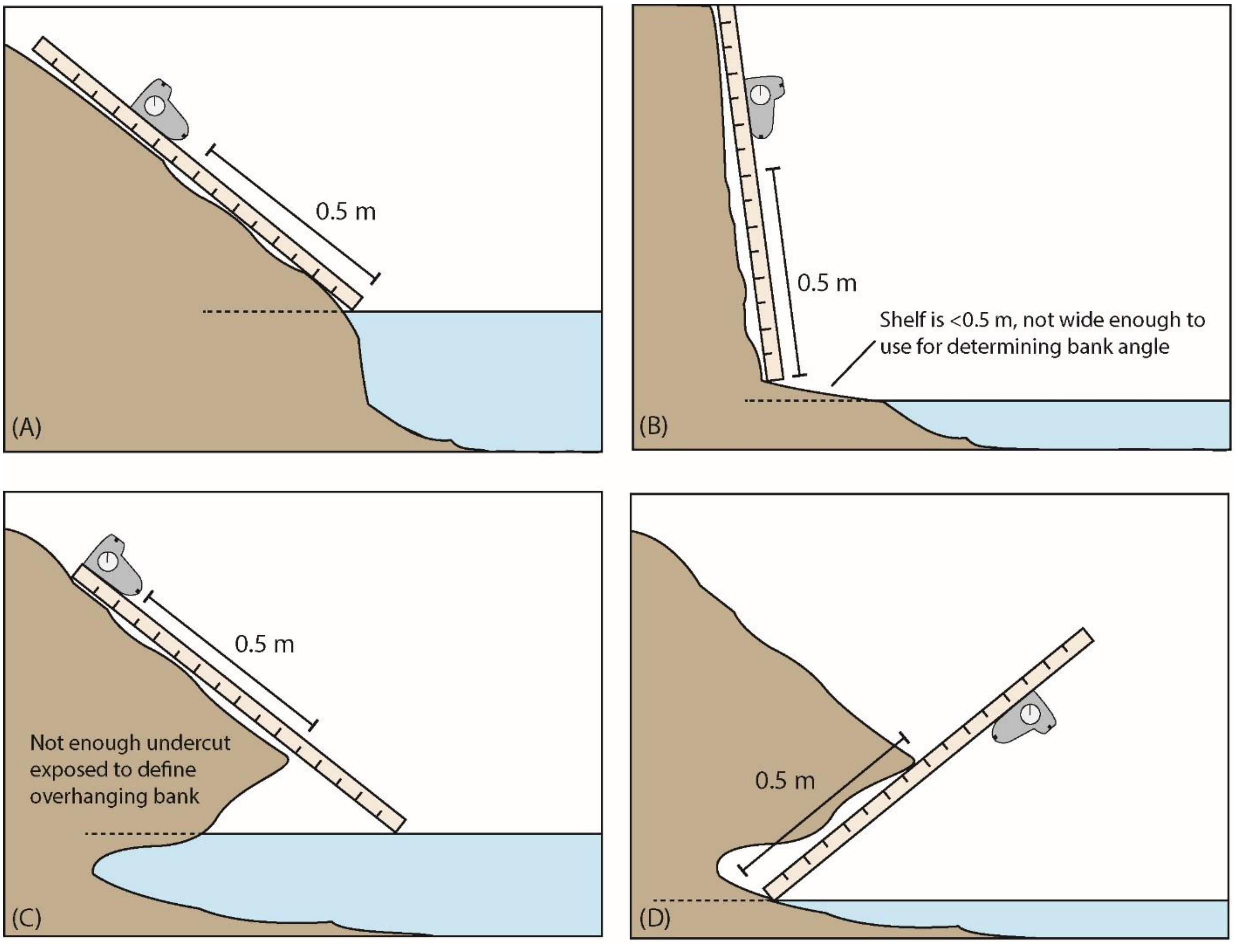

Figure 11. Determining shoreline bank angle for different bank types using a meter stick and clinometer. (A) Typical shoreline, (B) incised channel, (C) undercut stream bank, and (D) overhanging stream bank.

2. Determine the *Bank Revetment* (artificial bank reinforcement structures, **Figure 12**) through observations and record in Part C (2nd box) of the *Physical Habitat Characterization Datasheet* (Appendix A).
    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 12. 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.

3. Determine the Dominant (>30 %) and Sub-dominant (10-30 %) *Bank Texture* through observations and note this in Part C (3rd box) of the *Physical Habitat Characterization Datasheet* (Appendix A). 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 (i.e. glacial till)

B.6 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]).

SOP C 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.

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 can be found 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 densiometer and measure and record the number of filled points.

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

Step 5 – At stream sites, measure Stream Canopy Cover Density:

1. Measure canopy cover over the stream at each of the 10 transects using a convex spherical densiometer.
2. Measure the wetted width at each transect and divide that number by 2 for the mid-channel distance.
3. Take measurements in the four directions at mid-channel (pivoting around the monopod), and 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 measurements.

Step 4 – (All sites) Navigate to the first riparian assessment location.

Step 5 – Riparian Vegetation Structure:

Stand in the center of the stream and make qualitative (observational) measurements

a. Layers of Riparian Vegetation
b. Categorization of Cover

Step 6 – Riparian Bank Characteristics:

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

B.2 Locations for Riparian Habitat Assessment

Figure 13. Location of 10 transects in the stream and sub-location of data collection points within each cross-section transect:

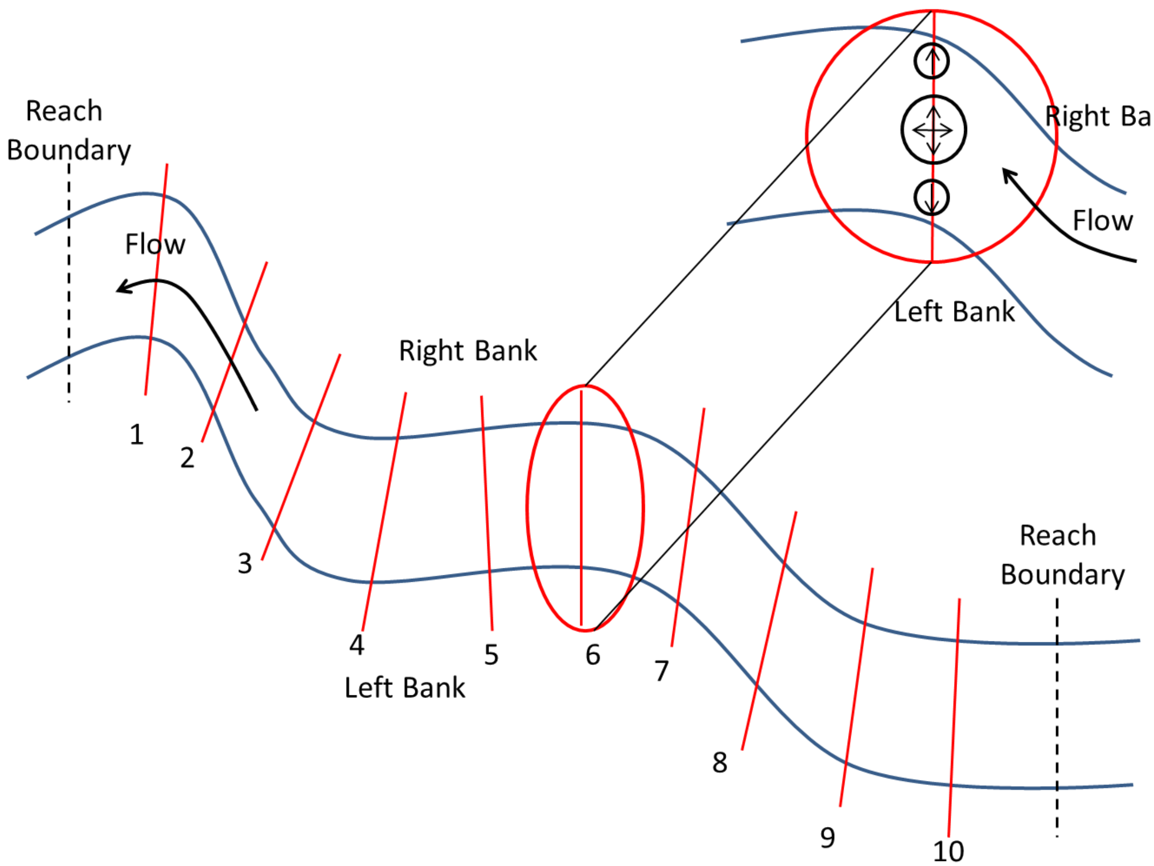
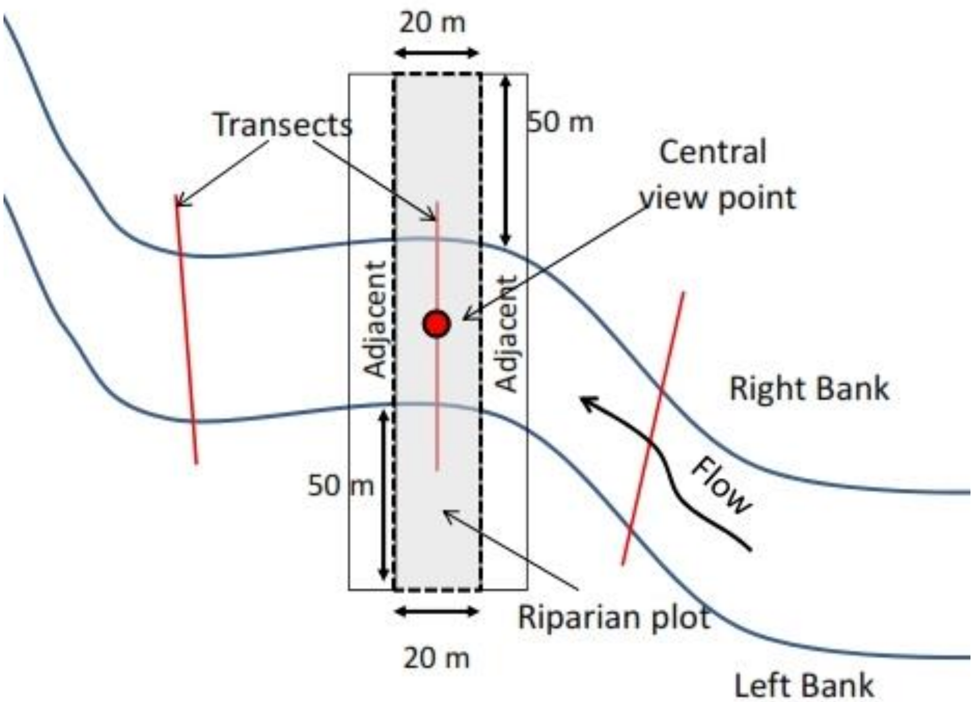
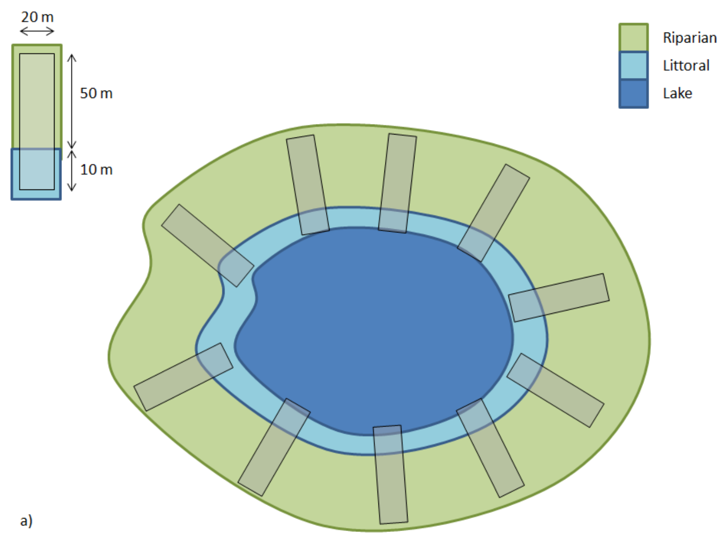


Figure 14. Riparian vegetation structure observation transects:

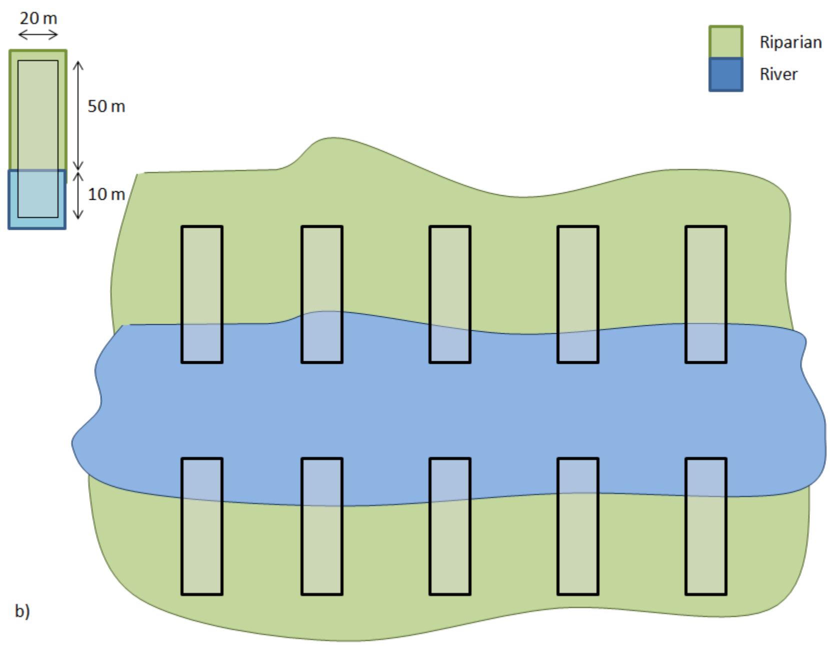
1. Streams



2. Lakes



3. Non-Wadeable Streams



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), and 1 measurement from the left bank (looking away from the stream into the terrestrial portion of the riparian transect) and 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 using the monopod.
- ☑ At all sites complete a separate *Physical Habitat Characterization Datasheet* for each 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 Datasheet* as well.

Ending the day: Be sure to…

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

APPENDIX D ESTIMATED DATES FOR ONSET AND CESSATION OF 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 dominant non-hydrophytic 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 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 particles smaller than stones and a vegetative cover less than 30 %
      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 - 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

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

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) 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

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) 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
   i) Persistent - Persistent emergents are emergent hydrophytes whose stems and leaves 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. The description for the dominant species type (>30 % species composition) will 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) 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.
2) Categorization of Cover:
   a) Absent 0%
   b) Sparse > 0 - 10 %
   c) Moderate > 10 - 40 %
   d) Heavy > 40 - 75 %
   e) Very Heavy > 75 %

Bank Features

1) Bank angle
   a) Vertical/Undercut >75° vertical
   b) Steep 30 – 75°
   c) Gradual <30°
2) 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
3) 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 (i.e. glacial till)
4) Water Level Fluctuations
   a) High mark
   b) Current gage height

APPENDIX F EQUIPMENT MANUALS

Clinometer Manual (Forestry Suppliers 2006)

Laser Rangefinder Manual (Bushnell 2011)

Spherical Densiometer (Forestry Suppliers 2013)