AOS PROTOCOL AND PROCEDURE:
RIPARIAN HABITAT ASSESSMENT IN WADEABLE STREAMS

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	07/02/2014	ECO-01124	Initial release
B	01/08/2015	ECO-02270	Revision
C	01/26/2015	ECO-02636	Migration to new protocol template
D	02/29/2016	ECO-03672	Major revisions based on technician review including title change, transect locations, photo documentation, and figure updates

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1 OVERVIEW

1.1 Background

Riparian areas are ecosystems adjacent to streams, rivers, lakes, wetlands, and floodplains that form complex and interrelated hydrological systems (Verry et al., 2000). 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). 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 variability and ecologically diverse 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).

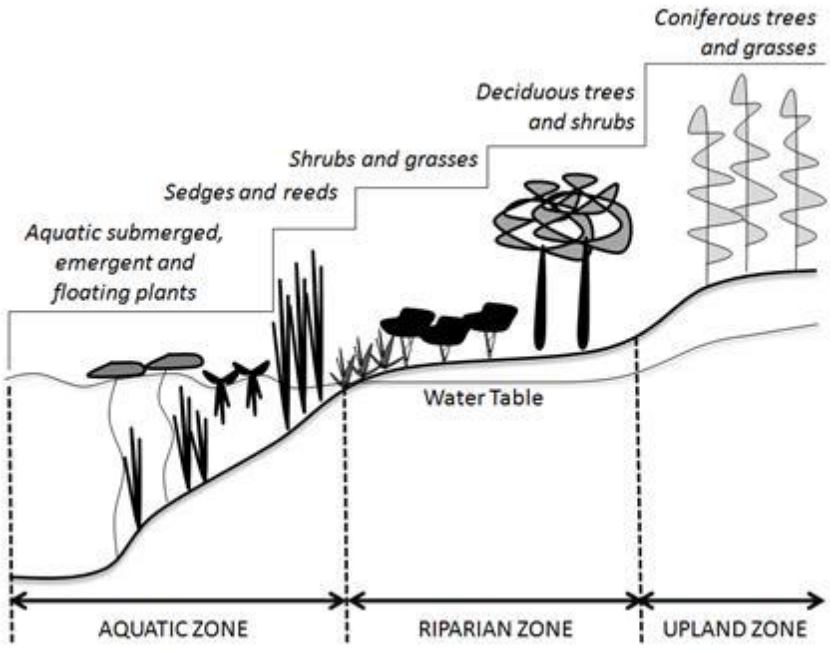

Figure 1. The riparian zone represents the land closest to the shoreline.

Figure 2. Examples of riparian habitats in different eco-climatic regions. a) D10 Central Plains; b) D18 Tundra; c) D11 Southern Plains; and d) D01 Northeast.

Water level fluctuations result in the establishment and presence of vegetation able to withstand wet and dry conditions and are, therefore, 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 providing wildlife habitat and food for fish and other aquatic organisms. These areas also provide nearshore habitat structural elements, such as 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).

The overall objective of riparian habitat mapping is to provide accurate and up-to-date data of riparian cover composition, distribution, and interspersion of riparian habitats within the study area and enable identification of potential change over time. Since the remote sensing images and imagery available for

interpretation may be dated and disturbances in the watershed can be rapid, it is important to consistently verify and update the maps through annual site visits. Stream riparian sampling will take place once per year preferably at low-flow conditions and during times of maximum canopy cover. The approach follows a modified version of the U.S. Environmental Protection Agency's EMAP (Kaufmann 2001) protocol. 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 within the permitted sampling reach.

1.2 Scope

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

1.2.1 NEON Science Requirements and Data Products

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

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

1.3 Acknowledgments

This protocol is based on modified versions of the U.S. Environmental Protection Agency (2008) and U.S. Fish and Wildlife Service (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.014051	NEON FSU Field and Laboratory Procedures Quality Assurance 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	TOS 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.003156	Datasheets for AOS Protocol and Procedure: Riparian Habitat Assessment in Wadeable Streams

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

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

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

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

Forested: Woody vegetation more than 6 meters in height.

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

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

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

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

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

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

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

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

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

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 which buffers the permitted reach. Observations derived from the riparian habitat assessment will ground truth NEON airborne observations within NEON stream sites. Orthoimagery are available through the U.S. Geological Survey (2016). "The National Map" or Google Earth are provided as baseline images of the riparian habitat. These base maps should be reviewed before each riparian habitat assessment to become more familiar with the site. Print out a paper copy of the Riparian Locations map from the AOS Site Specific Sampling Strategies document and bring the map out to the field. The paper map can be used to document observations that would otherwise not be detected outside of the designated riparian stations. For sites which prove to be difficult to access, this mapping component will prove critical for following long term changes in the habitat cover type and density.

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

1. Walk around the site within the permitted boundaries and observe the vegetation and note differences to the mapped vegetation directly on the map within the riparian zone.
2. Conduct whole stream nearshore observations.
3. Conduct transect observations within the stream at specified GPS locations.

On arrival in the field, technicians, where permitted and possible, walk up the perimeter of the stream and make observations of the vegetation and bank structures following the guidelines outlined in this protocol. The observations are made within the permitted boundary from the shoreline (Figure 3). Should the shore not be accessible or highly sensitive, general observations are made from the stream or stream edge.

The riparian portion of the plot extends up to 50 m from the shoreline towards the terrestrial systems and 20 m along the shoreline. The dimensions of the plot (50 m by 20 m) are determined using a compass and angle referencing clinometer or rangefinder (**Error! Reference source not found.**a and Figure 4b). At 10 transects in the stream, technicians measure percent canopy cover using a spherical densiometer (Figure 4c) and record information about the vegetation type and the height and areal coverage of trees, shrubs, and grasses using an inclinometer or rangefinder. In addition, observations of shoreline substratum (e.g., gravel, sand), the high-water mark, and bank slope characteristics are noted on the appropriate field datasheets. Anthropogenic activities and other features (e.g., buildings, land use, docks) will also be noted and any striking features seen adjacent to the plot. A photo is taken at each transect location for future reference and archived appropriately.

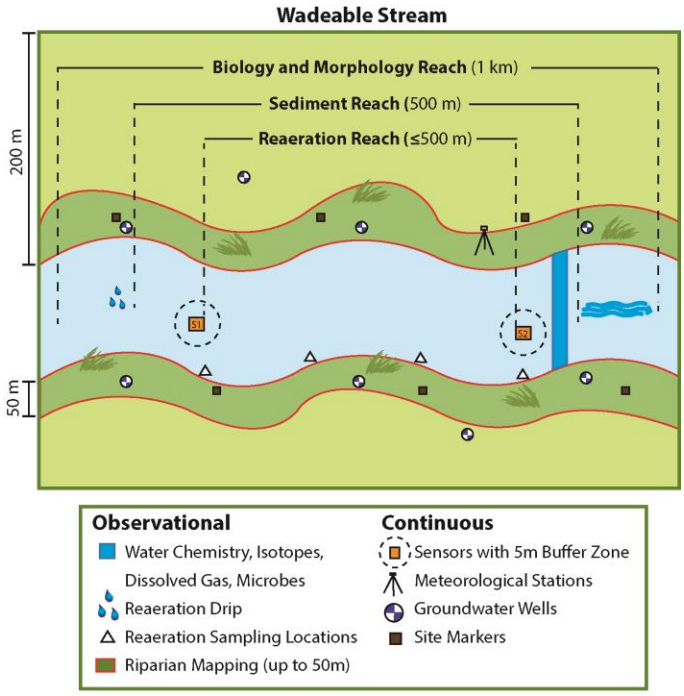

Figure 3. A generic wadeable stream site layout with riparian habitat assessment locations

Figure 4. 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 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).

The following modifications have been made:

- The 20 meter horizontal widths of the riparian areas in the field are determined using a compass and angle referencing clinometer rather than by estimation.

- This method follows Ode (2007) which uses the Strickler modification (17-point) of a convex spherical densiometer to correct for overestimation of canopy density (thickness and consistency of plant foliage) that occurs with unmodified readings (Strickler, 1959)).
- The distance in the riparian zone 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, sampling tips, and best practices for implementing this sampling procedure. To properly collect and process samples, field technicians **must** follow the protocol and associated SOPs. Use NEON's problem reporting system to resolve any field issues associated with implementing this protocol.

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

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

4 SAMPLING SCHEDULE

4.1 Sampling Frequency and Timing

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

4.2 Criteria for Determining Onset and Cessation of Sampling

Sampling for stream riparian habitat 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 sampling timeline (Appendix D and E). Should these windows not co-occur, safe wading conditions will take precedence in determining the best time to sample. 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 Sampling Timing Contingencies

Table 1. Contingent decisions

Delay/ Situation	Action	Outcome for Data Products
Hours	If you have 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), flag your field data sheet and comment on the conditions. Proceed by walking along the edge of the stream to make observations.	No adverse outcome.
	If the depth of water in the thalweg of the stream is too deep or the flow is too fast for safe wading, flag your field datasheet, comment on the conditions and continue with measurements from the stream banks.	No adverse outcome.
	If the weather and wading conditions become unsafe during sampling, stop sampling and resume as soon as safe conditions for wading are met. Unless physical change has occurred as a result of the change in weather and flow (i.e. bank erosion, movement of large woody debris etc.) sampling should resume from where it was left off and completed within the sampling window provided for the Riparian Habitat Assessment protocol.	No adverse outcome.
	If equipment stops functioning, stop the work and resume when equipment is functional.	No adverse outcome.
7 Days or More	Restart sampling if 7 or more days have passed since the previous samples were started or if the vegetation cover has changed significantly (loss of leaves or leaf on).	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).

6 PERSONNEL AND EQUIPMENT

6.1 Equipment

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

Table 2. Equipment list – Field equipment for stream riparian habitat assessment

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable items					
	R/S	Personal flotation devices	Safe wading	2	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
MX104742	R/S	Rangefinder (shared with FSU)	Determining angles, distance and height (alternate to using the clinometer)	1	N

Item No.	R/S	Description	Purpose	Quantity	Special Handling
	R	Plastic folding meter stick?	Measuring stream water depth	1	N
	R	Stream base map	Navigating to sampling locations	2	N
	R	Quick References (Appendix B)	Protocol field reference	1	N
	R	Camera	Photographing riparian locations	1	N
	R	Calculator	Calculating stream cover density	1	N
	R	First aid kit		1	N
	R	Waders	Safe wading	2	N
Consumable items					
	R	Canopy Cover Datasheets	Recording data	1	N
	R	Physical Habitat Characterization Datasheets	Recording data	10	N
	S	Field notebook	Recording field notes	2	N

R/S=Required/Suggested

6.2 Training Requirements

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

Personnel are to be trained in stream riparian habitat assessment measurements and safe working practices for stream work.

6.3 Specialized Skills

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

6.4 Estimated Time

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

We estimate that the stream riparian habitat assessment requires 2 technicians for 2 hours plus travel to and from the site.

7 STANDARD OPERATING PROCEDURES:

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

SOP A Preparing for Sampling

1. Ensure memory cards 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 1 Canopy Cover Datasheet and 10 Physical Habitat Characterization Datasheets (Appendix A).
6. Print out a paper copy of the Riparian Locations map from the AOS Site Specific Sampling Strategies for the appropriate domain (Appendix E) document and bring the map out to the field for the scheduled site. The paper map can be used to document observations that would otherwise not be detected outside of the designated riparian stations.
   a. Open the AOS Site Specific Sampling Strategies document.
   b. Ensure that the selected locations and GPS positions are identified on the printed map.
   c. Print this map. This will become the field map to document discrepancies or other observations while in the field.

7. The cross-section transect locations will be established at NEON headquarters (Figure 5). When available, transects will be selected based on the Wadeable Stream Morphology Protocol data RD[08]. Before heading out to the field, confirm the location of cross-section transects. Ten cross-section transects are placed at equal intervals along the full permitted reach length, but not greater than 100 m apart within a 1 km NEON sampling reach. For sites with permitted reaches less than 1 km, the ten transects will be spaced closer than 100 m apart. 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.

Figure 5. Example riparian habitat assessment overview with transect locations.

8. 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).

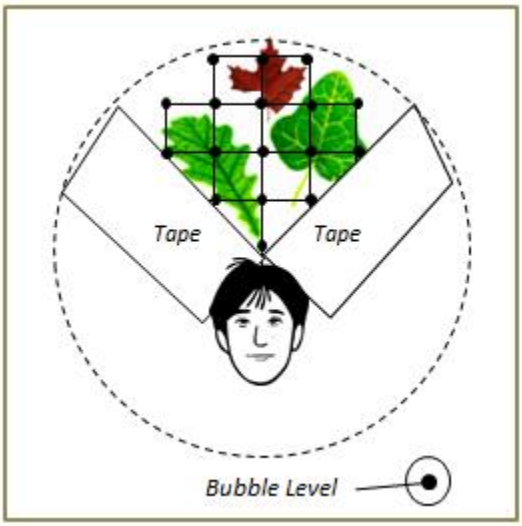

Figure 6. Preparing and reading a densiometer

9. Familiarize yourself with the most common species of plants in your domain/sites.
   a. Resources available include provided reference guides and the USDA NRCS online guide "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 yourselves with the clinometer, rangefinder, and spherical densiometer (Appendix G).

SOP B Field Sampling

B.1 Stream Canopy Cover

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 cross-section transects using a 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 facing upstream for a total of 6 measurements.

1. Using the Canopy Cover datasheet, enter the appropriate header data (site ID, technician ID, collection date, 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. Stand in the 1st transect (Figure 7) at mid-channel facing upstream.

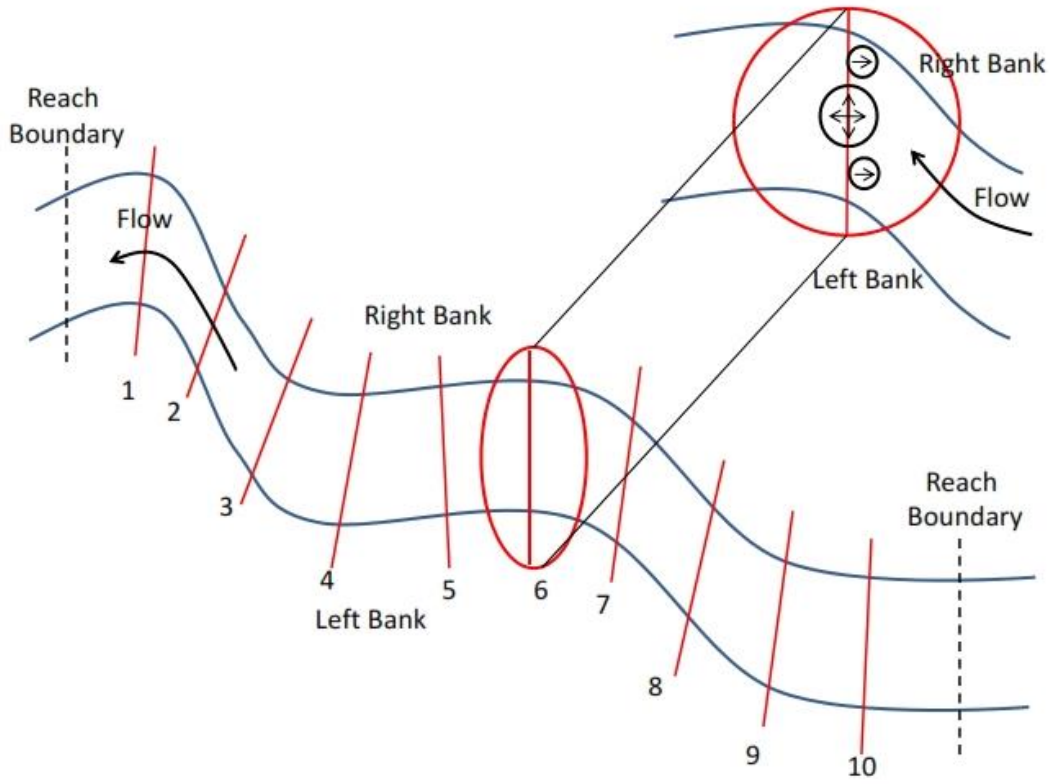

Figure 7. Location of 10 transects in the stream and sub-location of sampling points within each transect (Modified from Kaufmann, 2001).

4. Measure and record the depth of the stream water at mid-channel with plastic foldable meter stick.
5. Measure and record overstory canopy cover from the stream center (mid-channel).

   a. Hold the densiometer 0.3 meters above the water surface. This avoids errors stemming from people of different heights and water of varying depth.
   b. Hold the densiometer so that it 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 **Error! Reference source not found.**.
   c. Count the number of points covered by vegetation and enter this value in the datasheet under "# of points covered". Values will be between 0 for completely open and 17 for completely covered canopy.
   d. Divide the number of points covered by vegetation by 17. Multiply this number by 100 to determine overstory canopy cover in percent (%):

(number of filled points ÷ 17) * 100 = % Canopy Cover

   e. Take four densiometer readings from the stream center at each of the 10 transects, once each while facing upstream, left bank, downstream, and right bank . Average these four readings and enter the value.
   f. Record the values on the Canopy Cover Datasheet under "Center-Up", "Center-Left", "Center-Down", and "Center-Right" (**Error! Reference source not found.**).
6. Measure and record canopy cover percent standing 1 foot from the LEFT bank facing upstream. Take only one reading at this bank.
   a. Record the values on the Canopy Cover Datasheet under "Left Bank Up" (**Error! Reference source not found.**).
   b. Measure and record the depth of the stream water at left bank.
7. Measure and record canopy cover percent standing 1 foot from the RIGHT bank facing upstream. Take only one reading at this bank.
   a. Record the values on the Canopy Cover Datasheet under "Right Bank Up" (**Error! Reference source not found.**).
   b. Measure and record the depth of the stream water at right bank.

B.2 Physical Habitat Characterization

1. Using the Physical Habitat Characterization datasheet, enter the appropriate header data (site ID, technician ID, collection date and time, transect number, and GPS data).
2. In Part A of the datasheet, enter the full classification code following the Hierarchical Determination for Dominant System and USDA PLANTS symbol. Refer to Appendix F Classification System for detailed instructions to properly document the dominant plants.
3. Stand in the middle of the stream (or where safe and both banks are in view) on one transect.
4. Using Part B of the datasheet, face upstream, turn towards the Left bank, and make qualitative observations of the riparian vegetation structure and composition. Observations shall include up

to 50 meters inland from the stream bank and 10 meters on each side of the central view (**Error! Reference source not found.**). Also, record slope above the high water level mark. The high water mark can be identified as the area just below a line of terrestrial vegetation or upland soil that has been disturbed by the inundation of water. Often a line of leaf litter or other debris parallel to the current water line characterizes the high water mark. Turn towards the Right bank and record observations up to 50 meters inland and 10 meters on each side of the transect. If conditions do not allow for observations to be made from the center of the stream, record observations from one bank and make a note on the datasheet. This assessment is intended to be rapid so all observations should be made from the stream position when possible.

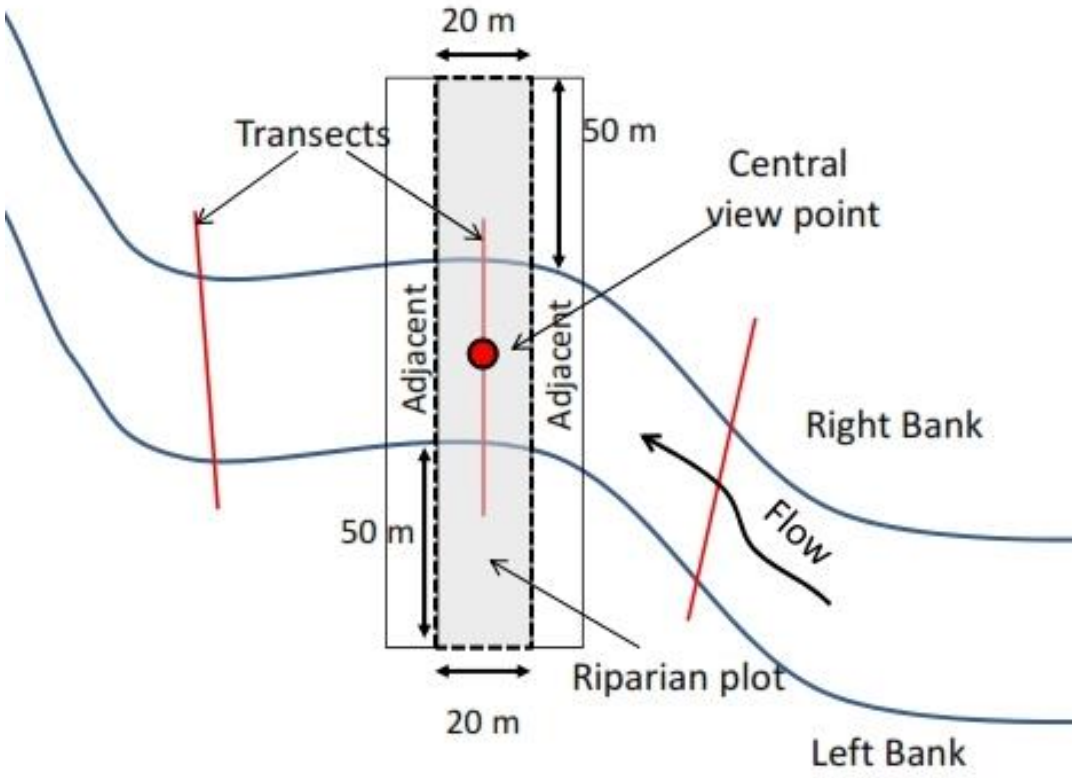

Figure 8. Determining the stations for riparian vegetation structure observations at each transect.

5. 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 in the field datasheet in the "Transect Photo Log" section.
6. 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 cover may total more than 100% (e.g. vegetation cover is near 100% and agricultural use is near 100% due to grazing).

7. 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 occur 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. Record these semi-quantitative (observational) measurements on the Physical Habitat Characterization datasheet, for each of the three vegetation layers and human influences.
8. Vegetation Structure and Composition
    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
            d) Bare dirt or duff
        4) **Human**
            a) Buildings, roads, boat ramps, lawns/parks, agriculture, industry, cleared lot/pavement, or trash.
    b. Categorization of Cover:
        1) Absent = 0%
        2) Sparse > 0 - < 10 %
        3) Moderate > 10 - < 40 %
        4) Heavy > 40 - < 75 %
        5) Very Heavy > 75 %
9. Record, on the datasheet, other observations made regarding areas that are *adjacent* (outside of the 10 m upstream and downstream transect) to those being sampled. This is particularly important where human disturbance is evident (i.e. house, road, boat ramp, lawn, power lines etc.). The adjacent sections should be each approximately 10 m wide.
10. Make every reasonable attempt to record physical habitat observations and measurements for the 10 riparian cross-section transects. Where this is impossible, indicate this in the metadata and make a comment on the Physical Habitat Characterization Datasheets (RD[09]) to clearly

indicate that no observations could be made for that feature at that particular station (U.S. Environmental Protection Agency 2007).

11. 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.3 Riparian Bank Characteristics

1. Using Part C of the Physical Habitat Characterization datasheet enter data from the following observations.
   a. With the clinometer, determine and record the (approximate) *Shoreline Bank Angle* in Part C 1st box of the *Physical Habitat Characterization Datasheet* (Appendix A). You may have a variety of angles; if two bank angles are predominate, check both.
      1) Vertical/undercut >75°
      2) Steep 30 – 75°
      3) Gradual <30°
   b. Determine the *Bank Revetment* through observations and record in Part C 2nd box of the *Physical Habitat Characterization Datasheet* (Appendix A).
      1) Hard Bank – Rip-rap (Figure 9a), rock covering over the bank, usually large angular boulders, concrete blocks or rectangular gabion wire baskets (Figure 9b)
      2) In-Stream – Human-placed large woody debris, tree root wads (Figure 9c), rock vanes, or J-hooks (Figure 9d) 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 9. 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.

2. Determine the Dominant and Subdominant *Bank Texture* through observations and note this in Part C 3rd box of the *Physical Habitat Characterization* Datasheet (Appendix A).
   a. Bedrock – very resistant to erosion
   b. Boulder/Cobble – boulders >10”/cobbles 2.5 to 10”. Moderate resistance to erosion
   c. Gravel – 0.08-2.5 “. Moderate to high erodibility when dominant component.
   d. Sand – 0.004 – 0.08”. High bank erodibility when dominant component
   e. Silt – 0.00008 – 0.004 “. Non-cohesive with high to very high erodibility
   f. Clay – < 0.00008”. Cohesive clays are relatively resistant to erosion
   g. Mix – Variety of particle sizes. i.e. glacial till
3. Record the water level to the nearest centimeter on the permanent staff gage in Part C of the *Physical Habitat Characterization* Datasheet (Appendix A).

B.4 Ending the Sampling 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

Field and domain data collected on paper datasheets should be digitally transcribed within 7 days of collection or the end of a sampling bout (where applicable). The maximum timeline for entering data is within 14 days of collection or the end of a sampling bout (where applicable). See TOS Protocol and Procedure: Manual Data Transcription (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 3. 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

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 Physical Habitat Characterization Datasheets (RD[09])

Step 3 – Ensure the General AQU Field Metadata Sheet (RD[06]) is completed on each field site visit.

Step 4 – Stream Cover Density:

1. Measure canopy cover over the stream at each of the 10 stations using a convex spherical densiometer.
2. Take measurements in the four directions at mid-channel, and 1 measurement from the left bank and right bank facing upstream for a total of 6 measurements.
3. Place tape over the bottom 2/3 of the densiometer and measure and record the number of filled points.
4. **(number of filled points ÷ 17) * 100 = % Canopy Cover**

Step 5 – Riparian Vegetation Structure:

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

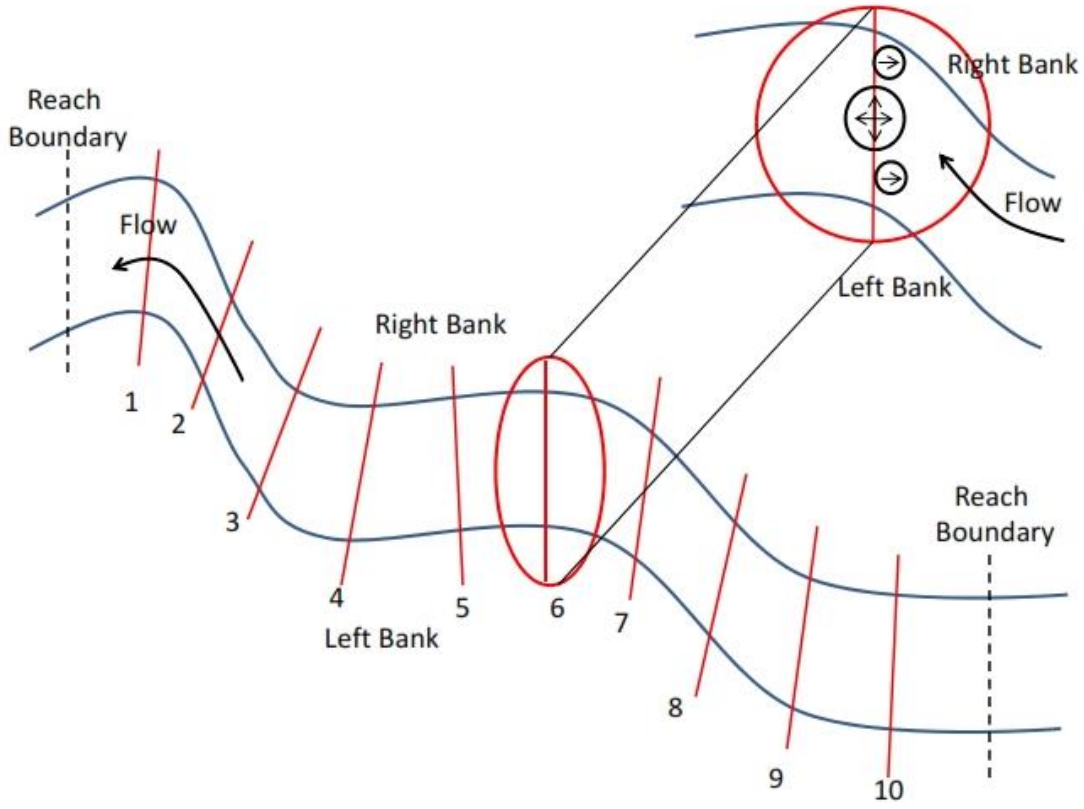
a. Layers of Riparian Vegetation
b. Categorization of Cover

Step 6 – Riparian Bank Characteristics:

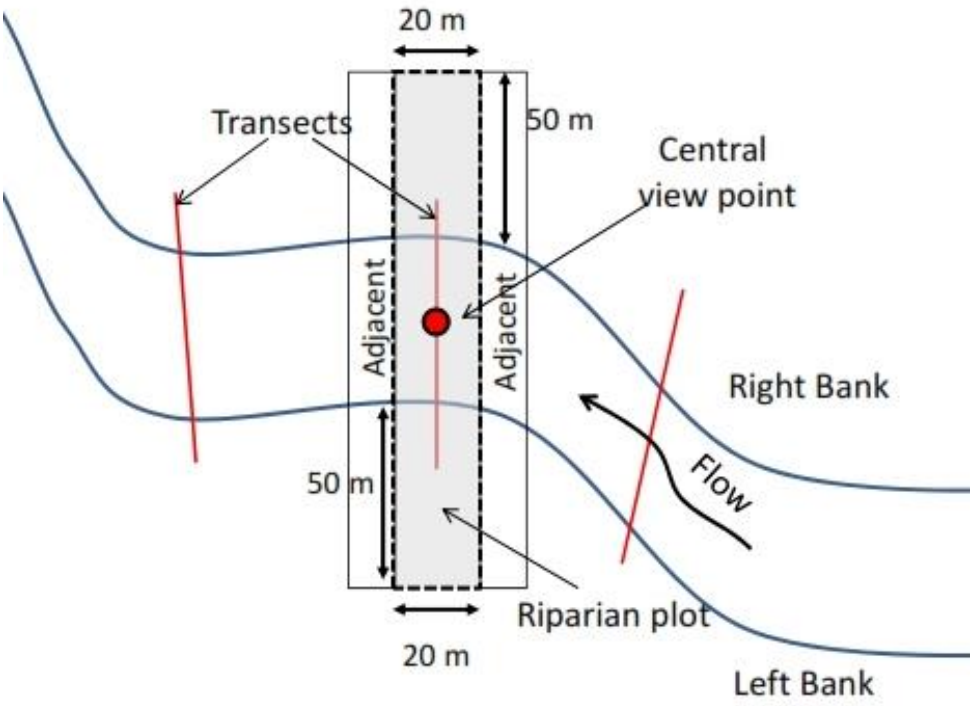
1. Shoreline Bank Angle
2. Bank Revetment
3. Bank Texture
4. Estimate and record the vertical distance between present water level and the high water mark
5. Take photos at all transect locations

B.2 Schematics for Stream Riparian Habitat Assessment

Location of 10 transects in the stream and sub-location of sampling points within each cross-section transect:



Riparian vegetation structure observation transects:



APPENDIX C REMINDERS

Before heading into the field: Make sure you…

- ☑ Collect and prepare all equipment and ensure batteries are full.
- ☑ Pre-print the *Canopy Cover* and *Physical Habitat Characterization Datasheets.*
- ☑ Familiarize yourself with the most common species of plants in your domain/sites.

Sample collection: Be sure to…

- ☑ Measure canopy cover over the stream at each of the 10 stations 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 upstream) and right bank facing upstream for a total of 6 measurements. REMINDER left and right banks are defines while looking downstream.
- ☑ Hold the densiometer 0.3 meters above the water surface.
- ☑ Complete a separate *Physical Habitat Characterization Datasheet* for <u>each</u> station.
- ☑ 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 SAMPLING

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

APPENDIX E SITE-SPECIFIC INFORMATION

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

APPENDIX F CLASSIFICATION SYSTEM

Hierarchical Determination of Dominant System

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

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

Table 4. Example of notation for hierarchical determination for dominant system.

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

Refer to Figure 9.**Error! Reference source not found.** for the determination of the dominant vegetation system.

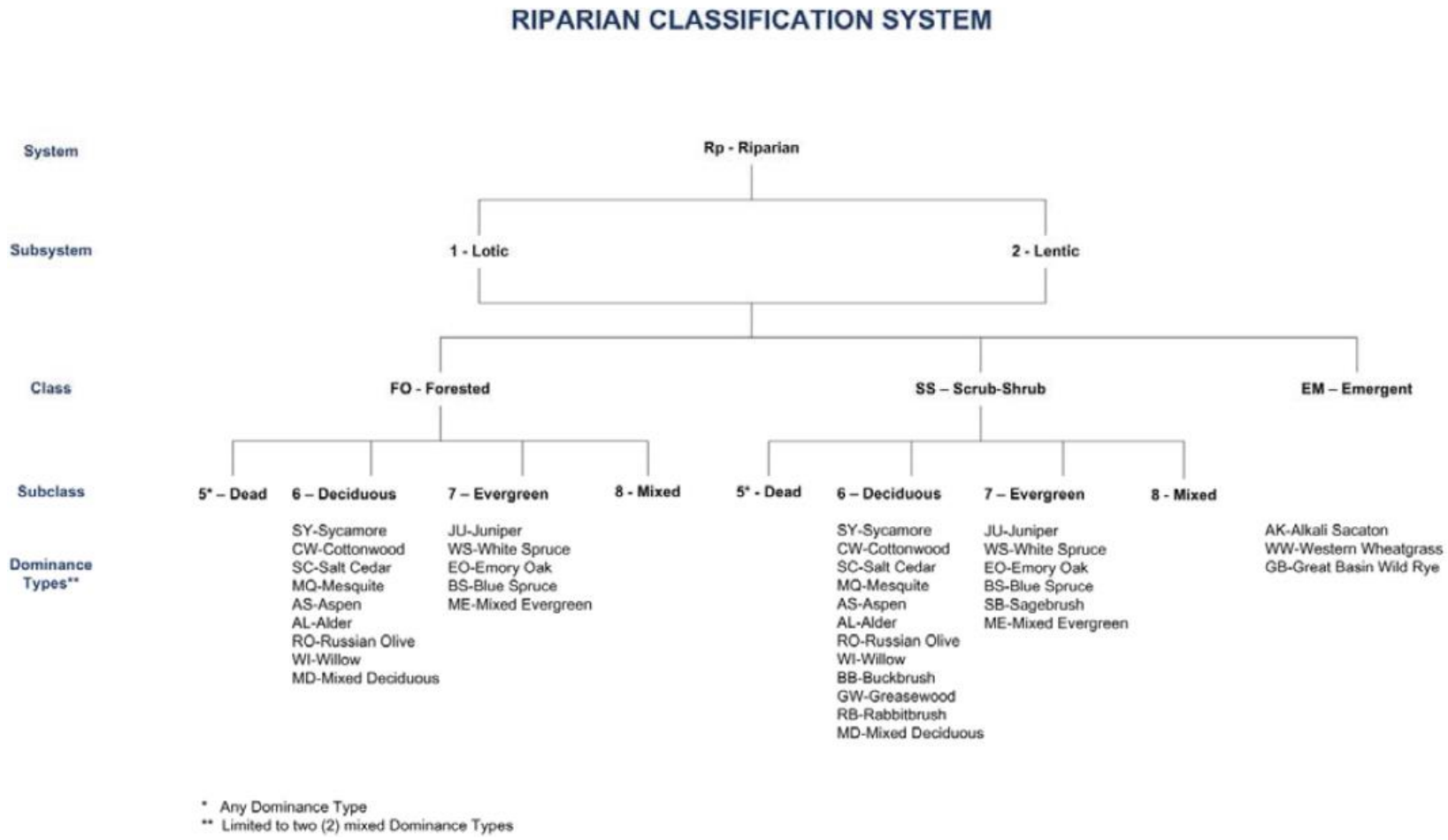


Figure 10. Example of riparian classification system from USFWS (2009) Hierarchical Riparian Mapping and Classification System with the USDA PLANTS Database (2015).

Classification of Riparian Vegetation

1) Layers of Riparian Vegetation:
   a) **Canopy** **>5 m height**
      i) Big Trees >0.3m DBH
      ii) Small Trees < 0.3m DBH
   b) **Understory** **0.5 to 5 m height**
      i) Woody shrubs and saplings
      ii) Tall herbs, grasses and forbs
   c) **Ground Shrubs** **<0.5 m height**
      i) Woody shrubs
      ii) Herbs, grasses and forbs
      iii) Standing water and inundated vegetation
      iv) 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 >75^{o} vertical/undercut
   b) Steep 30 – 75^{o}
   c) Gradual <30^{o}
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 large woody debris, 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/Coble – boulders >10”/cobbles 2.5 to 10”. Moderate resistance to erosion
   c) Gravel – 0.08-2.5 “. Moderate to high erodibility when dominant component.
   d) Sand – 0.004 – 0.08”. High bank erodibility when dominant component

e) Silt – 0.00008 – 0.004 ". Non-cohesive with high to very high erodibility
f) Clay – < 0.00008". Cohesive clays are relatively resistant to erosion
g) Mix – Variety of particle sizes. i.e. glacial till

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

APPENDIX G EQUIPMENT MANUALS

Clinometer Manual (Forestry Suppliers 2006)

Laser Rangefinder Manual (Bushnell 2011)

Spherical Densiometer (Forestry Suppliers 2013)