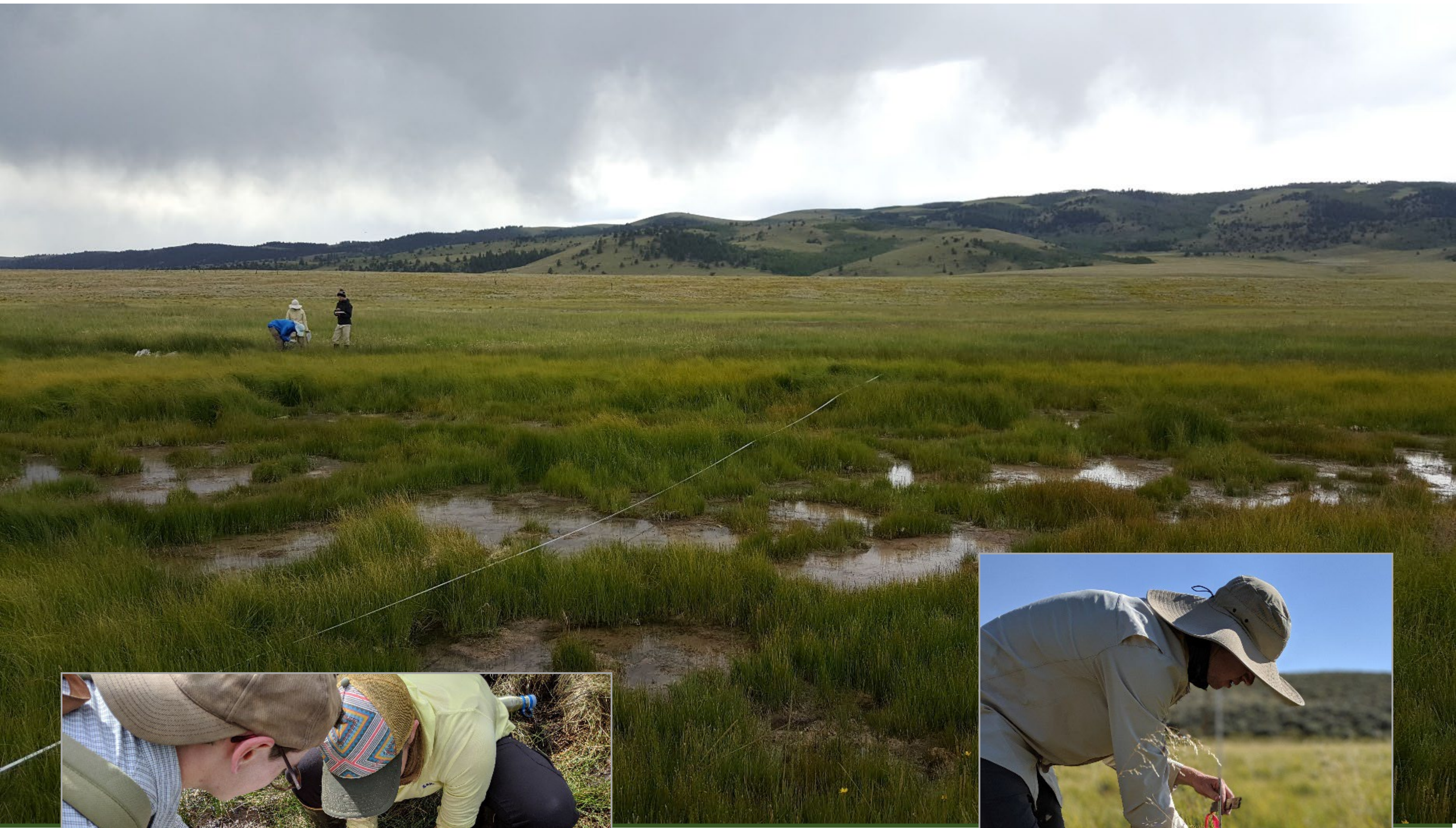
DRAFT AIM National Aquatic Monitoring Framework: Field Protocol for Lentic Riparian and Wetland Systems



Technical Reference 1735-3

March 2023

Suggested citation:
Bureau of Land Management. 2023. AIM National Aquatic Monitoring Framework: Field Protocol for Lentic Riparian and Wetland Systems. Tech Reference 1735-3. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO.

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Bureau of Land Management
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Denver, CO 80225

BLM/OC/ST-23/00#+1735

DRAFT AIM National Aquatic Monitoring Framework: Field Protocol for Lentic Riparian and Wetland Systems

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March 2023

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ACKNOWLEDGMENTS

Many people have contributed to the development of the “Field Protocol for Lentic Riparian and Wetland Systems” during more than 7 years of collaborative effort. We are deeply indebted to all the experts in wetland, riparian, and monitoring science and practice who offered careful review, field testing, and critical perspectives on this protocol including:

Bureau of Land Management: Alan Bass, Ryan Besser, Bryce Bohn, Colin Brady, Andrew Breibart, Jacob Burdick, Sarah Burnett, Timothy Burton, Chris Carlson, Ervin Cowley, Paula Cutillo, Nicole Cutler, Deschutes Field Office staff, Chris Dietrich, Robert Gibson, Nikki Grant-Hoffman, Kimberly Hackett, Steve Helm, Joel Humphries, Idaho staff, Nika Lepak, Lucy Littlejohn, Cassie Mellon, Kevin Miller, Rachel Miller, Alen Mosley, Robert Pattison, Sarah Peterson, Jessica Phillips, Boris Poff, Peggy Reddick, Cassy Rivas, Ed Rumbold, Nick Rzyska-Filipek, Aliza Segal, Alden Shallcross, Chris Sheridan, Ben Stratton, Gordon Toevs, J.A. Vacca, James Weigand, and Sandra Wyman

Natural Resources Conservation Service: Sebastian Tsocanos and Lenore Vasilas

U.S. Forest Service: Kate Dwire, Joseph Gurrieri, Brett Roper, Tim Stroope, and Dave Weixelman

Agricultural Research Service, Jornada Experimental Range: Nelson Stauffer

University and independent researchers: Marc Coles-Ritchie (Grand Canyon Trust), David Cooper (Colorado State University), Lindsey Flagstad (University of Alaska Anchorage), Jennifer Jones and the University of Montana team, Diane Menuz (Utah Geological Survey), Anjanette Steer (University of Alaska Anchorage), Sherman Swanson (University of Nevada), Aaron Wells, and ABR Inc., Alaska

Environmental Protection Agency: Mary Kentula, Gregg Serenbetz, and Teresa Magee

Because of the relationship between sections of this protocol and the Multiple Indicator Monitoring (MIM) protocol, some of the text included in this protocol was provided by the authors of the Multiple Indicator Monitoring Protocol (MIM) of Stream Channels and Streamside Vegetation (Burton et al. 2023 - in publication); we wish to thank them for providing written sections of their updated MIM protocol that were incorporated into this document. We thank Mark Gonzalez and Steve Smith for their writing, illustrations, and photo contributions, and for their comments to earlier drafts of this protocol.

We could not have made such significant progress on this protocol without the help of BLM resource specialists in California, Colorado, Idaho, Montana, Nevada, Utah, and Wyoming who assisted with the 2019-2021 pilot field seasons. This protocol incorporates many lessons learned in the field on BLM-managed lands across the West. In addition, no protocol can be carried out without technicians. Special thanks go to the technicians from Colorado State University and the University of Montana who spent their summers collecting data with draft versions of the protocol. Finally, we extend a loud and heartfelt thank you to the members of the National Riparian and Wetland AIM Team, which is a partnership between the BLM National Operations Center (NOC) and the Colorado Natural Heritage Program (CNHP), including Julian Scott and Michelle Stropky of the BLM NOC and Alexa Armstrong, Katrina Castro, Ruth Whittington, and Tess Webb of CNHP. Their input was essential and invaluable.

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1.0 INTRODUCTION

Riparian and wetland areas have high ecological value and are a priority for land management agencies in the Western United States. They hold water for longer periods of time and support higher amounts of biodiversity compared to adjacent uplands, while also providing ecosystem services such as nutrient cycling, carbon storage, sediment retention, flood attenuation, maintenance of water tables, and connectivity with streams. Outside of Alaska, riparian and wetland areas cover only 1-2% of the landscape in the Western U.S. (USFWS 2020). In Alaska, wetlands are more abundant, covering 26-36% of the landscape (Whitcomb et al. 2009; Clewley et al. 2015). Across the West, riparian and wetland areas have disproportionate ecological and economic value because they help sustain biodiversity and healthy fish and wildlife populations, maintain clean and abundant water, and store soil carbon (Zedler and Kercher 2005; Sabo et al. 2005). They are also valued for their recreational, cultural, and economic benefits, including wildlife viewing, traditional Indigenous uses, and livestock production.

The “Field Protocol for Lentic Riparian and Wetland Systems” was developed jointly by specialists from the Bureau of Land Management (BLM), U.S. Forest Service (USFS), and science partner Colorado Natural Heritage Program of Colorado State University. The protocol was developed in response to requests from land management personnel for standardized monitoring techniques that can be used to determine the condition, track trends, and measure the annual use of vegetated riparian and wetland areas, sometimes referred to as lentic riparian-wetland systems. This protocol is applicable to assessment and monitoring questions at various spatial scales, from fine scale (e.g., site, pasture, allotment) to broad scale (e.g., ecoregional, state, national). A multiscale approach ensures consistency across scales and allows local data to be viewed in context and to inform questions at broader scales.

The goal of this monitoring protocol is to provide a standard way to monitor riparian and wetland resources on public lands. This protocol targets a broader sample population of riparian and wetland areas than other existing protocols (EPA 2016; USFS 2012; Merritt et al. 2017) and is tailored for public lands in the western landscape (see Appendix A for a list of similar and related protocols). Data collected using this protocol can be used to evaluate the effectiveness of land management actions on maintaining or improving the biological, physical, and chemical integrity of riparian and wetland areas in order to inform policy, planning, and state and federal regulations. The protocol was developed following principles outlined in the BLM’s “National Aquatic Monitoring Framework” (BLM 2015), which recommends standardized indicators and associated field methodologies for monitoring aquatic environments consistent with BLM’s Assessment, Inventory, and Monitoring (AIM) Strategy (Toevs et al. 2011). However, the protocol can be used in any application where a standardized set of monitoring methods is needed for riparian and wetland areas.

To help facilitate consistent application of the protocol, Appendix B is a glossary that defines the technical terms used throughout the protocol. Glossary terms are distinguished throughout the protocol with ***bold and italic typeface***.

1.1 Intended Applications and Site Selection

Resource monitoring is an essential component of adaptive management (Williams et al. 2009). For the BLM and USFS, riparian monitoring is included in the integrated riparian management process (IRMP) outlined by the Proper Functioning Condition manuals (Dickard et al. 2015; Gonzalez and Smith 2020) (see Appendix A). In accordance with the AIM principle of structured implementation (Taylor et al. 2014), effective resource monitoring begins with identifying clear ***management goals***, which in turn guide ***monitoring objectives*** that specify when, where, and how often monitoring data are collected. This protocol addresses most monitoring objectives for riparian and wetland areas on public land. Within the IRMP or other adaptive management processes, data collected with this protocol can support assessments of land health and ecosystem function (Dickard et al. 2015; Gonzalez and Smith 2020; Pellant et al. 2020). Data collected with this protocol can be compared across time or management areas, aggregated to provide information about resource condition and trend, or analyzed to determine the effectiveness of management actions.

Management goals and monitoring objectives help define which type of ***sampling approach*** is appropriate for selecting sample sites. This protocol can be used to assess the condition and trends of an individual site through ***targeted monitoring*** or a population of sites using ***random sample designs***. Examples of site-scale targeted monitoring include repeat visits to a restoration site to monitor change over time or establishing a ***designated monitoring area (DMA)*** to monitor the impact of permitted uses. When a representative DMA is used and it is randomly located, data from that DMA can represent the broader riparian complex or area from which it was chosen. More detailed discussion of DMAs is in Section 3.4 and Appendix C. An example of population-scale random sampling would be assessing the condition of all riparian and wetland areas within a BLM field office for land use planning.

Monitoring objectives established by project managers will determine the number of monitoring plots and whether a targeted, random, or mixed-point ***sample design*** is appropriate. Site selection and survey designs are not covered in this protocol, but if new monitoring locations are being established, practitioners can reference BLM Technical Reference 1735-1 (BLM 2015), “Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems,” Volume II (Herrick et al. 2009) for guidance on random site selection, and Appendix C and BLM Technical Reference 1737-23 (Burton et al. 2011) for guidance on establishing DMAs. It is recommended that BLM practitioners work with the National AIM Team to optimize site selection procedures with monitoring objectives.

1.2 Applicable Ecosystems

This protocol is intended for vegetated ***riparian*** and ***wetland areas***, sometimes referred to as ***lentic areas*** (Gonzalez and Smith 2020; Dickard et al. 2015). These areas include wet and mesic meadows, marshes, seeps and springs, peatlands (fens, bogs, and muskegs), vegetated drainageways, swales, vegetated playas, kettle ponds, prairie potholes, vernal pools, riparian shrublands and forests, oxbows, beaver complexes, floodplains, and the margins of lakes, ponds, and reservoirs (Figure 1). This protocol was designed to monitor vegetated areas within these systems but not naturally bare areas, such as some playas and salt flats, or areas with deep water, such as the open water of ponds and lakes.


A
B
C
D

Figure 1. Examples of riparian and wetland systems that could be sampled with this protocol: (A) seasonal wet meadow, (B) flooded marsh, (C) saturated fen, (D) vegetated drainageway, (E) riparian shrubland, (F) riparian forest on the floodplain of a river, (G) Great Basin playa, and (H) northern prairie pothole. See Appendix L for detailed descriptions of wetland types.

Riparian and wetland areas are highly productive ecosystems influenced by the presence of plant-available water above or within the rooting zone. The concepts of riparian and wetland overlap and are not mutually exclusive (Figure 1a). They share many similarities and a few important differences (see inset box on riparian and wetland definitions). ***Riparian areas*** are plant communities contiguous to and affected by surface and sub-surface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have one or both of the following characteristics: (1) distinctively different vegetative species than adjacent areas, and (2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms (USFWS 2009).. They can include floodplains and other areas adjacent to streams, river channels, and spring brooks, as well as ponds and lake margins. Along streams and rivers, these areas are often influenced by periodic flooding and/or elevated groundwater connected to the stream channel. Similarly, riparian areas along the shores of ponds, lakes, and reservoirs are also influenced by both surface and groundwater. ***Wetlands*** are those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (USACE 1987). To meet the formal definition of a wetland, groundwater must be available within the rooting zone for at least 15 consecutive days during the growing season and is often present much longer (NRC 1995). Soil that is saturated for this length of time favors plant species adapted to saturated soils.

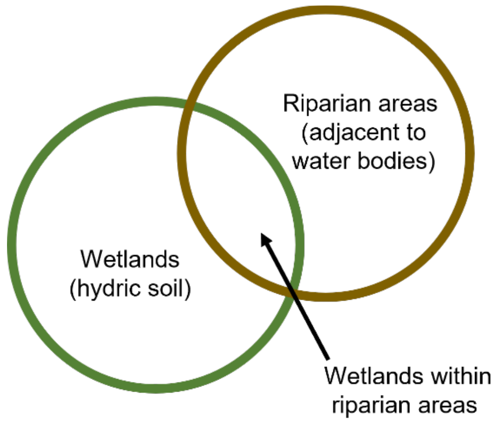


Figure 1a. Venn diagram of the overlapping concepts of wetland areas and riparian areas.

The two most important characteristics that define riparian areas and wetlands are: (1) landscape position and (2) the duration of soil saturation. The defining characteristic of riparian areas is a landscape position adjacent to and influenced by a surface water body. The defining characteristic of wetlands is the duration of soil saturation, which allows wetland soil properties to develop and influence plant species composition. While wetlands can occur within riparian landscape positions, not all riparian areas meet the formal definition of a wetland. Some riparian areas experience shorter durations of inundation and soil saturation and therefore do not exhibit wetland soils. Conversely, while many wetlands form adjacent to water bodies, wetlands can also form in landscape positions isolated from surface water bodies, such as areas of regional groundwater discharge at the base of slopes or in isolated depressions. Due to overlapping definitions of riparian and wetland areas and the natural hydrologic gradients that exist between and across these systems, the term ***riparian-wetland*** has sometimes been used to cover both concepts at once (Gonzalez and Smith 2020). For the purposes of this protocol, the phrase ***riparian and wetland areas*** is used hereafter to include all applicable ecosystems.

Riparian areas are plant communities contiguous to and affected by surface and sub-surface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have one or both of the following characteristics: (1) distinctively different vegetative species than adjacent areas, and (2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms (USFWS 2009).

Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (USACE 1987).

While field criteria have been developed to determine the boundaries of wetlands for federal regulatory purposes (USACE 1987), there are no explicitly defined criteria for determining the boundaries of riparian areas. A set of six field criteria defines riparian and wetland ecosystems to which this protocol applies (see inset box on criteria for applicable ecosystems at the end of this section). The inset box summarizes the criteria briefly, while the following text adds additional detail. All plant cover thresholds in the criteria can be determined by ocular estimate and do not need to be measured precisely. These criteria are appropriate for all areas in the Western U.S. except Alaska (see inset box on using the protocol in Alaska at the end of this section).

1. **Perennial vegetation**
2. **Hydrophytic vegetation**
3. **Hydrology**
4. **Limited scour channel**
5. **Shallow water**
6. **Sufficient area and width**

Perennial vegetation: This protocol is intended for riparian and wetland areas that have at least 10% cover of perennial vegetation under typical growing season conditions without disturbance (e.g., heavy use, wildfire, severe flooding, prolonged drought). The core methods included in this protocol are vegetation based and intended for vegetated systems. A minimum cover of vegetation ensures that the methods can detect a statistically significant change from the data collected. When establishing a plot, perennial vegetation may be evenly distributed or may be concentrated in patches. Bare ground can be included in a monitoring plot as long as the total cover of perennial vegetation is at least 10% of the monitoring plot. This criterion is meant to exclude bare playas and other temporary wetlands that naturally lack perennial vegetation, but not systems that have a large amount of bare ground due to disturbance. Bare ground caused by disturbance can be an indicator of condition and is not a reason to exclude a site from sampling.

Hydrophytic vegetation: Within existing cover, the vegetation must be dominated by ***hydrophytic*** (water-loving) species (i.e., obligate [OBL], facultative wetland [FACW], or facultative [FAC] species as defined by the National Wetland Plant List) (Lichvar et al. 2012, 2016; USACE 2018) (Table 1). For the purposes of this protocol, the ***upland*** limit of riparian and wetland environments occurs at the boundary between areas dominated by hydrophytic vegetation and areas dominated by nonhydrophytic vegetation. Some low cover of nonhydrophytic vegetation may occur within riparian and wetland areas that are sampleable, as long as hydrophytic vegetation dominates overall. Similarly, low cover of hydrophytic vegetation may occur in upland areas that are not sampleable. Discrete zones of upland vegetation, such as raised upland mounds, should be limited to 10% of the monitoring plot unless specified by monitoring objectives.

To define ***dominance*** for this protocol, the standard dominance test used for wetland delineation (USACE 1987, 2007, 2008, 2010a, 2010b) is modified. An area is dominated by hydrophytic vegetation when more than 50% of the dominant species are OBL, FACW, or FAC. Dominant species are defined as those species that individually or collectively account for more than 50% of the total cover of vegetation, plus any species that, by itself, accounts for at least 20% of the total. The procedure to determine dominance is the same as described in the U.S. Army Corps of Engineers (USACE) "Regional Supplement to the Corps of Engineers Wetland Delineation Manual," except that this protocol assesses dominant species for the community as a whole and not by strata (see Appendix D for examples). While this protocol uses the wetland delineation criteria for determining dominance, to include all riparian areas within the applicable ecosystems for this protocol, it is not necessary to identify indicators of wetland soil or wetland hydrology.

Table 1. Plant species wetland indicator status, designation as hydrophytic or nonhydrophytic, and qualitative description (Lichvar et al. 2012, 2016).

Wetland Indicator Status	Designation	Qualitative Description
Obligate (OBL)	Hydrophytic	Almost always occurs in wetlands.
Facultative wetland (FACW)	Hydrophytic	Usually occurs in wetlands but may occur in nonwetland areas.
Facultative (FAC)	Somewhat hydrophytic	Occurs in wetland and nonwetland areas.
Facultative upland (FACU)	Nonhydrophytic	Usually occurs in nonwetland areas but may occur in wetlands.
Upland (UPL)	Nonhydrophytic	Almost never occurs in wetlands.

Hydrology: To be sampleable, the area must be influenced by surface or groundwater at some point in the growing season. Riparian and wetland areas are both, by definition, influenced by surface or groundwater. The exact boundaries of this influence can be difficult to detect consistently in the field, which is why this protocol relies primarily on vegetation to indicate longer term patterns of inundation and saturation. Indicators of hydrology developed by the USACE can be used to identify the likely boundary. However, the hydrology criteria for this protocol only requires that the site be influenced by surface or groundwater, not that it meets the 15-day minimum requirement of wetland hydrology. If evidence of surface or groundwater is not immediately apparent, a dominance of hydrophytic vegetation is sufficient to indicate that the site is influenced by water.

Limited scour channel: To avoid sampling in active stream channels that are better monitored with other protocols, the portion of the monitoring plot that contains an unvegetated active river or stream channel is limited to 10%. Streams and rivers, sometimes referred to as ***lotic systems***, are characterized by fast or energetic flowing water. Moving water, concentrated in a channel, has enough shear stress to form and maintain a scour channel that is generally devoid of vegetation and capable of transporting sediment. Monitoring protocols developed for lotic stream systems that characterize instream habitat by focusing on channel geomorphology and aquatic life are more appropriate for the scour channel and immediate banks. Riparian and wetland protocols, such as this one, are more appropriate for vegetated areas extending beyond the channel and banks. Appendix A lists several recommended protocols used by federal agencies to monitor lotic stream systems. Some protocols include both the lotic channel and adjacent riparian areas (Merritt et al. 2017; Burton et al. 2011).

Along larger river systems, the boundary between the lotic river channel and its floodplain is often clear and both zones can be sizable. In these environments, this protocol should be used only on the floodplain, and monitoring plots should stop at the riverbank. No more than 10% of a monitoring plot should include the unvegetated active channel. However, in some environments, such as springs and small stream systems, the channel may be very narrow and even diffuse, without clear scour lines. In such environments, this protocol can be applied across the whole system. Lotic stream monitoring may also be applicable in these environments, depending on the monitoring objectives. Pairing monitoring of the lotic channel with monitoring of floodplain vegetation can provide the most complete assessment of stream and riparian resource condition.

Shallow water: The cover of permanent standing water deeper than 50 cm (20 in) during the growing season is limited to no more than 10% of the monitoring plot. It is logistically difficult or impossible to sample vegetation along a transect in water deeper than 50 cm. This criterion does not exclude an entire riparian or wetland area if only a portion has deep water. It merely excludes that portion with deep water. This criterion only applies to permanent deep water. If deep water is temporary and may recede during the growing season, the riparian or wetland area could be sampled at a later time.

Sufficient area and width: The final criterion is included to ensure an adequate sample area for the core methods. To be sampleable, the site must accommodate three 25-m transects spaced at least 5 m apart to ensure that data collected are comparable between sample plots. There is not one minimum area threshold as there are various configurations that can accommodate three 25-m transects, including sites that are very narrow but more than 75 m long. See Section 4.0 for plot layout options. In addition, sites must be at least 2 m wide to allow for adequate sampling of the woody vegetation using the prescribed methods. Small segments less than 2 m wide can be included, but the majority of the monitoring plot should be at least 2 m.

Criteria for Applicable Ecosystems

While riparian and wetland areas comprise a broad range of habitats, the following criteria define the specific ecosystems to which this protocol applies. Details on site evaluation and rejection criteria are discussed further in Section 3.0. To be sampleable with this protocol, a site must have:

1. **Perennial vegetation:** At least 10% cover of perennial vegetation under typical growing season conditions without disturbance (e.g., heavy use, wildfire, flooding). This criterion excludes bare playas and other temporary wetlands that naturally lack perennial vegetation but does not exclude systems that have a large amount of bare ground due to disturbance. If the cause of bare ground is unclear, consult with local resource specialists who know the area.
2. **Hydrophytic vegetation:** Within existing cover, a dominance of hydrophytic vegetation (OBL, FACW, or FAC species). An area is dominated by hydrophytic vegetation when more than 50% of the dominant species are OBL, FACW, or FAC. Discrete zones of upland vegetation, such as raised upland mounds, should be limited to 10% of the monitoring plot unless specified by monitoring objectives.
3. **Hydrology:** Evidence of hydrology influenced by surface or groundwater at some point in the growing season. If evidence of surface or groundwater is not immediately apparent, a dominance of hydrophytic vegetation is sufficient to indicate that the site is influenced by water.
4. **Limited scour channel:** The majority of the monitoring plot must be beyond the immediate banks of an unvegetated active river or stream channel. No more than 10% of the monitoring plot can contain an unvegetated active channel.
5. **Shallow water:** No more than 10% cover of permanent standing water deeper than 50 cm (20 in) during the growing season. This criterion does not exclude an entire riparian or wetland area if only a portion has deep water. It merely excludes that portion with deep water. It also does not exclude areas of temporary deep water. If water levels may recede later in the growing season, the area can be sampled at a later time.
6. **Sufficient area and width:** Sufficient area to accommodate three 25-m transects with individual transects spaced at least 5 m apart. There is not one minimum area threshold as there are various configurations that can accommodate three 25-m transects, including sites that are very narrow but more than 75 m long. See Section 4.0 for plot layout options. Narrow sites must have a minimum average width of 2 m. Small segments less than 2 m wide can be included, but the majority of the monitoring plot should be at least 2 m.

The methods described in this protocol are appropriate for the majority of riparian and wetland areas encountered in the field, whether targeted or randomly selected. However, some special or unusual situations, such as sites that are altered, developed, artificial, or subject to recent disturbance, may warrant slight procedural modifications. For these systems, please refer to Appendix E: Monitoring Altered, Developed, Artificial, or Fenced Sites. Section 3.4 also provides special considerations for targeted sites, including situations where monitoring plots may include upland plant communities if a monitoring objective is to track expansion or contraction of riparian or wetland vegetation over time.

Alaska: How to Use This Protocol

Wetlands are abundant across the Alaskan landscape and are often intermixed with upland areas in a complex mosaic. In addition, the uplands of Alaska are very different from the upland or terrestrial rangeland of the arid Western U.S. Terrestrial monitoring on BLM-managed lands in Alaska has often been carried out using the "Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems" (Herrick et al. 2017), the protocol of the Terrestrial AIM Program. Given the abundance and complexity of Alaskan wetlands, this protocol can also be used for all lands in Alaska. Several modifications have been made to the protocol for use in Alaska, which are highlighted throughout the protocol. Each modification specifies that it is for use in Alaska. The first difference is that all vegetated lands can be sampled in Alaska. The criteria for hydrophytic vegetation, hydrology, and area do not apply when sampling in Alaska. However, perennial vegetation and shallow water criteria do apply.

1.3 Covariate, Core, Contingent, and Annual Use Methods

Data collection with this protocol includes covariate, core, contingent, and annual use methods (Table 2). Supplemental data beyond the included methods can be collected as needed but are not covered by this protocol. Monitoring methods and covariates were selected for their ability to address management questions and objectives (Kachergis et al. 2020). The methods in this protocol were adapted to riparian and wetland environments from several well-established protocols (see source citations in Table 2). The selected methods and the indicators derived from them address one or more of the following needs:

- Provide quantitative data on hydrologic, geomorphic, and vegetation functions, processes, or attributes.
- Are relevant to and help inform common monitoring objectives.
- Are easily measured or quantified.
- Are consistently measured with general agreement among trained observers.
- Are responsive to common disturbances or management activities on time scales relevant to management decisions.
- Are sensitive to change over time in the processes governing formation and persistence of riparian and wetland ecosystems.
- Provide a means to differentiate a range of conditions.

Covariate methods and photographs characterize sites for the purposes of site classification, stratification, or determination of potential natural condition. Some covariates are determined directly from field observations and measurements, while others are determined using GIS or other ancillary data. Covariates are all required and should be collected at least once when the monitoring plot is established. For sites sampled more than once, repeat collection of covariate data is not required but can validate initial observations and track change in the hydrologic, geomorphic, or ecological characteristics of the site. Covariate methods and indicators include:

- Plot classification and description (***Cowardin*** and ***hydrogeomorphic*** classes, general wetland type, elevation, slope, and aspect)
- Hydrology and surface water characteristics (water sources, aerial extent of standing water, depth of standing water, characteristics of surface water bodies, and characteristics of channels)
- Soil profile description (soil color and texture, hydric soil indicators, depth of organic layer, depth to water table, and depth to permafrost)
- Natural and human disturbances in the monitoring plot and surrounding landscape

Photographs can provide qualitative information on site characteristics at a single point in time or through time. Photographs of the monitoring plot are required every time the site is monitored. Photographs can provide visual evidence of general condition and trends. The most useful photographs include:

- A broad, ground-based overview of the site taken from an adjacent, higher elevation area if possible
- Photographs from both ends of each monitoring transect
- Photographs of the soil pit and hydrologic features
- Photographs of areas within the site showing specific management concerns or notable features

Core methods are relevant across many different ecosystems and have widespread, cross-program applicability to fundamental monitoring objectives. Example indicators that can be calculated from core methods and used to inform land health include: species richness, vegetation cover and composition, ground surface attributes like bare ground, vegetation height, and woody vegetation structure. The core methods include:

- Plant species inventory and identification
- Line-point intercept (vegetation cover and ground surface attributes)
- Vegetation height and litter and water depths
- Woody structure

Contingent methods have the same cross-program applicability, but they are only measured where applicable to specific management objectives. Example indicators that can be calculated from contingent methods and used to inform land health include: percent cover of hummocks, hummock height, surface water pH and specific conductance, and surface water nitrogen and phosphorus concentrations. Contingent methods include:

- Hummocks
- Water quality

Annual use methods are included for monitoring the degree of vegetation use or soil alteration related to grazing or browsing by livestock, wild ungulates, wild horses and burros, and/or human activities. Short-term indicators that can be calculated from the annual use method include:

- Stubble height
- Soil alteration
- Riparian woody species use

Supplemental data collection: When monitoring objectives cannot be fully addressed with core, contingent, or annual use methods, monitoring teams should collect supplemental data that may be used for project-specific objectives. Supplemental data collection may include macroinvertebrate sampling, longer term hydrologic monitoring, eDNA, topographic surveys, sample collection for detailed water and soil chemistry analyses, or indepth investigation of wildlife use and habitat. Supplemental methods typically do not have consistent, cross-program applicability and are not covered by this protocol. Where needed, they should be selected using a method and indicator screening process outlined in the "National Aquatic Monitoring Framework" (BLM 2015) or equivalent and measured using an existing, peer-reviewed protocol.

Table 2. Methods and selected indicators covered by this protocol. Methods are listed by protocol section, type (covariate, core, contingent, or annual use), collection location (measured across the entire plot [P], in the center of the plot [C], along the transects [T], or in GIS), and the source citation from which each method was adapted.

Method	Selected Indicators*	Type	Collection Location	Source Citation
Plot Classification and Description (Section 5.1)	Classification (Cowardin, hydrogeomorphic, general wetland types)	Covariate	P	National Wetland Condition Assessment (NWCA) (EPA 2016)
	Elevation	Covariate	P	Terrestrial AIM (Herrick et al. 2017)
	Slope and aspect	Covariate	P	
Photo Points (Section 5.2)	Photo points: transects, overview, and features of interest	Covariate	P/T	
Hydrology and Surface Water Characteristics (Section 5.3)	Water sources	Covariate	P	NWCA (EPA 2016)
	Aerial extent of standing water	Covariate	P	
	Depth of standing water	Covariate	P/T	
	Characteristics of surface water body	Covariate	P	
	Characteristics of channels	Covariate	P	
Soil Profile Description (Section 5.4)	Soil color and texture	Covariate	C	
	Hydric soil indicators	Covariate	C	
	Depth of organic layer	Covariate	C	
	Depth to water table	Covariate	C	
	Depth to permafrost	Covariate	C	
Natural and Human Disturbances (Section 5.5)	Disturbances and degree of impacts	Covariate	GIS/P	NatureServe (Comer et al. 2017)
Plant Species Inventory and Identification (Section 6.1)	Species richness	Core	P	Terrestrial AIM (Herrick et al. 2017)

Method	Selected Indicators*	Type	Collection Location	Source Citation
Line-Point Intercept (Section 6.2)	Vegetation cover and composition (e.g., total foliar cover, native cover, hydrophytic species)	Core	T	NWCA (EPA 2016)
	Ground surface attributes (e.g., bare ground cover, litter cover)	Core	T	
Vegetation Height and Litter and Water Depths (Section 6.3)	Vegetation height	Core	T	
	Litter/thatch depth	Core	T	
	Water depth	Core	T	
Woody Structure (Section 6.4)	Woody population structure	Core	T	Multiple Indicator Monitoring (MIM) (Burton et al. 2011)
	Woody canopy structure	Core	T	
Hummocks (Section 7.1)	Percent cover of hummocks	Contingent	T	Newly developed for this protocol
	Hummock height	Contingent	T	
	Angle of side slopes	Contingent	T	
	Vegetation cover of side slopes	Contingent	T	
Water Quality (Section 7.2)	pH	Contingent	C	Lotic AIM (BLM 2021)
	Specific conductance	Contingent	C	
	Temperature	Contingent	C	
	Nutrients (nitrogen and phosphorus)	Contingent	C	
Annual Use (Section 8.0)	Stubble height	Annual Use	T	MIM (Burton et al. 2011)
	Soil alteration	Annual Use	T	
	Riparian woody species use	Annual Use	T	

*Selected indicators are examples of indicators that can be calculated from data collected with each method in the protocol. Additional indicators may also be calculated.

2.0 How to Use This Protocol

This protocol provides standard field methods for collecting data to calculate indicators of condition and trend for riparian and wetland areas (see Table 2 in Section 1.3). In addition, the protocol includes instructions for collecting covariate data to characterize, stratify, and classify riparian and wetland areas. The methods are explained in several sections:

- **Section 3.0: Site Evaluation.** Guidance to ensure that sites meet all criteria for sampling.
- **Section 4.0: Layout Options for Monitoring Plots.** Five plot layout options for riparian and wetland areas of different dimensions.
- **Section 5.0: Covariate Methods.** Field methods for covariate data and photo points.
- **Section 6.0: Core Methods.** Field methods for core data collection.
- **Section 7.0: Contingent Methods.** Field methods for contingent data collection.
- **Section 8.0: Annual Use Methods.** Field methods for annual use data collection.
- **Appendices.** Supplemental resources to aid in data collection.

In addition to studying the protocol, individuals should attend formal training on the “Field Protocol for Lentic Riparian and Wetland Systems” before implementing the methods. Expertise in riparian and wetland botany, ecology, hydrology, soils, or geomorphology is not an adequate substitute for protocol training. Training ensures that the methods are followed correctly and consistently, thus maximizing data accuracy and precision. Training also ensures method calibration among field personnel, which is an important part of the data quality assurance and quality control (QA/QC) process.

2.1 Monitoring Plot and Sampling Units

Data for all indicators and covariates are collected within a defined area surrounding or near a specific ***sample location*** (also referred to as a ***sample point***) located within a riparian or wetland ***site*** (or area). Sample locations are a set of spatial coordinates selected in advance using an appropriate ***sampling approach*** (e.g., randomly selected, targeted) based on monitoring objectives. The defined sampling area established around or near each sample location is called the ***monitoring plot.*** Proper placement of the monitoring plot is essential because it defines where data collection will occur.

The standard monitoring plot configuration is the ***spoke layout***: a 30-m radius circle demarcating a 0.3-ha (0.7-acre) monitoring plot that is often centered on the sample location (Figure 2). Data collection takes place across the entire plot, at the center of the plot, and along three 25-m transects radiating out from the center of the plot in a spoke design. Each transect starts 5 m from the center to avoid repeat data collection and sampling trampled vegetation at the center.

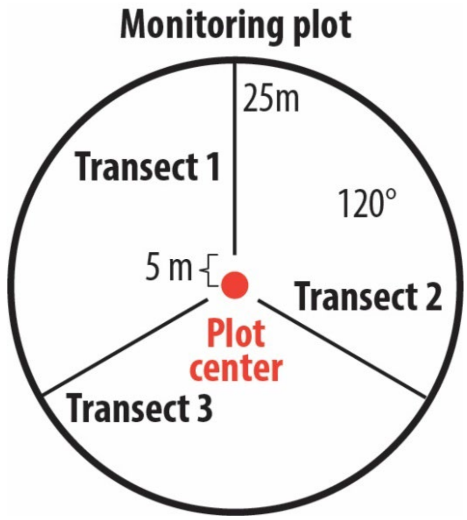


Figure 2. Standard spoke layout for a monitoring plot.

While the spoke layout is the standard plot configuration, many riparian and wetland areas are smaller than 0.3 ha or have an irregular shape that cannot accommodate a monitoring plot with a 30-m radius circle. Four alternate layouts are available for these sites. In addition, the monitoring plot may be shifted away from the sample location, if necessary, following specific rules. All plot layouts are described in Section 4.0 along with detailed guidance for shifting the monitoring plot if the sample location falls on the edge of a riparian or wetland area. For further questions, consult with the project manager or the agency's monitoring leads and take careful notes on how the plot was located and how the data were collected.

As with many other landscape-scale monitoring protocols, data collected using this protocol represent conditions within the monitoring plot, not necessarily across the entire riparian or wetland site. In a small and isolated wetland, the monitoring plot may encompass the entire wetland site; however, in a large riparian or wetland complex, data from the plot will only represent a portion of the site. For site-scale targeted monitoring, plots are often strategically located in areas where management action may have the greatest effect. If the targeted site is large and complex, more than one monitoring plot may be needed to adequately represent conditions. For population-scale random sampling, monitoring plots distributed across the landscape will represent the range of conditions within all riparian and wetland areas included in the sample frame across that landscape.

For AIM monitoring and assessment, the sampling unit for determining variance depends on the monitoring objectives and sampling approach. For site-scale targeted monitoring, measurements made within the plot (quadrats or transects) can be used as the sampling unit to derive average estimates and associated confidence intervals for the specific monitoring plot. These estimates can then be used to compare one plot against another or to calculate trend over time within the same plot but should not be extrapolated beyond the specific plot. Although appropriate pin drop, quadrat, and transect spacing has been analyzed for this protocol to ensure precision is not inflated, some caution should be applied when conducting site-scale analyses to ensure samples (quadrats or transects) are indeed independent. However, for population-scale analysis of randomly selected plots, the sampling unit is the monitoring plot, and multiple plots are required to derive average estimates and associated confidence intervals for an entire population. For population-scale applications, multiple measurements within a plot are intended to improve the accuracy of indicator values (e.g., plant cover), and the individual measurements are not intended as statistical replicates. The methods described in this field protocol should provide acceptable levels of accuracy and precision for deriving both: (1) site-scale condition estimates for individual targeted plots and (2) population-scale condition estimates, if a sufficient number of independent, randomly selected plots are sampled.

2.2 Recommended Flow of Data Collection

Each method within this protocol can be carried out independently. The approximate time requirements for each method are provided in Appendix F. In practice, a suite of methods is selected based on monitoring objectives and are usually all collected during the same site visit. To facilitate efficient data collection, Figure 3 illustrates the recommended order for completing all methods at a given monitoring plot. The recommended order assumes a three-person crew, with one crew member leading the vegetation data collection, another crew member leading the soil and water data collection, and a third crew member supporting the others. For some crews, those roles will remain consistent throughout the field season, but other crews may want to change roles at different sites to build skills in all components of the protocol. Additionally, many sites have conditions that may warrant a different order of data collection. The recommended order is presented as a default, but site-level factors should dictate how data collection is carried out.

For projects seeking to implement or evaluate BLM land health standards (43 CFR §4180.2) (BLM 2001; Kachergis et al. 2020), BLM resource management plan effectiveness, an integrated riparian management process (Gonzalez and Smith 2020), or a USFS land management plan (USDA 2012), data collection should include all of the core and covariate methods, and contingent and annual use methods where appropriate. For site-specific management questions or monitoring of annual use, users may select individual methods that address monitoring objectives.

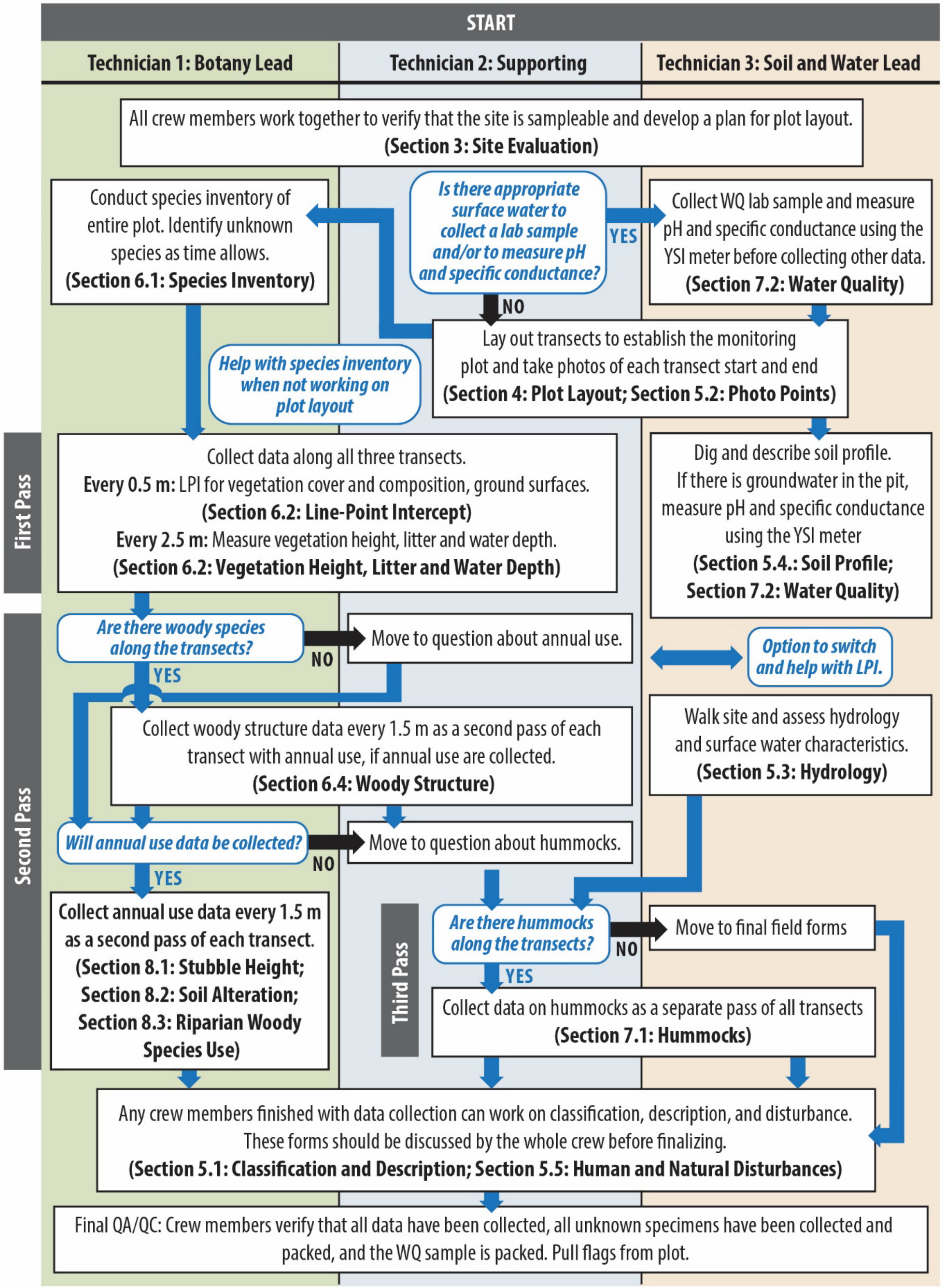


Figure 3. Recommended order of data collection for one monitoring plot in one site visit based on a three-person crew.

2.3 Timing of Data Collection

The optimal time to sample core methods in riparian and wetland areas is when vegetation is most identifiable, annual soil alteration or disturbance is minimal, and water levels have receded from their seasonal high level. In the Western U.S., optimal timing usually ranges from May to September, though exact timing should be confirmed with local knowledge. Species can be identified more easily in the middle of the growing season before any significant grazing, which can remove plant parts and cause trampling. Soil alteration and disturbance from grazing or human traffic will be less before livestock, wildlife, or recreation have impacted the sites; this is important because discriminating long-term features like ***hummocks*** from the current year's trampling can sometimes be difficult. Collecting field data on sites with standing surface water is more reliable during periods of low water levels when the vegetation is not submerged. For sites with standing surface water (e.g., springs, seeps, marshes, peatlands, lakes, ponds), water levels tend to be lower in mid-season than they are in spring or even fall (some springs can discharge more water in the fall when upland vegetation senesces or becomes dormant or when irrigation diversions are turned off). Every effort should be made to collect field data during the growing season to minimize variability, maximize the precision of condition estimates, and maximize the ability to detect trends over time (EPA 2002). While not all optimal conditions may be met when sampling a site, it is important to plan the sampling schedule with these factors in mind.

In contrast to core methods, the optimal time to collect annual use data depends on the local monitoring objectives and is often during or immediately following the use period of livestock grazing or other activities. However, recording annual use data simultaneously with core methods is also useful for interpreting long-term data. For monitoring projects that include annual use monitoring, this may mean more than one visit to the monitoring plot in a growing season. Additional information regarding the value, utility, and timing of annual use methods and how they relate to core methods is provided in Section 8.0.

When planning the timing of monitoring efforts, practitioners should evaluate the purpose and ultimate use of the data being collected and carefully consider how seasonality and management activities may affect the methods of interest. For instance, the optimal time to monitor habitat for specific wildlife species of concern may differ from the optimal timing to monitor for grazing permit renewals. For repeat monitoring of condition and trends at a specific site, it is generally advisable to collect repeat data during the same stage of seasonal progression and conditions that were present when the baseline data were initially recorded. Other key considerations include natural and anthropogenic disturbance events (e.g., floods, wildfires, concentrated recreational activities) that perturb the biophysical characteristics of a site and make data collection impossible or impractical. Often, vegetation and other site variables may recover during a matter of weeks or months following disturbance events, and the sample location can still be evaluated by a field crew during the same season.

2.4 Equipment and Data Sheets

A detailed equipment list is provided in Appendix G. Sampling equipment should be obtained well in advance of the field season. Note that felt-bottomed wading boots are strongly discouraged, as they are known to aid in the spread of aquatic invasive species. Additionally, all equipment, footwear, and vehicles used in field sampling that come in contact with water or soil should be properly decontaminated to prevent the spread of invasive organisms before moving to a new sampling point. For guidelines on gear decontamination, see Appendix H.

Data sheets and collection labels for all methods detailed in this protocol are available in Appendix I. Electronic data capture forms have also been developed for use within the BLM AIM Program and BLM data management system. Due to the rapidly changing nature of technology, the electronic data capture forms are addressed in a separate data management protocol, and all references to data collection in this protocol are based on the paper data sheets.

3.0 SITE EVALUATION

Site evaluation is a critical process for all monitoring projects. Once a sampling approach and associated sample locations have been selected, each location must be evaluated to ensure it fits within the ***target population*** of the monitoring project. In general, the target population will be the applicable riparian and wetland ecosystems defined for this protocol in the criteria box in Section 1.2. However, some monitoring projects may refine the target population further, for example by wetland type or management priority (e.g., sage-grouse habitat). Each potential sample location should be evaluated through a two-step process of (1) office evaluation, followed by (2) field evaluation.

Random sample designs: Each randomly selected sample location must be evaluated with respect to the Criteria for Applicable Ecosystems (criteria box in Section 1.2). Ensuring that each site meets the criteria enables accurate population-level parameter estimates and estimates of error in the sample frame resulting from rejected sites.

Targeted sample locations: The same general rules for site evaluation can be used for targeted sample locations, but they are less critical because targeted sites are selected for local and specific monitoring objectives, not population-level parameter estimates. The protocol can be used for targeted sampling in locations that do not meet the criteria for applicable ecosystems (e.g., a riparian area that is dominated by upland vegetation but is expected to transition back to hydrophytic vegetation following a restoration treatment). Section 3.4 provides additional factors to consider when evaluating targeted sites, including degraded or very small sites.

3.1 Office Evaluation of Sample Locations

Office evaluation of potential sample locations is key to successfully accessing and collecting data at monitoring sites. The value of this preparatory work cannot be underestimated as it is critical to field crew efficiency. The purpose of office evaluation is to: (1) determine whether the sample location or surrounding area is likely to meet the definition of the target population; (2) verify if the sample location is accessible and, if so, plan a travel route; and (3) develop a preliminary plan for laying out the monitoring plot. The monitoring plot can be shifted up to 50 m from the sample location (see Section 4.0 for plot layouts); thus, the entire area within 50 m of the sample location should be evaluated.

Anyone involved with the monitoring project can conduct the office evaluation, but it is most often conducted by the agency project lead or the field crew lead. Whenever possible, this step should be completed before the start of the field season to allow for adequate time to deal with access issues or other impediments. Office evaluation can include, but is not limited to: reviewing aerial imagery, topographic maps, riparian and wetland mapping, ownership boundaries, and other ancillary spatial information; compiling previously collected monitoring or assessment data; consulting with field office resource specialists for local knowledge; and contacting private landowners to obtain access permissions and instructions.

Office evaluations can be used to determine whether a sample location is a member of the target population and if it is accessible. Any determination to reject a site should always be based on at least two lines of evidence (e.g., aerial imagery and local knowledge, aerial imagery followed by a field visit). A sample location that is rejected during office evaluation needs to be assigned a category and a reason listed in Table 3. Because targeted sites have been selected for a specific management question, be sure to check with the project manager before rejecting any targeted sites.

If a sample location has been determined to meet or potentially meet the target population criteria and to be accessible, an access plan should be developed. The plan should include directions to the sample location, any potential obstacles or difficulties that may be encountered accessing the site, keys or lock combinations required for passage, and contact information of agency staff or private landowners, if needed. All site and access information obtained during the office evaluation should be given to the field crew prior to departure. If the person who performed the office evaluation is not going into the field, the crew should be given the opportunity to review the information prior to departing for the field in case they have questions.

Once crews are familiar with the site information and their planned route, they will need to assemble their navigational supplies and equipment. These should include at least the following:

- Road and topographic maps, with land ownership boundaries, for all areas the crew will visit. State gazetteers, agency-specific road maps, and 1:24k-scale surface ownership maps are strongly recommended.
- GPS and compass.
- Tablet with pre-loaded maps and navigation capability.
- Sample packet with information pertaining to the locations slated for sampling, including:
    - Sample location code
    - Sample location coordinates
    - Name of general area, if named
    - Closest city or town and highway
    - Closest hospital or urgent care center, in case of emergencies
    - Landowner contact information and access instructions, if applicable
    - Any available access information, such as directions on which roads to take, possible access routes, and comments from field crew managers, project managers, and field office staff

Lastly, careful consideration should be given to the potential plot layout by examining aerial imagery, topographic maps, and any existing wetland mapping. Based on the size and extent of the riparian or wetland site, use rules for plot layouts in Section 4.0 to determine a preliminary plot layout plan. The preliminary plan can be documented on an aerial photo or tablet that can be consulted in the field. While a preliminary plot layout plan may work effectively in the field, there may be times when field conditions result in a modification of the plot layout. Careful consideration should also be given to identifying the best possible window of time for sampling, which can be influenced by local precipitation regimes, regional phenology, and land use (see Section 2.3: Timing of Data Collection).

3.2 Field Evaluation of Sample Locations

All sample locations that pass the initial office evaluation must be visited in the field to verify that they meet the target population criteria and are accessible, following the flow diagram in Figure 4. If office evaluation determined that the site can be sampled or if access prevents multiple visits, field evaluation may be conducted immediately before sampling. However, if office evaluation is inconclusive, field evaluation should be conducted in advance of actual sampling to increase efficiency during the field season. In either case, when the site is visited for field evaluation, navigate as close to the sample location as possible and document the route used. Whenever attempting to access a sample location, ensure that private property is not crossed without obtaining permission.

If the sample location is accessible, determine if the sample location satisfies all the criteria for the target population and can be sampled. To meet the criteria, the sample location and area covered by the potential plot must have (see Section 1.2 for more detail):

- **Perennial vegetation:** At least 10% cover of perennial vegetation under typical growing season conditions without disturbance (e.g., heavy livestock use, wildfire, flooding).
- **Hydrophytic vegetation:** Within existing cover, a dominance of hydrophytic vegetation (OBL, FACW, or FAC species).
- **Hydrology:** Evidence of hydrology influenced by surface or groundwater at some point in the growing season.
- **Limited scour channel:** No more than 10% of the monitoring plot can contain an unvegetated active scour channel.
- **Shallow water:** No more than 10% cover of permanent standing water deeper than 50 cm (20 in) during the growing season.
- **Sufficient area and width:** Sufficient area to accommodate three 25-m transects with individual transects spaced at least 5 m apart. For narrow sites, a minimum average width of 2 m.

If all criteria are met, take photographs of the sample location to document its characteristics and review the preliminary plot layout plan based on the options outlined in Section 4.0. If the site is visited as a reconnaissance trip, document that the criteria have been met, record the site as "Not sampled – Reattempt needed" and "Recon visit" on the Site Evaluation Data Sheet (Appendix I), and include any helpful information for the sampling crew. If site evaluation is happening at the outset of the sampling visit, record the site as "Sampled" and prepare to set up the plot.

If the sample location is inaccessible or the crew is not able to sample at the time of the site visit, classify the sample location as "Not sampled" and either "Reattempt needed," "Permanently inaccessible," or "Nontarget" on the Site Evaluation Data Sheet using one of the categories from Table 3. After all efforts have been made to navigate to the sample location coordinates, record whether you arrived at the sample location. If the sample location was inaccessible, take GPS coordinates of the closest location that you were able to access. If the sample location was reached but is unsampleable, take photographs to document the outcome.

Provide detailed information on all attempts made to access and sample the plot, including directions, GPS coordinates, and photographs. Travel directions to the plot should start from a major town or landmark and include both driving and walking parts of the journey. Be complete and concise and note landmarks, permanent features, road names, land ownership issues, and segment distances. If the sample location could be accessed and sampled at a different time, be sure to note any stipulations that could help ensure the success of a reattempted visit to the site.

3.3 Outcomes of Sample Locations

The outcome of any field visit should be tracked throughout the field season. By the end of a field season, all potential sample locations should be placed in one of the following four categories based on office and field site evaluation and attempted sampling. Table 3 includes further detail on unsuccessful outcomes. As a reminder, be sure to check with the project manager before rejecting any targeted sites.

1. **Sampled**: The sample location or surrounding area is within the target population, data were successfully collected, and the sample location was fully sampled. In limited cases, a sample location may be partially sampled if weather or other safety concerns interrupt data collection and the crew is unable to return to finish the plot.
2. **Nontarget**: The sample location is not within the target population, and no data were collected.
3. **Permanently inaccessible**: The sample location may be within the target population, but data could not be collected because of permanent access issues or safety concerns.
4. **Reattempt needed**: The sample location is within the target population, but data were not collected because the visit was reconnaissance or because of temporary access issues or safety concerns. The sample location should be reattempted at a later date.

Table 3. General sample status and specific reasons for unsuccessful outcomes of a sample location. Descriptions apply to the sample location and all area within 50 m.

Sample Status	Reason Not Sampled	Description
Nontarget	**Uplands**	Sample location is upland. The vegetation is not dominated by hydrophytic species and is not influenced by surface or groundwater.
	No perennial vegetation	Sample location contains < 10% perennial vegetation during a typical growing season (e.g., not following heavy livestock use, wildfire, or flooding).
	Permanent deep water	Standing water at the sample location is deeper than 50 cm across more than 10% of the sample plot and is unlikely to recede.
	Size	Area cannot accommodate three 25-m transects or is less than 2 m wide.
	Administrative boundary	The sample location does not fall on lands administered by the appropriate agency.
Permanently Inaccessible	**Access denied, private**	The sample location can only be accessed by crossing private land, and landowner permission was explicitly denied.
	Access denied, terrain	All possible routes were attempted, but natural barriers such as cliffs, slopes greater than 50 percent, waterfalls, or permanently deep water prevented access.
	Distance prohibitive	The sample location falls more than 5 km (3.1 miles) from a road or UTV path, and transit time by foot is excessive. The specific distance threshold can be adjusted depending on programmatic goals.
Reattempt Needed	**Different route or permission needed**	The crew was unable to gain access to the sample location but could gain access at a later date with landowner permission or by taking a different route.
	Temporary deep water	Water at the sample location was deeper than 50 cm at the time of visit but will likely recede later in the season.
	Recon visit	The site was visited as a reconnaissance trip, sampling criteria have been met, and information helpful for the future sampling crew has been noted.
	Seasonality	Sample location meets all criteria, but the vegetation was unidentifiable because the visit was too early or too late in the season.
	Recent disturbance	Recent flood, fire, or other disturbance has caused significant impact on the vegetation, but it is likely to recover within the season or in the next season.
	Other	The crew started to access or sample but ran out of time; the crew was turned back by inclement weather; the sample location will require a backpacking crew, more capable truck, or all-terrain vehicle because it is remotely located or access road is too rugged; or other various reasons, including safety issues such as illegal activities or active wildfire in the vicinity of the sample location.

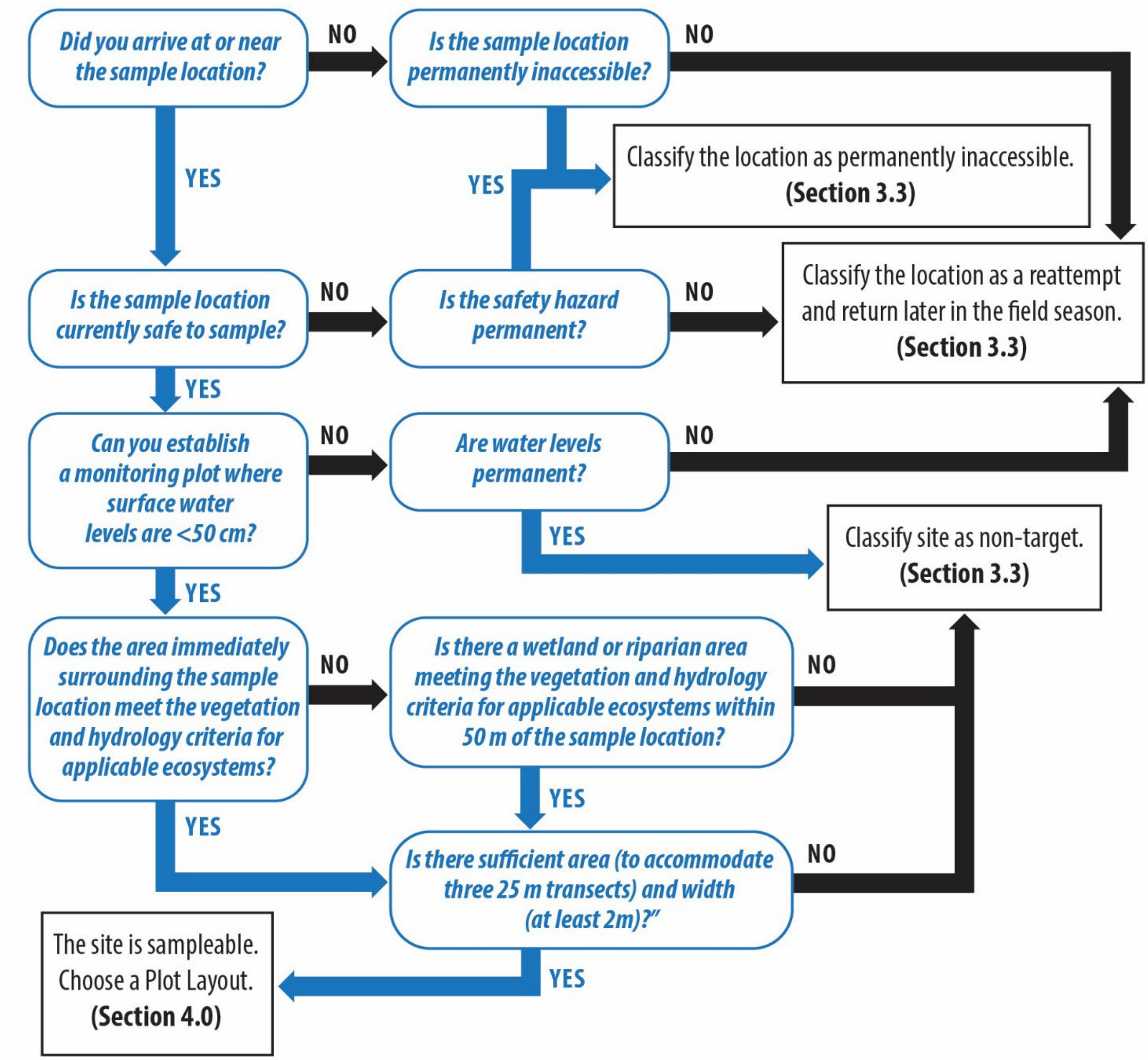


Figure 4. Flow diagram of the field evaluation process.

3.4 Special Considerations for Targeted Sites

Random sample designs answer broad management questions about the entire landscape, but they may not answer local management questions focused on specific areas. To address a variety of possible monitoring objectives at the local scale, project managers may choose to monitor targeted sites. Common targeted monitoring needs include treatment effectiveness, monitoring for management changes or restoration actions, or documenting special or unique values. Targeted sites may be selected to reflect the effects of management actions and thus may be located in areas that are most likely to respond to management actions, such as the most sensitive portion of a riparian or wetland area. They may be selected within a restoration area to track the effects of the restoration action. Or they may be selected because of their relative rarity and ecological importance (e.g., endemic species population, headwaters springs, sage-grouse habitat) or to represent reference conditions that help establish indicator benchmarks. Lastly, targeted sites may be necessary for places that lack adequate riparian or wetland mapping from which to select random sites. A random starting point within the targeted area can be used to reduce sampling bias; be aware that this is still different from a landscape random point because the area itself was selected for a specific reason, so the frame of inference is to the specific targeted area and not beyond. All methods and plot layouts in this protocol can be used in targeted sites. The following section describes specific situations when standard plot layout rules may be modified to address monitoring objectives.

As stated in Section 2.1, for site-scale targeted monitoring, measurements made within the plot (quadrats or transects) can be used as the sampling unit to derive average estimates and associated confidence intervals for the specific monitoring plot. These estimates can then be used to compare one individual plot against another or to calculate trend over time within the same plot but cannot be extrapolated beyond the specific plot.

Zones of interest within larger wetlands. Large wetlands and riparian areas can be heterogeneous in nature with multiple different patches of vegetation driven by differing hydrology and soils across the riparian or wetland area. Targeted sample locations may be placed in a smaller ***zone of interest*** within a larger riparian or wetland area, such as the mesic fringe, a greenline along a shore, or the wettest or lowest area in a wetland, to address specific monitoring objectives. In this case, the monitoring plot and associated transects will be placed to represent the zone of interest rather than the riparian or wetland area as a whole. Monitoring objectives should guide the placement of the monitoring plot within a zone of interest.

Sampling upland vegetation in historically wet areas. The footprints of many riparian and wetland areas in the Western United States have contracted or been lost entirely due to human impacts and degradation. Impacts include channels incision in wet meadows, streams with disconnected floodplains, and water withdrawals from dams, diversions, and groundwater extraction. All of these impacts contribute to the gradual decline of many riparian and wetland ecosystems. Degraded sites, however, may be excellent candidates for restoration or other management action aimed at reestablishing riparian or wetland habitat.

Where riparian and wetland areas have dried or contracted, upland species may dominate the vegetation. In these cases, historical photos and field observations of landform position and relict wetland soil or vegetation can help indicate site potential. If a targeted monitoring plot is selected to document response to a management activity (e.g., restoration, change in grazing practices), it may be desirable to establish a monitoring plot that includes the full site potential to document any increase in riparian or wetland area. In these cases, the transects may extend beyond the current edge of riparian or wetland vegetation into areas dominated by upland vegetation. Similarly, if there is concern about drying within a monitoring plot, the original plot layout should be maintained in repeat monitoring and not adjusted to match the change in riparian or wetland area. In either of these cases, it may also be useful to consider supplemental methods such as aerial photo analysis, measuring water table elevations with piezometers, and measuring soil moisture with soil probe instrumentation.

Sampling sites with fencing or exclosures. The use of fencing around specific wetlands or springs is a common management action and may provide a reference area for similar wetlands with no fencing. If targeted sites are selected to monitor effects of a fenced exclosure, it may be useful to place one plot inside the fence and one outside for comparison. See also Appendix E for more guidance.

Monitoring very small sites. For very small sites, every effort should be made to fit three 25-m transects, as it may be possible even in sites that initially appear too small. For sites that cannot accommodate three 25-m transects with individual transects spaced 5 m apart, such as very small springs, consider either shortening or reducing the number of transects or recording vegetative cover without transects (using estimated cover classes in species inventory); additionally, provide photo documentation and implement all nontransect portions of this protocol as written: Plot Classification and Description (Section 5.1), Photo Points (Section 5.2), Hydrology and Surface Water Characteristics (Section 5.3), Soil Profile Description (Section 5.4), Natural and Human Disturbances (Section 5.5), and Plant Species Inventory and Identification (Section 6.1). Using this protocol in small sites by shortening transects or shortening the spacing between points in the line-point intercept methods is possible but will lead to a less robust and less statistically valid representation of the plant community.

3.5 Designated Monitoring Areas

A ***designated monitoring area*** (DMA) is a permanently marked area of a riparian or wetland complex that has been selected for monitoring. DMAs are established by an interdisciplinary team of experienced personnel with knowledge of the management area (Burton et al. 2011). They are selected by identifying and grouping (stratifying) riparian and wetland areas into complexes with similar vegetation and physical characteristics. Once the riparian or wetland complexes have been identified, one or more plots are established for monitoring. DMA plot locations can be established randomly within a complex to represent conditions of the larger complex (representative DMA) or hand-selected to monitor a specific plot location (critical DMA) or to establish reference conditions (reference DMA) (Burton et al. 2011).

For the representative DMA approach, one or more monitoring plots are randomly selected within a riparian or wetland complex deemed to represent the target population. This approach is documented for wadeable stream environments in “Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation” (Burton et al. 2011) and can be applied to riparian and wetland areas with minor modifications (see Appendix C). This approach is a refinement of the “key area concept” used in rangeland monitoring (Elzinga et al. 1998; BLM 1996). DMAs are typically used for intermediate scales (e.g., grazing allotment, small group of allotments) and fine spatial scales (e.g., grazing pasture, single wet meadow). The target population for DMAs is generally restricted to ecological units (e.g., wetland complexes, parts of wetland complexes) most sensitive to the management activity of interest (e.g., low gradient herbaceous wetlands easily impacted by ungulates) (referred to in MIM as “sensitive complexes”). Once the target population is defined, the exact location of the plot is randomly selected within the larger riparian or wetland complex area. More detailed discussion of DMAs can be found in Appendix C.

4.0 LAYOUT OPTIONS FOR MONITORING PLOTS

This protocol is applicable to a wide variety of environments, which can occur in many different sizes and dimensions. For random sample designs, sample locations (sample points) are randomly located across the study area, and any riparian or wetland area within the target population has a probability of being selected. For targeted monitoring, sample locations are established within selected riparian and wetland areas based on monitoring objectives. Targeted monitoring may focus on a specific ***zone of interest*** within a larger riparian and wetland area (see Section 3.4). Any mention of riparian or wetland area dimensions in the plot layout descriptions that follow is equally applicable to specific zones of interest.

To provide maximum flexibility when applying this protocol, five plot layout options are available (***spoke, transverse, diagonal, linear,*** and mixed), explained in Figure 5 and illustrated in Figure 6. All layouts consist of three 25-m transects positioned around or near a sample location. For all layouts, the maximum size of a monitoring plot is 0.3 ha (~3,000 m^2 or 0.7 acres); however, monitoring plots may be smaller if the wetland, riparian area, or zone of interest is smaller than 0.3 ha. There is no minimum area for monitoring plots, but the minimum width is 2 m, the minimum length for linear plots is 75 m, and the maximum length is 200 m. Small inclusions of nontarget habitat, such as a distinct upland mound or pool of deep water, may be included within the monitoring plot but should be limited to < 10% of the entire plot. If the plot contains small nontarget inclusions, transects within the plot should be placed to avoid them; however, transects should not avoid individual upland species within a mosaic of hydrophytic and upland vegetation.

The spoke layout is the standard plot layout and should be used for all riparian and wetland areas that can accommodate a 30-m radius circle. When the size and shape of a riparian or wetland area will not accommodate a spoke layout, use the dichotomous key in Figure 5 to select an appropriate plot layout and document the rationale. Methods for establishing each plot layout are described in this section, along with guidance on combining elements of the first four layout options into a mixed layout. All methods assume that the sample location has passed the site evaluation process described in Section 3.0. For all nonspoke layouts, the general principle is to maintain three 25-m transects stretched across the site. As the width of a site narrows, the transects change from transverse (cross-cutting) to diagonal to linear.

1a. The riparian or wetland area is ≥ 60 m wide and can accommodate a 30-m radius circle ....**Spoke Layout** (Section 4.1)
1b. The riparian or wetland area is < 60 m wide **2**

2a. The riparian or wetland area is consistently ≥ 25 m wide ....**Transverse Layout** (Section 4.2)
2b. The riparian or wetland area is not consistently ≥ 25 m wide **3**

3a. The riparian or wetland area is consistently 2–25 m wide .... **Diagonal Layout** (Section 4.3)
3b. The riparian or wetland area is not consistently 2–25 m wide **4**

4a. The riparian or wetland area is consistently 2 m wide .... **Linear Layout** (Section 4.4)
4b. The riparian or wetland area is large enough to fit three transects but does not fit the dimensions for the plot layouts above. Combine elements from more than one layout .... **Mixed Layout** (Section 4.5)

Figure 5. Dichotomous key for choosing a plot layout based on the size and shape of a riparian or wetland area.

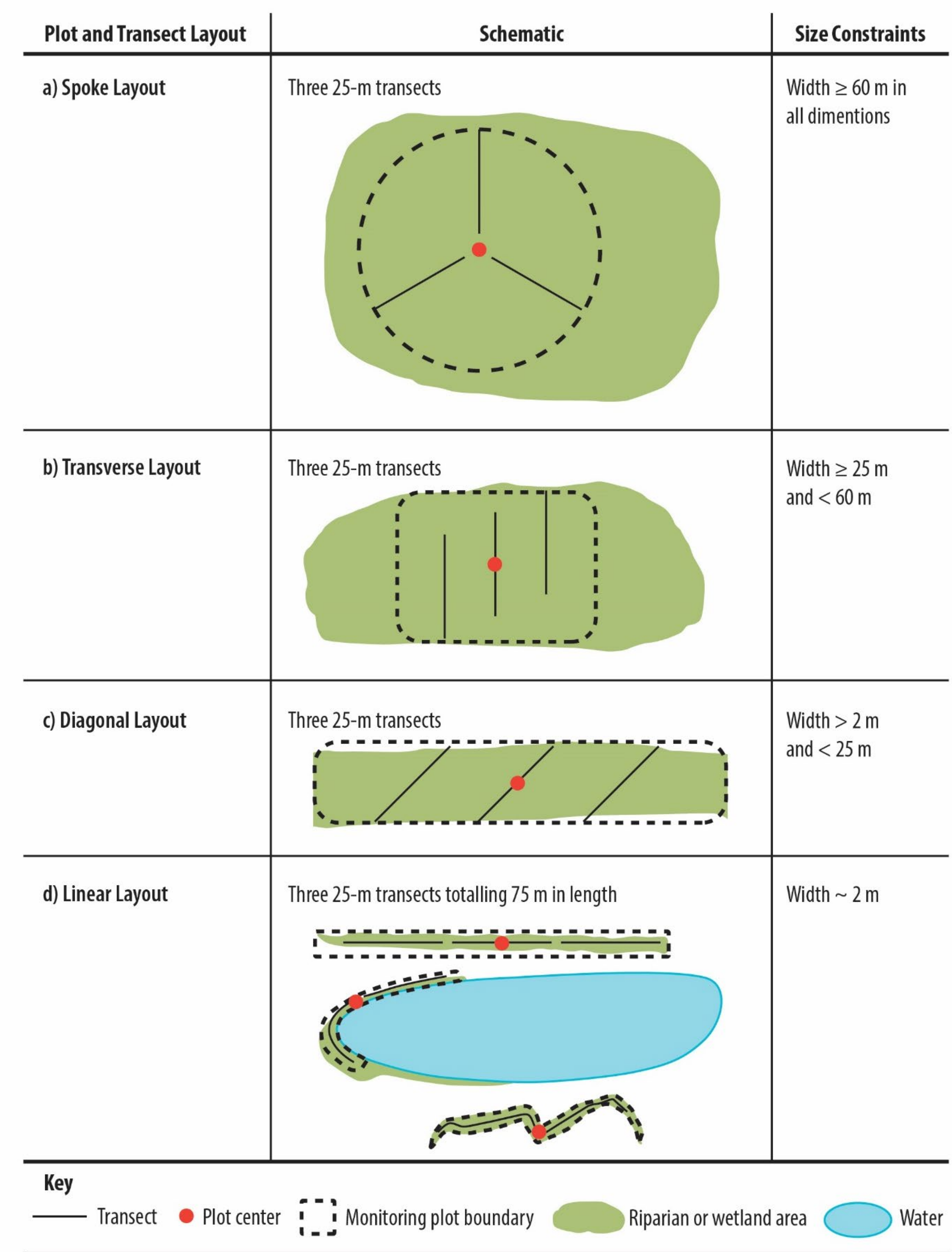


Figure 6. Illustrated matrix of plot layout descriptions.

Shifting the monitoring plot. Ideally, the monitoring plot should be centered on the sample location. However, because wetlands represent a small portion of the landscape and current wetland mapping is of variable precision, the sample location may be at or beyond the edge of the riparian or wetland area in upland vegetation, deep water, or other nontarget habitat. In these cases, a monitoring plot can be shifted away from the sample location and established in the closest applicable riparian or wetland area that is no farther than 50 m from the sample location. In other words, the edge of the monitoring plot must be within 50 m of the sample location, but the center of the plot can be further. In these cases, the monitoring plot does not need to be centered on or even contain the original sample location.

Monitoring plots may also be shifted if the shift will allow the plot to be located in a wider area of the wetland that can accommodate a spoke or transverse layout rather than a diagonal, linear, or mixed layout. Sampling wider areas is preferable to sampling narrow areas in order to limit edge effects and to facilitate plot establishment, unless the specific ***zone of interest*** is a narrow area. However, crews should seek to minimize shifting distance while establishing the most efficient plot layout possible. If the sample location was randomly selected, the plot should not be shifted based on subjective criteria, such as a moisture gradient (either wetter or drier), vegetation diversity, or degree of use. If the area around the sample location is within applicable riparian or wetland vegetation, it should be sampled, if an efficient plot can be established.

Another reason to shift a plot in either random or targeted sample designs is if the riparian or wetland area surrounding the sample location is modified or fenced. To adequately depict condition on one side of the fence or the other, the plot should be shifted to be entirely inside or entirely outside of the fenced areas. For more guidance, see Section 3.4 and Appendix E: Monitoring Altered, Developed, Artificial, or Fenced Sites.

The ability to shift monitoring plots is especially important in random sample designs selected from riparian or wetland mapping. In a random design, all area within the mapped polygons, including the edges, have a probability of being selected. In addition, the spatial accuracy of wetland mapping may be low, resulting in sample locations selected from polygons that do not align perfectly with wetlands on the ground. Shifting the plot allows these sample locations to be included, even if the plot cannot be centered at the exact location because it is at or beyond the edge of riparian or wetland vegetation. However, the distance is limited to 50 m to ensure the plot sampled represents the area at or near the sample location.

Rules limiting the distance for shifting plots do not apply for all targeted sites because they are placed to address monitoring objectives and not for population estimates. If the original sample location for a targeted site does not meet the target population, an area wider than 50 m around the sample location can be considered. However, all decisions regarding plot layout for targeted sites should be made based on monitoring objectives for the site and in consultation with the project lead or resource specialist who selected the site. See Section 3.4 for special considerations for targeted sites.

Prior to the initial site visit, agency staff, project leads, or field crews should review aerial imagery of the proposed sample location to draft a preliminary layout plan for the monitoring plot and transects to avoid bias once onsite. Field adjustments of the plot layout plan may occur as needed, once the field crew has examined conditions of the sample location in the field, but this should be kept to a minimum. If a plot will be revisited, the same plot layout should be used for all subsequent visits, and all attempts should be made to establish the transects in their original location. Using plot and transect monuments to relocate the transect positions as close as possible to previous data collection is critical for detecting change and trends over time (see the following inset box).

Monumenting Plot and Transect Locations:
Installing Permanent Markers for Revisit or Repeat Sampling

Permanent plot and transect markers such as plastic or rebar stakes can be installed to assist with plot relocation. Install markers at the end of each transect. Marker stakes should be made of securely capped or bent-over rebar or similar material. Straight or jagged rebar stakes and cut-off steel fence posts present a serious hazard to animals, people, and tires.

Photo monuments can also be used to relocate transects. For at least one of the transect photos, identify a feature on the landscape that will be used to monument and identify the transect location. Whenever possible, use an immovable, unburnable, permanent feature such as a boulder or fenceline. Large trees can work well but can burn.

For projects where permanent markers are not permitted, precise GPS coordinates and photos may suffice. For more information on plot monumenting, see Elzinga et al. (2001).

When setting up a monitoring plot, the field crew should minimize trampling in the plot, especially those areas where transects will be placed. Use caution when laying down backpacks and sampling equipment and limit the amount of walking through the sampling area until the plot and transects are established.

Materials for all plot layouts:

- Site Evaluation Data Sheet (Appendix I)
- Plot Characterization Data Sheet (Appendix I)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- GPS
- Compass (undeclinated)
- Laser range finder
- Three 25-meter measuring tapes in metric units, preferably with markings on both sides
- Chaining pins for anchoring tape (6-10)
- Pin flags for marking the plot center and ends of each transect (~20)

4.1 Spoke Layout

The spoke layout is intended for riparian or wetland areas (or zones of interest) that are large enough to accommodate a 30-m radius circle, demarcating a 0.3 ha monitoring plot (Figure 7). In the spoke layout, three 25-meter transects radiate from the plot center with a 5-meter gap to avoid repeat data collection and trampling. The transects are established 120^{o} apart. The default azimuth for transects are 0^{o} (N) for the first transect (T1), 120^{o} for the second transect (T2), and 240^{o} for the third transect (T3). If the monitoring plot contains nontarget inclusions (e.g., distinct mounds of upland vegetation, pools of deep water), transects should be adjusted in small increments until they are fully within the target habitat, as long as they maintain the 120^{o} separation. Adjust in whatever direction maintains transect azimuths as similar to the standard as possible.

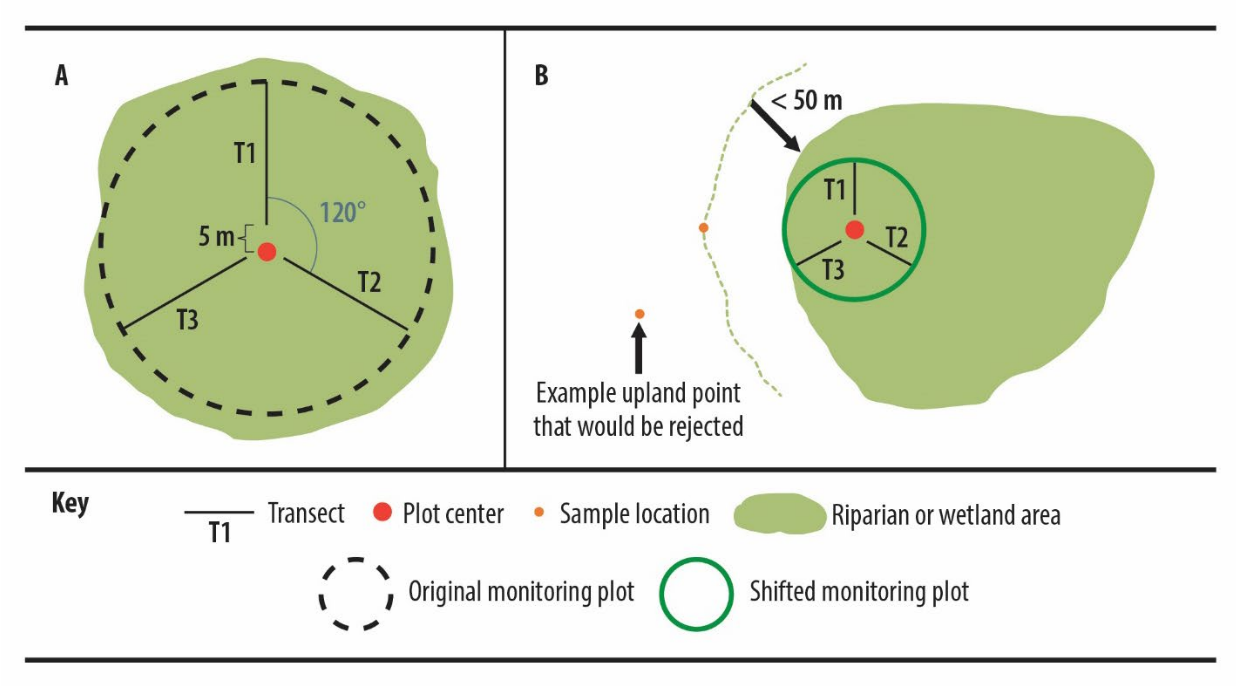


Figure 7. Configuration of the spoke layout: (A) centered on sample location and (B) shifted to closest riparian and wetland area within 50 m of the sample location.

The plot should be centered on the sample location whenever possible (Figure 7A). However, if the sample location is near the edge of the riparian or wetland area and half of the spoke layout would extend into the nontarget area, or if the sample location is beyond the edge of the riparian or wetland area and fully within nontarget area, the monitoring plot can be shifted away from the sample location and established in the closest riparian or wetland area so that the edge of the plot is no farther than 50 m from the sample location (Figure 7B). When shifting a plot, the distance measured is from the edge of the plot to the sample location. The center of the plot can be farther than 50 m.

Method for the spoke layout:

1. **Locate and evaluate the sample location**.
   1.1. If the plot can be centered on the sample location, complete all of step 1 and then skip to step 3. If the plot cannot be centered on the sample location, move directly to step 2.
   1.2. Place a pin flag into the ground at the sample location to serve as the plot center. This flag will also serve as the photo point camera location (see Section 5.2: Photo Points).
   1.3. On the Plot Characterization Data Sheet, mark that a spoke layout was used and that the monitoring plot was centered on the sample location.
   1.4. Draw the approximate monitoring plot boundary on a printed aerial photo or image on the tablet and keep the boundary in mind during plot layout and sampling. This drawing can be refined once transects are established.

2. **If necessary, shift the plot center away from the sample location**.
   2.1. If the plot cannot be centered on the sample location, evaluate the area near the sample location and determine if a 30-m radius circle can be established no farther than 50 m from the original sample location.
   2.2. Place a pin flag at the newly established plot center. This flag will also serve as the photo point camera location (see Section 5.2: Photo Points).
   2.3. On the Plot Characterization Data Sheet, mark that a spoke layout was used and that the monitoring plot was either: (1) shifted but includes the sample location or (2) shifted beyond the sample location.
   2.4. Draw the approximate monitoring plot boundary on a printed aerial photo or image on the tablet and keep the boundary in mind during plot layout and sampling. This drawing can be refined once transects are established.

3. **Establish the transects.**
   3.1. Determine the starting azimuth of the plot layout. By default, use 0^{o} (north) for transect 1 (T1) if conditions allow or rotate to accommodate conditions within the plot. Use magnetic north and do not adjust the compass for declination.
   3.2. Standing at the plot center, have one crew member sight the azimuth of the transect while a second walks the tape 5 m out from the plot center.
   3.3. Place a pin flag at the 5-m mark. This pin will serve as the 0-m end of the first transect (T1).
   3.4. With one crew member remaining at plot center to sight the azimuth, walk an additional 25 m in the same azimuth (30 m from plot center) to establish the transect (Figure 8).
   3.5. Place a pin flag at the 30-m mark. This pin will serve as the 25-m end of the first transect (T1).
   3.6. Walk an additional 5 m in the same azimuth to establish the photo point for the end of the first transect. Place a pin flag to mark the photo point.
   3.7. Walk back to the pin flag marking the 25-m end of the transect. The crew member at plot center should walk to the pin flag marking the 0-m end of the transect.

Figure 8. Using a compass to establish a transect.

3.8. Pull tape tight. Anchor both ends of the transect with chaining, keeping the tape as tight and low to the ground as possible. Use additional chaining pins in the middle of the transect, if necessary to keep the transect stable.

3.9. Repeat transect establishment twice more for a total of three transects, 120° apart, around the plot center.

4. Record the location of the transects on the Plot Characterization Data Sheet.

4.1. Record the coordinate system and datum used by your GPS unit. The recommended coordinate system is decimal degrees, and the recommended datum is WGS84.

4.2. Record the GPS coordinates of the plot center, which may be the same as the sample location.

4.3. Record the GPS coordinates of the start and end points of each transect. Verify that data are complete and accurate and make sure to allow the GPS enough time to maximize its accuracy by locating as many satellites as possible.

4.4. For each transect, record the azimuth in degrees (e.g., 120°), looking from the start of the transect to the end.

4.5. Draw the transects and the final monitoring plot on the aerial photo.

4.2 Transverse Layout

The ***transverse layout*** is intended for riparian and wetland areas (or zones of interest) that average between 25 and 60 m in width (Figure 9). The size and dimensions of the plot will be determined by the size and dimensions of the riparian and wetland area. Table 4 provides example plot dimensions. The transverse monitoring plot should be as large as possible, up to the standard plot size of 0.3 ha (~3,000 m^2 or 0.7 acres). However, the plot can be as small as 25 m x 25 m (625 m^2). The plot should be centered on the original sample location where possible (Figure 9A) or shifted away from the original sample location and established in the closest riparian or wetland area that is no farther than 50 m from the sample location (Figure 9B). If the plot is shifted, the edge of the monitoring plot must be no farther than 50 m from the sample location.

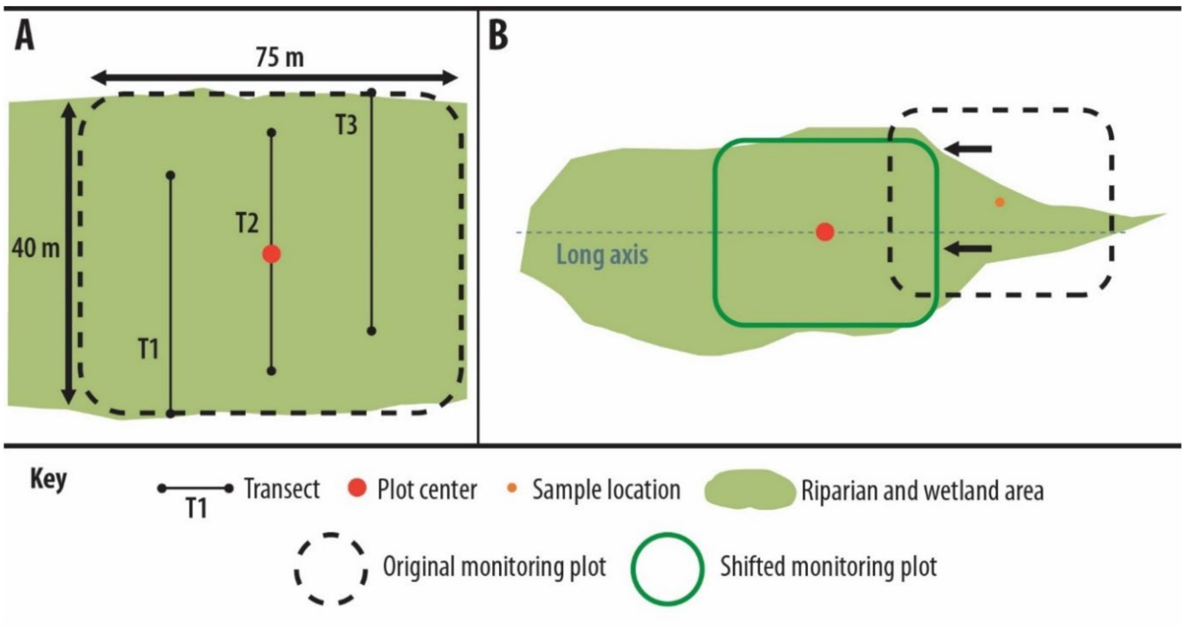


Figure 9. Configuration of the transverse layout: (A) centered on the sample location and (B) shifted within the riparian or wetland area.

In the transverse layout, three 25-m transects are established perpendicular to the long axis of the riparian and wetland area (Figure 9). They may or may not be parallel, depending on the curvature of the long axis. The transects should be spaced equidistant between the center of the plot and the far edges, which is determined by dividing the length of the monitoring plot by 4 (3 transects + 1). Where the average width is greater than 25 m, the transects should be staggered along on the short axis such that the first transect (T1) begins closer to one edge of the plot, the second transect (T2) is centered between the edges, and the third transect (T3) ends at the opposite edge (Figure 9A).

Method for the transverse layout:

1. **Locate and evaluate the sample location**.
   1.1. If sufficient riparian or wetland area extends in either direction of the sample location along the long axis, the plot should be centered on the sample location. Complete all of step 1 and then skip to step 3. If the plot cannot be centered on the sample location, move directly to step 2.

1.2 Place a pin flag into the ground at the sample location to mark where the central transect will be established.

1.3 On the Plot Characterization Data Sheet, mark that a transverse layout was used and that the monitoring plot was centered on the sample location.

2. **If necessary, shift the plot center away from the sample location**.
    2.1. If the plot cannot be centered on the sample location, evaluate the closest riparian or wetland area within 50 m of the sample location.
    2.2. Determine the dimensions of the monitoring plot (step 3) and then establish an approximate plot center that is as close to the sample location as possible.
    2.3. Place a pin flag into the ground at the newly established plot center to mark where the central transect will be established.
    2.4. On the Plot Characterization Data Sheet, mark that a transverse layout was used and that the monitoring plot was either: (1) shifted but includes the sample location or (2) shifted beyond the sample location.

3. **Determine the dimensions of the monitoring plot.**
    3.1. Measure the width of the sampleable riparian or wetland area in five representative locations at or near the sample location and record the average width on the Plot Characterization Data Sheet. Exclude large areas of nontarget habitat. If included, nontarget habitat should occupy < 10% of the monitoring plot.
    3.2. Divide the standard plot size (~3,000 m^2) by the average width to obtain the maximum plot length. Table 4 provides example plot dimensions. If the riparian or wetland area can accommodate the maximum plot length, it should be used. If the riparian or wetland area is too small to accommodate the maximum plot length, the plot length and area should be determined by the length of riparian or wetland area.
    3.3. Record the final plot width on the Plot Characterization Data Sheet.
    3.4. Draw the approximate monitoring plot boundary on a printed aerial photo or image on the tablet and keep the boundary in mind during plot layout and sampling. Documenting the monitoring plot boundary is especially important for nonspoke layouts and helps determine where transects should be placed. The drawing can be refined once transects are established.

4. **Determine placement and spacing of the transects.**
    4.1. Determine placement of the three 25-m transects along the long axis. The center transect (T2) should be located at the plot center flagged in either step 1 or step 2. Determine spacing of T1 and T3 by dividing the length of the monitoring plot by 4 (3 transects + 1). Table 4 provides spacing for several possible lengths.
    4.2. If the transects are parallel and the layout is straightforward, measure distance from one end of the transects along the edge of the plot.
    4.3. If the transects are not parallel, measure distance between transects from the midpoint of the transects. A temporary pin flag can be placed at the center of the first and third transects, if desired.
    4.4. Determine placement of the three 25-m transects along the short axis. If the average width of the monitoring plot is greater than 25 m, the starts and ends of the transects should be staggered on the short axis. The central transect (T2) should be centered between the edges of the monitoring plot. Transects on either side (T1, T3) should extend to alternate edges of the plot.

5. **Establish the transects.**
    5.1. Establish the center transect (T2) at the plot center flagged in either step 1 or step 2.

5.2. Extend the tape 25 m directly across the monitoring plot. While holding the tape, adjust the start and end points so the transect is centered between the edges and does not cross fully to either edge.
5.3. Place a pin flag and chaining pin into the ground at one end of the transect. This will serve as the 0-m end of the transect.
5.4. Walk back 5 m from the pin flag to establish the photo point (see Section 5.2: Photo Points) and mark with another pin flag.
5.5. Anchor the far end of the transect with a chaining pin and mark it with a pin flag. Use additional chaining pins in the middle of the transect, if necessary to keep the transect stable.
5.6. Repeat transect establishment for T1 and T3 on either side of the center transect, extending to alternate edges of the monitoring plot, if staggered. Even if staggered, the start of each transect should be on the same side of the monitoring plot.

6. **Record the location of the transects on the Plot Characterization Data Sheet.**
   6.1. Record the coordinate system and datum used by your GPS unit. The recommended coordinate system is decimal degrees, and the recommended datum is WGS84.
   6.2. Record GPS coordinates of the plot center, which may be the same as the sample location.
   6.3. Record the GPS coordinates of the start and end points of each transect. Verify that data are complete and accurate and make sure to allow the GPS enough time to maximize its accuracy by locating as many satellites as possible.
   6.4. For each transect, record the azimuth in degrees (e.g., 120°), looking from the start of the transect to the end.
   6.5. Draw the transects and the final monitoring plot on the aerial photo.

Table 4. Example plot dimensions and transect spacing for transverse layouts.

Average Plot Width	Maximum Plot Length*	Transect Spacing for Max Length	Minimum Plot Length**	Transect Spacing for Min Length	Plot Area with Minimum Length
50 m	60 m	15 m	50 m	12 m	2,500 m^2
45 m	67 m	17 m	45 m	11 m	2,025 m^2
40 m	75 m	19 m	40 m	10 m	1,600 m^2
35 m	86 m	21 m	35 m	9 m	1,225 m^2
30 m	100 m	25 m	30 m	7 m	900 m^2
25 m	120 m	30 m	25 m	6 m	625 m^2

*Maximum plot length is the length needed to achieve a 0.3 ha (~3,000 m^2) monitoring plot.
**Minimum plot length cannot be shorter than the width because length is measured on the long axis and width is measured on the short axis. Any length less than the maximum plot length will result in a monitoring plot smaller than 0.3 ha (~3,000 m^2).

4.3 Diagonal Layout

The ***diagonal layout*** is intended for riparian and wetland areas (or zones of interest) that average between 2 m and 25 m in width (Figure 10). The size and dimensions of the plot will be determined by the size and dimensions of the riparian or wetland area. Where possible, the diagonal monitoring plot should be as large as possible, up to the standard plot size of 0.3 ha (~3,000 m^2 or 0.7 acres), but can be as small as 2 m x 75 m (150 m^2). In addition, the maximum length of the plot is 200 m. This may result in narrow plots that are smaller than 0.3 ha, even if the riparian or wetland area continues. The plot should be centered on the sample location where possible (Figure 10A) but can be shifted away from the sample location and established in the closest riparian or wetland area that is no farther than 50 m from the sample location (Figure 10B). If the plot is shifted, the edge of the monitoring plot must be no farther than 50 m from the sample location.

In the diagonal layout, three 25-m transects are spaced equally across the riparian or wetland area and stretched from one edge to the other edge. They may or may not be parallel, depending on the curvature of the long axis, and the orientation of each transect may alternate if the system bends. In the case of long, narrow sites, transects can be laid out nearly end to end, in a nearly linear layout, but with the transects crossing the site rather than running down the middle. For narrow targeted sites or zones of interest, a diagonal layout can be used following monitoring goals along a shoreline, at the topographic low of a wetland, or along a mesic fringe, for example. If the geometry is highly sinuous, the transects may even bend to stay within the riparian or wetland area. The number of bends should be minimized, and the coordinates of each bend should be recorded.

Each transect should run diagonally across the long axis of the monitoring plot. This can be done by anchoring the 0-m mark of the transect to one edge of the riparian or wetland area and crossing the plot at an angle so that the 25-m mark of the transect coincides with the opposite edge of the riparian or wetland area. The transects should be spaced equidistant between the center of the plot and the edges of the plot, which is determined by dividing the length of the monitoring plot by the number of transects + 1. Spacing can be measured from the center of the transects for shorter plots where transects are close together or from the ends of the transects for longer plots where the transects are farther apart, whichever is easier in the field. If spacing is measured from the ends of the transect, the spacing should take into account the length occupied by the transects, which will depend on the angle of the transects. All spacing measurements can be estimated in the field to facilitate plot layout. Exact coordinates will be documented when transects are established.

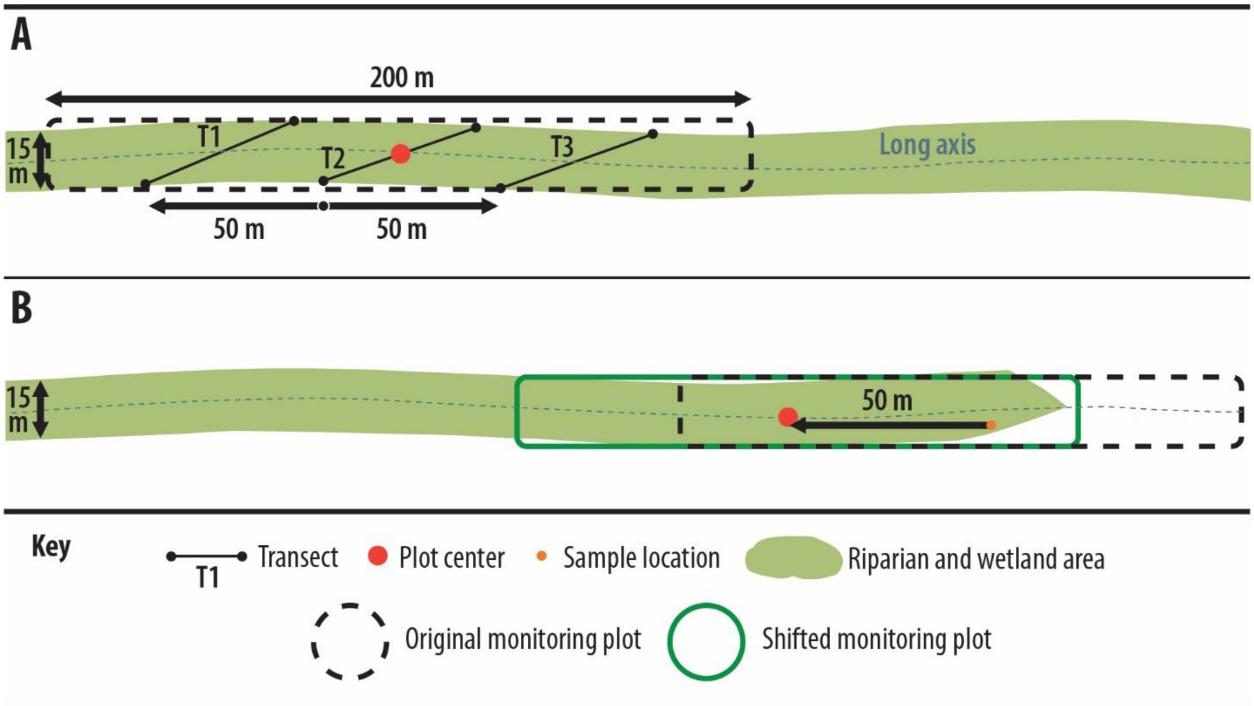


Figure 10. Configuration of the diagonal layout: (A) centered on the sample location or (B) shifted within the riparian or wetland area.

Method for the diagonal layout:

1. **Locate and evaluate the sample location**.
    1.1. If sufficient riparian or wetland area extends in either direction of the sample location along the long axis, the plot should be centered on the sample location. Complete all of step 1 and then skip to step 3. If the plot cannot be centered on the sample location, move directly to step 2.
    1.2. Place a pin flag into the ground at the sample location to mark where the central transect will be established.
    1.3. On the Plot Characterization Data Sheet, mark that a diagonal layout was used and that the monitoring plot was centered on the sample location.
2. **If necessary, shift the plot center away from the sample location**.
    2.1. If the plot cannot be centered on the sample location, evaluate the closest riparian or wetland area within 50 m of the sample location.
    2.2. Determine the dimensions of the monitoring plot (step 3) and then establish a plot center that is as close to the sample location as possible.
    2.3. Place a pin flag into the ground at the newly established plot center to mark where the central transect will be established.
    2.4. On the Plot Characterization Data Sheet, mark that a diagonal layout was used and that the monitoring plot was either: (1) shifted but includes the sample location or (2) shifted beyond the sample location.
3. **Determine the dimensions of the monitoring plot.**
    3.1. Measure the width of the sampleable riparian or wetland area in five representative locations at or near the sample location and record the average width on the Plot Characterization Data Sheet. Exclude large areas of nontarget habitat. If included, nontarget habitat should occupy < 10% of the monitoring plot.

3.2. Divide the standard plot size (~3,000 m^2) by the average width to obtain the maximum plot length. Table 5 provides example plot dimensions. If the riparian or wetland area can accommodate the maximum plot length, it should be used. However, if the riparian or wetland area is narrower than 15 m, the maximum plot length is capped at 200 m. If the riparian or wetland area is too small to accommodate the maximum plot length, the plot length and area should be determined by the length of riparian or wetland area.
3.3. Record the final plot length on the Plot Characterization Data Sheet.
3.4. Draw the approximate monitoring plot boundary on a printed aerial photo or image on the tablet and keep the boundary in mind during plot layout and sampling. Documenting the monitoring plot boundary is especially important for nonspoke layouts and helps determine where transects should be placed. The drawing can be refined once transects are established.

4. Determine placement and spacing of the transects.

4.1. Determine placement of the three 25-m transects along the long axis. The center transect (T2) should be located at the plot center flagged in either step 1 or step 2. Spacing of diagonal transects can be based on the distance between the end of one transect and the beginning of the next or between the midpoints. If the plot is long and transects are spaced far apart, measure distance between the transects from the end of one to the beginning of the next. If the plot is short and transects are close together, measure distance between transects from the midpoint of the transects. Spacing between transects must take into account the length occupied by the transects, which will depend on the width of the monitoring plot and angle of the transects. Table 5 provides spacing for several possible lengths.
4.2. If measuring from the ends of the transects, determine spacing of T1 and T3 by subtracting the total length occupied by the transects from the total plot length and dividing by 4 (3 transects + 1).
4.3. If measuring between the midpoints, determine spacing of T1 and T3 by dividing the length of the monitoring plot by 4 (3 transects + 1).
4.4. For all diagonal layouts, the orientation of the transects can alternate to best accommodate wetland shape (see Figure 11). They do not need to be parallel. Transects can even bend to stay within the riparian or wetland area. The number of bends should be minimized, and the coordinates of each bend should be recorded.

5. Establish the transects.

5.1. Establish the central transect (T2) to cross the plot center flagged in either step 1 or step 2.
5.2. Extend the tape 25 m directly across the monitoring plot at the angle needed to cross from one edge of the monitoring plot to the other. The transect will be more diagonal and approaching linear in narrower plots and closer to transverse in wider plots.
5.3. Place a pin flag and chaining pin into the ground at one end of the transect. This will serve as the 0-m end of the transect.
5.4. Walk back 5 m from the pin flag to establish the photo point (see Section 5.2: Photo Points) and mark with another pin flag.
5.5. Anchor the far end of the transect with a chaining pin and mark it with a pin flag. Use additional chaining pins in the middle of the transect, if necessary to keep the transect stable.
5.6. Repeat transect establishment for T1 and T3 on either side of the center transect.

6. Record the location of the transects on the Plot Characterization Data Sheet.

6.1. Record the coordinate system and datum used by your GPS unit. The recommended coordinate system is decimal degrees, and the recommended datum is WGS84.
6.2. Record GPS coordinates of the plot center, which may be the same as the sample location.

6.3. Record the GPS coordinates of the start and end points of each transect. Verify that data are complete and accurate and make sure to allow the GPS enough time to maximize its accuracy by locating as many satellites as possible.
6.4. For each transect, record the azimuth in degrees (e.g., 120°), looking from the start of the transect to the end.
6.5. Draw the transects and the final monitoring plot on the aerial photo.

Table 5. Example plot dimensions and transect spacing for diagonal layouts. Step 4 includes two different formulas for determining transect spacing, one between ends and one from midpoints.

Average Plot Width	Length Occupied by Transect*	Maximum Plot Length**	Transect Spacing for Max Length (Use Spacing between Ends for Long Plots)	Minimum Plot Length***	Transect Spacing for Min Length (Use Spacing from Midpoints for Short Plots)	Plot Area with Minimum Length
20 m	15 m	150 m	26 m between ends	25 m	5 m from midpoints	500 m^2
15 m	20 m	200 m	35 m between ends	36 m	8 m from midpoints	540 m^2
10 m	23 m	200 m	32.5 m between ends	45 m	10 m from midpoints	450 m^2
5 m	24.5 m	200 m	31.6 m between ends	60 m	15 m from midpoints	300 m^2

*Length occupied is calculated based on a right triangle in which the 25-m transect is the hypotenuse, the plot width is the rise of the triangle, and the length along the plot occupied by the transect is the run. These measurements are given to facilitate layout in the field.

**Maximum length is the length needed to achieve a 0.30 ha (3,000 m^2) monitoring plot but is capped at 200 m to prevent monitoring plots that are impractically or excessively long.

***Minimum plot length cannot be shorter than the width because length is measured on the long axis and width is measured on the short axis. For diagonal layouts, the minimum plot length increases as the width decreases and the transects become more linear.

.

Figure 11. Example of a diagonal layout in a vegetated drainageway. Yellow "X" indicates the original plot center, the yellow star indicates shifted plot center, and the red lines indicate the transects.

4.4 Linear Layout

The ***linear layout*** is intended for riparian or wetland areas (or zones of interest) that average approximately 2 m in width. The minimum plot length is 75 m and the maximum is 200 m, even if the riparian or wetland area continues. The plot area will therefore be less than 0.3 ha. The plot should be centered on the original sample location where possible but can be shifted away from the sample location and established in the closest riparian or wetland area that is no farther than 50 m from the original sample location. If the plot is shifted, the edge of the monitoring plot must be no farther than 50 m from the sample location.

Linear layouts are applicable in narrow vegetated drainages, along the shore of a lake or pond, or when the zone of interest is a narrow band of vegetation in a larger site (e.g., the mesic fringe of a wetland) (Figure 6d). In the linear layout, three 25-m transects are established along the long axis of the riparian or wetland area. If the geometry is sinuous, the transects may bend to stay within the riparian or wetland area or the zone of interest. The number of bends should be minimized, and the coordinates of each bend should be recorded. If the site is > 75 m long, each transect should be spaced evenly throughout the site. If the site is exactly 75 m, three transects can be laid out end to end to run the length of the plot.

Method for the linear layout:

1. **Locate and evaluate the sample location**.
   - 1.1. If sufficient riparian or wetland area extends in either direction of the sample location along the long axis, the plot should be centered on the sample location. Complete all of step 1 and then skip to step 3. If the plot cannot be centered on the sample location, move directly to step 2.
   - 1.2. Place a pin flag into the ground at the sample location to mark where the central transect will be established.
   - 1.3. On the Plot Characterization Data Sheet, mark that a linear layout was used and that the monitoring plot was centered on the sample location.

2. **If necessary, shift the plot center away from the sample location**.
   - 2.1. If the plot cannot be centered on the sample location, evaluate the closest riparian or wetland area within 50 m of the sample location.
   - 2.2. Determine the dimensions of the monitoring plot (step 3) and then establish a plot center that is as close to the original sample location as possible.
   - 2.3. Place a pin flag into the ground at the newly established plot center to mark where the central transect will be established.
   - 2.4. On the Plot Characterization Data Sheet, mark that a linear layout was used and that the monitoring plot was either: (1) shifted but includes the sample location or (2) shifted beyond the sample location.

3. **Determine the dimensions of the monitoring plot.**
   - 3.1. Determine the length of the monitoring plot. The maximum plot length is capped at 200 m for all linear layouts. If the riparian or wetland area is ≥ 200 m, this length should be used. If the riparian or wetland area is < 200 m, the full length of the sampleable area should be used. The minimum plot length is 75 m to accommodate all three transects.
   - 3.2. Record the final plot length on the Plot Characterization Data Sheet.
   - 3.3. Draw the approximate monitoring plot boundary on a printed aerial photo or image on the tablet and keep the boundary in mind during plot layout and sampling. Documenting the

monitoring plot boundary is especially important for nonspoke layouts and helps determine where transects should be placed. The drawing can be refined once transects are established.

4. **Determine placement and spacing of the transects.**
   4.1. Determine placement of the three 25-m transects along the long axis. The center transect (T2) should be located at the plot center flagged in either step 1 or step 2.
   4.2. Spacing of linear transects should be based on the distance between the end of one transect and the beginning of the next, rather than the midpoints. If the site is > 75 m long, each transect should be spaced evenly throughout the site. If the site is 75 m, three transects can be laid out end to end to run the length of the plot.
   4.3. Determine spacing of T1 and T3 by subtracting the total transect length (75 m) from the total plot length and dividing by 4 (3 transects + 1).
   4.4. If the riparian or wetland area is discontinuous, upland interruptions should represent < 10% of the overall monitoring plot.

5. **Establish the transects.**
   5.1. Establish the central transect(s) to cross the plot center flagged in either step 1 or step 2.
   5.2. Extend the tape 25 m through the center of the monitoring plot along the long axis. The transect may bend to stay within the riparian or wetland area, but the number of bends should be minimized.
   5.3. Place a pin flag and chaining pin into the ground at one end of the first transect. This will serve as the 0-m end of the transect.
   5.4 Walk back 5 m from the pin flag to establish the photo point (see Section 5.2: Photo Points) and mark with another pin flag.
   5.5. Anchor the far end of the transect with a chaining pin and mark it with a pin flag.
   5.6. Anchor the transect with a chaining pin wherever bends are necessary.
   5.7. Repeat transect establishment for T1 and T3 on either side of the center transect.

6. **Record the location of the transects on the Plot Characterization Data Sheet.**
   6.1 Record the coordinate system and datum used by your GPS unit. The recommended coordinate system is decimal degrees, and the recommended datum is WGS84.
   6.2 Record GPS coordinates of the plot center, which may be the same as the sample location.
   6.3 Record the GPS coordinates of the start and end points of each transect. Verify that data are complete and accurate and make sure to allow the GPS enough time to maximize its accuracy by locating as many satellites as possible.
   6.4 If the transect bends along its length, take a GPS point at each bend and record the coordinates as well as the meter location on the tape in the comments section for future reference.
   6.5 For each transect, record the azimuth in degrees (e.g., 120°), looking from the start of the transect to the end or to the first bend. Repeat azimuths at each bend.
   6.6 Draw the transects and the final monitoring plot on the aerial photo.

4.5 Mixed Layouts

Elements of the plot layout options can be combined if the riparian or wetland area at the sample location is not one consistent width. The spoke layout is only used if the riparian or wetland area can accommodate a full 30-m radius circle; therefore, it cannot be combined with other layouts. However, the three nonspoke layouts can be combined if the width of a site ranges from wider to narrower. In these cases, first determine if there is a consistently wide area within 50 m of the sample location in which you can establish the widest plot possible. Sampling wider areas is preferable to sampling narrow areas, unless the monitoring objective specifically focuses on the narrow mesic fringe. If there is not a consistently wide area to sample, then lay out a mix of transverse, diagonal, and linear transects to fit the site (Figure 12). Transects should be spaced evenly across the monitoring plot and should be as perpendicular to the long axis of the site as possible, while still stretching 25 m across the site.

Draw the approximate monitoring plot boundary on a printed aerial photo or image on the tablet and keep the boundary in mind during plot layout and sampling. Documenting the monitoring plot boundary is especially important for nonspoke layouts and helps determine where transects should be placed. The drawing can be refined once transects are established.

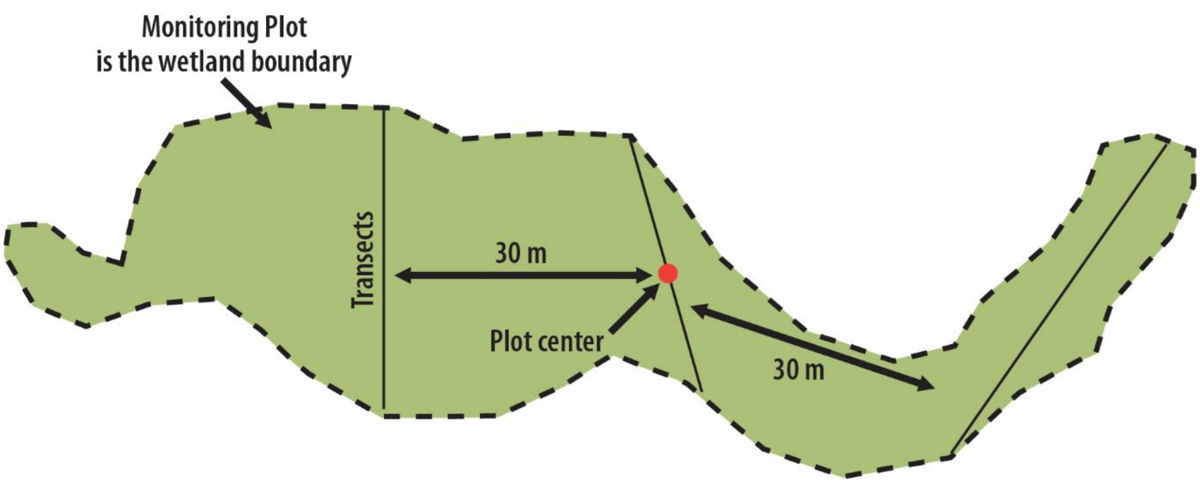


Figure 12. Example of a mixed layout that combines one transverse transect with two diagonal transects. In this example, the monitoring plot boundary is the wetland boundary. Transects are spaced evenly across the plot and extend from one upland edge to the other. Each transect is 25 m long.

Quality Assurance
☐ Plot layout and any shifting of plot center are noted and documented on the Plot Characterization Data Sheet. ☐ Avoid disturbing vegetation and the soil surface in the transect area. ☐ Three transects have been established with chaining pins and pulled as straight as possible. ☐ GPS coordinates of transect start and end points and azimuth of each transect have been recorded. ☐ Always walk on the same side of the transect tape. Avoid the left side of the tape where data will be collected. ☐ GPS coordinates, coordinate system, and datum are recorded correctly and conform to organization standard.

5.0 Covariate Methods

Covariate information collected in the sampled riparian or wetland area characterizes the site, informs site potential, and groups similar monitoring plots for data analysis and interpretation. Covariate methods include: (1) classification and description of the monitoring plot; (2) photos of the plot and each transect; (3) quantitative and qualitative measurements of plot hydrology; (4) a detailed soil profile description from at least one soil pit within the plot; and (5) an inventory of natural and human disturbances surrounding and within the plot. All covariate indicators should be collected during the initial establishment visit, and most should be collected during visits in subsequent years. However, the soil profile does not need to be repeated after the second visit if the data do not change between visits and there is no obvious new disturbance to the soil surface. All covariate methods in this section have been adapted from existing protocols for application in riparian and wetland areas (Table 2).

Covariate data are collected in three basic stages: (1) prior to field data collection, (2) at the plot, and (3) as part of the quality control process. Topographic maps, aerial photos, and other ancillary data sources can be studied to understand potential water sources and disturbances. Soil maps may be consulted to determine the dominant soil types and ecological sites surrounding the plot. While at the plot, the five main types of characterization and covariate data are collected, and distinctive elements of the plot are photographed. After data collection, plot characterization and covariate data sheets are reviewed for clarity, completeness, and accuracy.

Site-Scale Elevation and Topographic Data: Important Supplemental Data

Riparian and wetland vegetation is often tied to topographic position and water availability. Vegetation growing at lower topographic positions, closer to the groundwater table, stream channel, or standing surface water, is adapted to wetter and sometimes anoxic conditions. Vegetation growing at higher topographic positions in relation to the groundwater table, stream channel, or standing surface water can tolerate drier conditions. Plant communities within riparian and wetland areas often grade from wet areas to drier, more upland areas within the site. Although not required for this protocol, practitioners may decide that detailed topographic information would be helpful for a site and conduct a topographic survey to obtain fine-scale elevation data along each transect and across the plot. This facilitates relating vegetation and other indicators along the plot transects to topographic position and gradients like water availability that can vary with topography. Topographic surveys along transects and through the plot can be accomplished with a laser level, total station, survey-grade GPS device such as real-time kinematic (RTK) surveying, UAV- or pole-mounted camera photogrammetry (structure-for-motion), or LiDAR imaging. This protocol does not include methods for topographic surveying; however, the U.S. Geological Survey has extensive publications on land survey methods in their publications warehouse (https://pubs.er.usgs.gov/), such as Rylund and Densmore (2012).

5.1 Plot Classification and Description

Overview: Riparian and wetland areas occur in a variety of landscape settings. Classifying the type of riparian or wetland area encompassed by the monitoring plot will aid in data interpretation and provide ground-truthing for site attributes initially derived from aerial imagery interpretation or remote sensing. Indicators calculated from the core and contingent methods, such as vegetation and water quality data, are best interpreted when compared against similar riparian and wetland types. For instance, the species richness of a playa is typically significantly lower than a riparian area, and these two types should not be compared against the same benchmark. Placing each monitoring plot into the proper class will ensure a robust understanding of the site and landscape context for data analysis and management decisions.

There are multiple nationally recognized classification systems for riparian and wetland areas, as well as local or colloquial classification systems used in different parts of the country. For this protocol, each plot will be classified by the two most widely used wetland classification systems, the ***Cowardin classification system*** (Cowardin et al. 1979; FGDC 2013) used by the U.S. Fish and Wildlife Service (USFWS) for ***National Wetland Inventory (NWI)*** mapping and the ***hydrogeomorphic (HGM)*** **classification** (Brinson 1993; Smith et al. 1995; NRCS 2008). The Cowardin classification system emphasizes dominant lifeform of the vegetation (e.g., emergent herbaceous, scrub-shrub, forested) and water regime (e.g., temporarily flooded, permanently saturated), while the HGM classification emphasizes landscape position, water source, and hydrodynamics. Used together, they describe many characteristics of riparian or wetland areas. In addition to the Cowardin and HGM classifications, each plot will be classified into a general riparian or wetland type using colloquial names such as a meadow, riparian shrubland, playa, spring, etc. Sites can be given an initial classification in the office prior to the site visit, but all classifications should be verified in the field. Many resources should be used when assigning a final classification.

Materials:

- Plot Characterization Data Sheet (Appendix I)
- Plot Drawing Data Sheet (Appendix I)
- Keys and descriptions of each classification system (Appendices J, K, and L)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- GPS
- Compass (undeclinated)
- Clinometer

Method:

1. **Complete top section of Plot Characterization Data Sheet.**
   1.1. Record plot ID. In most applications, the plot ID will be established prior to sampling and should be known by the crew. In other applications, a system for establishing plot IDs for new sites may be developed. Once a plot ID is established for that plot and visit date, it is permanent and can never be changed.
   1.2. Record plot observer(s), date of current visit, and establishment date. If this is the first visit to that location, visit date and establishment date will be the same.

1.3. Record site name. Use a regionally applicable geographic name, such as a nearby landform, town, creek, or other water body. In some places, wetlands and meadows themselves are named on USGS maps or have locally known names. The same name can be repeated if more than one monitoring plot is established in the same general area. The plot ID will distinguish the plots from one another. However, distinguishing characteristics like Upper Jack Creek vs. Lower Jack Creek or Beaver Meadow Exclosure vs. Beaver Meadow Outside Exclosure can be added. Site names should be short phrases with only a few words, not a full sentence description. The first letter of each word should be capitalized.
1.4. Select the sampling approach used to select the point: random or targeted.

2. Describe the elevation, slope, and aspect of the monitoring plot in the Plot Characterization Data Sheet.

2.1. Record the elevation of the plot (in meters) using the GPS elevation in the field.
2.2. Record the slope (in percent) in the direction that overland water would flow through the center of the plot. Slope can be determined using a clinometer. Consider the entire area encompassed by the plot, from the upslope edge to the downslope edge. Do not be too concerned with microtopographical variation within the plot. If the vegetation is dense in the center of the plot, try measuring slope just beyond the plot in an area with similar slope but more open vegetation. This is often possible in riparian shrublands.
2.3. Record the aspect of the slope (in degrees) facing downslope from plot center. Use magnetic north and do not adjust the compass for declination. If a plot has a slope less than 1%, record the aspect as NA.

3. Classify the monitoring plot in the Plot Characterization Data Sheet.

3.1. All information obtained during data collection should be used to classify the monitoring plot. For this reason, classification is typically assigned at the end of the sampling visit.
3.2. Review a detailed topographic map of the site to understand landscape position. Walk the whole site plot and consider likely water sources (see Section 5.3), soils (see Section 5.4), and plant communities (see Section 6.0). Review supplemental data, including climate data, floodplain maps, soil maps, and geologic maps, as needed. When applying each classification system, pay careful attention to how each system informs the others.
3.3. Use the descriptions provided in Appendix J to classify the plot by predominant Cowardin system, class, water regime, and optional modifiers.
3.4. Use the key and descriptions provided in Appendix K to classify the plot by HGM class and optional subclass.
3.5. Use the key and descriptions provided in Appendix L to classify the plot by general wetland type.
3.6. Document any ambiguity about the three classification systems in "Classification Comments."
3.7. Additional local classification systems or classification systems specific to certain riparian or wetland types can also be added in "Classification Comments." One example would be the Springer and Stevens classification for springs (Springer and Stevens 2008), if applicable.

4. Describe the monitoring plot in words and illustration in the Plot Drawing Data Sheet.

4.1. Draw a rough sketch of the plot on the Plot Drawing Data Sheet to approximate scale (Figure 13). Add an arrow for magnetic north. Draw the boundary of the monitoring plot and include each of the three transects with the start and end labeled. Mark the locations of the soil pit(s) and water quality samples. Indicate predominant water flow paths and channels using arrows. Document slope and aspect, prominent landscape and vegetation features, range improvements, and human and animal impacts. Use the following standard symbols where appropriate:

- Plot center: X
- Soil pit: upside down triangle ∇
- Water quality: rain drop or circle O
- Water flow path: dashed arrow - - - ->
- Transect start and end: 1A, 1B, 2A, 2B...
- Transect lines: Solid lines _____

4.2. Describe the major characteristics of the plot in a short paragraph on page 2 of the Plot Characterization Data Sheet (Figure 14). Include the following in the description:
- Wetland type
- Landscape position
- Dominant vegetation
- General hydrology
- Soil type
- Major land uses

4.3. **Optional:** Note the presence of any species of concern (e.g., spring snails) and related habitat features at the bottom of page 2 of the Plot Characterization Data Sheet. Consult the project lead for potential species of concern and relevant details.

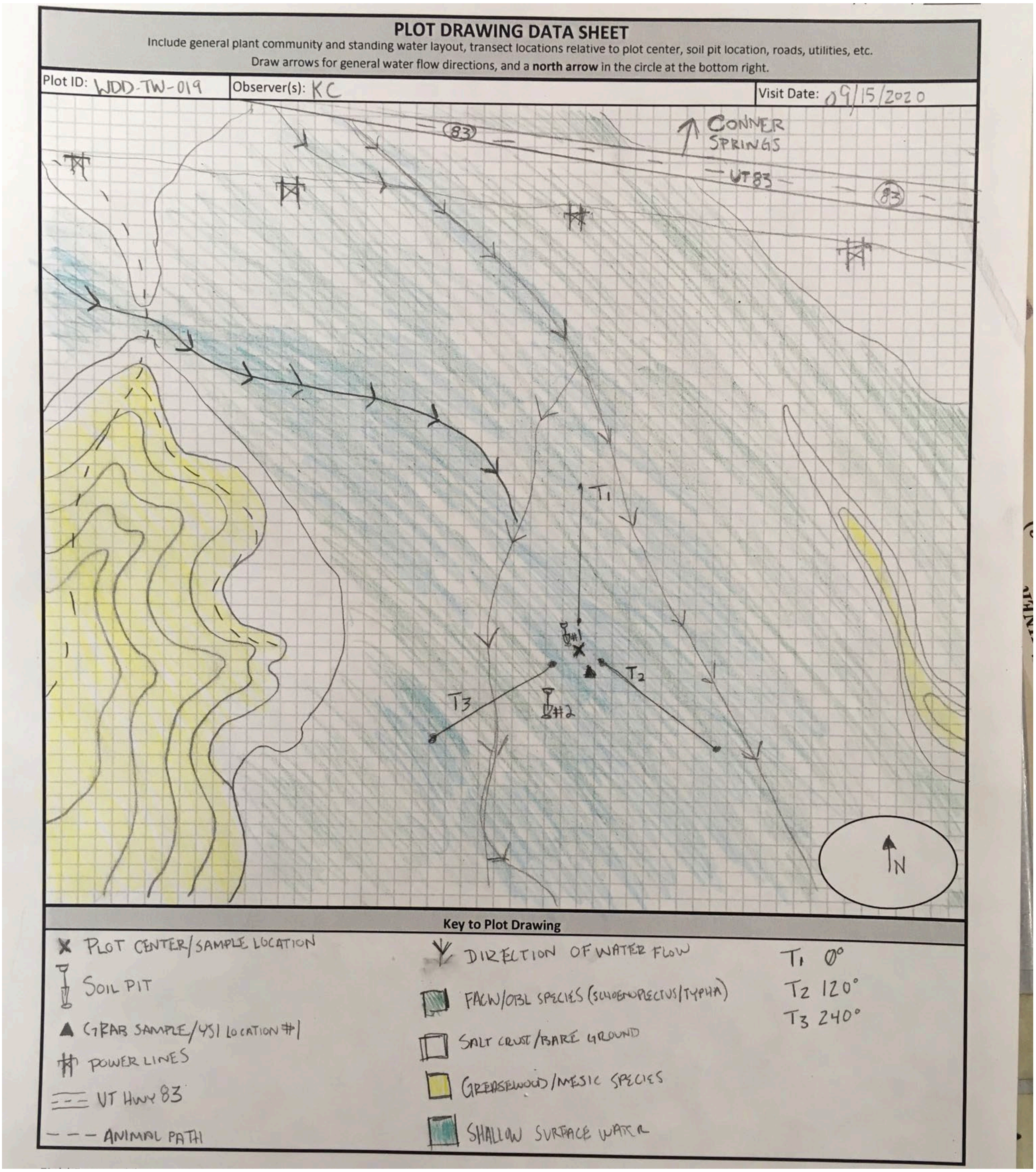


Figure 13. Example plot drawing with details noted.

Reviewed by (initials): ________

PLOT CHARACTERIZATION DATA SHEET, PAGE 1

Complete when Plot is established, along with a sketch of the Plot layout on the Sample Plot drawing sheet.

Plot ID: Big Meadow-32 | **Observer(s):** Daniel Garcia, Lily Smith | **Visit Date:** 2019-07-23

Site Name: Big Meadow

Sampling Approach: ☒ Random ☐ Targeted | **Plot Layout:** ☒ Spoke ☐ Transverse ☐ Diagonal ☐ Linear ☐ Mixed

Coordinates of Plot Center and Transects

Coordinate System: Decimal Degrees | **Datum:** WGS84

	Latitude	*Longitude*	*Azimuth*	*Length (m)*	*Photo #*
Plot Center	37.938243	-107.545338	NA	NA	1254
T1 start	37.938314	-107.545324	0	0	1255
T1 end	37.938547	-107.545295	180	25	1256
T2 start	37.938256	-107.545265	120	0	1257
T2 end	37.938145	-107.545090	300	25	1258
T3 start	37.938256	-107.545337	240	0	1259
T3 end	37.938181	-107.545613	60	25	1260

Elevation (m): 3139 | Slope (%): 6 | Aspect: 240

Plot Layout Comments

The site was large enough to fit a spoke.

General Wetland Type (add others as needed)

☐ Wet/Mesic Meadow ☐ Riparian Forest ☐ Playa ☐ Pond Edge ☐ Other:
☐ Marsh ☒ Fen/Bog ☐ Vernal Pool ☐ Impounded drainage
☐ Riparian Shrubland ☐ Vegetated drainage ☐ Spring/Seep ☐ Hanging Garden

Hydrogeomorphic Type (mark the HGM class and the subclass that best fits the sample plot)

HGM Class	Subclass (Optional)		
☒ Slope	☐ Stratographic (side of hill)	☒ Topographic (toe of slope)	☐ Vegetated drainage
☐ Depression	☐ Closed	☐ Open	
☐ Riverine	☐ Floodplain	☐ Complex	☐ Beaver-impounded
☐ Lacustrine Fringe	☐ Natural Lake	☐ Reservoir	
☐ Flat	☐ Mineral Soil	☐ Organic Soil	

Predominant Cowardin Type (circle one from System, Class, Water Regime, and Optional Modifier)

System	Class		
☒ P: Palustrine	☒ EM: Emergent	☐ SS: Scrub-Shrub	☐ FO: Forested
	☐ AB: Aquatic Bed	☐ US: Unconsol. Shore	☐ UB: Unconsol. Bottom
☐ Rp: Non-Wet Riparian	☐ EM: Emergent	☐ SS: Scrub-Shrub	☐ FO: Forested

Water Regime

☐ A: Temporarily Flooded ☐ D: Permanently Saturated ☐ G: Intermittently Exposed
☐ B: Seasonally Saturated ☒ E: Seasonally Flooded/Saturated ☐ H: Permanently Flooded
☐ C: Seasonally Flooded ☐ F: Semipermanently Flooded ☐ J: Intermittently Flooded

Modifier (Optional)

☒ b: Beaver ☐ d: Partly Drained/Ditched ☐ h: Diked/Impounded ☐ x: Excavated

Classification Comments

A small beaver dam was observed in the main stream channel northeast of plot center.

General Plot Description

This plot is a subalpine fen dominated by Carex aquatilis. It is groundwater fed with saturated soils and surface water throughout. Other water sources include snowmelt (visible at higher elevations near the plot) and springs. There are no streams within the plot, but there are many within the landscape, with one coming directly along the north side of the plot on the outside of Transect 1. This stream does not contribute much water to the plot itself; however if/when overbank-flooding occurs, at least some of the plot would be affected. A small beaver dam was observed in the main stream channel northeast of plot center. Several springs are located north of the stream. The plot is just below Big Meadow Pass, which is frequented by OHV users, but the plot itself does not have evidence of vehicle use. The soil pit revealed over 50cm of fibric organic material and the dominant hydric soil indicator is A1 (histosol). Dominant species include Carex aquatilis and Caltha leptosepala. Salix planifolia seedlings were scattered throughout the plot.

Figure 14. Example Plot Characterization Data Sheet.

Quality Assurance
☐ Notes are as complete and exact as possible, using professional language to record observations rather than value statements. ☐ Classifications have been discussed and checked among crew members. ☐ Abbreviations are defined. ☐ All required fields are filled out. ☐ GPS coordinates, coordinate system, and datum are recorded correctly and conform to organization standard.

5.2 Photo Points

Overview: Photo points are used to qualitatively monitor site changes over time. Repeat photographs of a landscape are useful for detecting changes in vegetation structure and water levels, visually documenting measured changes, and aiding in verifying and interpreting quantitative data back in the office. Photos are also vital for locating a plot or transect on subsequent visits. Several photos are required at each site visit, including two photos of each transect, an overview photo of the monitoring plots, photos of the soil pit and hydrologic features, and any other notable feature of interest. Because riparian and wetland vegetation is often tall and thick, two people are needed to take all transect photos, one to hold the photo ID board and the second to take the photos. For more information on photo point monitoring, see the USFS “Photo Point Monitoring Handbook” (Hall 2002) or the “Photo Monitoring for Ranchers Technical Guide” (Gearhart and Launchbaugh 2015). With rapidly developing technology, alternative approaches to photo points may be applicable and can be used if they provide high-quality images of the monitoring plot with clear spatial reference.

Materials:

- Plot Characterization Data Sheet (Appendix I)
- Photo Log Data Sheet (Appendix I)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Photo ID board (chalk or whiteboard) or laminated photo ID card on a clipboard (Appendix I)
- Thick marking pen or dry-erase marker in a dark color
- Clean rag for removing marker or chalk from photo ID board (optional)
- Isopropyl alcohol for periodically cleaning whiteboard (optional)
- Compass (undeclinated)
- High-resolution camera or tablet with high-resolution camera
- One 1.5 m (5 ft) long, 3/4-inch diameter PVC pipe

Method:

1. **Set up the first transect photo.**
   1.1. Check the camera’s settings. Adjust the field of view to minimum zoom and infinite focus settings. Do not use the flash. See quality assurance box at the end of this section for more techniques for taking high-quality photos.
   1.2. Prepare a legible photo ID board. Fill in all information on the photo board and make sure written lettering is thick and clear. Key information on the photo board includes: plot ID, date, transect number, and azimuth. Date should be written as month/day/year (e.g., 07/15/2021 for July 15, 2021). Photos of the transect start (0-m end) should be noted with an A after the transect number, and photos of the transect end (25-m end) should be noted with a B (e.g., 1A, 1B, 2A, etc.).
   1.3. Stand back 5 m (16.4 feet) from the start of the transect in line with the azimuth of the transect (Figure 15). This is the camera location. In a spoke layout, the camera location for all transect start photos should be the center of the plot. For nonspoke layouts, the camera location may be beyond the monitoring plot. If you are unable to stand 5 m from the transect start due to

topography or dense vegetation, note the distance from the transect start on the photo ID board and in the photo comments.

1.4. Set the camera body on top of the 1.5-m (5-ft) PVC pipe (the default height for a transect photo) and point the camera lens toward the first transect such that the photo will be taken in landscape orientation. The bottom of the pipe should rest on the ground. In tall or dense vegetation, a different height may be necessary. If deviating from the default height, note the specific deviation on the photo ID board and in the photo comments.

2. **Take the first transect photo.**
    2.1. Have a colleague hold the photo ID board so that it is visible in the left or right edge of the screen, in front of vegetation and as low and unobtrusive as possible. Do not include the person holding the board in the photo, only the hand holding the board (Figure 15).
    2.2. Ensure that the photo ID board is in a lower corner but leave some space below and to the side of the board. This demonstrates to future viewers that all data on the board has been photographed and has not been cut off.
    2.3. Ensure that the photo includes some of the horizon, if possible. The sky should fill approximately one-third of the frame unless obstructed by tall vegetation or a significant slope. If the desired features do not show well when attempting to capture the horizon, prioritize the best representation of the transect in the official transect photo and take an additional photo to show the horizon.
    2.4. If photos were taken of the plot in the past, make sure current photos are taken at the same distance from the transect, azimuth, and with the same horizon. It may be helpful to bring copies of past photos to the field for reference.
    2.5. Signal data collection crew to exit the field of view.
    2.6. Take the photo and immediately check that it saved to the camera's memory card and that the photo board is readable. If not, adjust the settings and retake the photo.
    2.7. If tall vegetation or large rocks obstruct all of the transect from the original camera location, take a second photo at a location farther down the transect, pointing in the same direction. Note the new camera location on the ID board and in the photo comments.
    2.8. Record the photo number (default number assigned by the camera) by transect number on the Plot Characterization Data Sheet. Make a note of any monuments and the transect with which they are associated in the photo comments.

Figure 15. Example photo point pictures in (A) an herbaceous wetland and (B) a woody riparian area.

3. **Take start and end photos for each additional transect.**
   3.1. Repeat steps 1 and 2 for photos of the start (0-m end) of each additional transect.
   3.2. Move to the end (25-m end) of each transect and take photos within the same setup rules.

4. **Take a monument photo.**
   4.1. Stand at plot center and identify a direction to take a photo that includes a monument feature. A monument feature on the landscape should be an immovable, unburnable, permanent feature such as a boulder, fence line, or notable hill. Large trees can work well but can burn.
   4.2. Record the azimuth of the monument photo and record any notes about the monument feature.

5. **Take one or more overview photos of the plot.**
   5.1. Take one or more overview photos of the monitoring plot, preferably from higher ground, to provide context for the site and the surrounding area (Figure 16).
   5.2. If you are using a tablet, use the draw tools to indicate the placement of all three transects on a copy of the overview photo. Ensure that a clean version of the overview photo is saved along with the marked-up copy. In addition to the transects, indicate the location of the original sample location (if visible), the soil pit (if visible), and other major features. If you are recording data on paper, draw the transect line on an aerial photo of the site.
   5.3. Photograph any other monuments (e.g., rebar, large boulders, trees) that are installed or identified in order to revisit plot and transect locations. This can be in addition to any monuments identified in the monument photo. See inset box on installing permanent markers in Section 4.0.

6. **Take additional required and optional photos.**
   6.1. Several additional photographs are required and detailed throughout the protocol, including photographs of hydrologic features (Section 5.3), the soil pit (Section 5.4), and disturbances (Section 5.5). See Table 6 for a complete list of required photographs.
   6.2. In addition to the required photographs, take photos of features of interest that occur in or immediately surrounding the plot, including, but not limited to: noxious weeds or other invasive species, evidence of plant disease or recent fire, conservation practices, seeding, fence line contrasts, soil disturbance, hummocks, water developments, beaver evidence, berms, gullies, rills, headcuts, or other erosion patterns (Figure 17).
   6.3. Refrain from marking-up additional photos besides the overview. Provide explanatory comments in the photo form.

7. **Document all photos on the Photo Log Data Sheet**
   7.1. For all photos taken at the plot, record the photo number, photo type, and a short written explanation in the comment section (Figure 18).
   7.2. Use the photo types listed in Table 6.

Table 6. List of required and optional photographs, by type.

Photo Type	Photo Name	Required (Y/N)
Overview	Site Overview (No Markup)	Yes
Overview	Site Overview with Markup	Yes
Overview	Directions Help	No
Overview	Plot Drawing	Yes
Overview	Original Sample Location	Yes, if different from plot center
Overview	Plot Center	Yes
Monument	Monument Photo	Yes
Transects	Transect 1 Start	Yes
Transects	Transect 1 End	Yes
Transects	Transect 2 Start	Yes
Transects	Transect 2 End	Yes
Transects	Transect 3 Start	Yes
Transects	Transect 3 End	Yes
Soil	Soil Pit	Yes
Soil	Soil Profile	Yes
Soil	Soil Pit Overview	Yes
Hydrology	Hydrology Feature	No
Hydrology	Grab Sample	Yes, if sample taken
Hydrology	Top of Channel	Yes, if channel present
Hydrology	Bottom of Channel	Yes, if channel present
Disturbance	Natural or Human Disturbance	No
Other	Other Features of Interest	No

Figure 16. Example plot overview photos that are unmarked (top row) and marked with transects (bottom row).

Figure 17. Example photos of features of interest: (A) a noxious weed (purple loosestrife), (B) fence-line contrast in herbaceous vegetation, (C) evidence of channel incision or headcut, and (D) developed spring source.

PHOTO LOG DATA FORM		
Plot ID: Baker Creek-003	Observers: Willow Jones, Jacob Anderson	
Visit Date: 2020-06-11		
Photo Number	**Photo Type**	**Comment**
248	Site Overview	photo taken from east bank upslope of plot center
249	Site Overview	photo taken from top of canyon wall west of plot center
250	Landmark	beaver dam facing east toward plot center
251	Miscellaneous	noxious weed patch - Leucanthemum vulgare
252	Miscellaneous	beaver dam located about 20m west of plot center
253	Miscellaneous	oily sheen present in standing surface water patches

Figure 18. Example photo log entries with detailed comments for each photo.

Quality Assurance

- ☐ Select camera settings that give the greatest depth of field and minimum zoom.
- ☐ All photos are taken in landscape orientation.
- ☐ Include one-third horizon in the photo, if possible, to help establish scale and provide reference points for future replication and/or comparison.
- ☐ Photo ID board is in each photo and includes the date, plot number, line number, transect azimuth, and/or other pertinent info.
- ☐ Where possible, avoid taking photos looking into the sun. Ideally, photos should be taken with the sun at your back.
- ☐ Avoid photos where part of the frame is in sunlight and part is in shadows.
- ☐ Include something in each photo for scale (clipboard, tape measure, fence post, etc.)
- ☐ Do not use the flash. If low light conditions exist, increase the exposure settings.
- ☐ Immediately review each photo to ensure:
    - ☐ Photo is in focus.
    - ☐ The photo board is legible.
    - ☐ Reference points are visible.
    - ☐ Photos are saved to the device.

5.3 Hydrology and Surface Water Characteristics

Overview: Hydrology is a key driver for plant community composition, ***hydric soil*** formation, the creation and retention of soil organic matter, and other biogeochemical processes in riparian and wetland systems. Prior to a site visit, field crews should examine topographic maps, current aerial photos, historic aerial photos (if available), and other ancillary data such as local climate data, floodplain maps, soil maps, geologic maps, and groundwater well and water diversion data to evaluate hydrology on site. These types of data can be particularly helpful for seasonal wetlands, such as meadows, playas, or vernal pools, that may be dry at the time of sampling. During the site visit, walk the plot and use the list of Wetland Hydrology Indicators in Appendix M to look for indicators of wetland hydrology such as visible surface or groundwater or evidence of high water marks from past inundation. Based on field observations and review of ancillary data, document likely water sources and characterize the distribution of surface water (if present) and of channels within the plot (if present). In some wet meadow systems, the presence and development of channels can be an important indicator of degradation. Longer term hydrologic characteristics, including the change in channel dimensions or fluctuating groundwater levels, may be of particular interest in specific sites. The level of data collection included within this protocol is intended to identify features of interest and collect enough data to characterize the site. If management questions require repeat monitoring of channel width and depth, flow from springs, or long-term groundwater levels, more quantitative methods should be added.

Materials:

- Hydrology and Water Quality Data Sheet (Appendix I)
- Wetland Hydrology Indicators (Appendix M)
- Decision tree for identifying groundwater-dependent wetlands (Appendix N)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Metric ruler or staff gage with centimeter markings, at least 1 m long
- High-resolution camera or tablet with high-resolution camera

Method:

1. **Complete the top section of the Hydrology and Water Quality Data Sheet.**
    1.1. Record plot ID, observer(s), and visit date.

2. **Document evidence of hydrology influenced by surface or groundwater.**
    2.1. Walk the plot and look for current surface or groundwater and/or saturated soils, which indicate a high groundwater table.
    2.2. Look for evidence of past inundation or saturation that indicates the range of hydrologic conditions. Evidence may include high water marks or stains on vegetation or rocks; flood debris deposited in trees, shrubs, and other vegetation; soil cracks or biotic crusts; dried algae or aquatic organisms; and/or proximity to a stream or water body with seasonally high flows or water levels.
    2.3. If there is current surface or groundwater and/or evidence of past inundation or saturation, document the observations in the data sheet under "General Plot Hydrology Description" using

terms consistent with the U.S. Army Corps of Engineers (USACE) wetland hydrology indicators where possible (Appendix M). List evidence in groups from Appendix M:

- **Group A** – Observation of Surface Water or Saturated Soils
- **Group B** – Evidence of Recent Inundation
- **Group C** – Evidence of Current or Recent Soil Saturation
- **Group D** – Evidence from Other Site Conditions or Data

2.4. If there is no evidence of saturation or surface water, write “None” in the space provided.

3. Document water sources in the data sheet under “Water Sources.”

3.1. Walk the plot and observe likely water sources based on landscape position, onsite water levels and flow paths, spatial distribution of plant communities, and surrounding land use (see inset box on water source definitions and Figure 19). Review the decision tree for identifying groundwater-dependent wetlands (Appendix N) when determining water sources.

3.2. Review a detailed topographic map, aerial photography, and any available supplemental data, including climate data, floodplain maps, soil maps, geologic maps, and water diversion data, to help determine major water sources.

3.3. In the second “Water Sources” column on the data sheet, select one dominant water source and mark it clearly in the column provided. Carefully consider the classification (e.g., fen, playa, floodplain wetland) and how the wetland likely formed when choosing a dominant water source. In addition to the dominant water source, check additional water sources in the first column that are present within and directly influencing the hydrology within the plot. If only one water source is observed, no additional water sources are required.

3.4. **[Alaska only]** If there is evidence of permafrost, check the box for permafrost influence on the data sheet.

Water Source Definitions

Groundwater Sources

Sites dominated or influenced by groundwater occur in areas where the water table intersects the ground surface or rooting zone for extended periods during the growing season. Groundwater exists in saturated zones beneath the land surface and may be observed as nonpoint seepage or at a specific discharge point like a spring. It may also be observed in a soil pit intersecting the water table. Refer to the decision tree in Appendix N for identifying groundwater-dependent wetlands.

- **Groundwater:** Use this water source for riparian or wetland areas that are supported through diffuse groundwater discharge at the surface and/or soil saturation within the root zone. Groundwater is often the dominant water source at the base of slopes or alluvial fans where aquifers intersect or approach the land surface. Soils frozen for extended periods, like permafrost, and subsurface geologic features such as low-permeability bedrock or glacial till can cause high water tables, diffuse surface discharge, or subsurface throughflow.
- **Spring:** Use this water source to indicate a specific point source of localized groundwater discharge (springhead), occurring either in isolation or in addition to more diffuse groundwater. If springs are identified, note in the “General Plot Hydrology Description” if there is one or many springheads within the plot.

Surface Water Body Sources

Sites dominated or influenced by these sources are adjacent to and receive water from a surface water body, such as a river or stream, pond, lake or reservoir, or the ocean. A riparian or wetland area may receive water from a water body via obvious surface connections (e.g., channelized input, flooding) and less obvious subsurface connections (e.g., streams or lakes losing or contributing water to the adjacent soil substrate). Beyond landscape position, evidence that the site is receiving water from a surface water body includes drift deposits, flood debris, sediment deposits, channelized flow paths, and plant species indicative of stream processes (e.g., cottonwoods).

- **Stream or river:** Use this water source for riparian or wetland areas on floodplains adjacent to stream or river channels when it is evident that they receive water directly from the water body via surface or subsurface flow paths. In a typical floodplain, water passes through these sites in the downstream direction through either surface or subsurface connections. However, this water source also covers depressional wetlands found at the terminus of streams. In all sites, flooding and subsurface flow recharge soil moisture in unconsolidated alluvial sediments. Sites dominated by streams or rivers include most beaver complexes and associated ponds. In areas where groundwater is observed to discharge from surrounding slopes, consider which is the dominant water source for the site. Adjacency to a stream or river alone is not sufficient to select this water source. Rather, groundwater may be the dominant water source for a site in a floodplain if it is evident that the site is primarily receiving water from groundwater discharge, rather than the stream or river water. Note that stream and river channels can become so incised as to be hydrologically disconnected from their floodplain. In the absence of hydrophytic vegetation (including cottonwoods or other riparian trees), these abandoned floodplain areas may not qualify for this protocol.
- **Pond, lake, or reservoir:** Use this water source for riparian or wetland areas located on the margins of ponds, lakes, or reservoirs whose moisture regimes are tied to rising and falling water levels in the pond, lake, or reservoir via surface or subsurface connections. Not all wetlands on pond, lake, or reservoir margins are solely tied to the open water body: consider other sources like upslope groundwater discharge or adjacent rivers or streams. In the case of beaver ponds, the primary source should be considered “Stream or river,” but “Pond, lake, or reservoir” can be considered a secondary source if the wetland is strongly influenced by ponded water.
- **Estuarine or tidal influence:** Use this water source for riparian or wetland areas located along a coast where part or all of the hydrology is connected to and influenced by ocean water. Water levels may rise and fall with daily tidal fluctuations. Surface water in the riparian or wetland area may be as saline as ocean water or may be brackish, with a mix of freshwater inputs and ocean water. Deltas are areas where freshwater streams or rivers join the ocean. Wetlands can form in deltas at the interface between fresh and saline water. In these cases, use both “Stream or river” and “Estuarine or tidal influence” and choose which is dominant based on proximity to the ocean.

Precipitation Sources

Sites dominated or influenced by precipitation rely on atmospheric moisture either directly (direct precipitation) or indirectly (overland flow or snowmelt) to sustain soil moisture.

- **Direct precipitation:** Use this water source for riparian or wetland areas where rain, snow, or other forms of precipitation fall to the ground in sufficient quantities to maintain soil saturation. Wetlands dominated by direct precipitation are restricted to areas with high seasonal or annual precipitation, such as northern latitudes. Very high precipitation levels can support bog wetlands (saturated wetlands isolated from the groundwater) and mineral or organic flats. To assign this as a water source, consider whether direct precipitation is the wetland’s predominant water source, not whether the wetland occasionally receives precipitation.

- **Overland flow (runoff):** Use this water source for riparian or wetland areas influenced by diffuse, nonchannelized, downslope movement of water over land that occurs when precipitation exceeds the capacity of the ground surface to infiltrate water. Overland flow is considered a water source when the wetland is fed by accumulated runoff from precipitation events (i.e., precipitation as an indirect source rather than direct source). Examples of overland flow-dominated wetlands include nonchannelized depressions like playas or vernal pools that accumulate runoff after large rainfall events and often have low-permeability soil or bedrock layers that collect and “perch” water from immediately adjacent areas.
- **Melting snowfields or glaciers:** Use this water source for snowmelt-fed sites, which are commonly in montane to alpine zones where slowly melting snowfields, snowbanks, or glaciers provide a consistent water source in the spring and summer. These sites receive water from immediately adjacent melting snowfields or glaciers, not from distant melting features higher up in the watershed.

Other Sources

Irrigation return flows or seepage: Use this water source for riparian or wetland areas influenced by excess irrigation water applied to farm fields, irrigated hay fields, or other irrigated landscaping that flows downslope and accumulates in drainages or other low points. Irrigation canals can also seep on the downslope side.

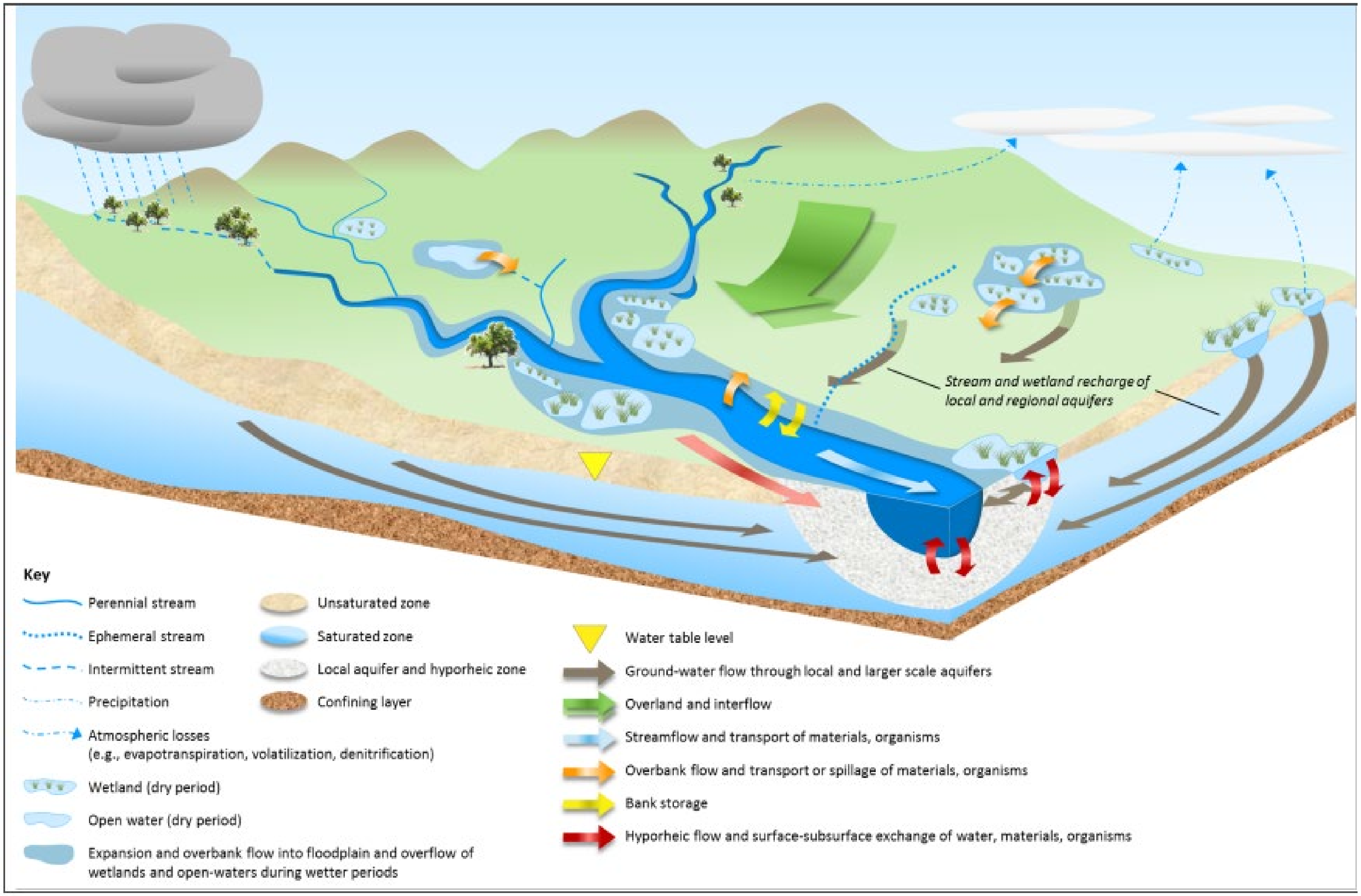


Figure 19. A watershed view and underground cross-section of common riparian and wetland area water sources. Arrows represent surface water and groundwater flow throughout the watershed. Adapted from EPA 2015.

4. Document characteristics of the surface water, if present.

4.1. If surface water is observed in the plot, check the "yes" box for surface water present and complete the rest of the section based on the surface water present. If surface water is not observed during the site visit, check the "no" box for surface water present and continue to step 5.

4.2. Estimate and record the extent of surface water as a percent of the entire monitoring plot in increments of 10% (Figure 20).

4.3. Estimate and record the predominant depth of surface water across the entire monitoring plot by averaging several representative locations. Do not include areas without surface water. Use the choices provided: < 2 cm, 2-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, 40-50 cm.

4.4. Record if surface water is found in a distinct water body (pond or channel), multiple smaller patches, or as shallow standing water (Figure 20). More than one choice may be selected if the surface water distribution is complex.

4.5. Record characteristics of the surface water (Figure 21), including the water surface, the smell of the water, and the substrate beneath the surface water body. For each characteristic, more than one option may be selected if appropriate. Read the definitions of surface water characteristics in the inset box that follows.

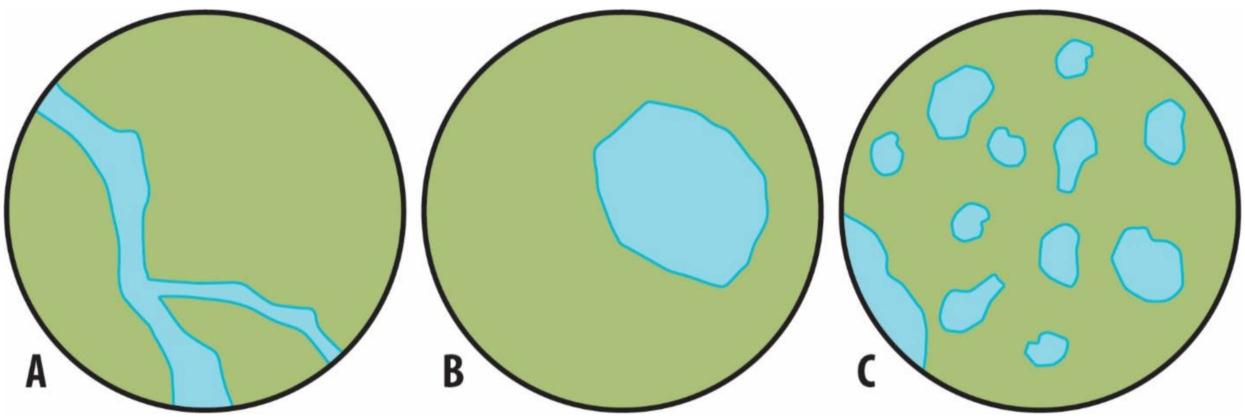


Figure 20. Examples of surface water extent in various distribution patterns: (A) 10% surface water in a distinct body in the form of small channels, (B) 20% surface water in a single ponded water body, and (C) 30% surface water in many small patches of ponded water.

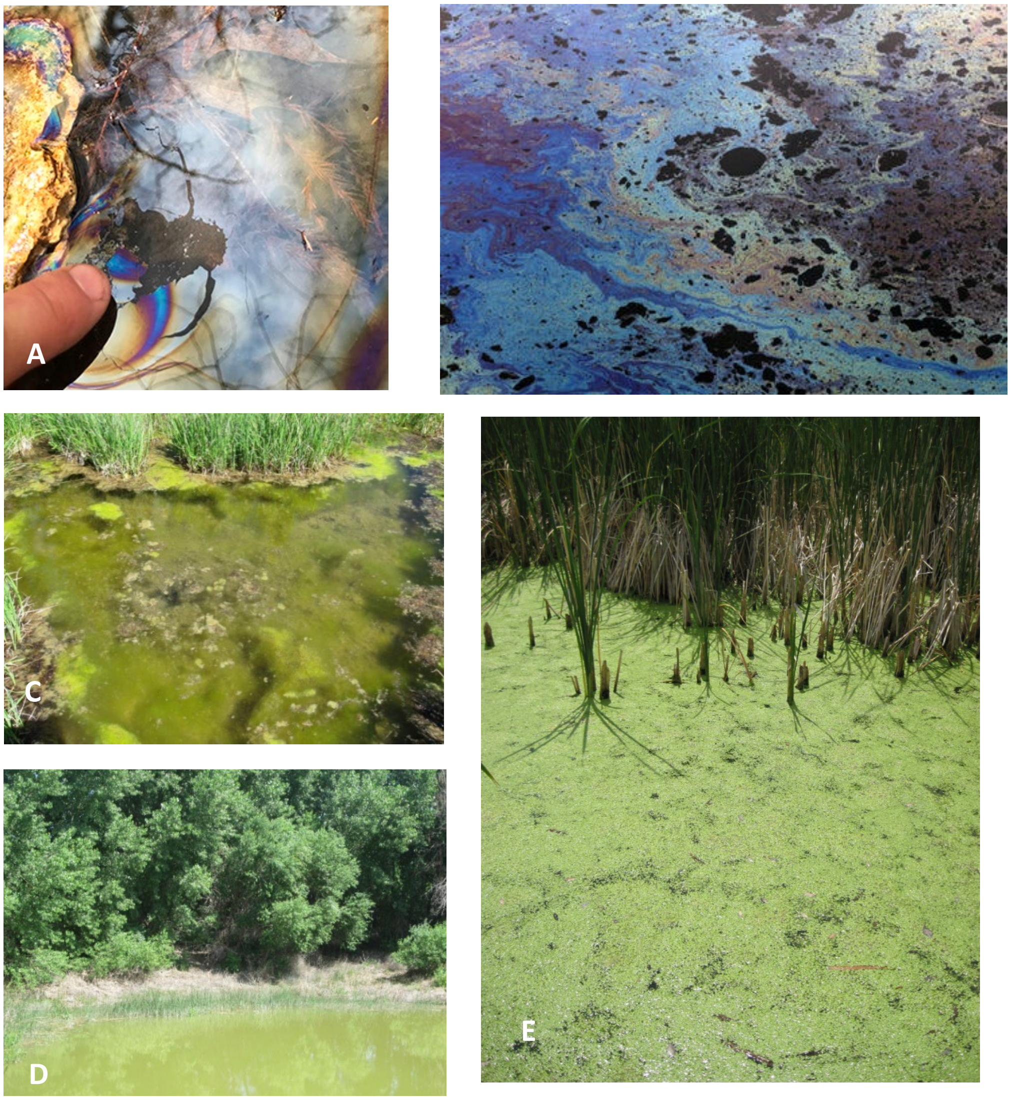


Figure 21. Examples of water surface characteristics: (A) biological film, (B) petrochemical spill, (C) algae as clumps on the water surface, (D) algae in the water column, (E) vegetation (duckweed). Photo of biological film from City of Austin; petrochemical spill from Focusedone; algae and vegetation from Colorado Natural Heritage Program.

Characteristics of Surface Water Body

Water Surface

- **Biological films** (natural, nonpetrochemical) are thin, biologically derived films, sheens, or coatings floating on the water surface, often caused by bacteria and/or iron-rich groundwater inputs. They can be yellow or orange in color and often have no odor. When a stick is poked or a stone is dropped into a biological film, it will typically break into small platelets. See next definition to contrast with petrochemical spills.
- **Petrochemical spills** (nonnatural) float on the surface of the water and look obviously oily. They can be bluish in color and often smell chemically, like natural gas, gasoline, or diesel fuel. If disturbed, a petrochemical spill will quickly try to reform after any disturbance.
- **Algae** in the water can appear as clumps or strands or can be dispersed throughout the water and give the water body an overall green tint or cloudiness.
- **Vegetation** refers to floating vegetation on the water surface, such as duckweed (*Lemna* spp.), pondweed (*Potamogeton* spp.), smartweed (*Polygonum* spp.), watercress (*Nasturtium officinale*), or other floating plants.

Water Smell

- **Chemical** smells may be sharp, metallic, or even slightly sweet depending on the source. They can be derived from spills of agricultural chemicals or leaching from mine waste. **Note**: Please use caution if you smell chemicals in the plot; this may be a reason to permanently or temporarily reject a site.
- **Sulfur (hydrogen sulfide)** smells like rotten eggs and indicates the anaerobic (oxygen-free) breakdown of organic matter by bacteria in saturated soil. This smell is common in marshes or other wetlands sites that experience prolonged flooding or saturation.
- **Fishy** smells may occur in stagnant water bodies and may either be caused by die-off of fish or by other bacteria.
- **Decomposing vegetation** smells earthy like the breakdown of organic matter. It can also occur in stagnant water or moist soil.

Substrate Beneath the Water

- **Mineral soil or sand** is any fine mineral soil material that is < 5 mm in diameter.
- **Gravel** is defined as mid-size particles between 5-76 mm in diameter.
- **Cobble or stone** is defined as larger particles > 76 mm in diameter.
- **Organic material** is defined as soil material with high organic carbon content composed of partially to totally decomposed plant material (roots, leaves, etc.). Plant parts may be visible or primarily decomposed.

5. **Document characteristics of the dominant channel flowing through the plot, if present.**
   5.1. A ***channel*** is defined as a linear feature formed by concentrated water flow and sediment transport between definable banks (Wohl 2018). Channel banks are discernable inflection points where the ground slope changes from relatively flat above the banks (bench or floodplain) to relatively steep on the banks and back to relatively flat between the banks (channel bed) (Figure 22). Channels may include stable stream channels, rivulets (small channels), channels formed by headcuts, and incisions in wet meadows (Figure 23). Many small channels in riparian and wetland areas are not well-developed and lack a greenline, scour line, or bankfull indicators; but they are still considered channels if they have definable banks and there is evidence that they were formed by concentrated water flow and sediment transport. See Appendix M for types of observations that may constitute evidence of water flow and sediment transport.
   5.2. For the purposes of this protocol, the majority of the channel must be located within the plot (at least one bank and most of the channel bed). Channels located adjacent to the plot should not be measured. Measured channels should also be smaller than the scale of the entire plot, meaning the entire plot should not be considered a channel even if it is within a valley bottom. Vegetated drainageways themselves should not be measured as channels, but they may contain distinct channels that should be measured.
   5.3. If one or more channels flow through the plot, check the "yes" box and complete the section to document channel characteristics. If channels are not observed during the site visit, check the "no" box and continue to step 6.
   5.4. If there are multiple channels within the site, make estimates of channel dimensions on the widest channel. In sites with multiple diffuse channels, it may be difficult to identify the widest channel. Do your best to identify the widest channel and describe the rest in the channel comments.
   5.5. Estimate the length of the channel through the plot in meters. The length should include meanders that the channel takes through the plot. If estimated in the field and the feature is large enough to be visible in aerial imagery, the estimate can also be checked in the office in GIS.
   5.6. Estimate average channel width between the top of the right bank and the top of the left bank of the channel (Figure 22). Estimate width based on channel morphology and not the water level because the water level can vary over time. If the top of the two banks are different elevations, measure width from the top of the lower bank to the point where a level line intersects the opposite bank. If possible, measure channel width in up to five representative locations and calculate the average. If channel width is highly variable through the plot, estimate the most representative width and note high channel width variability in the comments. Record estimated average channel width using the choices provided:
      - < 100 cm
      - 100-200 cm
      - > 200 cm
   5.7. Estimate average channel depth from the top of the right or top of the left bank, whichever is lower, to the deepest part of the channel (Figure 22). Like channel width, estimate channel depth based on channel morphology and not water depth. If possible, measure channel depth in up to five representative locations and calculate the average. If channel depth is highly variable, estimate the most representative depth and note high channel depth variability in the comments. Record estimated average channel depth using the choices provided:
      - < 50 cm
      - 50-100 cm
      - > 100 cm

5.8. Estimate average depth of water at the thalweg (deepest part from bank to bank) of the channel (Figure 22). If water depth at the thalweg is variable along the channel, estimate the most representative depth. Record estimated average depth of water using the choices provided:

- 0 cm (dry)
- < 50 cm
- 50-100 cm
- > 100 cm

5.9. Write a short description of the measured channel in the channel comments. If there are multiple small channels throughout the site, count them and briefly describe their presence.

5.10. Make sure to indicate channels, at least the widest one, on the plot drawing (see Section 5.1, step 4).

5.11. Take at least one (and up to four) photos of the channel measured. Take photos at the most visible and representative location of the channel, facing into the plot if possible, and note the direction that the photo is facing in the photo comments. The most visible location is one where vegetation is least obstructing the view of the photo. Take the photos at an adequate distance to see the channel in the context of the monitoring plot, include the horizon, and always include a meter stick or other known object for scale in the photos. Make a mark-up copy of the most representative photo, indicate top of banks, and where width and depth were measured. See step 7 for taking additional hydrology photographs.

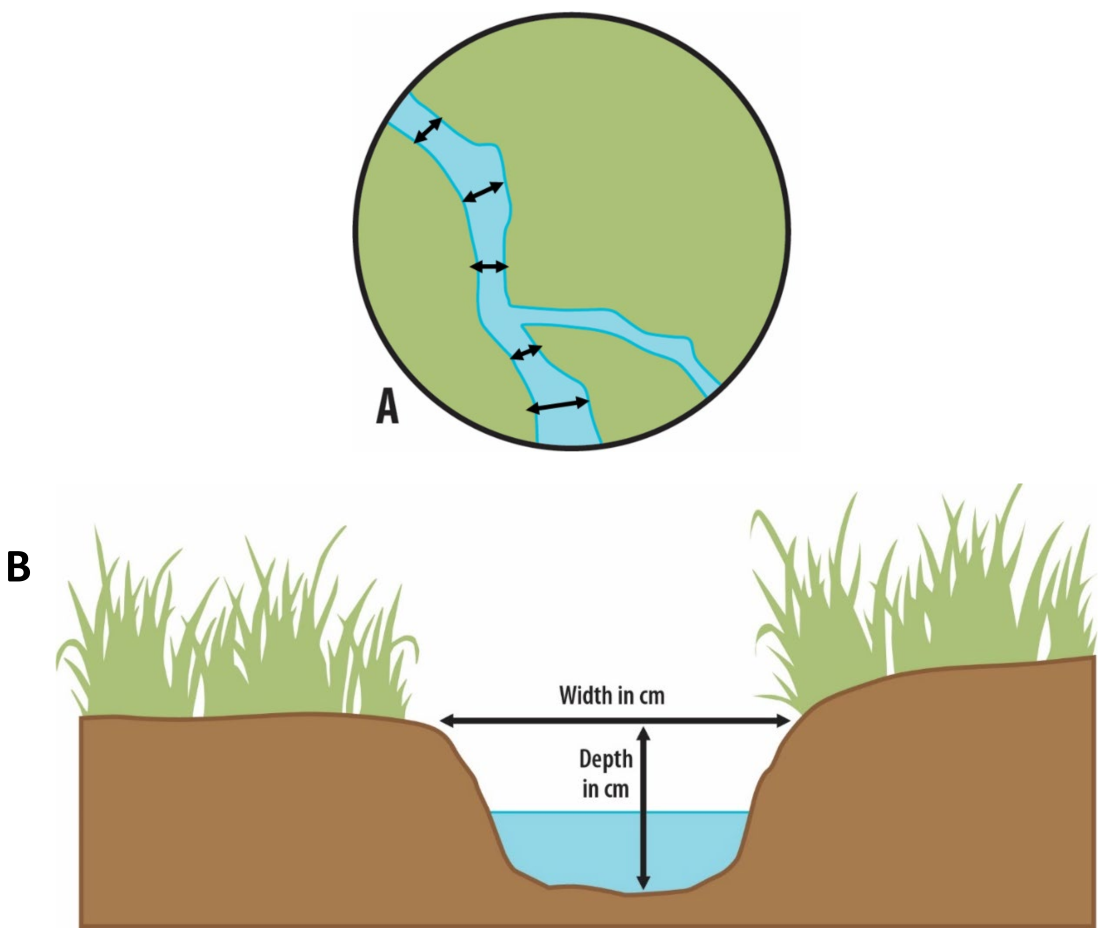


Figure 22. Panel A shows example locations of channel width and depth measurements across a plot with multiple channels; always record channel measurements for the largest channel. Panel B shows a cross-section example of width and depth measurements.

Figure 23. Examples of channels within riparian and wetland monitoring plots. Larger channels may be too large to be included in a monitoring plot, but a monitoring plot can be located on their adjacent floodplain. Lotic stream monitoring protocols should also be considered for well-developed lotic stream systems with channels (BLM 2021; Burton et al. 2011).

6. **Describe the general hydrology of the monitoring plot.**
   6.1. Take careful notes on overall site hydrology (inflows, outflows, seasonality of flows), as well as any alterations to the natural hydrologic regime, and record them in the "General Plot Hydrology Description" section (Figure 24).
   6.2. Make sure to include surface water patterns, channels, and hydrologic disturbances such as headcuts, berms, deeply dug pits, etc., in the plot drawing (see Section 5.1, step 4). If there is a seep or spring, note whether there is a single spring head or multiple spring heads.
   6.3. Note any evidence of wetter or drier historic conditions, including information derived from historic aerial photos or maps. Evidence may include, but is not limited to: recently dead vegetation (including trees, shrubs, and herbaceous vegetation) from too much or too little water; rill or gully erosion; headcuts; collapsible soil or sediment; large shrinkage cracks in soil or sediment; and new, old, or breached beaver dams in the area.
7. **Photograph elements of plot hydrology.**
   7.1. Take overview photos of hydrology, illustrating the extent and distribution of surface water.
   7.2. If present, also take photos of headcuts, rills, channels, berms, deeply dug pits, or sediment deposition. For smaller features, take one contextual photo and one detail photo for each feature. Use a measuring tape, ruler, quadrat, or other object for scale if not obvious in the photo.
   7.3. Record photo numbers and a short, written explanation on the Photo Log Data Sheet (Figure 18). Mark the locations of hydrology photos on the plot drawing (Figure 13).

General Plot Hydrology Description
Sample plot is located along Salt Wells Rd where multiple springs and seeps emerge and form alkaline marshes. The sample plot is located within an alkaline marsh with groundwater inflows dominating the site's hydrology. Spring influence and surface water runoff also appear to influence the site. Surface water was observed throughout the entire plot at the time of sampling (late in the growing season). The alkaline nature of the site is observed through the salt crusts along the bases of emergent vegetation and on the ground surface surrounding the plot. The extent of surface water present at the time of sampling suggests that the site maintains a relatively stable water table throughout the growing season during most years. When approaching the site, a ditch was crossed. The ditch appears to be diverting a significant amount of surface water to a stock pond/impoundment nearby. The presence of one or two dead woody species within the sample plot may suggest a period of drier conditions.

Figure 24. Example general plot hydrology description.

Quality Assurance
☐ All required fields are filled out. ☐ Notes are as complete and exact as possible. ☐ Water sources, surface water, channels, and general hydrology have been discussed and checked among crew members. ☐ Abbreviations are defined. ☐ Photos of hydrologic features are adequate (see quality assurance box on photos at the end of Section 5.2). ☐ Walk around the site, some distance upstream/downstream or upslope/downslope, to ensure hydrology in and around the site has been adequately captured.

5.4 Soil Profile Description

Overview: Soils are a fundamental indicator of wetland presence and play an important role in cycling nutrients and regulating water movement. Soil characteristics can provide a long-term history of a site's hydrology, geomorphology, and disturbance, both natural and anthropogenic. Soils within riparian and wetland areas may undergo periods of inundation, saturation, and depletion of oxygen (anoxic conditions). These conditions influence the formation of ***hydric soil indicators***, such as a rotten egg smell, ***gleying***, ***redoximorphic features***, and ***organic soil material*** (Table 7). The chemical properties of ***hydric soil***, in turn, influence the type of vegetation that can exist in different riparian and wetland settings.

Within this protocol, soil properties are intended to classify, stratify, and determine the ecological potential of the monitoring plot and surrounding riparian and wetland area. Soils are characterized when a new monitoring plot is established. Soil data may be collected on repeat visits, if changes in soil properties are of management interest, but repeat data collection is not necessary. Specific management questions and the environmental setting may also necessitate collecting additional soil information (e.g., soil chemistry, bulk density, lab analysis of ***soil texture***); however, the methods to collect additional soil data are beyond the intent of this protocol. Interested parties should consult the many resources of the Natural Resources Conservation Service (NRCS) for additional field methods and analysis.

Table 7. Hydric soil processes and properties. Adapted from Gonzalez and Smith (2020).

Hydric Soil Process	Cause	Example Hydric Soil Property
Sulfate Reduction	Microbial conversion of sulfate (SO_4^{2-}) to hydrogen sulfide gas (H_2S).	● Rotten egg odor
Iron and Manganese Oxidation, Reduction, Translocation, Accumulation	Transformation of iron or manganese between insoluble and soluble forms in soils with elevated or fluctuating water tables. Ferric (Fe^{3+}) ↔ ferrous (Fe^{2+}) iron. Manganic (Mn^{4+}) ↔ manganous (Mn^{2+}) manganese.	● ***Gleyed matrix*** (loss of iron) ● ***Depleted matrix*** (reduction of iron) ● ***Redoximorphic concentrations,*** including oxidized root channels (localized accumulations of oxidized iron and manganese) ● ***Redoximorphic depletions*** (localized depletions of reduced iron and manganese)
Organic Matter Accumulation	Accumulation of organic matter that exceeds decomposition due to saturation.	● Fibric organic soil (***peat***), plant fibers mostly still visible ● Hemic organic soil (***mucky peat***), plant fibers somewhat visible ● Sapric organic soil (***muck***), plant fibers largely decomposed, rarely visible ● ***Mucky mineral*** soil

Materials:

- Soil Data Sheet (Appendix I)
- Soil Properties and Hydric Soil Indicators (Appendix O)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- GPS unit
- High-resolution camera or tablet with high-resolution camera
- Soft measuring tape for measuring soil horizons, at least 1 m long, in metric units
- Shovel, auger, and/or soil probe (sharpshooter or tile spade preferred for most conditions)
- Knife or trowel with ~10 cm (~4 in) long blade (dulled to prevent injury)
- Spray bottle with water
- Small hand trowel
- Horizon markers (golf tees, 16-penny nails, short strips of flagging, etc.)
- “Munsell Soil Color Book” (with Gley 1 and Gley 2 color pages)
- Dark plastic tarp (a dark color is better for photographs)
- Bailing bucket (optional)
- Ecological site descriptions and soil map unit descriptions (where available)
- “Field Book for Describing and Sampling Soils” (Schoeneberger et al. 2012), Version 3.0 or most recent update
- “Field Indicators of Hydric Soils in the United States: A Guide for Identifying and Delineating Hydric Soils” (NRCS 2018), Version 8.2 or most recent update
- Appropriate “Regional Supplement to the Corps of Engineers Wetland Delineation Manual” (USACE 2007, 2008, 2010a, 2010b)

Method:

1. **Complete the top section of the Soil Data Sheet.**
   1.1. Record plot ID, observer(s), and visit date.
2. **Select an appropriate location for a soil pit.**
   2.1. The soil pit should be excavated in a location that represents the monitoring plot, in the most dominant vegetation community and/or geomorphic setting. Choose the most undisturbed location as possible.
   2.2. If the site is homogeneous, the default location is within a 5-m-radius circle of the plot center and at least 2 m from a sampling transect to avoid disruption to vegetation and other features along the transects (Figure 25).
   2.3. Once the location is selected, mark it with pin flags and advise all crew members to avoid walking within a 2-m-radius circle of the location to avoid compaction.
   2.4. If this central location is not representative in some way (e.g., upland inclusion, deeper water, uncommon plant community, excessive soil disturbance), locate the pit in a representative location as close to the plot center as possible.
   2.5. Avoid unusual, sensitive, or protected features on the site (e.g., rare plants, rodent mounds, cultural or historical resources), as well as obstacles that prevent excavation of a soil pit such as logs, boulders, or trees.
   2.6. Record the GPS coordinates of the soil pit on the data sheet.

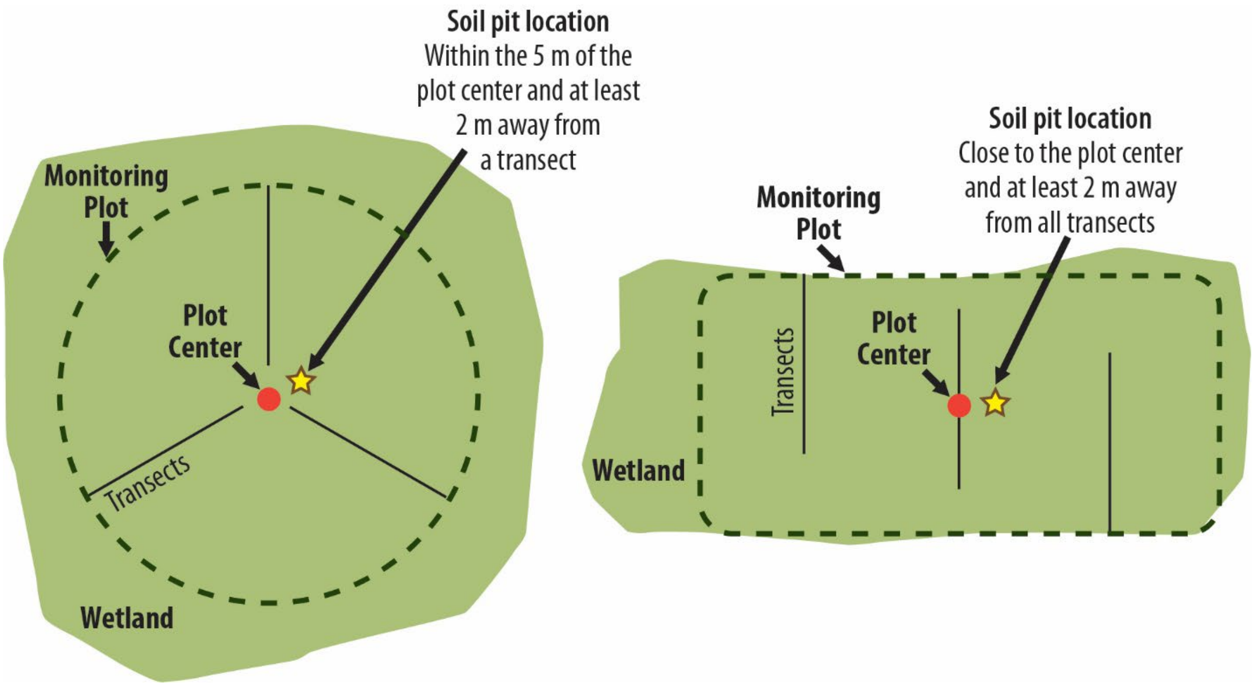


Figure 25. Recommended soil pit location in various plot layouts.

3. **Excavate the soil pit to a depth of at least 50 cm (20 in).**
    3.1. Select a side of the pit that will be used to describe the soil profile and that has optimal light exposure for photography. The soil profile should be entirely in the sun or entirely shaded (shade tends to produce the best photos) to avoid the problems of poor photographic exposure under high contrast. Avoid compacting, standing on, or otherwise disturbing the ground surface and vegetation on this side of the pit. Set a tarp or plastic sheet on the opposite side of the pit to hold extracted soil material.
    3.2. Prepare excavation tools. A tile spade or sharpshooter shovel is the recommended tool for excavation. Soil augers and probes can be useful for extending the depth of soil observations beyond the length of the shovel blade or in situations where digging with a shovel is difficult. However, soil probes may compact the soil and augers may expand the soil. If an auger or probe is used, mark or put your finger on the tool at the surface of the soil before extracting the auger or probe and then measuring from the bottom of the tool to the soil surface. Alternatively, measure from the bottom of the hole with a tape each time the tool is extracted to determine the length of the profile represented. If an auger is used, mark the depth of the pit excavated with a shovel and the depth extracted with an auger on the data sheet.
    3.3. Use shallow cuts with the shovel blade to define the area of the soil pit as a rectangle just wider than the shovel (~20 cm) and approximately as long as the shovel (~30–40 cm). Begin removing the surface vegetation layer by cutting through the roots with shallow cuts (~15 cm deep). If needed, use pruners to cut through larger roots. Set topsoil aside on the tarp next to the soil pit with the vegetation facing up. Take care to preserve the vegetation cap. It should be replaced after the pit is backfilled, allowing the vegetation to reestablish.
    3.4. Use the shovel to excavate the soil pit to a depth of at least 50 cm. Excavate only the area needed to extract and view an intact soil profile to a depth of 50 cm. Stockpile excavated soil on the tarp next to the soil pit.
    3.5. If water or slumping soil fills the pit, try removing the water with a bailing bucket. If the pit fills too quickly to effectively remove the water and/or the soil is not sufficiently cohesive to maintain vertical pit walls, stop digging and describe the soil above the water table before continuing to the lower layers.

3.6. If an impenetrable obstacle or layer is encountered that prevents excavation to a depth of 50 cm (e.g., coarse substrate, permafrost, hardpan, bedrock, large tree roots), indicate the limiting factor in the comments section of the data sheet. Consider digging a second soil pit to reach the full 50 cm depth.

3.7. Once the pit has been excavated, expose a natural surface across the face of the soil profile with a soil knife or trowel. This is especially important if the face has been disturbed or altered during the excavation process, such as smeared with the shovel. Use a soil knife to pick away clods of soil until a natural surface can be observed across the face.

3.8. If the soil is saturated, note the initial matrix color in a notebook as soon as the face is exposed to determine if the color changes with exposure to air. See step 6 for more on determining matrix color.

3.9. If the soil profile can easily be viewed within the pit, photograph and make all observations of the soil from the cleaned, natural soil face (Figure 26A). If conditions prevent good access to the soil face, use the shovel to extract a soil column or slab from the face and lay it intact (i.e., in stratigraphic order) on a dark plastic tarp adjacent to the pit (Figure 26B).

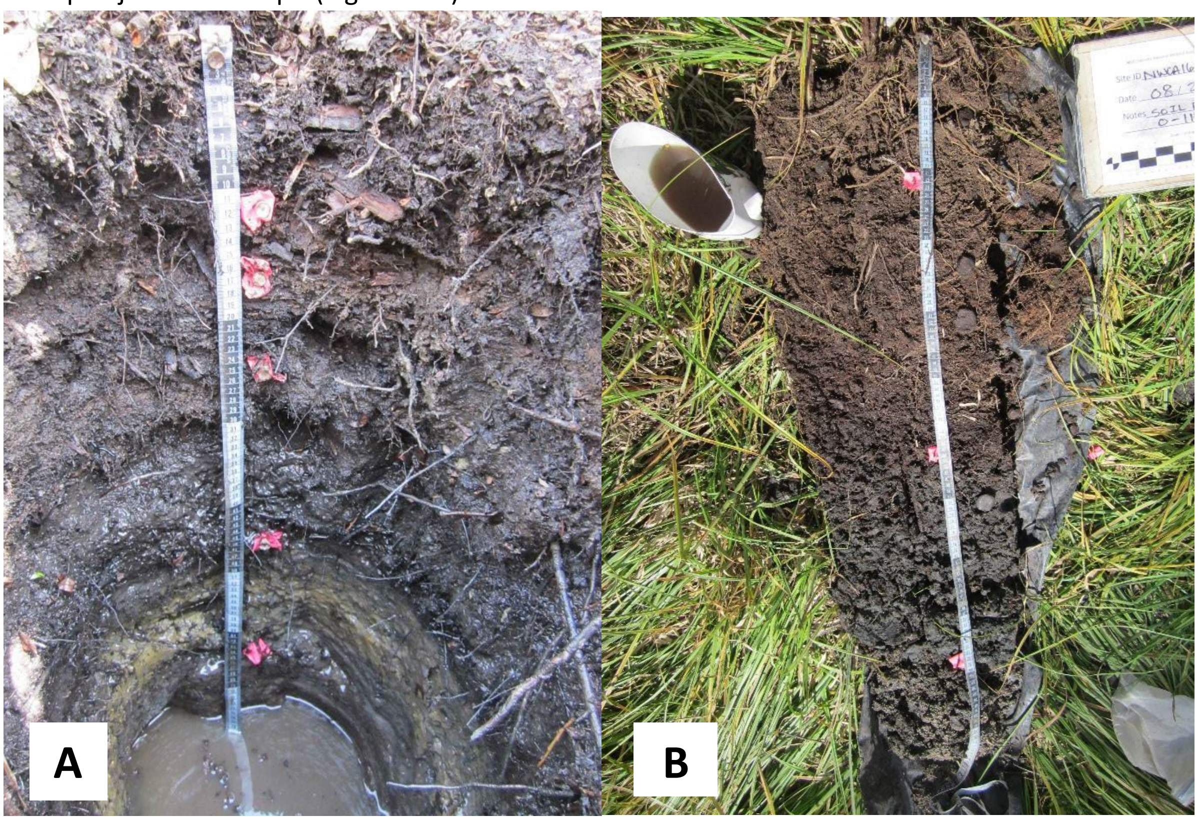


Figure 26. Example photos of wetland soil pit: (A) with the face of the soil profile in place and (B) with the profile removed from the pit and divided lengthwise into a slab.

4. Identify distinct horizons within the soil profile.

4.1. Identify distinct soils horizons based on changes in ***soil structure***, color, texture, and the accumulation or loss of different soil materials (Figure 26). Place a marker (golf tee, nail with flagging, etc.) at the lower boundary of each horizon.

4.2. Number each horizon in order starting at the top of the profile (Horizon 1 occurs at the soil surface). Record the depth of each horizon from the soil surface to the lower boundary of the horizon.

4.3. **Optional.** If a trained soil scientist is present at the time of sampling, record the master horizon name with suffixes and other horizon modifiers. This step is not recommended for crews without a trained soil scientist.

5. **Photograph the soil profile.**
   5.1. Position the zero-mark of a measuring tape at the top of the soil profile (i.e., the soil surface) and extend the tape to the bottom of the soil pit or profile. Ensure the markers (golf tee, nail, flagging, etc.) are clearly visible at the lower boundary of each ***horizon***.
   5.2. If the soil profile is being described in place, take a photograph of the face of the soil profile in portrait orientation (Figure 26A). Hold the camera to minimize parallax and to maximize focus on the entire soil profile. Preferably, the entire profile should be completely in the shade for the best exposure, and the entire face should be captured in one photo. If necessary, take two photos, one with flash and one without.
   5.3. For extracted soil profiles and/or cores, split the sample in half lengthwise (top to bottom) to expose a natural, minimally disturbed soil face. Position tape measure with zero-mark at the top of the profile. Take a photograph with the camera lens orthogonal to the soil sample (Figure 26B).
   5.4. Take additional photos and close-up images of each horizon or important soil features, as needed. Take a photograph of the landscape around the soil pit for reference. Include an object for scale in all photos.
   5.5. Record all photo number(s) on the data sheet.

6. **Describe the soil profile.** A comprehensive soil description is not expected. The primary observations include a description of soil color(s), soil texture, hydric soil indicators, and depth to water table. Refer to Appendix O for guidance on soil characteristics and texturing. For each horizon, record the following information.
   6.1. If the soil is saturated, immediately note features than can change with exposure to air, including presence of H_2S (hydrogen sulfide) odor and initial matrix color in any saturated horizons (see step 3.8). Change in the matrix color with exposure to air can be evidence of a reduced matrix.
   6.2. Determine the soil ***matrix color*** (dominant color across the horizon) using the "Munsell Soil Color Book" and record each of the components (hue, value, ***chroma***). Soil colors should be determined with moist soil. Moisten dry soils until the color no longer changes and allow wet soils to dry until water no longer glistens on surface of the soil sample. Use ***ped*** interiors to obtain soil matrix colors. Remove sunglasses before taking soil color and have the sun at your back.
   6.3. Record the color of any primary and secondary redoximorphic (redox) features using the "Munsell Soil Color Book" (see details in step 6.2). Redox features are color patterns that differ from the soil matrix and are formed as iron and/or manganese are changed chemically and translocated in the soil due to reduction and oxidation associated with wetting and drying cycles.
   6.4. Determine the percent area of redox features in the horizon and record the prevalence as a percentage. See Appendix P for visual guidance on estimating percent cover.
   6.5. Determine soil texture on moist samples by hand. For organic horizons, distinguish fibric, hemic, and sapric organic material.
   6.6. If there are ***rock fragments*** within the soil, visually estimate the percent volume by three different size classes: gravel (5–76 mm), cobbles (76–250 mm), stones (250–600 mm).
   6.7. **[Alaska only]** Determine the pH of the horizon using a pH probe, pH testing strips, or similar. If the soil is unsaturated, make a slurry of the soil with deionized water and measure the pH of the slurry.
   6.8. Document any unusual features such as concretions, expanding clays, salt accumulation, presence and type/size of roots, evidence of compaction, ash, etc., in the comments field. Use terminology from NRCS soil references (e.g., Schoeneberger et al. 2012; NRCS 2018) whenever possible.

7. **Record depth to water and depth to saturated soil within the pit or standing water level above the ground surface.**
   7.1. Measure and record the depth to water within the soil pit. All measurements below the soil surface should be recorded as negative numbers (Figure 27). Allow sufficient time for water to infiltrate into the pit and to equilibrate with the elevation of the surrounding water table. **Note:** In fine-textured soils, it may take one or more hours for water to fill to the level of the water table or to seep onto the walls of a soil pit. If this is the case, excavate the soil pit as soon as possible but delay observations of water table position until the end of a site visit.
   7.2. Alternatively, if there is standing water at the ground surface surrounding the soil pit, measure and record the depth of standing water. All measurements above the soil surface should be recorded as positive numbers.
   7.3. Measure and record the depth to saturated soil in the soil pit. This may be at the same elevation as the depth to water, slightly higher within the pit, or occasionally lower than the water if there is positive hydraulic pressure. Look closely at the face of the soil pit to determine the elevation at which the soil is saturated and water appears to be seeping into the pit (Figures 27 and 28). To determine if the soil is saturated, it may be helpful to shake a small ped of soil to see if droplets appear on the outside of the soil. This can be particularly helpful in dense clay soils.
   7.4. Note how long the pit was left to settle.

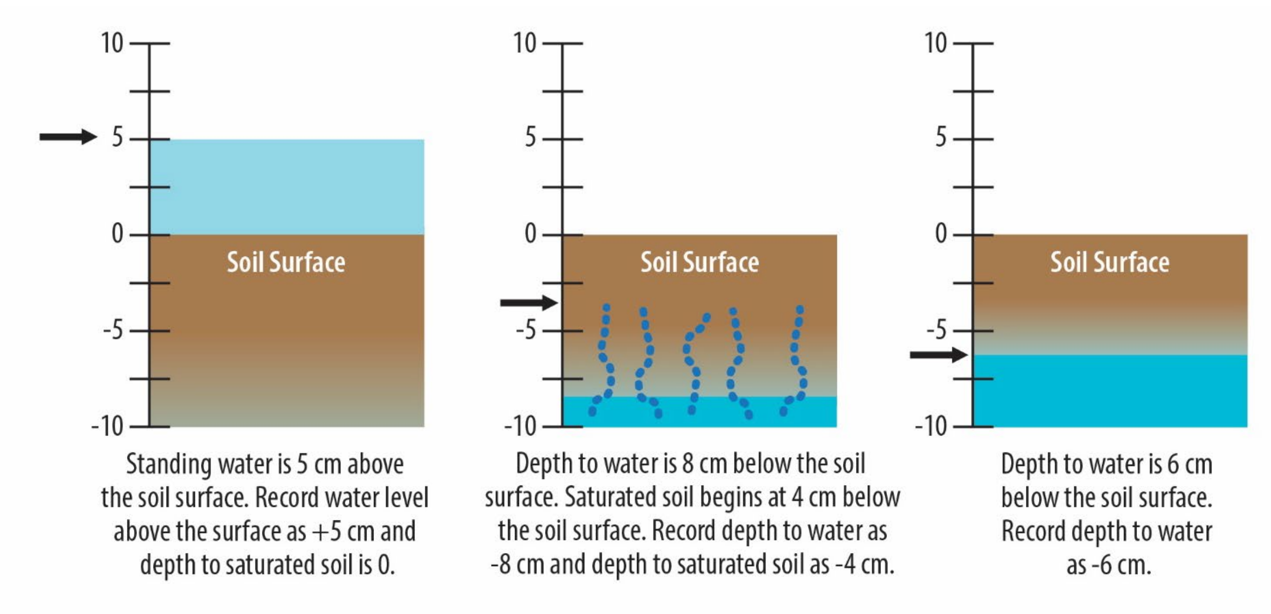


Figure 27. Measuring water level above the soil surface, depth to saturated soil, and depth to water within a soil pit.

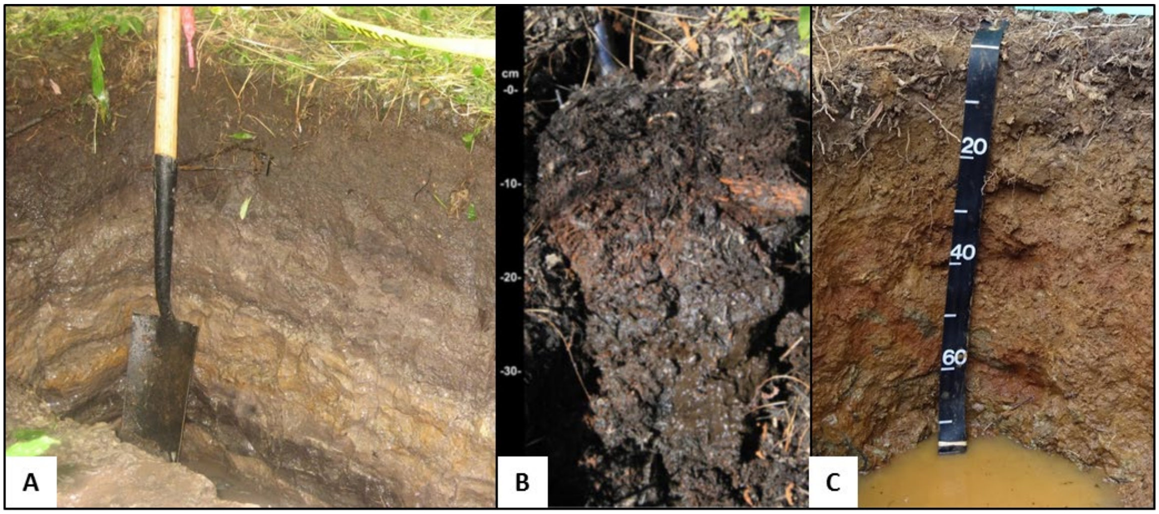


Figure 28. Examples of soil saturation. (A) Pit surface with sheen of moisture. Photo by Ann Rossi. (B) Water seepage. (C) Standing water in soil pit. Photo by Ann Rossi.

8. **Document hydric soil indicators observed, if any. Some soil pits may lack hydric soil indicators.**
    8.1. Crews should familiarize themselves with the common hydric soil indicators within their region at the start of the field season. For hydric soil indicators, regions are defined by USDA Land Resource Regions (see Appendix O).
    8.2. Closely follow guidance within "Field Indicators of Hydric Soils in the United States: A Guide for Identifying and Delineating Hydric Soils," Version 8.2 (NRCS 2018), and identify any indicators that match the characteristics of the soil profile description. In some cases, more than one indicator may apply. For some indicators, such as A12: Thick Dark Surface, excavation deeper than 50 cm may be required. In these cases, a soil auger may be used to extend the soil pit.

9. **Backfill soil pit.**
    9.1. Once soil data have been collected and you have allowed sufficient settling time, backfill the soil pit with subsoil and then cover with stockpiled topsoil and vegetation cap.

10. **Excavate and describe additional soil pits, if necessary.**
    10.1. Locate additional soil pits if necessary, repeating steps 2.3 through 2.6. Additional soil pits may be needed if site heterogeneity is high and there is more than one plant community of interest, if there is reason to suspect that the riparian and wetland area is increasing or decreasing in size (e.g., dead or dying upland or wetland vegetation), if a depth of 50 cm was not reached in the first soil pit, or if a site has annual use or management concerns and is high priority for a management change.
    10.2. Excavate and describe the soil pit following steps 3 through 9.
    10.3. If multiple soil pits are described, mark the "Representative Pit" box for the pit located in the most dominant vegetation community and/or geomorphic setting. Explain in the comments of each additional pit why the location was selected.

Quality Assurance
☐ All required fields are filled out. ☐ Notes and descriptions of soil horizons, water levels, and hydric soil indicators are as complete and exact as possible. ☐ Adequate time has elapsed to allow groundwater levels to stabilize in the pit. ☐ Soil horizons, water levels, and hydric soil indicators have been discussed and checked among crew members. ☐ Abbreviations are defined. ☐ Photos of soil features are adequate (see quality assurance box on photos at the end of Section 5.2).

5.5 Natural and Human Disturbances

Overview: Documenting natural and human-caused disturbances can help interpret present and potential future conditions of riparian and wetland systems. Some disturbances, including channel incision or water withdrawals, may impact a site's functional capacity, while other disturbances, including recent beaver activity or active restoration, may increase functional capacity. The natural and human disturbances checklist included in this protocol is a rapid evaluation of disturbances within and surrounding the monitoring plot. The BLM and other land management agencies have developed several indepth interdisciplinary protocols for assessing land health and ecosystem function, including "Interpreting Indicators of Rangeland Health" (Pellant et al. 2020), "Proper Functioning Condition Assessment for Lentic Areas" (Gonzalez and Smith 2020), and "Proper Functioning Condition Assessment for Lotic Areas" (Dickard et al. 2015). Where possible, language and guidance from existing protocols is incorporated into the disturbance checklist. This checklist is not meant to replace those assessment methods. Instead, the checklist serves as an initial opportunity to highlight recent disturbances and flag potential issues for additional followup by resource specialists.

The natural and human disturbance evaluation can be initiated in the office prior to the field visit using aerial photography and ancillary data sources, such as land cover and land use. However, all values should be verified in the field. Each disturbance should be evaluated separately for the monitoring plot and for a 100-m envelope surrounding the monitoring plot boundary, which may be entirely upland or may contain additional riparian and wetland area adjacent to the plot. Most disturbances present are rated from 1 to 4 based on the geographic scope and the degree of disturbance to the landscape or to the monitoring plot observed in the field. Disturbances to hydrology are rated present/absent only because their scope and degree can be difficult to determine. Scope and degree rating are adapted from the Human Stressor Index used by NatureServe and state Natural Heritage Programs (see Comer et al. 2017).

Materials:

- Natural and Human Disturbances Data Sheet (Appendix I)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Aerial photos of the monitoring plot and surrounding landscape

Method:

1. **Complete the top section of the Natural and Human Disturbances Data Sheet.**
   1.1. Record plot ID, observer(s), and visit date.

2. **Estimate the scope and degree of natural and human disturbances observed in the surrounding landscape within 100 m of the monitoring plot.**
   2.1. Mentally delineate an approximate 100-m envelope from the plot boundary. This envelope defines the surrounding landscape to assess. Do not include the plot itself, which is assessed separately.
   2.2. Walk as much of the surrounding landscape as possible to view and characterize disturbances. It is not necessary to walk the entire 100-m envelope and may not be possible if land ownership boundaries or physical obstacles prevent exploration. Pay careful attention to the surrounding landscape while traveling to and from the plot and use those observations to inform the ratings.
   2.3. Identify disturbances from Table 9 observed in the surrounding landscape.

2.4. Use the scope ratings provided in Table 8 and on the data sheet to estimate the portion of the landscape affected by the disturbance. Rate disturbances for their extent of the 100-m envelope, not in the plot itself. Only rate the disturbances that are observed. Do not rate disturbances that are absent.
2.5. Use the narrative descriptions provided in Table 9 to document the degree of the disturbances. Rate disturbances for their degree within the 100-m envelope, not in the plot itself.
2.6. If disturbances were preliminarily estimated in the office using aerial images, Google Earth time series photography, and/or ancillary data sources, verify the initial estimates during the field visit.
2.7. Record the ratings within the "100-m Surrounding Landscape" columns on both page 1 and page 2 of the data sheet. Add comments to describe the observed disturbances.

3. **Estimate the scope and degree of natural and human disturbances in the monitoring plot itself.**
   3.1. Walk through the entire monitoring plot to view and characterize disturbances.
   3.2. Identify disturbances from Table 9 observed in the monitoring plot.
   3.3. Use the scope ratings provided in Table 8 and on the data sheet to estimate the portion of the monitoring plot affected by the disturbance.
   3.4. Use the narrative descriptions in Table 9 to document the degree of the disturbances.
   3.5. Record the ratings within the "Monitoring Plot" columns on both page 1 and page 2 of the data sheet. Add comments to describe the observed disturbances.

Table 8. Scope ratings for natural and human disturbances.

Scope of Disturbance (% of surrounding landscape or plot affected by the disturbance)	
1 = Rare	Affects a small portion (1-10%) of the landscape or plot
2 = Restricted	Affects some (11-30%) of the landscape or plot
3 = Large	Affects much (31-70%) of the landscape or plot
4 = Pervasive	Affects all or most (71-100%) of the landscape or plot
P = Present	Used for hydrology disturbances only

Table 9. Natural and human disturbance degree ratings and narrative descriptions.

Disturbance	Degree Ratings			
	1 = Low	2 = Moderate	3 = High	4 = Highest
Buildings and development	NA	Isolated or dispersed development (e.g., individual houses or cabins)	Residential development	Industrial and commercial development
Pavement/cleared lots (e.g., paved, graveled, dirt parking lot or foundation)	NA	Cleared lots	Gravel lots for parking or other uses	Paved lots and/or parking areas, hardened foundations
Oil and gas wells, well pads, and disturbed footprint (not road network)	NA	NA	NA	Footprint of the wells and pad
Roads	Non-eroding two-track or unimproved roads	Improved gravel roads or other dirt roads that cause visible erosion or water diversion/concentration	Paved roads or railroads	Highways
Agriculture	Fenced pasture. This does not include fences on native rangeland.	Hay fields	Row crops	Feed lots
Utility, power line, or pipeline corridor	Small rural electric line or remediated pipeline	Intermediate lines	Major transmission line or heavily disturbed pipeline corridor	Power station
Landfills, trash, or refuse dumping (e.g., cans, bottles, trash heaps)	Scattered individual pieces of litter	One or more piles of litter	Unofficial dumping of trash	Landfill
Recreation (hunting, fishing, camping, hiking, birding, canoe/kayak/rafting, ATV, motorboats)	Low-impact or dispersed recreation (fishing lures, shotgun shells, fire rings)	Higher impact or concentrated recreation, evidence of soil and vegetation disturbance (established campsite, hiking trails)	Motorized recreation, frequent soil and vegetation disturbance (hiking trails, vehicle ruts)	Extensive recreation impacts from both motorized and nonmotorized use
Logging (tree cutting, removal, or fuels treatments)	NA	Low-density selective cuts	Higher density selective cuts	Clear cuts
Parks, maintained lawns, or other vegetation management or treatment (cutting, mowing)	NA	Mowing of grasses	Cutting of shrubs, wood removal	NA

Disturbance	Degree Ratings			
	1 = Low	2 = Moderate	3 = High	4 = Highest
Evidence of grazed/browsed vegetation[1] from livestock, wild horses/burros, or native ungulates such as moose, elk, deer, or caribou	Herbaceous forage plants slightly topped or used. Current seedstalks and young plants are little disturbed. Utilization < 20%.	At least 15-25% of current seedstalks of herbaceous species remain intact. No more than 10% of low-value herbaceous forage is utilized. Utilization 20–60%.	Herbaceous species are almost completely utilized, with less than 10% of current seedstalks remaining. Shoots of rhizomatous grasses are missing. More than 10% of low-value herbaceous forage has been utilized. Utilization 60-80%.	The rangeland has a completely mown appearance. There is no evidence of reproductive or seedstalks. Herbaceous forage species are completely utilized. The remaining stubble is grazed to the soil surface. Utilization > 80%.
Evidence of soil disturbances from livestock, wild horses/burros, or native ungulates (feces, loafing areas, trails, etc.)	Slight evidence of minor soil disturbances. Some trampling and/or soil displacement.	Evidence of moderate soil disturbances. Some trampling, soil displacement, loafing areas, or trails.	Evidence of serious soil disturbances. Extensive trampling, soil displacement, and frequently used loafing areas and/or trails.	Extensive soil disturbances. Ubiquitous soil displacement, heavily used loafing areas and/or trails.
Invasive plant species	NA	Nonstate-listed invasive species are observed (kochia, Russian thistle, cheatgrass, other local invasive species).	State listed noxious weeds observed but not dominant. (Refer to appropriate state list online.)	The area is dominated by invasive plant species.
Evidence of agricultural chemical application, herbicide spraying for invasive species and other weeds, or other vegetation treatment	Spot application of agricultural chemicals or vegetation treatment.	Agriculture chemicals or treatment have affected no more than 20% of the vegetation cover in an area.	Agriculture chemicals or treatment have affected more than 20% of the vegetation cover in an area.	NA
Insect pest damage	Less than 20% of individual plants in an area are affected, and effects have not caused mortality in most individuals.	Up to 40% of individual plants in an area are affected, or effects have caused mortality in up to half of infested individuals.	Up to 80% of individual plants in an area are affected, or effects have caused mortality in more than half of infested individuals.	All individual plants in an area are affected, or effects have caused mortality in all infested individuals.

Disturbance	Degree Ratings			
	1 = Low	2 = Moderate	3 = High	4 = Highest
Evidence of recent fire (< 10 years ago)	Less than 20% of canopy trees show burn scars AND effects have not caused mortality in most trees. Understory is intact.	Up to 40% of canopy trees show burn scars OR up to half of burned trees have died. Burn scars are evident in patches of the understory.	Up to 80% of canopy trees show burn scars AND more than half of burned trees have died. Understory vegetation is more than half burned.	Entire forest canopy has been burned AND most trees have died. Understory is completely burned and there are signs of soil sealing.
Evidence of recent flood (< 5 years ago)	Slight evidence of flooding, limited pushed over vegetation, and newly deposited sediment.	Moderate evidence of flooding, pushed over or buried herbaceous vegetation, newly deposited sediment, and small flood debris deposits.	Serious evidence of flooding, buried herbaceous vegetation, large areas of newly deposited sediment, flood debris deposits in shrubs and trees.	Extensive and extreme evidence of flooding, large areas of deep, newly deposited sediment, flood debris deposits in shrubs and trees, nearly all herbaceous vegetation has been buried.
Beaver activity (pond, dam, lodge, or chewed stems)	Beaver-chewed stems.	Chewed stems, small dam, and/or lodge, with associated pond, submerged vegetation.	Chewed stems, large dam, and/or lodge, with associated pond, submerged vegetation.	NA
Beaver dam blowout	NA	Small beaver dam has been breached, spreading a low to moderate amount of sediment.	Large beaver dam has been breached, spreading a considerable amount of sediment and/or impacting surrounding vegetation.	NA

Disturbance	Degree Ratings			
	1 = Low	2 = Moderate	3 = High	4 = Highest
Soil erosion or deposition in upland areas (sheet, rill, or gully erosion or sediment deposition)[2]	Evidence of erosion is scarce. Minor erosional and/or depositional areas, but they are rarely connected. If gullies are present, vegetation occurs on the banks and/or bottoms.	Evidence of erosion is common (sheet or rill). Minor erosional and/or depositional areas occur but are infrequently connected. If rills present, they are moderate in number and size, occur mostly in exposed areas. If gullies are present, moderate vegetation on banks or gully bottom.	Evidence of erosion is widespread. Erosional and/or depositional areas are common and occasionally connected. If rills are present, they are moderate in number, but at frequent intervals, many are large in size, occurring in exposed and vegetated areas. If gullies are present, they have intermittent vegetation on banks or in bottoms.	Evidence of erosion is extensive. Flow patterns are long and wide, potentially associated with landslides. Erosional and/or depositional areas widespread and usually connected. If rills present, they are numerous, large, and frequent throughout, occurring in exposed and vegetated areas. If gullies present, active erosion and no vegetation occurring on banks and bottoms.
Channel formation and/or incision in riparian or wetland areas	No headcuts, few nickpoints, and/or minimal downcutting.	Occasional nickpoints, slight downcutting, moderate size.	Nickpoints common, moderate bank and bottom erosion, downcutting, active headcuts may be present.	Numerous nickpoints, downcutting, substantial gully size, and/or active headcuts.
Hummock (wet soils) or pedestal (dry soils) formation[2]	Hummocks (wet soils) and pedestals (dry soils) are shallow, vegetated roots rarely exposed.	Hummocks (wet soils) and pedestals (dry soils) are moderately tall, some bare soil on or between features, roots occasionally exposed.	Hummocks (wet soils) and pedestals (dry soils) are tall, bare soil between features is common, roots commonly exposed.	Hummocks (wet soils) and pedestals (dry soils) are tall with sheer sides, soil between features is bare, roots frequently exposed.
Mining (including excavation, peat, rock, sand, gravel, minerals, and other mining)	NA	NA	Shallow pits from historic peat, rock, sand, or gravel mining.	Deep excavation for current rock, sand, or gravel mining. Spoils from placer mining. Evidence of historic or current mine tailings.
Natural salinity or nonnatural salinity inputs from roads or agriculture (dead or stressed plants, salt crusts)	Thin film of salt.	Moderate salt crust.	Thick crust of salt without dead vegetation.	Thick crust of salt and noticeable dead vegetation.

Disturbance	Degree Ratings			
	1 = Low	2 = Moderate	3 = High	4 = Highest
Inlet/outlet pipes or other evidence of point source or nonpoint source discharge (wastewater treatment, factory discharge, septic, urban/stormwater runoff, agricultural runoff, feedlots, mining runoff)	Rate hydrology disturbances as "present" if they are observed.			
Dams/reservoirs, impoundments, berms, dikes, levees, or excavated ponds that control and hold water in or out				
Canals, diversions, ditches, pumps that move water in or out				
Groundwater extraction (wells)				
Spring development				
Engineered channels (culverts, paved stream crossings, riprap, armored channel bank or bed, weir/drop structure, dredging)				
Instream habitat restoration (e.g., gabion rock baskets, cabled large wood, beaver dam analog structures, post-assisted log structures)				

[1]Herbaceous utilization class descriptions adapted from "Utilization Studies and Residual Measurements," TR 1734-3 (BLM 1996).
[2]Narrative rating descriptions for erosion and pedestals adapted from "Interpreting Indicators of Rangeland Health," TR 1734-6 (Pellant et al. 2020).

Quality Assurance

- ☐ All required fields are filled out.
- ☐ Disturbances have been discussed and checked among crew members.
- ☐ Notes and descriptions of disturbances are as complete and exact as possible.
- ☐ Abbreviations are defined.

6.0 Core Methods

Core methods generate data used to calculate indicators that describe key ecosystem attributes. ***Indicators*** are structural or functional measures that either directly or indirectly provide quantitative information on the condition of critical ecosystem processes and/or attributes. ***Core indicators*** are measurable ecosystem components applicable across many different riparian and wetland types, management objectives, programs, and agencies. Core methods should be carried out wherever this protocol is applied to monitor or assess the condition of riparian and wetland areas.

6.1 Plant Species Inventory and Identification

Overview: A plot-level vascular plant species inventory provides a rapid estimate of species richness. A thorough search of the plot can detect less-frequently occurring species that may not be recorded in cover measurements (e.g., line-point intercept). The timing of the species inventory is flexible depending on site conditions. In sites with lower diversity, the full species inventory should take place before line-point intercept. In sites with high species diversity, it may be most efficient to conduct a preliminary reconnaissance of dominant species before line-point intercept to familiarize the crew with species found along the transect. The full species inventory protocol can be finished after line-point intercept.

Species-level plant identification is critical to successfully completing line-point intercept and other vegetation data methods. Whenever possible, plants should be identified to species in the field and recorded using full scientific names from the U.S. Department of Agriculture (USDA) PLANTS Database (https://plants.usda.gov). Crews should familiarize themselves with local rare and sensitive plants (e.g., orchids) to avoid collecting or adversely impacting these species during the sampling effort. Many regions have detailed field guides, plant keys, and identification resources available in both paper and digital formats. If you are unable to identify a plant with > 1% canopy cover in the field, collect a specimen for later identification. Some projects and areas have regulations that govern where and how specimens are collected. Where herbarium-level specimen collection is permitted, the simple plant collection procedure that follows can be used to preserve unknown plant specimens until identified. Once a specimen is identified, it may be preserved in a binder for the remainder of the field season or discarded, if preferred.

Materials:

In the field:

- Plant Species Inventory Data Sheet (Appendix I)
- Unknown Plant Species Data Sheet (Appendix I)
- Cover Estimate Guides (Appendix P)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Stopwatch
- Pin flags to mark unknown plants
- High-resolution camera
- Plant identification keys and books

- Small garden knife for collecting specimens with root material
- Masking tape and marker for distinguishing unknown specimens
- Small ruler or notebook with measurements to show size of plants in photos
- Sealed plastic bags (gallon size or larger) for temporary plant specimen storage
- Cooler with ice packs for storing collected plants on site or in the vehicle, if temperatures are high

For pressing and mounting out of the field:

- Plant specimen labels (Appendix I)
- Plant press with cardboard dividers and dual straps
- Paper for drying during pressing (newspapers are best)
- Blotter paper to remove excess moisture
- Small envelopes or paper bags for storing seeds and other small plant materials to accompany collected plant specimens
- Paper for mounting (thick paper is best, but 8.5-by-11-in typing paper or A4 paper will work)
- Clear tape
- Binder with removable plastic sleeves

Method:

1. Complete the top section of the Plant Species Inventory Data Sheet.

1.1. Record plot ID, observer(s), recorder, visit date, and plot layout.

2. Systematically and uniformly search the entire monitoring plot for vascular plant species.

2.1. Mentally demarcate the boundaries of the species inventory search area, which is the entire monitoring plot (Figure 29).

2.2. Search the entire monitoring plot, focusing on the area between the transects and avoiding a 2-m band on either side of the transects to prevent trampling.

2.3. Work from the center of the plot toward the outer edge of the plot in a systematic or zigzag search pattern. Search all areas between the transects.

2.4. Search for at least 30 minutes with successive 10-minute increments as needed to detect the majority of species. End after the first 10-minute increment of active searching that does not find more than three additional species (not counting time spent identifying species).

2.5. The plot can be searched by all members of the field crew, with one specifically acting as a recorder.

3. Record each species found within the monitoring plot.

3.1. Species can be rooted inside the plot boundary or overhanging the plot. Any species that could be encountered along a line-point intercept transect should be included in the species inventory.

3.2. Record each known and unknown species found within the plot in the “Species Scientific Name/Temporary Name of Unknown Species” column of the data sheet. If the species is known, record the species name (fully spelled out) and USDA PLANTS Database species code. Assign a temporary name to unknown plants. Names can be descriptive (e.g., "yellow aster," "Carex brown head," "spikey grass," "Black stemmed shrub"). List each species only once, even if it occurs in multiple growth forms (e.g., seedling and mature tree).

3.3. Flag unknown species encountered during the search for later reference or collection using the "Unknown" column on the data sheet.

3.4. It can be helpful to collect a few flowering heads or leaves of unknown species to carry during the species inventory and compare with other species encountered.

3.5. Time may be spent on species identification (step 5) or specimen collection for later identification (step 6) during the search to reduce the number of unidentified species in the list. However, it is important to balance identification with other data collection activities. It may be helpful for one crew member to focus on species identification while others complete the species search.

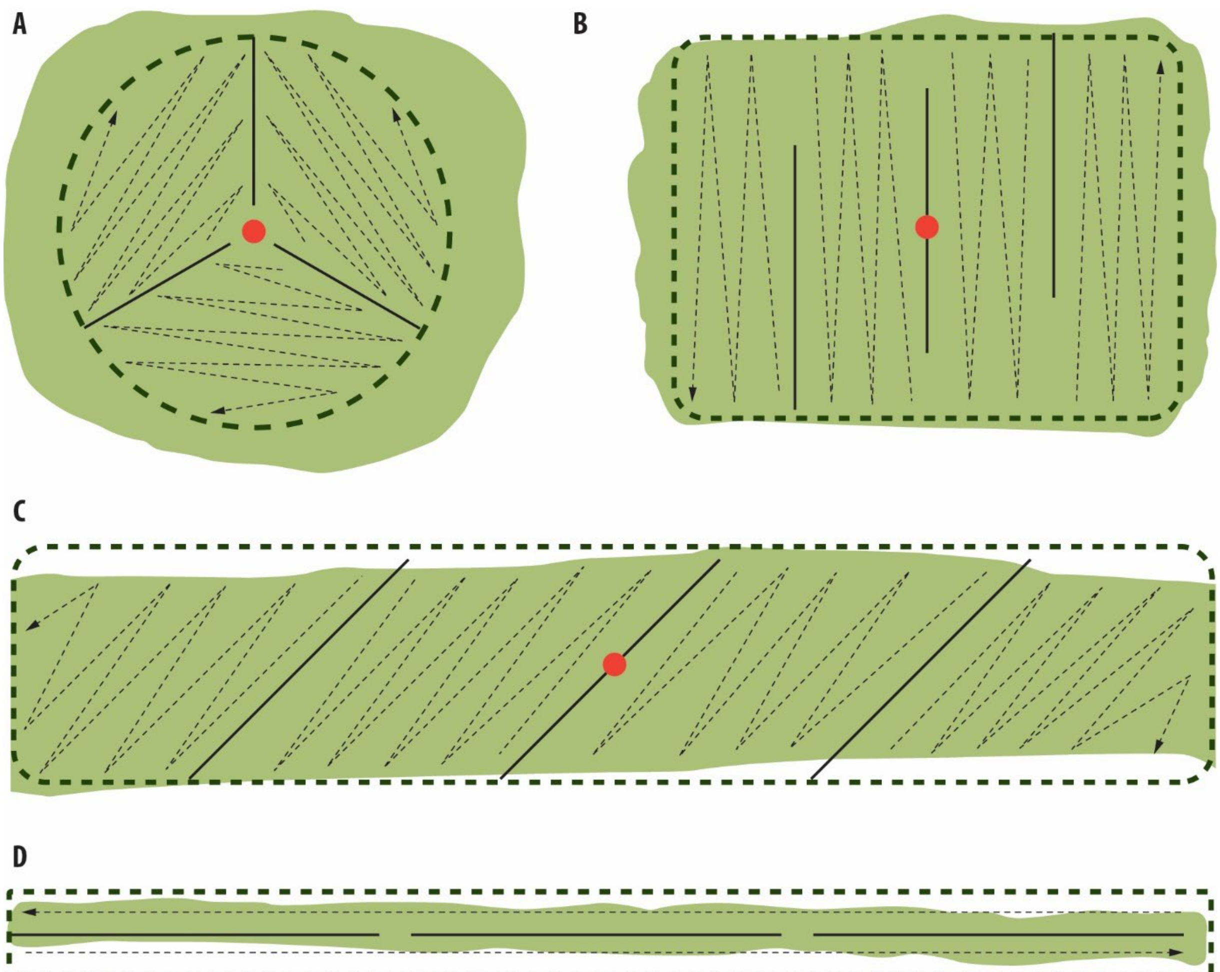


Figure 29. Search patterns (dashed lines) for species inventory around transects (solid lines) in a (A) spoke layout, (B) transverse layout, (C) diagonal layout, and (D) linear layout.

4. **Estimate cover class for each species found within the monitoring plot.**
   4.1. Once all species have been found or the time has expired, assign a cover class to each species in the list based on its ***canopy cover*** within the plot using the following cover classes (***absolute cover,*** not ***relative cover***). Use the visual estimate guides in Appendix P to help calibrate crews.
   - 1: Present (< 1% canopy cover)
   - 2: Occasional (1 to < 10% canopy cover)
   - 3: Common (10 to < 50% canopy cover)
   - 4: Ubiquitous (≥ 50% canopy cover)

   4.2. Cover classes should be assigned by at least two crew members standing in different locations within or on the edge of the monitoring plot. Crew members should observe the plot from different perspectives and agree on a cover class.

5. **Attempt to identify all unknown species with > 1% canopy cover and record known information.**
   5.1. Once all species have been recorded, return to the remaining unknown species and attempt to identify them in the field. Alternatively, one crew member can focus on species identification while the others complete the species search. Prioritize species with > 1% cover. Species with ≤ 1% cover can also be identified (and collected in step 6), but time should be focused on those with higher cover.
   5.2. If field identification is possible, erase or cross off the temporary name and replace it with the fully spelled out species name and USDA PLANTS Database species code, if known.
   5.3. If field identification is not possible, retain the temporary name and fill in an official unknown code in the "USDA Species Code/Unknown Code" column, as subsequently explained.
   5.4. Unknown codes for each plot are constructed with two pieces of information.
   - First is a set of letters to convey the level of information known about the species. See Table 10 for a list of acceptable unknown codes. This list includes the most common families and genera encountered in riparian and wetland environments in the West. If the family or genus is not known, or is not on the list, use the lifeform codes. More information about the potential family or genus can be included on the Unknown Plant Species Data Sheet (see step 7).
   - After the letters, assign a two-digit collection number to each unknown species. The number should begin at 01 for each plot and continue through all unknown species in the plot.
   - The unknown codes for any given monitoring plot will only apply to that plot. Codes are not repeated from one plot to another, even if a similar unknown species is encountered.

   5.5. **Note:** Crews may work on species identification throughout the time they are on the plot. If a species is identified on the plot after the species inventory has been finished, cross out and replace the temporary name and code only if line-point intercept data collection has not begun (Section 6.2). Once line-point intercept has begun, please leave all temporary names and unknown codes on the Plant Species Inventory Data Sheet and enter all unidentified names on the Unknown Plant Species Data Sheet (see step 7).

6. **Collect specimens of unknown species with > 1% canopy cover for identification out of the field.**
   6.1. If a species with > 1% canopy cover cannot be identified in the field, collect a specimen from either within or surrounding the plot.
   6.2. Before collecting, ensure that laws and regulations allow collection of specimens. Be aware of rare plants and do not collect those species.
   6.3. If the plant species is uncommon inside or surrounding the plot, only collect a specimen if you observe more than 10 individuals on the plot.
   6.4. Collect as many features of the unknown species as possible to aid in identification: roots, stems, branching, leaves, flowers, fruits, and seeds. It may be helpful to collect multiple specimens of a species (especially reproductive parts).
   6.5. Label each specimen clearly with plot ID, date, and the unknown code used on the data sheet. Write label information on a long piece of masking tape or flagging and wrap around the base of the specimen, including all portions of the specimens sampled.
   6.6. Place the specimens in a sealed plastic bag and place in a cool environment, out of direct sunlight. If the temperature is very hot, it is advisable to have a cooler with ice available to store plants in the field.

7. **For every specimen collected, fill out a section on the Unknown Plant Species Data Sheet.**
   7.1. In the field, fill out the following fields:
      - Unknown Code
      - Temporary Name of Unknown Species
      - Growth Habit
      - Duration
      - Family or Genus, if known
      - Specimen Collected?
      - Photos Taken?
      - Photo Numbers, if applicable
      - Additional Description (optional)

   The remaining fields will be filled in once the species is identified.

Table 10. Accepted unknown code prefixes and example Plant Species Inventory Data Sheet showing unknown codes and numbering. Additional accepted unknown codes may be available for nonvascular species in Alaska.

Initial Unknown Code	Taxa Name
Lifeform Codes	
AF	Annual Forb Generic
PF	Perennial Forb Generic
AG	Annual Graminoid Generic
PG	Perennial Graminoid Generic
SH	Shrub Generic
TR	Tree Generic
MO	Moss Generic (AK only)
LI	Lichen Generic (AK only)
NV	Nonvascular Generic (AK only)

Family Level Codes	
APIACE	Apiaceae
ASTERA	Asteraceae
BRASSI	Brassicaceae
CYPERA	Cyperaceae
FABACE	Fabaceae
LAMIAC	Lamiaceae
POACEA	Poaceae
RANUNC	Ranunculaceae
Genus Level Codes	
ARTEM	*Artemisia*
ASTRA	*Astragalus*
ATRIP	*Atriplex*
CAREX	*Carex*
CHENO	*Chenopodium*
CHRYS9	*Chrysothamnus*
CIRSI	*Cirsium*
ELEOC	*Eleocharis*
ELYMU	*Elymus*
EPILO	*Epilobium*
EQUIS	*Equisetum*
ERIGE2	*Erigeron*
JUNCU	*Juncus*
POLYG4	*Polygonum*
POTEN	*Potentilla*
SALIX	*Salix*
STELL	*Stellaria*
VIOLA	*Viola*

SPECIES INVENTORY DATA SHEET, PAGE 1

Plot ID: *RMD-TW-016*	Observer: *J. Lemly*	Recorder: *R. Whittington*	
Visit Date: *July 7, 2022*	Plot Layout: *Spoke*		

No.	Unkn √	Species Scientific Name / Temporary Name of Unknown Species	Unknown Code Prefix	Collection #	Cover Class (1, 2, 3, 4)
1		*Carex nebrascensis*			*3*
2		*Juncus arcticus ssp. littoralis*			*2*
3		*Achillea millefolium*			*1*
4		*Cirsuim arvense*			*1*
5	*x*	*Carex spp. (small brown head)*	*CAREX*	*01*	*1*
6		*Elymus trachucaulus*			*2*
7	*x*	*Unknown grass (loose open panicle)*	*POACEA*	*02*	*1*
8		*Sonchus asper*			*1*
9		*Hordeum jubatum*			*1*
10		*Epilobium ciliatum ssp. ciliatum*			*1*
11	*x*	*Unknown annual forb (small white flowers)*	*AF*	*03*	*1*
12		*Carex simulata*			*2*
13	*x*	*Unknown shrub (2-4 m, thorns)*	*SH*	*04*	*2*
14		*Typha latifolia*			*1*

8. **If field collection is not possible, take photographs of the unknown plant.**
    8.1. Capture diagnostic features of the plant in situ. If plants cannot be collected, it is especially important to take several photographs, focusing on different features of the plant (e.g., leaves, flower, overall appearance), as multiple photos will be needed for identification. It is helpful to take photos of plant parts next to a ruler with mm and cm markings.
    8.2. Use the "macro" feature of the camera to capture details, if possible.
    8.3. Include a photo ID card, specimen label, or another object for scale and record the unknown code on the card, if possible.
    8.4. For every unknown species photographed, fill out a section in the Unknown Plant Species Data Sheet as described in step 7.

9. **Identify unknown species out of the field.**
    9.1. Once out of the field, attempt to identify all collected species. This can be done in the evening after sampling the plot or at the end of a multiday sampling trip.
    9.2. If identification is possible, do not erase or cross off the temporary name or unknown code on the Plant Species Inventory Data Sheet. Track all identification on the Unknown Plant Species Data Sheet.
    9.3. For every specimen identified, fill out the remaining sections on the Unknown Plant Species Data Sheet, including:
        - Identified USDA Code
        - Identified Scientific Species Name
        - Identified By
        - Date Identified
        - Verified By (if an independent professional botanist has verified the identification)
        - Date Verified
    9.4. This procedure should be used for any specimens that are identified out of the field, including after they have been pressed.

10. **Press collected plants for later identification.**

10.1. If identification out of the field is not possible within a few days of collection, press the specimen to preserve it for later identification.

10.2. Place a piece of cardboard on the wooden frame of the plant press and then add a blotter.

10.3. Lay newspaper on top of the blotter. Clearly label the outside of the newspaper with the plot ID, date, the name of the collector, and the unknown code used on the data sheet.

10.4. Clean as much dirt as possible off the plant material before placing it in the newspaper. Place the plant material inside the sheet of newspaper so that it lies entirely within the dimensions of the plant press. Stems may need to be bent to fit within the press. For large specimens, bend stems into a V or N shape so they fit within the press frame. Avoid curving or twisting stems. Thick stems, large fruit, or bulbs may be trimmed to reduce bulk by cutting them in half lengthwise.

Figure 30. Assembling a plant press with newsprint, blotter, and cardboard dividers. A) A plant specimen laid out neatly within a sheet of newsprint and B) a tightly closed plant press. Photos by Kent D. Perkins, University of Florida Herbarium, used by permission from EPA (2016).

10.5. Carefully arrange the plant material to display diagnostic features, such as leaves, flowers, seeds, or roots (Figure 30A). Lay the specimen flat and avoid overlapping plant parts. Spread leaves, flowers, and fruits so they can be easily observed from different perspectives. Show upper and lower surfaces of leaves and flowers. If possible, arrange material so some flowers are open and some are pressed in side view. Multiple individuals of smaller plants of the same species should be pressed together on one sheet.

10.6. Examples of small, loose plant parts (e.g., seeds, *Carex* perigynia) should be placed in a small paper packet or envelope inside of the newspaper.

10.7. Once the plant material is arranged, fold the newspaper closed.

10.8. Add another blotter and then add a cardboard on top of the folded newspaper.

10.9. To begin pressing the next specimen, place a blotter over the top of the cardboard in the stack. Repeat steps 10.3 to 10.8 until all specimens have been pressed.

10.10. Place the wooden frame top on the last cardboard and firmly pull on straps to tighten (Figure 30B).

11. **Dry the pressed specimens in a warm, dry location.**
    11.1. Ideally, full plant presses will be returned to the base location after a few field days and placed on a plant dryer that provides steady bottom heat.
    11.2. If a plant dryer is not available, keep the full presses in a warm, dry, well-ventilated location. Check the press every couple of days and replace wet blotters to speed drying.
    11.3. Periodically tighten the straps on the press as the specimens dry to maintain pressure on the press.
    11.4. Once the specimens are dry, remove them from the press and keep individual specimens within their labeled newspapers until they are identified.

12. **Optional. Once a specimen is identified, mount the pressed specimens and store within a binder for later reference.**
    12.1. Tape or glue the plant securely to the mounting paper. If specimens will be submitted to an herbarium, specific instructions should be followed for the herbarium. In some cases, herbarium sheets may be bigger than binder paper, so choose mounting methods that are reasonable for storage either for temporary binders or long-term herbarium sheets.
    12.2. Attach a label to the corner of the paper. Include identified name, plot ID, location information, date collected, and the names of the collector(s).
    12.3. Store mounted specimens in plastic sleeves inside a binder for future reference.

Quality Assurance
☐ The Plant Species Inventory Data Sheet is complete. All fields are filled out including plot ID, observer, recorder, visit date, and plot layout. ☐ Boundaries of search area are clearly marked and understood, and total search time is noted and recorded. ☐ In the Unknown Plant Species Data Sheet, unknown plants are described and documented according to the unknown plant protocols, photographed, collected, and pressed. ☐ Data collection team confirms species list is complete and correct. ☐ Number and type of species are consistent with plot observations.

6.2 Line-Point Intercept (Vegetation Cover and Ground Surface Attributes)

Overview: Line-point intercept is a rapid, accurate method for quantifying vegetation and ground surface cover, including litter, soils, and water. These measurements are related to vegetation composition, site hydrology, soil cover, and the ability of the site to resist and recover from disturbance. The Line-point intercept method in this section has been adapted for riparian and wetland areas from Herrick et al. 2017 (Table 2). Points are denoted with a pin flag or a laser point over 0.5 m along the transect. For simplicity's sake, the term "pin drop" is used hereafter to denote use of either tool. Line-point intercept can be measured together with vegetation heights (Section 6.3).

Materials:

- Line-Point Intercept with Height Data Sheet (Appendix I)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Pointer (straight piece of wire or rod, such as a long pin flag, at least 75 cm (2.5 ft) long and with a maximum diameter of 1 mm (0.04 in), best if wrapped in brightly colored electrical tape or flagging or spray painted a bright color to facilitate use in dense herbaceous vegetation)
- Small laser with 1-mm point mounted on a dowel or rod with a bubble level (optional)

Method:

1. **Complete the top section of the Line-Point Intercept with Height Data Sheet.**
   1.1. Record plot ID, observer(s), recorder, visit date, transect number, and azimuth.
2. **Collect data at 0.5-m intervals along each transect.**
   2.1. The first point for data collection is located at the 0.5-m mark on the transect tape.
   2.2. As you move from one end of the tape to the other, always stand on the right side of the tape as you walk from the beginning of the transect to the end, and record vegetation hits to the left of the tape. From the right side of the tape, the numbers should be facing you. If the numbers are upside down, you are on the wrong side of the tape.
3. **Drop a pin flag to the ground from a standard height next to the tape (Figure 31).**
   3.1. Keep the pin vertical to the center of the Earth, regardless of slope.
   3.2. Hold the pin a few centimeters from the tape on the side opposite from where you are standing.
   3.3. Make a "controlled drop" of the pin from the same height each time. The ideal height may be different from plot to plot or transect to transect depending on the vegetation. Position the pin so its lower end is slightly above the ground surface or above the main mass of vegetation, if herbaceous vegetation is dense. Release it and allow it to slip through the hand until it hits the ground. A low drop height minimizes "bounces" off vegetation but increases the possibility for bias. Do not guide the pin all the way to the ground. It is more important for the pin to fall freely to the ground than to fall precisely on the transect tape mark.
   3.4. Once dropped, if the pin is caught in a thick litter or thatch layer, apply gentle pressure until it reaches the ground surface.

3.5. For sites with water, soft sediment, or algae on the soil surface, do not push or pull up on the pin if it encounters soft sediment. Take measurements based on where the pin naturally stops when dropped.
3.6. A laser with a bubble level can be used instead of a pin or in addition to a pin. This tool is useful in ecosystems where plant layers are above eye level (Figure 31C). If using a laser in addition to a pin flag, drop the pin flag first and then position the laser above the pin flag to project the point upwards. Make a note in the data sheet that a laser is being used instead of a pin and note any offset (cm) from the laser to the pole.

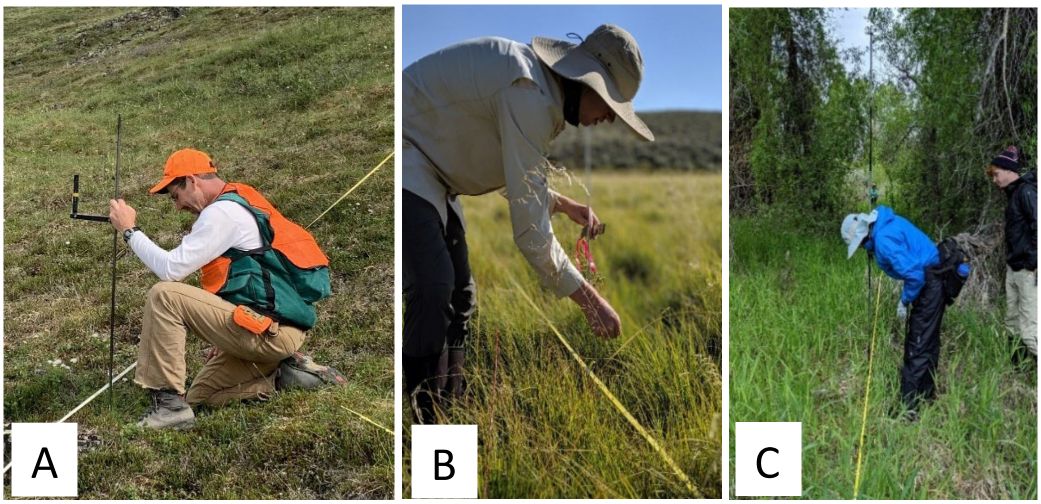
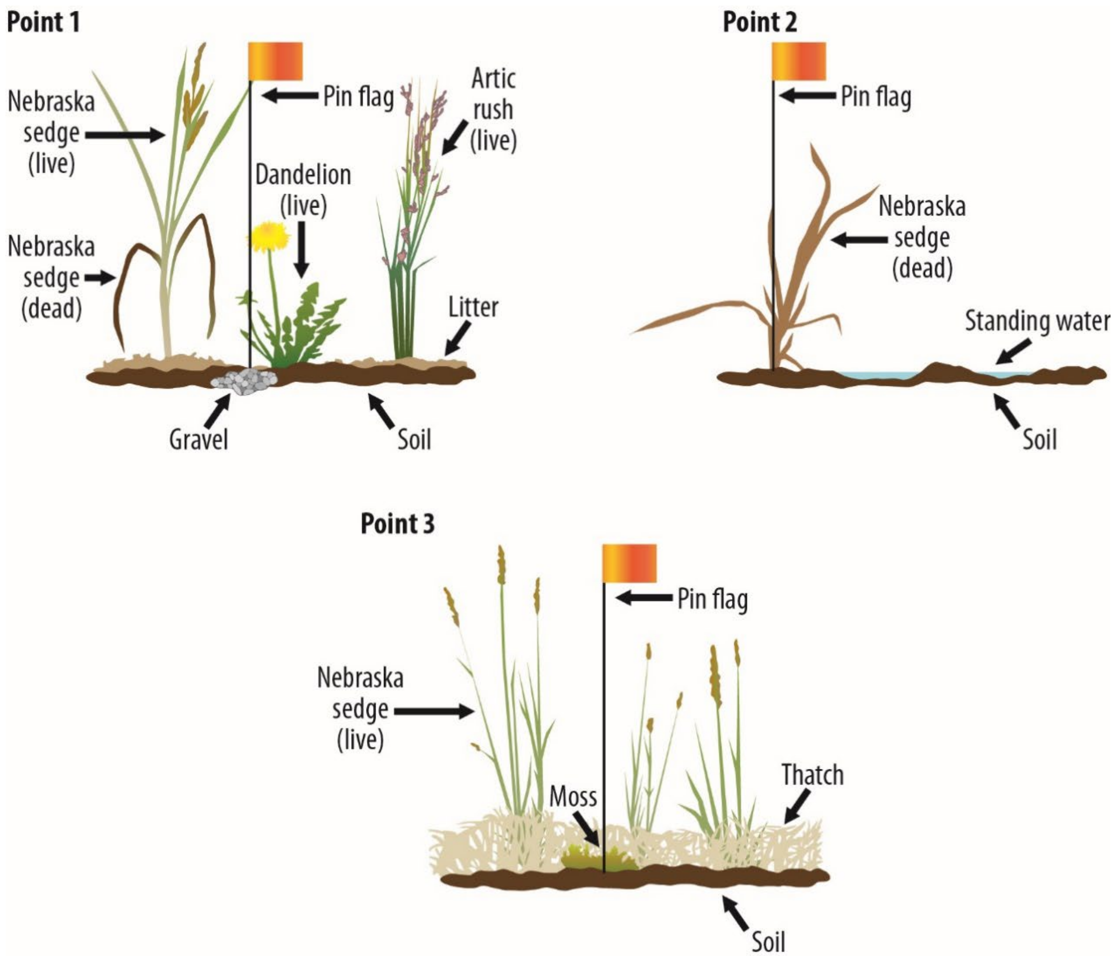


Figure 31. Examples of line-point intercept data collection areas along transects with either (A) a mounted laser setup or (B and C) pin flags.

4. **Once the pin flag has made contact with the ground, record the first vascular plant species it intercepts or touches in the "Top Layer" column (Figure 32).**
   4.1. Hold the pin as vertical as possible. If the pin is angled towards the ground, it will intercept additional species.
   4.2. Remember that the top layer may be above your head in sites with tall woody vegetation (Figure 31C).
   4.3. Record the species of the uppermost stem, leaf, or plant base that intercepts (touches) the pin using codes listed in Table 11. Foliage can be live or dead. If only dead plant material from a given species touches the pin, circle the species code on the form (see inset box on live vs. dead plant parts).
   4.4. If the scientific species name is known, use the USDA PLANTS Database species code (https://plants.usda.gov). If the scientific species name is not known, use the same unknown code used for that species in the species inventory.
   4.5. If the species was not encountered during the species inventory, add the name to the list. If the species name is unknown, mark the species and return to collect a sample at the end of the transect for later identification. Try to find a specimen off the transect, if possible.
   4.6. If no leaf, stem, or plant base is intercepted or touches the pin, record "N" for none in the "Top Layer" column.
   4.7. No other codes should be entered in the "Top Layer" column, only USDA codes for known species, unknown codes for unknown species, or "N" for no vascular plant intercepts.



PT.	TOP LAYER	LOWER LAYERS			SOIL SURFACE
		CODE 1	CODE 2	CODE 3	
1	CANE	TAOF			R
2	(CANE)				(CANE)
3	N	TH	M		S
etc.					

Figure 32. Example pin drops. The images above show the first three points along the transect, and the example datasheet at bottom shows how the data are recorded. In Point 1, the pin flag is touching live Nebraska sedge (CANE2), and live dandelion (TAOF), and gravel. In Point 2, the flag touches dead tufted hairgrass (DECE) and its dead plant base, indicating a basal hit instead of soil or other ground surface. In Point 3, the flag has no top hits of identifiable vascular species, so "N" is recorded for the top hit, and then it hits thatch (TH), a lower layer hit of moss (M), and moss again as a basal hit.

5. **Record all additional vascular and nonvascular species that intercept or touch the pin, in the order that they are observed from top to bottom, in the "Lower Layers" columns. Also record water, litter, thatch, or other appropriate codes in the "Lower Layers" columns using codes listed in Table 11.**
   5.1. Record each plant species only once, the first time it is intercepted, even if it is intercepted several times as one or multiple individuals. If a species has been recorded in the "Top Layer" column, it should not be repeated in the "Lower Layer" column.
   5.2. Foliage can be live or dead (see inset box on live vs. dead plant parts), but only record each species once at each pin drop. If both live and dead intercepts for the same species is hit on the same point, record the hit as live, even if a dead culm or leaf was encountered first.
   5.3. Nonvascular species can either be recorded with a general code of "M" for moss or with the species codes for each species, if known.
   5.4. If standing water occurs at the pin drop, record it as "W" in the "Lower Layers" column. Plant species may occur both above and below standing water and should be recorded in the order in which they occur. Viewing species that touch the pin below water is more difficult as water depth increases, especially if the water is cloudy or turbid. Attempt to discern if additional plants are intercepted by the pin below the water surface.
   5.5. If shallow standing water is mixing with soft soil, it may be difficult to determine if there is actual standing water or simply wet soil. If the water is forming a perfectly smooth surface, record a hit for water. If there is texture, consider it wet soil and do not record water. If it is difficult to determine, record a hit for water. Depth measurements will show the shallowness of the water.
   5.6. If the pin intercepts litter, record the appropriate code in the "Lower Layers" columns. Record "HL" for herbaceous litter that is detached stems, roots, herbaceous leaves, haybales, dung, and any woody litter less than 5 mm in diameter. Record "DL" for deciduous leaf litter. Record "WL" for detached woody litter greater than 5 mm in diameter. Record "NL" for nonvegetative litter (e.g., plastic, metal, rubber). All litter must be detached. Attached dead plant parts are either standing dead or thatch (see inset box on standing dead vs. thatch vs. litter).
   5.7. If the pin intercepts thatch, record "TH" in the "Lower Layers" columns (Figure 33). If both thatch and herbaceous litter occur on the same pin drop, only record thatch. Other litter types (deciduous litter, woody litter, and nonvegetative litter) should be called out separately from thatch.

Live vs. Dead Plant Parts

Distinguishing dead vs. live plant parts is important for many objectives. A pin intercept is a standing dead hit if the pin touches a dead plant part.

- Rooted plant parts that grew in the current growing season are considered live, even if they have already senesced (e.g., early season annual forbs encountered in later summer). Rooted plant parts from previous growing seasons are considered dead.
- Perennial and woody plant parts (stems and branches) that support live foliage and/or stems further out on the stem are considered live, even if the live vegetation is not where the pin intercepts. Perennial and woody plant parts that do not support live vegetation are considered dead.
- Points where only dead plants or plant parts are intercepted can be recorded on paper by circling the species on paper data sheet.

5.8. Less common codes that can be used in the "Lower Layers" columns include: "AE" for any form of algae, "SA" for salt crust on the soil surface, "VL" for vagrant or detached lichen, or "DS" for deposited sediment or soil overlying a live plant base.

5.9. If nonvascular species, water, litter, thatch, or other lower layer codes occur above the first vascular species at the pin drop, the first vascular species should be recorded in the "Top Layer" column and the other codes should only be in the "Lower Layer" columns, even if this is not the true order in which they occur. This is the only circumstance in which the information recorded is in a different order than observed.

Standing Dead vs. Thatch vs. Litter

Riparian and wetland environments often have dense herbaceous layers of multiple graminoid species. Live plant material can be interwoven with leaves and stems from previous years. This layer of entrained dead plant material, called ***thatch,*** is important in riparian and wetland areas, both as an indicator of organic inputs to the system and as a physical component of habitat. It can be difficult to distinguish species represented by dead plant parts within a thatch layer. Thatch only occurs in dense herbaceous layers where individual plants are growing close together. It does not occur where plants are spaced farther apart. It is important to correctly distinguish between standing dead, thatch, and litter at each pin drop:

Standing dead: past years' stems and leaves that are attached and not entrained. These should be recorded by species.

Thatch: past years' stems and leaves at < 45° angles and entrained (not loose), whether attached or not. Thatch is a tightly intermingled layer of living and dead stems, leaves, and roots that accumulates between the layer of actively growing vegetation and the soil underneath. Only occurs where species grow closely together.

Litter: detached stems, roots, leaves, dung, or hay from haybales. Herbaceous litter can include any woody litter < 5 mm in diameter and any herbaceous litter > 5 mm in diameter as long as it is indeed nonwoody. Litter must be completely detached.

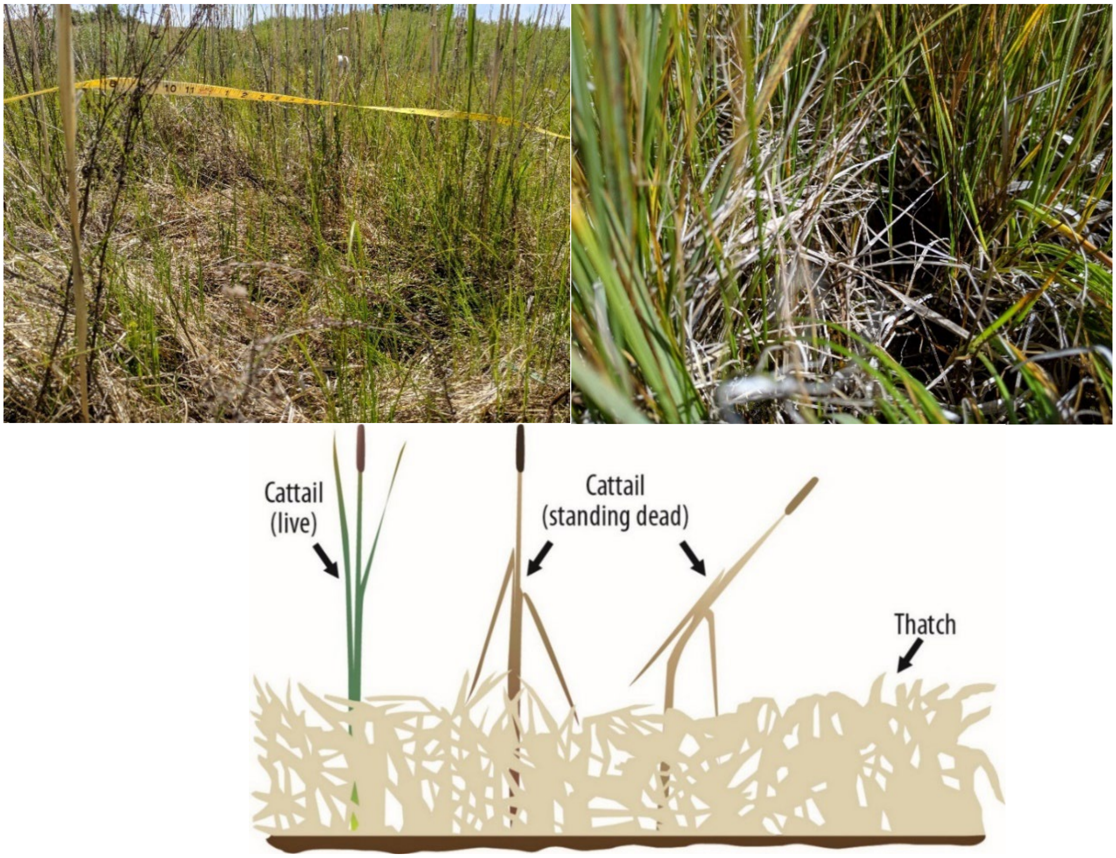


Figure 33. Thatch within dense herbaceous communities in photos (above) and an illustrated cross-section of example wetland vegetation (below).

6. **Record the ground surface where the end of the pin flag rests in the "Surface" column using the codes listed in Table 11.**
   6.1. If the pin flag lands directly within a vascular or nonvascular plant base (including moss or lichen), record the species code or "M" if moss in the "Surface" column. An intercept with a plant base or "basal hit" occurs when the end of the pin either rests on or immediately adjacent to living or dead plant material that is rooted in the soil. Carefully scrutinize if the pin is touching small, single-stemmed plants. Moss is recorded as a basal hit if it is dense, even if the pin sinks into the moss layer. However, loose moss that touches farther up the pin should be recorded in the "Lower Layers" columns only.
   6.2. If a species is recorded as a basal hit, it should also be recorded as a foliar hit in the "Top Layer" or "Lower Layers" columns. If the species (or moss) was already intercepted by the pin, there is no need to record it again in the "Lower Layers" columns. If the species (or moss) was intercepted for the first time as a basal hit, make sure to include in in the "Lower Layers" columns as well as the "Surface" column.
   6.3. If the end of the pin rests on a lichen crust attached to the soil surface, record "LC" in the "Surface" column.
   6.4. If the end of the pin rests on organic material that is clearly organic soil material or if it is impossible to distinguish between partially decomposed litter or thatch and the soil layer beneath, record "OM" in the "Surface" column.

6.5. If the end of the pin rests on woody litter that is embedded within the soil and cannot easily be moved, record “EL” in the “Surface” column. If the woody litter is not embedded, record it in the “Lower Layers” columns and choose a different ground surface code.
6.6. If the pin is in water > 50 cm deep, record “W” in the “Surface” column. For water ≤ 50 cm, record “W” in the “Lower Layers” columns and chose a different ground surface code.
6.7. If the end of the pin rests on mineral soil or sand < 5 mm in diameter, record “S” in the “Surface” column. Soil can be beneath moss (if not a basal hit), water, litter, thatch, or other lower layer codes.
6.8. If the end of the pin rests on a rock fragment ≥ 5 mm in diameter, record “R” in the “Surface” column or an optional rock fragment size class.

7. **Repeat steps 3 through 6 at 0.5-m intervals along the transect.**

Table 11. Accepted codes for top layer, lower layer, and surface columns on the Line-Point Intercept with Height Data Sheet.

Line-Point Intercept Layer	Permitted Categories/Codes		Description or Source	Comments
Top layer codes	N		No vascular species hit	Record "N" if the pin does not make contact with a leaf, stem, or plant base of a vascular plant.
	Plant name or code		From USDA PLANTS Database	Record the first (highest) plant species to hit the pin (either vascular or nonvascular).
	Unknown plant code		User assigned code (Section 6.1, step 5.4)	
Lower layer codes	Plant name or code		From USDA PLANTS Database	Record all remaining vascular plant species to hit the pin, in the order they are encountered. Foliage can be alive or dead, but only record each species once at each pin drop. If both live and dead canopy for the same species is hit on the same point, record the hit as live, even if a dead culm or leaf was encountered first.
	Unknown plant code		User assigned code (Section 6.1, step 5.4)	
	M (species code if known)		Moss or other nonvascular species	If all nonvascular species are lumped, record "M" when the first species is encountered. If nonvascular species codes are used, such as in Alaska, do not use "M" and record all species in the order they are encountered.
	W		Water	Plant species may be above or below the water, but water cannot be entered in the Top Layer.
	Litter	HL	Herbaceous litter (including dung, haybales, and any WL < 5-mm diameter)	Litter must be completely detached. Herbaceous litter can be > 5 mm in diameter as long as it is indeed nonwoody. Litter cannot be entered in the top layer, even if it occurs above the first vascular plant.
		DL	Deciduous leaf litter	
		WL	Woody litter > 5-mm diameter	
		NL	Nonvegetative litter (plastic, metal, rubber, etc.)	
	TH		Thatch	Past years' stems and leaves at < 45° angles and entrained (not loose), whether attached or not. Thatch is a tightly intermingled layer of living and dead stems, leaves, and roots that accumulates between the layer of actively growing vegetation and the soil underneath. Only occurs where species grow closely together. If you record "TH," you do not need to look for "HL" underneath.
	AE		Algae	Algae can occur on the water surface or as a dried crust on the soil surface. A few species of macroalgae, such as *Chara* sp., can occur in wetland environments.

Line-Point Intercept Layer	Permitted Categories/Codes		Description or Source	Comments
	SA		Salt crust	Salt crusts occur in saline environments and can be natural or irrigation-induced.
	VL		Vagrant lichen or any loose lichen	Lichens that are loose, never attached to any substrate. If lichen species codes are used, such as in Alaska, do not use "VL" and record all species in the order they are encountered.
	DS		Deposited sediment or soil	Sediment or soil deposited over a live plant base.
Ground surface codes	Plant code		From USDA PLANTS Database	Record a basal hit if the end of the pin rests on or immediately adjacent to a vascular or nonvascular species. There is no minimum height to basal hits. Record a foliar hit of the same species above any basal hit, even if no apparent pin contact is made with leaf or stem.
	Unknown plant code		User assigned code (Section 6.1, step 5.4)	
	M (species code if known)		Moss or other bryophyte	
	LC (species code if known)		Visible lichen crust	Visible lichen crusts (crustose lichen) attached to soil surface. Record if attached to soil but not if on rock. If lichen species codes are used, such as in Alaska, do not use "LC" and record all species in the order they are encountered.
	OM		Organic material	Soil surface that is clearly organic or is impossible to differentiate from partially decomposed litter.
	EL		Embedded woody litter	Embedded woody litter > 5 mm in diameter that cannot easily be moved.
	W		Water	Only record water as a ground surface code if the water is > 50 cm.
	S		Base soil or sand	Mineral soil or sand that is < 5 mm in diameter.
	R	GR (optional)	Gravel: Rock fragments 5–76 mm	Record "R" for any rock or rock fragments. Alternatively, differentiate rock fragments by size with the size classes listed at left.
		CB (optional)	Cobble: Rock fragments 76–250 mm	
		ST (optional)	Stone: Rock fragments 250–600 mm	
		BY (optional)	Boulder: Rock fragments > 600 mm	
		BR (optional)	Bedrock	

Quality Assurance
☐ Data sheet is complete, including plot ID, observer, recorder, visit date, transect, and azimuth. Scan every point entry to make sure they are legible. ☐ Each pin drop is made as close to vertical as possible, and observers avoid leaning too far over the line in either direction in order to avoid parallax. Parallax issues can increase variability year to year because different amounts of plant canopy are measured among years. ☐ Every “Top Layer” and “Surface” cell has an entry. Any species occurs only once in the “Top Layer” and “Lower Layers” columns. ☐ Ensure any top layers observed as none are recorded as "N." ☐ Fill every cell with its appropriate data; do not draw vertical lines down through multiple cells or columns to indicate repeating values. ☐ Cover values are consistent with plot observations. ☐ Species recorded are appropriate for plot. Species cannot be added to or altered on data sheets after leaving a site, unless they are accounted for with an unknown plant code. ☐ Species codes are complete, correct, and consistent with project plant coding system. ☐ Unknown plants are described according to unknown plant protocols, photographed, and voucher specimens collected.

6.3 Vegetation Height and Litter and Water Depths

Overview: Vegetation height and litter and water depths provide plot-level vertical structure information necessary to characterize wildlife habitat and predict various ecological processes. Vegetation height and litter and water depths are usually measured at the same time as line-point intercept (Section 6.2). The method in this section has been adapted for riparian and wetland areas (Table 2).

Materials:

- Line-point Intercept with Height Data Sheet (Appendix I)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Graduated survey rod or height measuring stick with graduations in centimeters and meters, such as an avalanche pole with clear markings
- Ruler notched to create a 15-cm radius circle or AIM monitoring tool
- Clinometer or extendable range pole
- Laser range finder with vertical distance calculator (optional)

Method:

1. **Measure plant heights at regular intervals (2.5 m) for a minimum of 30 measurements per plot (10 per transect).**
    1.1. The first point for data collection is located at the 2.5-m mark of the transect tape.
    1.2. At each designated transect mark, place the measuring rod 15 cm from the edge of the tape opposite from where you are standing. Use the ruler to create a 15-cm radius circle on the far side of the tape (Figures 34 and 35).
    1.3. Moving the ruler up and down as a guide, determine the tallest living or dead herbaceous AND tallest living or dead woody plant parts intersecting a projected 15-cm radius cylinder tangent to the line (Figure 36). Do not stretch or move any plant parts.
    1.4. Consider all plant parts existing inside the projected cylinder including leaves, stems, culms, inflorescences, etc., whether they are rooted inside or outside the 15-cm radius circular area (Figure 36).
    1.5. Measure one individual for herbaceous plants and one individual for woody plants, if present. Record the USDA PLANTS Database species codes or unknown codes for the herbaceous and woody or in the “Species” column.
    1.6. If the species was not encountered during the species inventory, add the name to the list. If the species name is unknown, mark the species and return to collect a sample at the end of the transect for later identification.
    1.7. Record if the plant elements are alive or dead, using the guidance to determine live vs. dead provided in Section 6.2. If only dead plant material from a given species touches the pin, circle the species code on the form.
    1.8. Record height from the ground surface, even if the soil surface is uneven, mounded or bumpy, or if the soil surface is underwater (Figure 36). Height is determined as the perpendicular distance (relative to the Earth's center, regardless of slope) from the soil surface at the center of the cylinder to the tallest plant part contained within the cylinder.

1.9. For plants ≤ 2 m tall, record height to the nearest centimeter. For plants > 2 m, record height to the nearest 30 cm. Plants > 8 m should be recorded as 8 m tall. If vegetation is taller than 4 m, a clinometer, laser ranger finder with vertical-distance calculator, phone application, or geometric technique can be used to estimate height.

1.10. Where no herbaceous or woody vegetation is present, mark "NA" or "None" in the species column and "0" in the height column of the data sheet. Do not leave the cells blank.

Figure 34. Measuring vegetation height and litter and water depths using a measuring rod and a ruler notched to create a 15-cm radius circle.

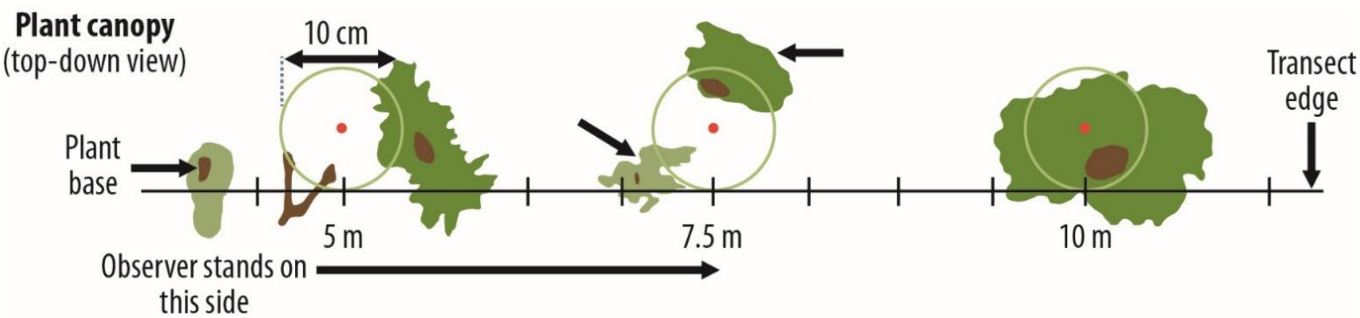
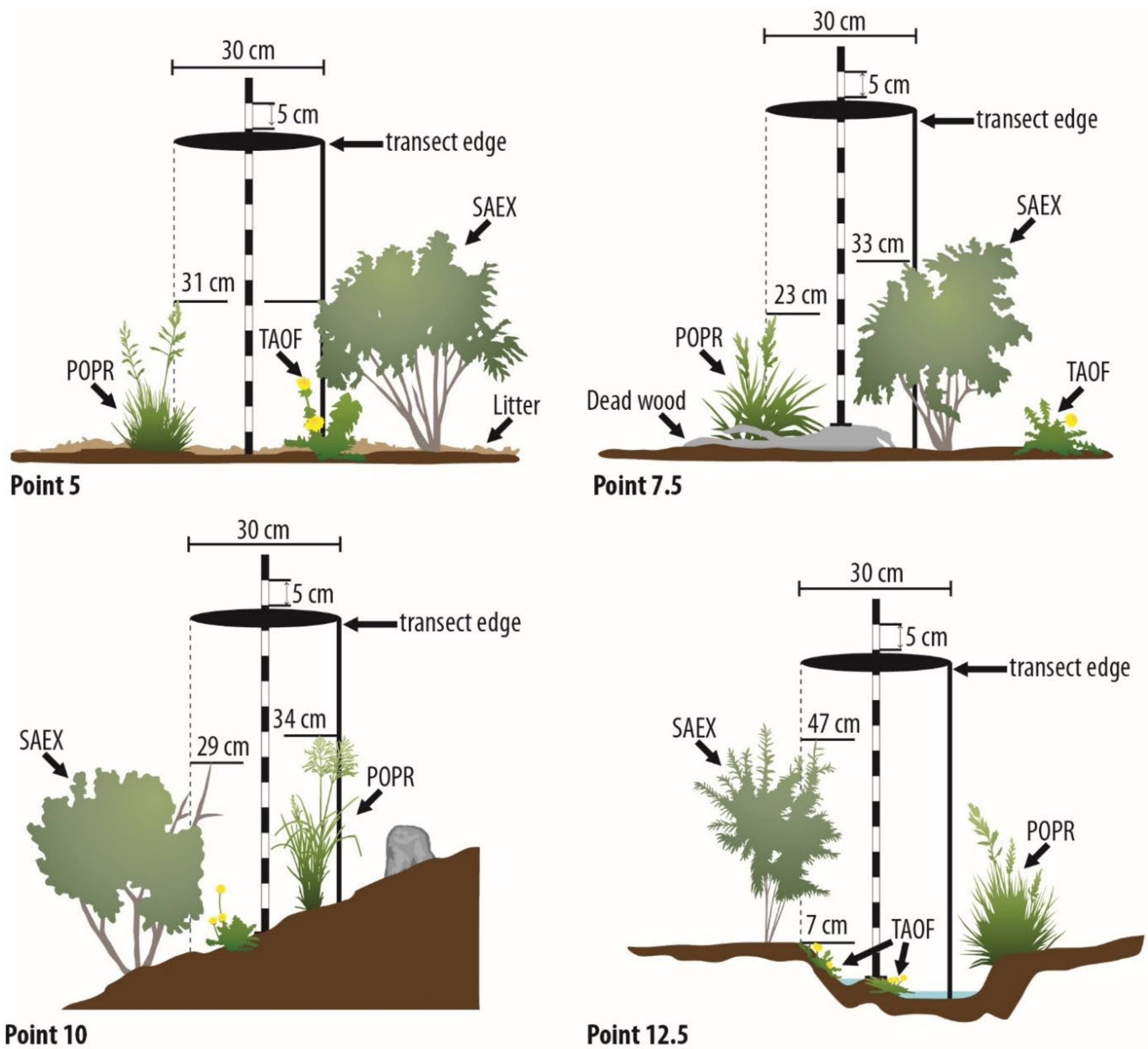


Figure 35. Example of measurement intervals for vegetation height and litter and water depths and the area tangent to the line in which the tallest woody and herbaceous plant elements are measured.



Height Measurement Interval: 2.5 ☑m ☐ft Height: ☑cm ☐in

POINT	SPECIES	WOODY HT.	SPECIES	HERBACEOUS HT.
5	SAEX	31	POPR	31
7.5	SAEX	33	POPR	23
10	SAEX	29	POPR	34
12.5	SAEX	47	TAOF	7

Figure 36. Example woody and herbaceous height measurements at four points along a transect, with example data sheet. Shrubs in the drawing are narrowleaf willow (SAEX), herbs are Kentucky bluegrass (POPR), and flowers are dandelion (TAOF). Height is measured from the center point of the cylinder even if the point is on a rock (7.5 m), a slope (10 m), or in a slight depression (12.5 m). Where no woody or herbaceous vegetation are present, mark "0" on the data sheet.

2. **Measure the depth of litter or thatch at the same intervals as vegetation height.**
    2.1. Measure litter or thatch depth within the same 15-cm radius cylinder used for vegetation height. Take only one measurement for herbaceous litter, thatch, deciduous litter, or woody litter. If multiple litter types occur, measure the tallest piece of litter.
    2.2. Measure depth from the top of the litter or thatch mass to the ground surface. Do not compress litter or thatch; measure the highest piece of litter or thatch that occurs within the 15-cm cylinder.
    2.3. Measure in increments of 1 cm. Where litter or thatch occur shallower than 1 cm, record 1 cm.
    2.4. In some cases, the litter or thatch may occur under water. Mark where litter or thatch occur on the measuring rod with your finger and pull the measuring rod slightly out of the water to read the measurement.
    2.5. If litter and thatch occur over a soft soil surface, it may be difficult to determine where the litter ends and soil surface begins. Do not push or pull up on the measuring rod if it encounters soft sediment. Take measurements where the measuring rod naturally stops when dropped.
    2.6. Record whether the litter measured is predominantly: (1) herbaceous litter or thatch, (2) deciduous litter, or (3) woody litter.
    2.7. Where no litter or thatch is present, mark "0" in the “Litter/Thatch” column of the data sheet. Do not leave the cells blank.

3. **Measure water depth at the same intervals as vegetation height.**
    3.1. Measure water depth at the center of the 15-cm radius cylinder used for vegetation height.
    3.2. Measure water depth from the top of the water to the ground surface.
    3.3. Measure water in increments of 1 cm. Where water occurs shallower than 1 cm, record 1 cm.
    3.4. If water occurs over a soft soil surface, do not push or pull up on the measuring rod. Take measurements where the measuring rod naturally stops when dropped.
    3.5. Where no water is present, mark "0" in the “Water” column of the data sheet. Do not leave the cells blank.

Quality Assurance
☐ Data sheet is complete, including plot ID, observer, recorder, visit date, transect, and azimuth. ☐ Vegetation heights are collected at the correct intervals on the transect. ☐ Observers only measure plant elements within the cylinder tangent to the line. ☐ Species, if recorded, are included in the species list. ☐ Species names or codes are complete, correct, and consistent with project plant coding system. ☐ Unknown plants are described according to unknown plant protocols, photographed, and voucher specimens collected when permissible.

6.4 Woody Structure

Overview: The woody structure method, including height class, age class, and stem size, provides information on canopy structure, recruitment, and population parameters of woody species (Table 2). For riparian and wetland areas with the potential to support woody vegetation, quantifying canopy structure using height classes provides an understanding of woody habitat complexity, heights of canopy layers, and percentiles of woody species in each height class. Quantifying age classes of riparian shrub species and stem sizes of trees, which can be linked to age, provides an understanding of size distributions and whether populations of woody species are increasing, decreasing, or maintaining numbers. Stem sizes of trees can also be used to calculate stem density and basal area across the plot.

Woody structure is measured in a 2 m x 1 m quadrat extending across both sides of the transect beginning at the 0-m end of the transect and at every 2.5 m thereafter (Figure 37). Height class is measured for all woody species, either rooted in or overhanging the quadrat. Age class is measured for all riparian shrub species that are rooted in the quadrat. Rhizomatous and dwarf shrub species, however, are difficult to separate as individuals (e.g., wild rose [*Rosa* spp.], narrowleaf willow [*Salix exigua*], or alpine willow [*Salix petrophila*]); therefore, these species are simply noted as “rhizomatous” or “dwarf shrub” and not assigned age classes. Max height and stem size are measured for all individual trees. Woody structure is usually measured as a separate pass of the transect along with annual use methods (stubble height, soil alteration, and woody use), if annual use is being measured (Section 8.0).

Materials:

- Woody Structure and Annual Use Data Sheet (Appendix I)
- List of Common Rhizomatous and Dwarf Shrub Species (Appendix Q)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Graduated survey rod or height measuring stick with graduations in centimeters and meters, such as a meter stick or avalanche pole with clear markings
- Diameter tape, AIM monitoring tool, or other measuring device to measure diameter at breast height (DBH)

Method:

1. **Complete the top section of the Woody Structure and Annual Use Data Sheet.**
   1.1. Record plot ID, observer(s), recorder, visit date, transect number, and azimuth.

2. **Measure woody structure in 2 m x 1 m quadrats at regular intervals (2.5 m) for 30 measurements per plot (10 per transect).**
   2.1. The first point for data collection is located at the 0-m mark on the transect tape.
   2.2. At each designated mark, place the measuring rod perpendicular to the transect extending 1 m out on both sides of the transect. The woody structure quadrat is formed by 1 m on both sides of the transect and 1 m along the transect tape beginning at the 0-m end and repeated every 2.5 m (250 cm) thereafter (Figure 37).

2.3. For all data collected in each quadrat, record the location in meters along the transect in the "Loc." column (e.g., 0 m, 2.5 m, 5.0 m, 7.5 m). Since there may be multiple woody species rooted in or overhanging the quadrat, there may be multiple lines on the data sheet for each location. Each line on the datasheet must have an associated location in the "Loc." column.

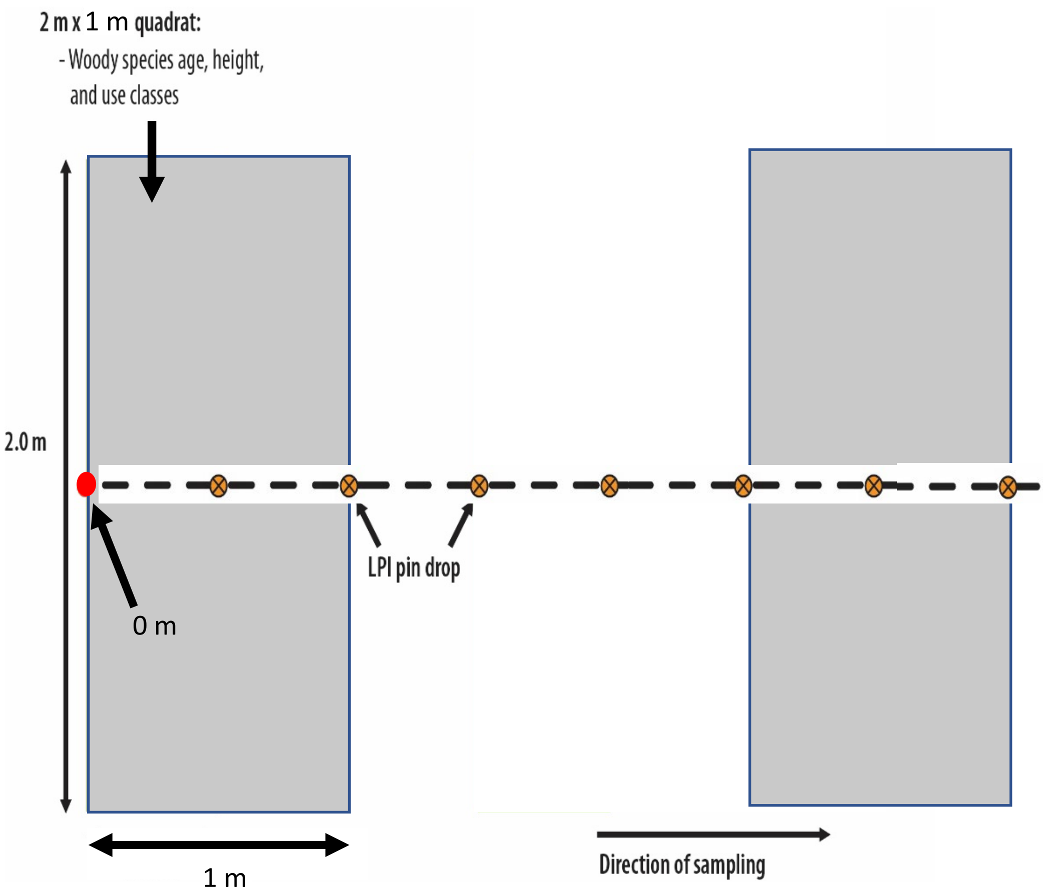


Figure 37. Quadrats (2 m x 1 m) for woody structure and riparian woody species use, in relation to the line-point intercept transect. Measurements are taken at 2.5-m intervals along the transect. Woody structure (Section 6.4) and riparian woody species use (Section 8.4) are collected as a separate pass of the transect from line-point intercept.

3. **Identify all woody species that are rooted in or overhanging the 2 m x 1 m quadrat.**
   3.1. Look at the entire 2 m x 1 m quadrat and identify all woody species within the quadrat, whether rooted in or overhanging. Record information about each species separately.
   3.2. Similar to line-point intercept, a laser with a bubble level can be used to determine if woody species are within the quadrat if branches are above eye level (Figure 31C).
   3.3. For each species, record the USDA PLANTS Database species code or unknown code in the "Woody Species" column. If the species was not encountered during the species inventory, add the name to the list.

4. **For each woody species, record whether the species is alive or dead.**
    4.1. For each woody species, record whether the species is alive or dead by circling the species code of any dead shrub species on the form. Record as live or dead based on all branches intersecting the quadrat, whether the individuals are rooted in or overhanging the quadrat. Only record as dead if all intersecting stems and branches of the species are dead.
    4.2. For tree species, live vs. dead is also recorded for individuals rooted in the quadrat in step 9.

5. **For each woody species, record the growth habit and whether the species is riparian.**
    5.1. For each woody species, record the growth habit using one of three categories: (1) tree (T), (2) shrub (nonrhizomatous/dwarf) (Sh), or (3) rhizomatous/dwarf shrub (R/Dw). Record the typical growth habit of the species, not the observed growth habit in the quadrat.
    5.2. **Note:** Rhizomatous shrubs and dwarf shrubs (also called subshrubs, usually < 0.5 m at maturity) are always recorded as rhizomatous/dwarf shrubs based on the typical growth habit of the species, not the observed growth habit in a quadrat. Examples of rhizomatous species include wild rose (*Rosa* spp.), snowberry (*Symphoricarpos* spp.), currant (*Ribes* spp.), and narrowleaf willow (*Salix exigua*). Examples of dwarf shrubs include alpine willow (*Salix petrophila*), arctic willow (*Salix arctica*), and alpine laurel *(Kalmia microphylla).* Some shrub species are both rhizomatous and dwarf. A list of common rhizomatous and/or dwarf shrubs is provided in Appendix Q for consistency, but consult local botanical experts for other potential species in the state.
    5.3. For each woody species, record if the species is riparian or not. Riparian woody species are those with a wetland indicator status of obligate (OBL), facultative wetland (FACW), or facultative (FAC), as defined by the National Wetland Plant List, which varies by region.

6. **For each woody species, record whether any individuals are rooted in the quadrat or if all branches are overhanging the quadrat.**
    6.1. Determine if any individuals are rooted in the quadrat. If any individuals are at least partially rooted in the quadrat, record "Y" in the "Rooted In?" column. If all individuals are not rooted in and all branches are overhanging the quadrat, record "N" in the "Rooted In?" column.
    6.2. If an individual is rooted in more than one quadrat, only record "Y" for the first quadrat.
    6.3. **Note:** Some single-stemmed species, such as Alder (*Alnus* spp.), grow along the ground for a distance before growing upright. In this case, only consider the individual as "rooted in" if its upright stem is inside the quadrat.

7. **For each woody species, estimate the tallest intersecting height.**
    7.1. For each woody species, estimate the height of the tallest live or dead portion of the species that intersects the quadrat.
    7.2. Estimate height from the ground surface in the quadrat. Record the height using classes in Table 12.
    7.3. For species that are entirely overhanging, are rhizomatous and/or dwarf shrubs, or are nonriparian shrubs, intersecting height class is the only measurement to record, and data collection ends here.

8. **For each riparian shrub species (nonrhizomatous or dwarf) with individuals that are rooted in the quadrat, count and record the number of individuals within each age class.**
   8.1. Count and record individuals within each age class using classes in Table 13.
   8.2. **Note:** It can be difficult to distinguish individual multistemmed shrubs from each other when they are growing close together. In such cases, consider stems to be from different individuals if there is a 0.3-m (12-inch) gap between one cluster of stems and another at ground level (or as close to ground level as is visible). However, seedlings commonly germinate and initiate growth very close together but are clearly individual plants and should be recorded as such. This may result in separate individual seedlings closer than 0.3 m from each other.
   8.3. For riparian shrub species (nonrhizomatous or dwarf), data collection ends here.

9. **For each tree species with individuals that are rooted in the quadrat, tally the number of tree <u>seedlings</u>, and record the maximum height and diameter at breast height (DBH) of each larger individual.**
   9.1. For each tree species, tally and record the number of seedlings of that species. Tree seedlings are individuals <1 m tall AND have a DBH <2.5 cm. Any individual that is ≥1 m tall OR has a DBH ≥2.5 cm should be recorded separately in the following steps.
   9.2. For each individual tree larger than a seedling, record whether the individual is alive or dead by circling the species code of any dead individuals on the data sheet. Record as live or dead based on the entire individual, including stems and branches outside the quadrat. Only record as dead if all stems and branches considered are dead.
   9.3. For each individual tree, estimate the maximum height of the individual's tallest stems or branches, regardless of whether those stems or branches are within the quadrat or not. Record the maximum height using classes in Table 12.
   [Alaska only]: Estimate and record maximum tree heights above 4 m in a separate field. Estimate height to the nearest 2 to 5 m, whichever is most accurate.
   9.4. For each individual tree, measure the stem diameter at breast height (DBH) (1.37 m or 4.5 ft) or diameter at 50% of height, whichever is lower. Use a diameter tape for a precise measurement or estimate to the nearest cm using an AIM monitoring tool or other measuring device. Record measurement in cm. If the diameter is less than 1 cm, record as 0.5 cm.
   9.5. **Note:** For trees with more than one stem, measure the DBH or diameter at 50% of height as in step 9.3 for each stem and add the diameters together. Record the diameter sum for that individual.
   9.6. **Note:** For broken trees whose main stem is broken off above DBH, measure DBH. If the main stem is broken below DBH, do not count or measure that individual. For trees that are dead and leaning, only count and measure individuals that are leaning above a 45° angle to the ground. Do not count and measure individuals leaning below a 45° angle to the ground.

10. **If there are no woody species within the quadrat, mark "None" in the "Woody Species" column.**

Table 12. Woody species height classes.

Height Class	Height Range
0	0.0–0.2 m
1	0.2–0.5 m
2	> 0.5–1.0 m
3	> 1.0–2.0 m
4	> 2.0–4.0 m
5	> 4.0–8.0 m
6	> 8.0 m

Table 13. Age classes for riparian shrub species (nonrhizomatous or dwarf) (e.g., willow, alder, birch).

Age Class	Stem Counts and Sizes
Seedling	1 stem < 0.5 m tall AND < 0.5 cm at the base
Young	2-10 stems < 1 m tall (or shorter than standard mature height) OR 1 stem > 0.5 m tall OR 1 stem > 0.5 cm at the base
Mature	≥ 2 stems ≥ 1 m tall (or standard mature height)

Quality Assurance

- ☐ Data sheet is complete, including plot ID, observer, recorder, visit date, transect, and azimuth.
- ☐ Data for woody structure quadrats are collected at the correct intervals on the transect.
- ☐ Species, if recorded, are included in the species list.
- ☐ Species names or codes are complete, correct, and consistent with project plant coding system.
- ☐ Unknown plants are described according to unknown plant protocols, photographed, and voucher specimens collected when permissible.
- ☐ Rhizomatous and dwarf shrub species are only list once per quadrat.
- ☐ Height classes within the quadrat are measured on individuals that are both rooted in and overhanging the quadrat.
- ☐ Maximum height classes and stem size are only measured for individuals that are rooted in the quadrat.
- ☐ Maximum height class and stem diameter or age class are not measured for rhizomatous and dwarf shrub species.

7.0 CONTINGENT METHODS

Contingent methods measure ecosystem components with cross-program utility and consistent definitions, similar to core methods, but they are not required. Contingent methods are only used when they are important for management purposes and are not necessarily applicable in all sites. Contingent methods in this protocol include hummocks and water quality (Table 2). Project leads should decide if and when these methods are carried out based on monitoring objectives. If one or both contingent methods are included in the monitoring plan for a project or a specific plot, but there are no hummocks and/or surface water at the time of sampling, crews should record the absence as negative data. In contrast, if one or both of the methods are not included in the monitoring plan for a project or specific plot, no data will be collected even if hummocks or surface water are observed.

7.1 Hummocks

Overview: Microtopography plays an important role in the hydrology, biogeochemistry, and plant community composition of many wetland sites (e.g., Vivian-Smith 1997; Bruland and Richardson 2005). Natural microtopography in wetlands may be the result of bioturbation, including ant mounds, vole burrows, or elk and bison wallows. Other microtopographic features may be caused by water flow paths, scouring, or tussocks formed by cespitose graminoids, downed wood, or other vegetation. In high-altitude or northern regions, where a substantial portion of topsoil freezes during the winter, freeze-thaw dynamics contribute to microtopography referred to as ***hummocks*** (Figure 38). Hummocks occur more frequently in wetlands with fine-textured soils, including those with high silt content (Grab 2005; Smith et al. 2012) and organic matter. The formation of hummocks may also be caused or exaggerated by ungulate behavior, specifically the degree of soil disturbance and plant use on susceptible soils (Booth et al. 2014; Davies et al. 2020). Irregularities in the ground surface tend to encourage ungulates to walk in the interspaces between mounds. Consequently, interspaces become more vulnerable to soil loss and soil compaction, while mounds become vulnerable to additional frost heave, dewatering, and erosion.

Data collection on hummocks is intended to characterize the physical structure of hummocks within the plot and to help detect changes due to livestock use, erosion, hydrologic modification, and/or changes in the biotic community over time. This method is not intended to be used to characterize tussocks formed by cespitose vegetation, such as tussock tundra in Alaska. The hummock method detailed in this section records the number, height, length, slope, and vegetated condition of hummocks within the plot. These data are collected as a separate pass of each transect where hummocks occur, after the vegetation data has been collected. Hummocks (sometimes called pedestals in other literature) are defined in this method as surface features with 10 cm (4 in) or more of microrelief from the top of the feature to the adjacent interspace or depression adjacent to the feature and that continue for 10 cm or more along the transect. For the purposes of this protocol, holes and soil displacement created by single livestock or ungulate hoof prints (aka “pugging” or “post holes”) are not counted as high or low points, even if they are > 10 cm deep. These features are monitored as soil alteration (Section 8.3).

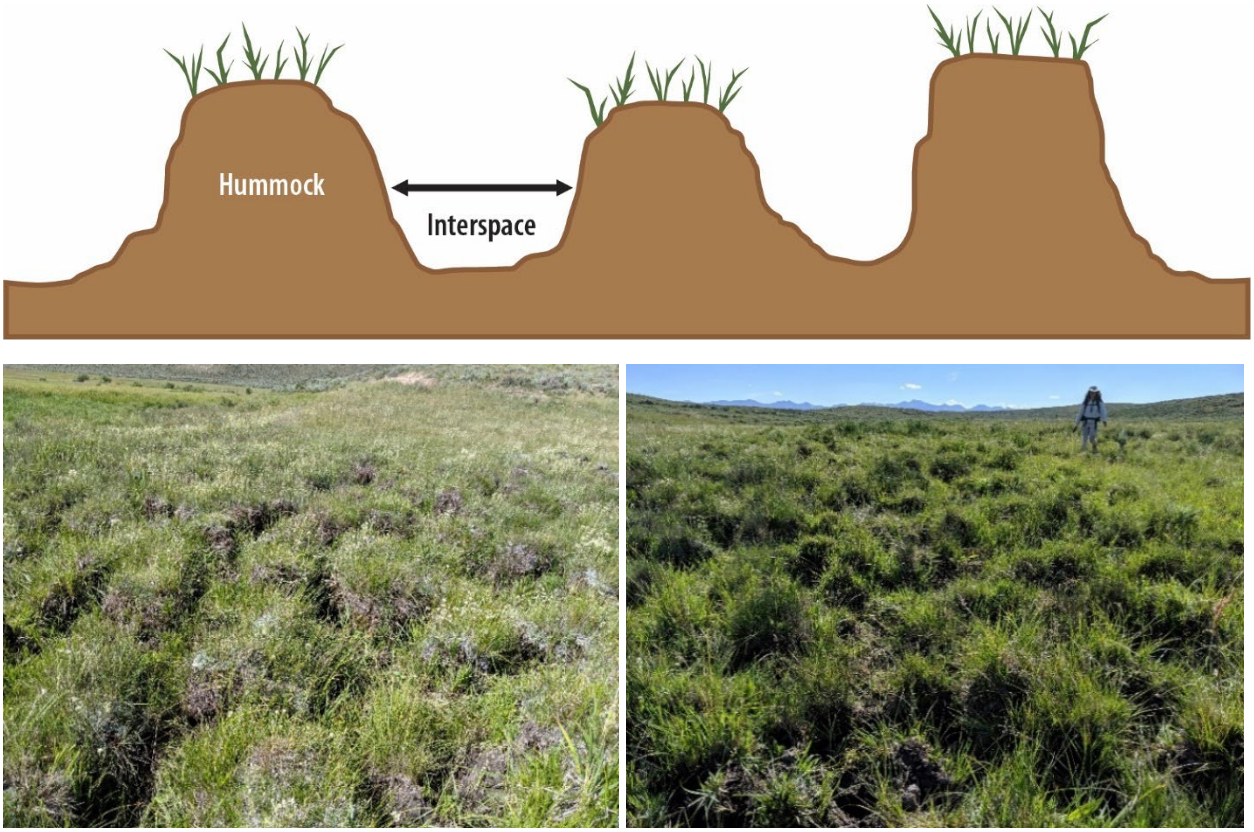


Figure 38. Schematic of raised hummocks and interspaces between hummocks (top) and photographs of hummocks (below).

Materials:

- Hummocks Data Sheet (Appendix I)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Clinometer, digital protractor (or angle finder), compass, or other device to measure angles in degrees
- Graduated survey rod or height measuring stick with graduations in centimeters and meters, such as a meter stick or avalanche pole with clear markings
- Small stiff ruler or other flat stiff object or AIM monitoring tool

Method:

1. Complete the top section of the Hummocks Data Sheet.

1.1. Record plot ID, observer(s), recorder, visit date, transect number, and azimuth.

2. Identify the first qualifying hummock.

2.1. Beginning at the 0-m mark on the transect tape, look straight down and focus on the edge of the tape with marked graduations. Do not change sides of the tape during the measurement. All measurements are collected along the two-dimensional line formed by the transect.

2.2. From the beginning of each transect (0-m end), follow the transect looking for features with ≥ 10 cm relief from the top of the hummock to the bottom of an adjacent interspace or depression on either side of the feature (Figure 39). Because the ground surface can be very uneven, the interspace between hummocks may be deeper on one side than the other. Consider a feature to be a qualifying hummock if it is ≥ 10 cm in height on either side**.** The only exception to this rule is if the ground surface is relatively flat before hummocks start. The flat ground would not be considered a hummock even if an adjacent depression was > 10 cm lower.
2.3. Qualifying hummocks must extend for ≥ 10 cm along the transect. If the end of a hummock intercepts a transect for less than 10 cm, do not record it.
2.4. Do not measure annual disturbance, such as hoof prints. For the purposes of this protocol, holes and soil displacement created by single livestock or ungulate hoof prints (aka "pugging" or "post holes") are not counted as depressions between hummocks. Additionally, there can be a hoof print within a hummock that might interrupt the surface of the hummock, but this hoof print should not be considered an interspace; it is still part of the hummock.
2.5. Make sure to push back any vegetation that may obscure high and low points along the tape.
2.6. Standing water can make accurate measurements of hummocks difficult. If standing water occurs along the transect, hummocks should be measured if the tops of the hummocks are above the water level. If the tops are below water, do not measure the hummocks but add a comment that deep water above the hummocks prevented measurements.

3. Record the location and length of each hummock you encounter.

3.1. Record the location along the transect where the feature starts, in cm.
3.2. If the 0-m end of the transect is in the middle of a hummock, record the start as 0 cm.
3.3. Consider the start and end of the hummock to be where there is a noticeable change in slope from the adjacent ground surface to the hummock. This is more obvious if the hummock has steeply sloping sides and less obvious with shallowly sloping sides (Figures 39 and 40).
3.4. Record the location along the transect where the feature ends, in cm.

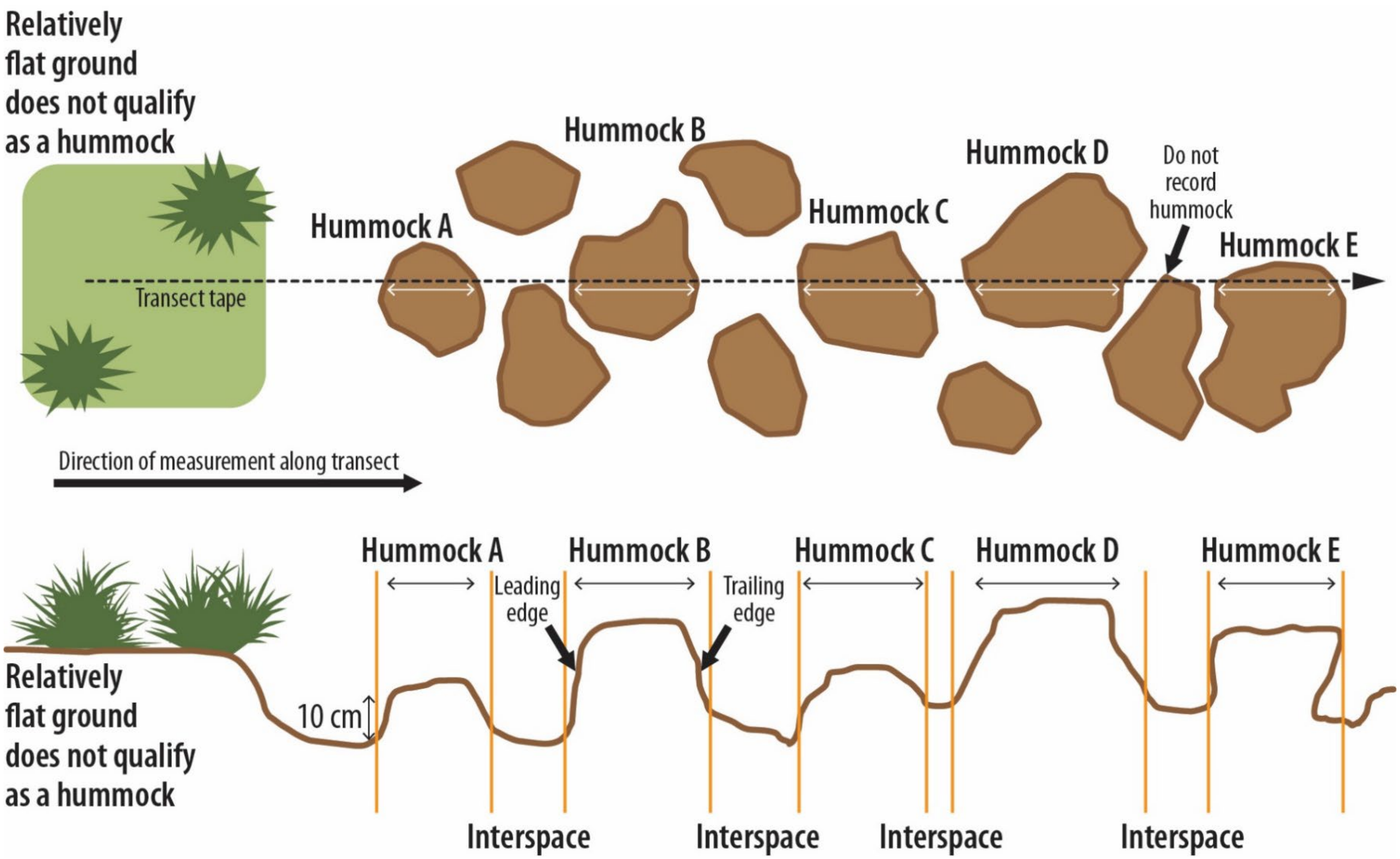


Figure 39. Aerial view (top) and cross-section (bottom) of hummocks along a transect. The relatively level ground before the hummocks start is not measured. All hummocks that are ≥ 10 cm above the interspace or depression on either side are counted as qualifying hummocks. Note that Hummock C in the cross-section view is taller on the leading edge than the trailing edge but would still be counted. The start and end of each hummock should be measured from where there is a noticeable change in slope. For hummocks with shallower slopes, such as Hummock D in the cross-section view, this can be more difficult to determine. Do not measure hummocks if they intercept the line for less than 10 cm, such as the hummock between D and E in the aerial view.

4. **Measure and record the slope of the leading edge of each hummock (Figure 41).**
    4.1. Use a compass or digital protractor to measure the slope of the leading edge of each hummock. Ninety degrees is vertical. Undercut sides would be considered > 90° and should be recorded as 90°.
    4.2. Place the straight edge of a ruler against the leading edge of the hummock, from the bottom of the hummock to the top, in line with the transect tape. Place a clinometer, protractor, or compass against the ruler to measure the angle (Figures 42 and 43). If using a compass, ensure that the dial is oriented correctly to get an accurate angle measurement (the 90° or 270° mark is in line with the north arrow.)
    4.3. If there are two distinct angles, measure the angle of the most dominant section of the hummock face (Figure 42). If there is not an obvious dominant angle or there are three or more angles, measure the average angle by laying the straight edge of a ruler where it is most representative of the overall angle.
    4.4. Record the slope on the data sheet.

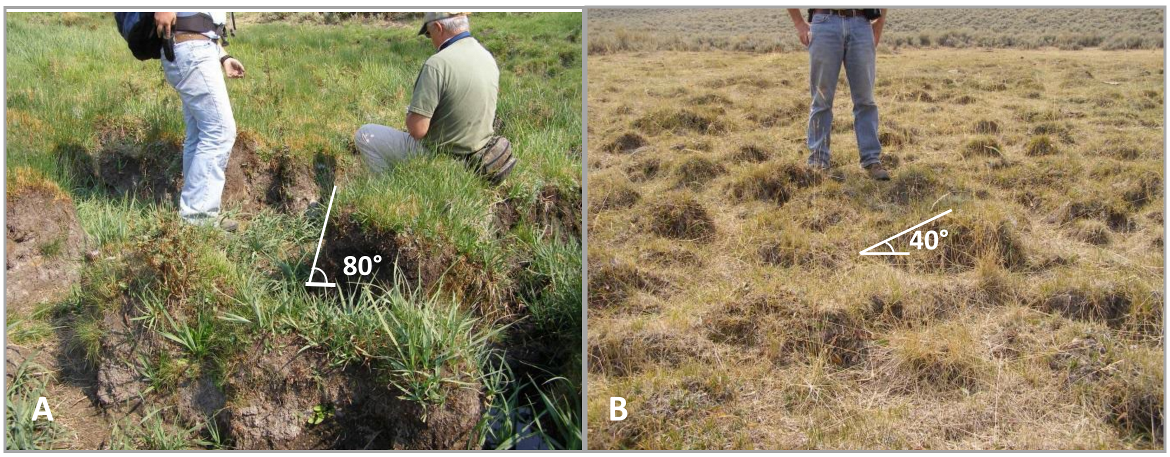


Figure 40. Hummock examples that illustrate (A) steep side slopes and (B) moderately shallow side slopes.

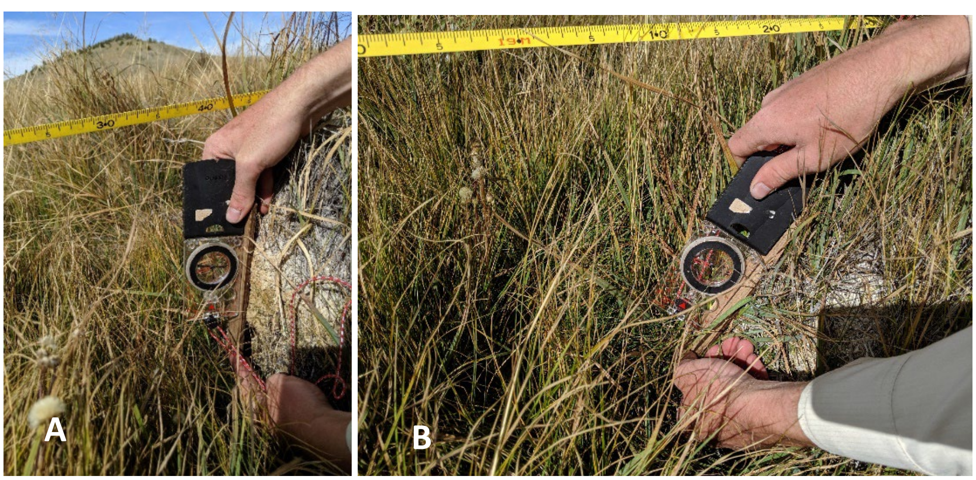


Figure 41. Measuring slope of the leading edge with a ruler and compass, showing (A) a steeper side slope and (B) a moderately shallow side slope.

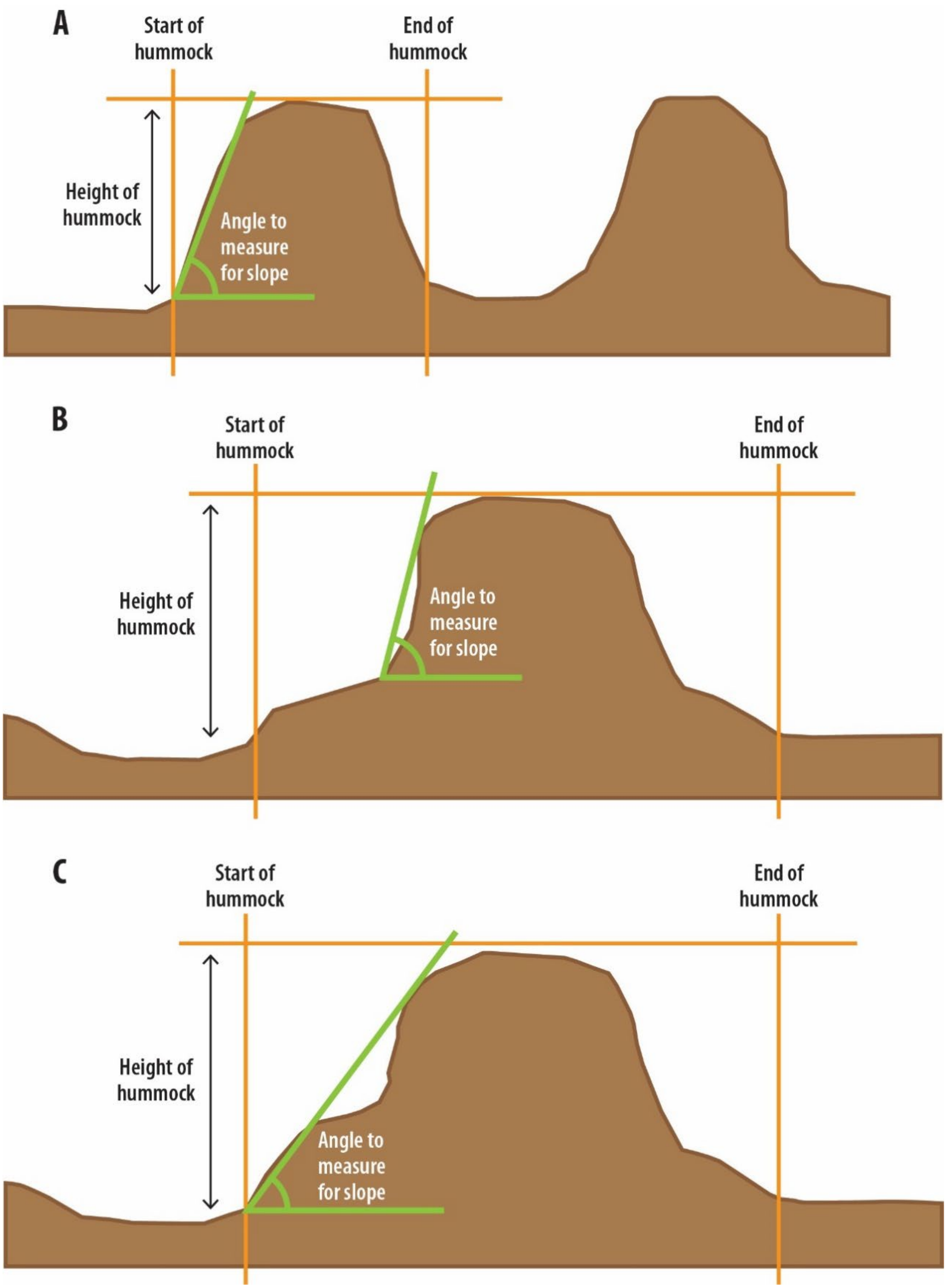


Figure 42. Three different hummocks showing the measurements to be taken. (A) A hummock with consistent steep slopes. (B) A hummock with two different slopes. The more dominant of the two slopes should be measured. (C) Hummock with multiple slopes and not one dominant slope. The average slope should be taken.

5. **Estimate and record the percent vegetation cover on the leading edge of each hummock.**
   5.1. Delineate an area on the hummock face on the leading edge between the initiation point (noticeable change in slope) to the shoulder (just below the top of the hummock). Do not include the very top of the hummock. Draw a box in your mind that extends 10 cm on either side of the transect tape (Figure 43).
   5.2. If there are leaves, litter, or thatch hanging down from the top of the hummock and covering the face, pull it back and look at the exposed face of the hummock. However, thatch from plants rooted on the face can be counted as part of vegetation cover, especially if it is entrained within the plant leaves.
   5.3. Estimate the ***canopy cover*** of rooted vascular and nonvascular plants, plus any entrained thatch.
   5.4. Record using the appropriate vegetation cover class (Figure 44):
      - 1 = Unvegetated (≤ 25% cover)
      - 2 = Partly vegetated (> 25–50%)
      - 3 = Mostly vegetated (> 50–75%)
      - 4 = Well vegetated (> 75%)

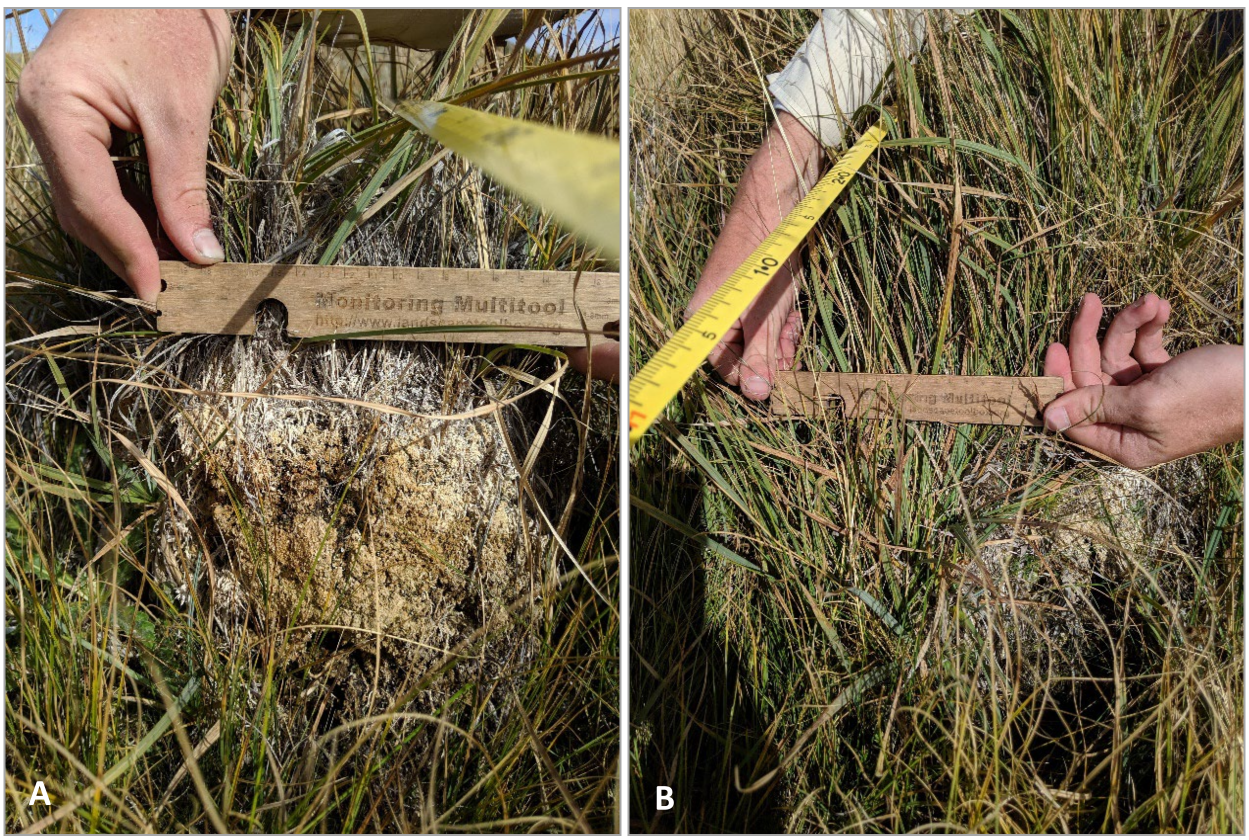


Figure 43. Estimating vegetation canopy cover on the leading edge of a hummock. Delineate a box from the base of the hummock to the shoulder and extending 10 cm on either side of the tape. Photos show (A) an unvegetated slope and (B) a mostly vegetated slope.

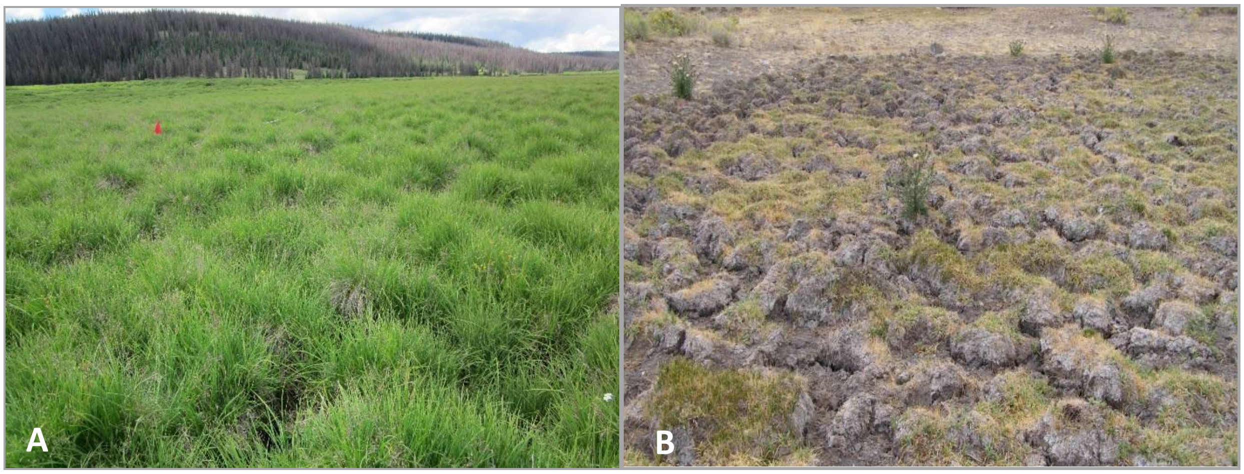


Figure 44. Examples illustrating (A) well-vegetated hummocks (vegetation class 4) and (B) unvegetated hummocks (vegetation class 1).

6. **Measure and record the height of the leading edge of each hummock.**
   - 6.1. Place a ruler or other straight object flat on the top of the hummock to be measured (Figure 45). If the top of the hummock is uneven, press the ruler down to make it as level as possible. Use the floating arrow of a compass to verify that the ruler is level.
   - 6.2. Measure the vertical distance from the base or initiation point of the hummock (noticeable change in slope) to the top of the hummock on the leading edge (Figure 42).
   - 6.3. Record height to the nearest centimeter.
   - 6.4. If the hummock height is < 10 cm on the leading edge, record the height on the trailing edge and circle the measurement on the paper data form.

7. **Move on to the next hummock.**
   - 7.1. Repeat steps 2 through 6 until you reach the end of the transect**.**

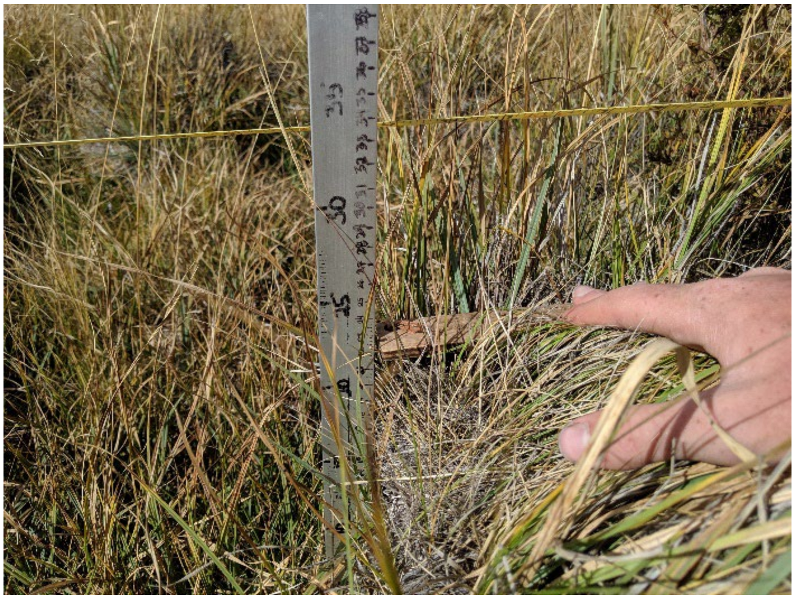


Figure 45. To measure the height of a hummock, rest a ruler or other straight object on the top of the hummock. Measure the vertical distance from the base of the hummock to the bottom of the ruler.

Quality Assurance
☐ Data sheet is complete, including plot ID, observer, recorder, visit date, transect, and azimuth. ☐ Hummocks do not extend beyond either end of the transect. ☐ The location start of each hummock (cm) must be a greater number (cm mark) along the transect than the end of the last hummock. ☐ The difference between all start and ends of a hummock is at least the designated minimum size. ☐ Size, number, and cover of hummocks is consistent with plot observations. ☐ Keep each hummock observation point directly above the tape edge to avoid parallax. Parallax problems can cause inconsistency among observers because a different area of hummock would be measured by each observer.

7.2 Water Quality

Overview: Water quality measurements of pH, specific conductance, temperature, and nutrients (total nitrogen and total phosphorus) are considered contingent indicators within this protocol. Project leads should decide if and when these measurements are collected based on monitoring objectives. Many riparian and wetland areas have intermittent or seasonal hydrology and lack standing water throughout much of the growing season. If water quality constituents are of management interest, sites should be sampled when standing water is expected, and the timing of potential nonpoint source inputs should be considered. If water quality measurements are taken, these measurements should be made before any other data are recorded to minimize sediment disturbance and turbidity in the water column, which can influence water quality measurements. Collecting water samples early in the sampling day will also limit the impact of diurnal changes in water quality due to temperature fluctuations and metabolic activity of organisms in the water.

There are two types of water quality methods in this section: (1) in situ measurements of pH, specific conductance, and temperature should be taken from multiple locations within the monitoring plot, including within the soil pit, and can include measurements of both surface and groundwater; and (2) a single "grab sample" of surface water should be taken at one location within the monitoring plot for laboratory analysis of total nitrogen and total phosphorus. This sample should be stabilized with concentrated sulfuric acid in the field and frozen back at the office. Duplicate and blank samples should be collected at 10% of sites where total nitrogen and phosphorus samples are collected. The optimal location for obtaining a surface water grab sample will differ by site depending on factors such as water depth, surrounding vegetation, recent weather, time of day, and season. The only limiting factor for determining if a surface water grab sample can be taken is whether the surface water depth is sufficient to obtain a clean sample while not disturbing bottom sediments. If there are multiple potential locations, preference should be given to surface water areas that are: at least 15 cm deep, close to the plot center, within the middle of a water body rather than on the edge, and away from inlets and outlets.

Materials:

- Hydrology and Water Quality Data Sheet (Appendix I)
- Water Quality Sample Labels printed on Rite in the Rain paper (Appendix I)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Multiparameter water quality probe, including a minimum of temperature, pH, and specific conductance. The preferred probe is a YSI 1030 pH/SPC, but equivalent probes may be used if they meet the following requirements:
    - pH: accuracy of ±0.2 SU and resolution of 0.1 SU
    - Specific conductance: accuracy of ±2 µS/cm or ±10%, whichever is greater, and resolution of 0.1 µS/cm
    - Temperature: accuracy of ±0.2° C and resolution of 0.1° C
- Calibration solution appropriate for the water quality probe
- Two 250-mL plastic graduated cylinders, one for calibration and one for taking in situ measurements from shallow flowing water
- 125-mL HDPE Nalgene water sample bottles, up to three per site
- Nitrile gloves

- Packing tape
- Deionized or distilled water
- Long-handled dipper (optional)
- Dropper of sulfuric acid in a Nalgene storage bottle containing baking soda
- Safety glasses (optional if sunglasses are worn)

Method:

1. Complete the top section of the Hydrology and Water Quality Data Sheet, if not already completed.

1.1. Record plot ID, observer(s), and visit date.

Method for collecting a surface water grab sample for total nitrogen and total phosphorus.

2. Establish one location for collecting a surface water grab sample and prepare the sample vial.

2.1. Select the optimal sample location and flag off the area to prevent trampling or stirring up sediment. Preference should be given to surface water areas that are: at least 15 cm deep, close to the plot center, within the middle of a water body rather than on the edge, and away from inlets and outlets. Surface water grab samples are not collected from within the soil pit. If surface water within the plot is shallower than 15 cm, only collect if you can obtain a sample without disturbing the sediment. For example, a sample could be collected from a shallow flowing channel but not from ponded water in a shallow depression or hoofprint.

2.2. Obtain a pair of new, sterile nitrile gloves and place them on both hands, being careful not to contaminate the outside of the gloves with substances such as sunscreen. Dispose of gloves after use.

2.3. Obtain a new 125-mL HDPE Nalgene water sample bottle and a water quality sample label. Water quality labels must be on Rite in the Rain paper and filled out with a pencil. Labels that are not Rite in the Rain paper will not withstand wet and frozen environments, while ink from pens will leach and become illegible. Clearly write the plot ID, geographical state (which may be different from the BLM administrative state), date, site name (if known), and your initials on the label. Record the date of collection as day, month, and year, making sure to use letters rather than numerals for the month and to use four digits for the year (e.g., 27Aug2018). If sampling takes place over 2 days, use the date that the water sample was actually collected.

2.4. Check the appropriate box noting whether the sample is the original, blank, or duplicate.

2.5. Tape the label on the outside of the bottle with clear packing tape, making sure the tape is wrapped completely around the bottle. It is important that the bottle is labeled before sampling, as the labels and tape do not stick to wet bottles.

3. Collect the water sample.

3.1. Approach the water sample location carefully. Do not step too close to the sample location to avoid disturbing sediments. All other field crew members should avoid walking close to or upstream of the sample location.

3.2. If the water is flowing, samples can be collected carefully by hand. If collecting the sample by hand, reach as far as possible from where you are standing and let the water flow into the sample bottle (Figure 46A).

3.3. If the water is stagnant or if standing too close will disturb sediments, use a long-handled dipper to collect the sample (Figure 46B and 46C).
3.4. If using a long-handled dipper for sampling, rinse the dipper cup five times before collecting the sample by immersing it in the water while being careful not to stir or otherwise disturb bottom sediments. Pour the rinse water away from the area to be sampled so that the discarded water does not drain back into the sample area. If the water is shallow, rinse the dipper cup near the sample area instead of in the sample area.
3.5. Rinse the sample bottle and lid five times with water from the water sample location, either by hand or using the dipper. Be careful not to overly disturb bottom sediments.
3.6. Fill the bottle halfway with water from the water sample location, either by hand or using the dipper. Filling the bottle halfway leaves head space to accommodate expansion during freezing. Close securely with the lid.

Figure 46. Two methods for collecting a water quality grab sample in riparian and wetland environments: (A) collecting the sample by hand in flowing water and (B and C) collecting the sample using a long-handled dipper.

4. **Collect blank and duplicate samples at the first and every 10th site where samples are collected.**
   4.1. Crews should maintain a log for collecting water quality samples to track when blank and duplicate samples should be taken.
   4.2. If collecting blank and duplicate samples, use three separate sample bottles and clearly label each one, checking appropriate boxes for whether the sample is the original, blank, or duplicate.
   4.3. Label and collect the blank sample first before collecting sample water to avoid contaminating your gloves with water from the wetland or channel.
   4.4. To collect a blank sample, rinse a 125-mL HDPE Nalgene water sample bottle five times with deionized (or distilled) water and then fill the bottle halfway with deionized (or distilled) water to allow head space for freezing. Set the blank sample aside in order to not confuse it with original and duplicate samples.
   4.5. Collect the duplicate in exactly the same way as the original sample. If filling the bottles with the long-handled dipper, fill each bottle partway with each dip of the dipper rather than filling one bottle first and then refilling the dipper. This ensures that any differences between dips of the dipper are distributed between the two bottles.
5. **Stabilize all samples, including blank samples, with concentrated sulfuric acid.**
   5.1. Remove the sulfuric acid dropper from a Nalgene storage bottle containing baking soda.
   5.2. Carefully remove the dropper bottle cap, while keeping clear of face. Invert and add 3 drops (0.15 mL) of sulfuric acid to the water quality sample, being careful not to touch the water sample with the dropper bottle tip.
   5.3. Replace the dropper bottle cap and return the dropper to the Nalgene storage bottle.
   5.4. Place the top on the water quality sample and shake vigorously for 5 seconds.
   5.5. **Safety Note:** Exercise extreme caution and ensure nitrile gloves and sunglasses or safety glasses are worn at all times when working with acid. If acid comes in contact with the skin, rinse with a mild soapy solution or rinse continuously with water if soap is not available. Do not apply baking soda to your skin. If acid comes in contact with the ground, apply generous amounts of baking soda to neutralize the spill and surrounding area. Continue addition baking soda until all acid is neutralized (i.e., cessation of bubbling and gas).

Method for collecting in situ measurement of pH, specific conductance, and temperature.

6. **Prepare to collect in situ water quality measurements. Ensure that the water quality probe is calibrated before taking measurements.**
   6.1. Crews should maintain a calibration log documenting when and how the water quality probe was calibrated (e.g., 3-point pH calibration [4.0, 7.0, 10.0] completed on 8/22/2019).
   6.2. Check probe for any small particles or debris on the sensors before sampling. Fill end cap with enough deionized (or distilled) water to keep the sensors wet in between site visits or when not in use.
   6.3. Review the calibration log to ensure the probe has been calibrated for both pH and specific conductance following manufacturer recommendations or within the last 7 days, whichever is shorter.
   6.4. If the probe has not been calibrated in the last 7 days or within the manufacturer's recommended timeframe, recalibrate the probe following the manufacturer's directions.
   6.5. Record the most current calibration date in the data sheet.

7. **Collect in situ measurements of pH, specific conductance, and temperature with the water quality probe in up to four locations within the plot.**
   7.1. Before taking the first water quality measurement, record the ambient air temperature in Celsius based on the reading from the probe.
   7.2. Select at least one and up to four locations within the monitoring plot that represent surface or groundwater conditions. Surface water includes channels and pools; groundwater includes springs sources and water within the soil pit (Figure 47).
   7.3. For each sample location, take a GPS waypoint and record time of data collection.
   7.4. Record location within the monitoring plot (channel, pool or pond, springhead, shallow surface water, or soil pit) and whether surface water or groundwater is being sampled.
   7.5. Measure and record water depth (positive for surface water; negative for water below the ground surface). For surface water, note whether the water is standing or flowing, clear or turbid, and open or shaded by vegetation or other overhanging features at the time of sampling.
   7.6. Lower the water quality probe to a depth of 0.5 m below the water surface, if possible, or as low as possible without making contact with the sediment. The full length of the probe should be submerged to get an accurate reading.
   7.7. If it is not possible to submerge the probe without disturbing the sediment, a 250-mL graduated cylinder can be used to collect water. Rinse the graduated cylinder five times with the water before taking the measurement and dispose of the rinse water away from the collection location. Fill the cylinder a sixth time and take the measurements by submerging the probe in the cylinder. Take the measurement immediately after rinsing the cylinder to ensure accurate values. Do not wait to take the reading back at the truck, as the values can change with temperature. **Note:** Only use the graduated cylinder for shallow flowing water that can be collected with little sediment. Do not attempt to collect shallow standing water in a cylinder as this will likely introduce sediment to the sample.
   7.8. Once the probe is submerged, wait for the readings on the screen to stabilize (this could take a few minutes).
   7.9. Record pH, specific conductance (µS/cm), and temperature (℃) following the manufacturer's instructions for recording water quality parameters. Ensure the probe is set to measure in the appropriate units and that temperature-corrected conductivity (i.e., specific conductance) is being measured.

Figure 47. Measuring pH, specific conductance, and temperature with a water quality probe in (A) surface water and (B) groundwater within a soil pit.

Quality Assurance
☐ Data sheet is complete, including plot ID, observer(s), and visit date. ☐ Ensure the water quality location is left as undisturbed as possible (i.e., no sediment or aquatic vegetation disturbance). ☐ Ensure water quality probe is adequately submerged in the water before a measurement is taken or take the measurement from a graduated cylinder. ☐ Ensure readings have stabilized before recording the measure. ☐ Ensure water sample bottles are properly labeled. ☐ Ensure water samples are collected at maximum arm's length to disturb the water as little as possible. ☐ Collect blanks and duplicates according to protocol. ☐ Stabilize samples as quickly as possible according to protocol.

8.0 Annual Use Methods

Annual use methods in this section have been adapted and modified for use along a transect in riparian and wetland areas from "Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation" (Burton et al. 2011) and "Utilization Studies and Residual Measurements" (BLM 1996) to monitor impacts related to grazing or browsing by livestock, wild ungulates, wild horses, or wild burros, and use by humans. The methods described in this section include:

1. **Stubble height** measures the residual height of herbaceous vegetation remaining after grazing.
2. **Soil alteration** measures the annual ground disturbance, trampling, and hoof shearing.
3. **Riparian woody species use** estimates the degree of grazing utilization (i.e., browsing) on woody plants, shrubs, and trees.

These methods are neither core nor contingent but are specifically related to grazing and other short-term, permitted uses. These methods may be subject to change in conjunction and coordination with the BLM Range Program with future revisions of Technical Reference 1734-3 (BLM 1996), the MIM protocol (Burton et al. 2011), and other relevant technical references. Practitioners should check for recent updates to these protocols and use the latest version of relevant methods. The intent for providing the following methods is to ensure consistent annual use data collection when these indicators are a part of AIM sampling projects in riparian and wetland areas. Where applicable, collecting annual use data with core and contingent methods can be an efficient use of a plot visit and provide the opportunity to review core, contingent, and annual use data in conjunction with one another.

Benefits of measuring annual use:

1. Annual use measurements may help determine whether the current season's livestock grazing is meeting grazing use criteria and the degree to which wild ungulates, wild horses and burros, or humans are impacting a site.
2. They serve as early warning indicators that current grazing, browsing, or human impacts may prevent the achievement of management objectives.
3. They provide information to evaluate management decisions, provide context for core indicators, and help establish associations between short-term management and long-term conditions.
4. They provide efficiencies for plot visits since visiting monitoring sites represents a significant cost in terms of resources and time.

8.1 Considerations for Appropriate Application of Annual Use Methods and Calculated Indicators

The first step in understanding whether to use one or more of the following annual use methods is to determine if the annual use indicators are needed to answer management questions. The second step is to determine whether existing annual use methods are already prescribed. In some cases, annual use monitoring protocols may already be established based on resource management plan direction to inform authorized grazing, wild horse and burro management, or other managed uses. This is particularly important if specific methods have already been prescribed and established for use in an adaptive management context, such as modification of livestock use. This information may be found in land use planning documents, grazing decisions, biological opinions, field office monitoring plans, and other documents. It is imperative that methods, practices (i.e., timing of sampling, number of observations), and evaluation criteria currently in use for an existing permit, consultation, or legal determination be used rather than the methodology included in this section. Changes to data collection methodology should be made in collaboration with appropriate interdisciplinary team members and the authorized officer for the local management area. Changes in field methods and/or calculations can lead to differences in measured indicator values. Therefore, if a decision is made to adopt new methods, it may also be necessary to review any existing annual use criteria, such as stubble height values, and consider whether they should also be changed to ensure that they continue to provide the intended information for adaptive management. If an alternative, established methodology is implemented as part of an AIM project, project leads must provide adequate documentation for future reference.

Criteria for including annual use measurements in an AIM sample design:

- Do annual use indicators answer short-term management questions or assist with interpretation of long-term monitoring data?
  - If yes, consider using the following methods.
- Are there already prescribed monitoring methods for the management area?
  - If no, consider using the following methods.

Once you have determined that the methods included in this section are applicable to your project or monitoring objectives, it is important to understand that these methods are not intended to provide any guidance on evaluation criteria—only to provide guidance on how to measure an indicator in a consistent way.

Considerations for selecting annual use methods:

Depending on local management objectives and the resources to be monitored, it may be appropriate to use one or more of the annual use methods. Annual use methods should be used in combination with longer term core methods to assist with understanding the relationship between resource uses and ecological condition. The following criteria should be considered (modified from Bryant et al. 2006):

1. What are the dominant plant life forms and physical structure of the site? For example, is the dominant vegetation herbaceous or woody, or are rocks common? Stubble height measurements can be a useful way to monitor residual herbaceous vegetation following grazing by wildlife and/or livestock. However, if woody vegetation and/or rocks control soil stability,

stubble height should not be used. Instead, monitoring of woody browse or soil disturbance is more applicable.

2. What is the appropriate timing for monitoring measurements? It is important to understand the most appropriate timing for monitoring use. For example, should monitoring occur within season, at an end point, or part of a short-, mid-, or long-term assessment based on prescribed grazing documents or adaptive management plans?

Timing and frequency of measuring annual use:

The timing of measuring annual use is important. Annual use is typically recorded during the use period to provide data that may trigger a pasture move or immediately following grazing or other activities to provide a record of use intensity for that period. If measured after the use period, it is best to record annual use as soon as possible (preferably no more than 7-10 days) after grazing or other activities have ended to isolate the effects of those uses and before regrowth or precipitation events occur that could obscure the impacts of those activities. Recent weather conditions are a consideration for measuring soil alteration. Rainfall, streamflow, plant growth, freeze-thaw action, and erosion can immediately act to obliterate soil alterations. Therefore, it is important to measure soil alterations as soon as possible after livestock leave a pasture or use area.

Appropriate timing of annual use measurements usually requires close coordination with livestock operators and rangeland management specialists because livestock grazing time periods often vary from year to year and may be adjusted within the grazing season based on annual conditions. Annual use may also be measured at the end of the growing season to provide a record of conditions prior to the dormant season. For example, if the management prescription requires a certain amount of residual vegetation remaining to protect slopes and shorelines from disturbance and to promote long-term plant vigor, it is helpful to measure stubble height after the growing season has ended and livestock have been removed from the area. An additional application would be to record herbaceous regrowth. For example, if stubble height is measured both immediately after the use period and at the end of the growing season, regrowth can be calculated from the difference between those two measures. When there is a need to isolate the effect of livestock grazing from the effects of wildlife or from wild horses and burros, annual use may be measured prior to livestock grazing so that other uses can be estimated separately from livestock uses. Annual use could be measured 2 or 3 times per year. For example, annual use could be measured once immediately before livestock enter a pasture to evaluate wild ungulate use, again immediately after livestock leave a pasture, and if necessary, a third time at the end of the growing season.

It is important to remember that the optimal time for measuring annual use does not necessarily coincide with the best time for performing core methods. Core methods for vegetation cover and composition are best recorded when vegetation is most easily identified and mature, which is generally in mid-growing season and before any significant level of grazing has occurred. Measuring annual use along with core methods can provide a baseline against which to compare data collected later in the season. Annual use data are most useful when information about the livestock and/or wildlife use that preceded sampling is also collected and stored with the annual use data. If annual use prior to sampling is unknown, there will be little context for interpreting the calculated indicator values. In addition, annual use methods at a monitoring site can also be performed with greater frequency (annually or multiple times per year) than core methods, which are performed at 3- to 6-year intervals.

When planning annual use monitoring efforts, practitioners should evaluate the purpose and ultimate use of the data being collected and carefully consider how seasonality and management activities may affect the data needs and when data should be collected. As prescribed by monitoring goals, there will be instances when crews use this protocol to gather only annual use measurements.

Annual use methods only protocol:

If you are revisiting a site to collect only annual use data during or after grazing or other permitted uses, you will need to relocate the plot center and transect locations using GPS coordinates and/or permanent markers such as rebar, if installed. Mark the center of the plot and then reestablish the transects in the same places they were laid at the original site visit. Use the notes, photos, and data from the original visit to lay out the transects on the correct compass azimuth, exactly as they were configured in the original visit. Refer to Section 4.0 for detailed instructions on plot layout.

When collecting only annual use data, a modified version of the protocol can be used. All three annual use methods can be collected in a single pass of each transect. Start at the 0-m end of the transect and evaluate stubble height and soil alteration, and then evaluate riparian woody species use in a quadrat that extends from the 0-m end of the transect to the 2.5-m point on the transect tape. At 2.5 m, evaluate stubble height and soil alteration again and then continue with the next riparian woody species use quadrat extending from 2.5 m to 5.0 m and on down the line.

For further questions about appropriate use of annual use methods, please contact your local range specialist or a member of the author team.

8.2 Stubble Height

Overview: Stubble height measures the residual height of herbaceous vegetation remaining after grazing. The amount of biomass remaining above ground is important for keeping plants healthy, maintaining or promoting root systems, and protecting the soil from erosion by slowing the movement of water. The measurement can be used as a trigger for moving livestock to another grazing unit, as an indicator of the amount of use after the entire grazing season, or to estimate and compare livestock use to wild horse and burro or native ungulate use. Stubble height alone is not a substitute for vegetation condition; however, it does provide information that may be used to determine the degree to which grazing is influencing condition over time.

In this protocol, stubble height can be measured on either specific herbaceous ***key species*** or the closest graminoid vegetation within the measurement area. Key species are commonly used by range managers to record annual grazing use and are defined as plant species that are important (relatively common and desirable) in the plant community, are relatively palatable to livestock (or other ungulates of interest) and serve as indicators of change. Well-defined monitoring objectives that reflect riparian management objectives, biological opinions, or other monitoring requirements should guide decisions as to which method to use. For example, the key species approach is commonly used to evaluate annual grazing-use criteria or in the application of surrogates of take (i.e., statements of incidental take) related to endangered species; the closest-species approach is used if specific management objectives or management practices dictate that measuring all graminoid species is appropriate (e.g., specific graminoid stubble heights are necessary to protect soil surfaces). Regardless of which approach is used, data collection crews should coordinate with local field office staff (including range specialists): (1) to obtain a list of key species for each monitoring site (if key species are used), (2) to determine which annual-use indicators are appropriate to measure at which sites, and (3) to determine when the most appropriate time would be to obtain useful data at each site. Detailed instructions on how to select key species are included in the stubble height methods of MIM (Burton et al. 2023). Stubble height is measured at the same interval used for the other annual use methods (every 2.5 m along the transect). This method is based on and modified from the stubble height method in the MIM protocol (Burton et al. 2011). Please check for recent updates and use the most recent version of either this protocol or MIM, whichever is most current.

If collected during the same plot visit as the core methods, stubble height should be collected during a second pass of the transects along with the other annual use measurements of soil alteration (Section 8.3) and riparian woody species use (Section 8.4) and with the woody structure core method (Section 6.4). Alternatively, the three short-term annual use measurements can be collected on their own at a subsequent plot visit.

Materials:

- Woody Structure and Annual Use Data Sheet (Appendix I) or Annual Use Data Sheet (Appendix I)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Graduated survey rod or height measuring stick with graduations in centimeters and meters, such as a meter stick or avalanche pole with clear markings
- Multiple Indicator Monitoring (MIM) frame (double Daubenmire frame) (Appendix R)

Method:

1. **Complete the top section of the Woody Structure and Annual Use Data Sheet, if not already completed (or the Annual Use Data Sheet).**
   1.1. Record plot ID, observer(s), recorder, visit date, transect number, and azimuth.

2. **Measure stubble height at regular intervals (2.5 m) for a minimum of 30 measurements per plot (10 per transect).**
   2.1. The first point of data collection is located at the 0-m mark on the transect tape. As you move from one end of the tape to the other, always stand on the right side of the tape as you walk from the beginning of the transect to the end. Place the MIM frame and record stubble height to the left of the tape. From the right side of the tape, the numbers should be facing you. If the numbers are upside down, you are on the wrong side of the tape.
   2.2. At each designated mark, place the MIM frame along the transect on the opposite side of the tape from where you are standing to form a 20 x 50 cm quadrat. The long (50-cm) edge should be parallel to the tape, and the left short (42-cm) edge should be perpendicular to the tape in line with the designated mark (0 m, 2.5 m, 5.0 m, etc.) (Figure 48). The quadrat for stubble height is the half of the MIM frame closest to the tape.

3. **Identify a tuft of graminoid vegetation to measure.**
   3.1. Locate a 7.5 cm (3 in) wide tuft of any graminoid vegetation or key species closest to the upper left corner of the rectangle made by the tape and the MIM frame, nearest the MIM frame handle, on the far side of the tape from where you are standing (Figure 48). Most riparian and wetland graminoids grow tightly together, forming dense mats with little separation between individual plants. Often, several rhizomatous species may be growing together. Thus, the method uses the 7.5-cm diameter tuft of all co-occurring graminoid vegetation or key species.
   3.2. If graminoid vegetation or key species are sparse and part of the closest tuft is outside the quadrat, measure the entire 7.5-cm tuft.
   3.3. If graminoid vegetation or key species is not at least 7.5 cm in diameter, do not record stubble height for that quadrat; mark “None” in the “Dominant Species” column and mark "NA" in the “Stubble Height” column.
   3.4. Stubble height is measured for graminoid species only. If the vegetation in the quadrat is a mix of graminoids and forbs, disregard the forbs and measure graminoid leaves only.

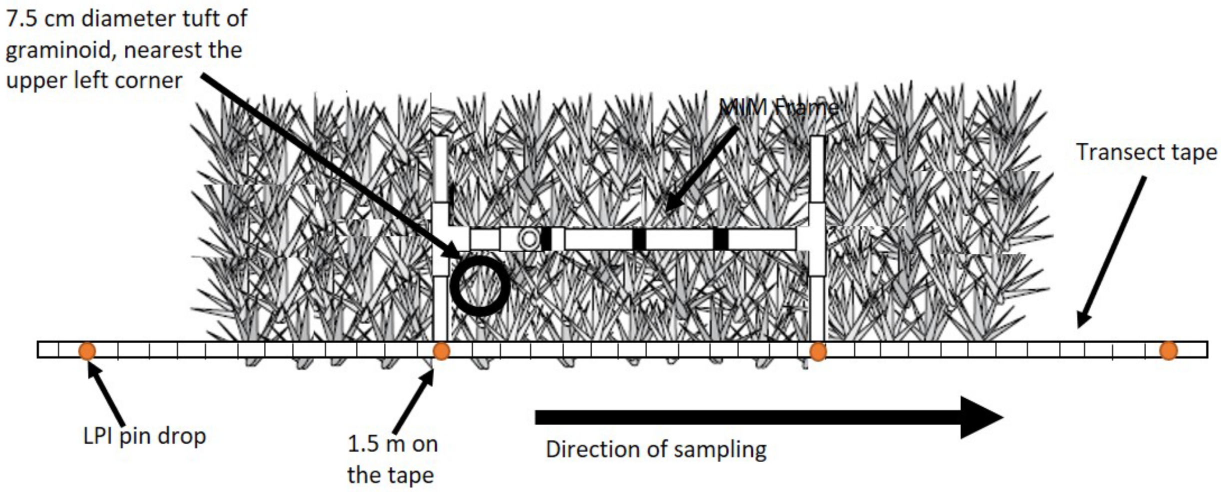


Figure 48. Overhead view of the MIM frame quadrat in relation to the transect. The 7.5-cm diameter tuft to measure stubble height is in the upper left corner of the rectangle created by the frame and transect tape, nearest the handle of the MIM frame.

4. **Using the measuring rod or a separate ruler, identify the dominant species within the tuft and measure the median length (cm) of all the graminoid leaves.**
   4.1. For each tuft, record the USDA PLANTS Database (https://plants.usda.gov) species code or unknown code of the dominant species or key species in the "Dominant Species" column. If there are multiple species intermingled in the tuft, record one species that is dominant in the tuft, but measure the median leaf length for the whole multispecies tuft. If key species are to be measured, select and measure only key species' leaves.
   4.2. Mark a "Yes" in the "Grazed" column if it appears that any leaves in the tuft have been grazed.
   4.3. Record the median leaf height in the "Stubble Height" column.
   4.4. Measure leaf height only. Do not measure seed stalks (culms) unless the culms are relatively palatable and leaflike, including some spikerushes (e.g., *Eleocharis* spp.), rushes (e.g., *Juncus* spp.), and bulrushes (e.g., *Schoenoplectus* spp., *Scirpus* spp.).
   4.5. Determining the median leaf height will take some practice. Be sure to include all leaves within the tuft. The easiest method of doing this is to grasp the sample near the base of the leaves, stand the leaves upright, move the hand up the leaves until about half of them fall away, and then measure the height at that location (Figures 49 and 50).
   4.6. Grazed and ungrazed leaves are measured from the ground surface to the top of the remaining leaves. All leaves within the tuft should be lifted to determine their length. Account for very short leaves as well as tall leaves.
   4.7. If part of an individual plant or part of the tuft occurs outside the quadrat, measure the median leaf length of the entire plant or the entire tuft, regardless of the fact that part is outside the quadrat.

5. **If there are no graminoid species within the quadrat, mark "None" in the "Dominant Species" column and mark "NA" in the "Stubble Height" column.**

Figure 49. Stubble height is measured by grasping an approximate 7.5-cm diameter tuft of graminoid vegetation and determining the median leaf length. Exclude forbs in the tuft and exclude seed stalks for most species.

Figure 50. Examples of measuring stubble height within riparian and wetland areas. Remember to remove any forbs, measure only graminoid leaves, and exclude the seed stalks when estimating stubble height.

Quality Assurance
☐ Data sheet is complete, including plot ID, observer, recorder, visit date, transect, and azimuth. ☐ Stubble height is recorded for the appropriate interval along the transect. ☐ Stubble height measures are made by standing leaves straight up against a ruler, or other measuring device, and the ruler is perpendicular to the ground surface, to avoid inaccurate height measurements. ☐ Species recorded are appropriate for the plot. Species cannot be added to or altered on data sheets after leaving a site, unless they are accounted for with an unknown plant code. ☐ Species codes are complete, correct, and consistent with project plant coding system.

8.3 Soil Alteration

Overview: Soil alteration is a measure of annual (i.e., current season) ground disturbance, trampling, and hoof shearing within riparian and wetland areas, which can cause soil compaction, a loss of soil stability, and creation of artificial drainage channels that can, over time, lower the groundwater table and shrink the size of riparian and wetland areas. The soil alteration method described here is an intercept approach along a transect, adapted for riparian and wetland areas (Table 2). Soil alteration is measured as the presence or absence of an alteration (e.g., hoof print, footprint, wheel track) intercepting one or more of five lines within a quadrat. It is not a measure of the percent of the area altered but rather an estimate of the percent of the length of the transect that has some soil alteration. For example, a hoof print or other alteration intercepting one of five lines in a quadrat would be recorded as 20 percent alteration for that quadrat. Intercepted lines are added across quadrats along the transect to calculate percent of the transect length that is altered. Thus, the soil alteration indicator calculated using this method approximates the length of the transect altered. This method is based on the streambank alteration method in the MIM protocol (Burton et al. 2011). Please check for recent updates and use the most recent version of either this protocol or MIM, whichever is most current.

If collected during the same plot visit as the core methods, soil alteration should be collected during a second pass of the transects along with the other annual use measurements of stubble height (Section 8.2) and riparian woody species use (Section 8.4) and with the woody structure core method (Section 6.4). Alternatively, the three short-term annual use measurements can be collected separately at a subsequent plot visit.

Materials:

- Woody Structure and Annual Use Data Sheet (Appendix I) or Annual Use Data Sheet (Appendix I)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Multiple Indicator Monitoring (MIM) frame (double Daubenmire frame) (Appendix R)

Method:

1. **Measure soil alteration at regular intervals (2.5 m) for a minimum of 30 measurements per plot (10 per transect).**
    1.1. The first point of data collection is located at the 0-m mark on the transect tape.
    1.2. At each designated mark, place the MIM frame along the transect on the opposite side of the tape from where you are standing to form a 42 x 50 cm quadrat. The long (50-cm) edge should be parallel to the tape, and the left short (42-cm) edge should be perpendicular to the tape in line with the designated mark (0 m, 2.5 m, 5.0 m, etc.) (Figure 51).

2. **Locate the observation lines.**
    2.1. Soil alteration is measured in both halves of the quadrat: the entire 42- by 50-cm monitoring frame. Five lines (two end bars of the frame and 3 intermediate lines spaced 12.5 cm apart) are projected across the frame perpendicular to the center bar of the frame (Figure 51).

3. **Count the lines that intercept an alteration.**
   3.1. Look down at the entire frame and determine the number of lines within the quadrat that intersect an alteration. The soil is considered altered when there is evidence of trampling, shearing, trailing, or puddling:
   - **Trampling:** hoof prints, footprints, or wheel or tread-track depressions in the soil at least 0.5 in (13 mm) that exposes bare soil. The depression is measured from the top of the soil surface to the bottom of the impression. Alternatively, trampling can be identified as displaced soil moved into a pile that is at least 0.5 in (13 mm) high.
   - **Shearing:** the removal of a portion of soil by ungulate hooves leaving a smooth vertical surface and an indentation of a hoofprint at the bottom or along the sides.
   - **Trailing:** when hooves, feet, or wheels/treads have repeatedly moved over the same area to create a compacted or devegetated path, even though the soil may be depressed less than 0.5 in (13 mm).
   - **Puddling**: a rut, depression, or puddle that has formed from hoof prints, footprints, or wheels/treads and has held or is able to hold water or alter surface hydrology.

4. **Record the number of lines (0-5) that intersect one or more alterations in the "Soil Alteration" column**.

   4.1. Record only one occurrence of soil alteration (trampling, shearing, trailing, or puddling) per line. There may be one or many alterations along a single observation line, but the number of lines with alterations are counted, not the number of alterations that intersect a line (Figure 51).

   4.2. Record only the current year's soil alterations (i.e., features that are obvious). Disturbance features that are old, such as relict disturbances from a previous year, tend to be nondistinctive. Follow these guidelines when determining which number to record:
   - Hoof prints or trampling with fully developed, deep-rooted vegetation (e.g., *Carex* spp., *Juncus* spp., *Salix* spp.) is not recorded as alteration unless plant roots or bare soil is exposed, and the minimum 0.5 in (13 mm) displacement or impression has been created.
   - Record an alteration when an observation line crosses a vertical face that has formed from hoof shear.
   - Compacted or devegetated livestock, game, or foot trails (or vehicle paths) on or crossing the quadrat that are the obvious result of the current season's use are counted as alterations. Preexisting trails that have revegetated are not considered current season's alterations and are not counted.
   - If the quadrat falls underneath a shrub and the surface is inaccessible to view, it is unlikely that a large ungulate could have or would have stepped on the quadrat, and it is acceptable to record "0" alterations.
   - While collecting annual use data, avoid walking or stepping around the transect so that the act of monitoring does not generate soil alterations.

- A folding ruler or other measuring rod can be used to trace the path of an observation line when there is question whether the line intersects or misses an alteration.
- A hoofprint that is completely submerged under water is not considered a soil alteration and is not counted. In contrast, a deep hoof print, also referred to as pugging, that is above a water line and holds water is an alteration.

4.3. Record a “0” for no alteration. Do not leave the cell blank if there are no alterations.

Figure 51. Soil alteration is evaluated by projecting five lines (red dashed lines) across the frame and perpendicular to the center bar. Two lines coincide with the outer cross pieces of the frame, and three inner lines are spaced 12.5 cm apart. In this example, soil alteration would be recorded as 3 because the second, third, and fifth lines intersect soil alteration. The second and third lines both intersect the same large hoof print.

Quality Assurance
☐ Data sheet is complete, including plot ID, observer, recorder, visit date, transect, and azimuth. ☐ Soil alteration is recorded for the appropriate interval along the transect. ☐ Quadrat is laid as flat to the ground surface as possible for each observation, along the transect line. ☐ Each observation is made as close to vertical over the quadrat as possible, and observers avoid leaning too far over the quadrat in either direction in order to avoid parallax. Parallax issues can increase variability because different amounts of alteration are measured. ☐ Soil alteration measures are consistent with plot observations.

8.4 Riparian Woody Species Use

Overview: Riparian woody species use is a short-term annual use indicator of grazing utilization (i.e., browsing) on woody plants, shrubs, and trees in riparian and wetland areas. Woody species use may serve as a trigger for moving livestock, help determine the level of browsing during the grazing period, and show relationships between the level of grazing use by large native (elk, deer) and nonnative (cattle, horses, burros) herbivores and the long-term condition of woody plants.

In this protocol, riparian woody species use can be measured on either specific woody key species or any riparian woody species (with a wetland indicator status of facultative (FAC), facultative wetland (FACW) or obligate wetland (OBL), as defined by the most recent version of the National Wetland Plant List (e.g., USACE 2018)). Key species are defined as plant species that are important (relatively common and desirable) in the plant community, are relatively palatable to livestock (or other ungulates of interest) and serve as indicators of change. Well defined monitoring objectives that reflect riparian management objectives, biological opinions, or other monitoring requirements should guide decisions as to which method to use. For example, the key species approach is commonly used to evaluate annual grazing-use criteria or in the application of surrogates of take (i.e., statements of incidental take) related to endangered species; the all-riparian-species approach can be used if specific management objectives or management practices dictate that measuring all riparian woody species is appropriate (e.g., specific woody cover is necessary for bank stability). Regardless of which approach is used, data collection crews should coordinate with local field office staff (including range specialists): (1) to obtain a list of key species for each monitoring site (if key species are used), (2) to determine which annual-use indicators are appropriate to measure at which sites, and (3) to determine when the most appropriate time would be to obtain useful data at each site. Detailed instructions on how to select riparian woody key species are included in the woody riparian species use method in the MIM protocol (Burton et al. 2011). This method is based on and modified from the woody riparian species use method in the MIM protocol (Burton et al. 2011). Please check for recent updates and use the most recent version of either this protocol or MIM, whichever is most current.

Riparian woody species use, if collected during the same plot visit as the core methods, should be collected during a second pass of the transects along with the other annual use measurements of stubble height (Section 8.2) and soil alteration (Section 8.3) and with the woody structure core method (Section 6.4). Alternatively, the three short-term annual use measurements can be collected separately at a subsequent plot visit.

Materials:

- Woody Structure and Annual Use Data Sheet (Appendix I) or Annual Use Data Sheet (Appendix I)
- Clipboard and pencil(s) or electronic device for paperless data collection (preferred)
- Graduated survey rod or height measuring stick with graduations in centimeters and meters, such as a meter stick or avalanche pole with clear markings

Method:

1. **Determine riparian woody use at regular intervals (2.5 m) for a minimum of 30 measurements per plot (10 per transect).**
    1.1. Data collection starts at the 0-m mark on the transect tape. At the 0-m mark and each 2.5-m interval after, place the measuring rod on the ground perpendicular to the transect extending 1 m out on both sides of the transect (Figure 52).
    1.2. The riparian woody species use quadrat is 2 m wide (1 m on each side of the tape) by 2.5 m (the length of the sample interval). Use a 1-m or 2-m rod to define the 2 m width of the quadrat (Figure 52).
2. **Locate the closest individual of each riparian or key woody species rooted in or overhanging the quadrat.**
    2.1. Record the location in meters along the transect associated with the quadrat in the "Loc." column (e.g., 0 m, 2.5 m, 5.0 m, etc.). Since there may be multiple woody species rooted in the quadrat, there may be multiple lines on the data sheet for each location. Each line must have an associated location in the "Loc." column.
    2.2. Riparian woody species are any riparian shrub or tree species with a wetland indicator status of facultative (FAC), facultative wetland (FACW), or obligate wetland (OBL), as defined by the National Wetland Plant List (Lichvar et al. 2012). Key species, if used, are identified by local offices or project leads.
    2.3. Within the quadrat, locate the first individual of each riparian or key woody species encountered when proceeding down the transect. The individuals can be rooted in or overhanging the quadrat.
    2.4. If multiple individuals of the same species occur within the quadrat, only the first individual encountered (i.e., located closest to the back of the quadrat) is considered (Figure 52).
    2.5. If the riparian woody plant(s) straddles the boundary of the quadrat (some parts rooted both inside and outside the quadrat), evaluate the entire plant, even if part of the plant is outside the quadrat.
    2.6. If the riparian woody plant straddles the sample interval (is rooted in two adjoining quadrats), include the plant in the quadrat with the most rooted stems, and estimate its browse only once (not in both quadrats).

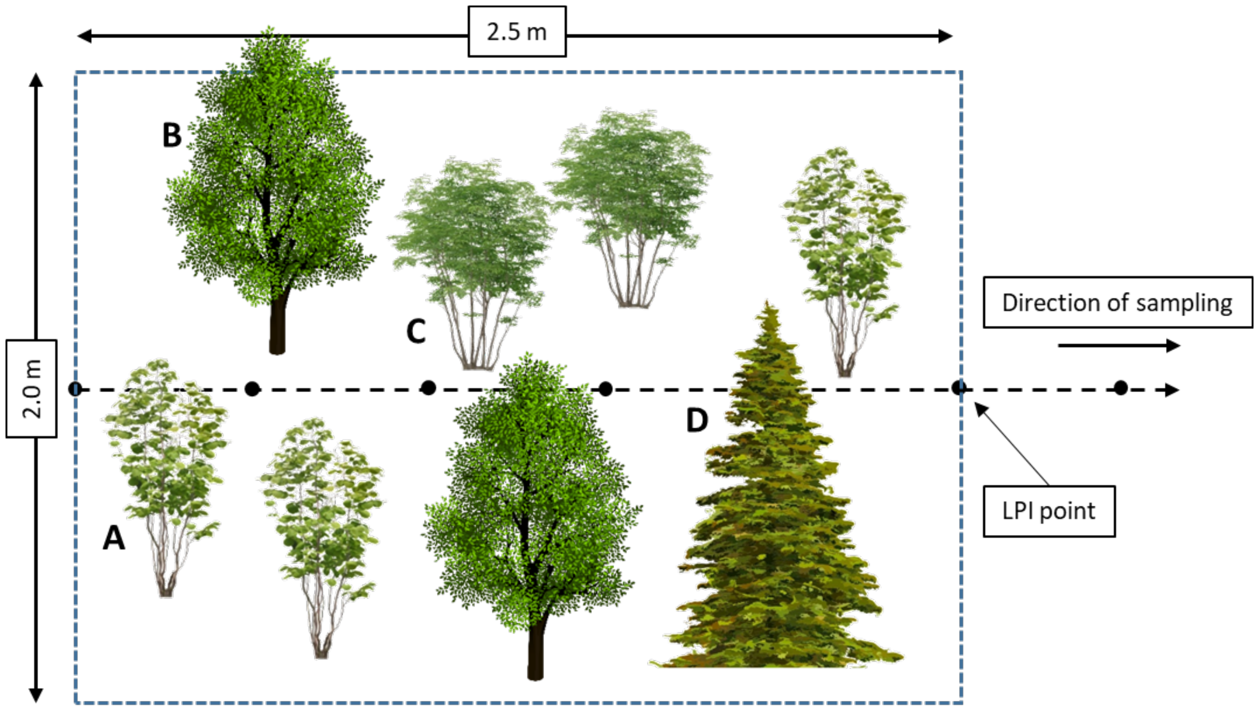


Figure 52. Select the riparian woody plant (A) closest to the start (smallest meter mark) of the quadrat and determine the utilization on that plant. This is repeated for each riparian woody species (B and C) within the quadrat. Only determine utilization on the first individual encountered for each riparian woody species. Do not include nonriparian woody species (D). A 2-m measuring rod centered on the transect line may be used to locate plants within the quadrat.

3. **Distinguish individual plants, as needed.** See step 8 of the woody structure method (Section 6.4).
    3.1. It can be difficult to distinguish individual multistemmed shrubs from each other when they are growing close together. In such cases, consider stems to be from different individuals if there is a 0.3-m (12-inch) gap between one cluster of stems and another at ground level (or as close to ground level as is visible).
    3.2. However, seedlings (individual stems < 0.5 m tall AND < 0.5 cm at the base) commonly germinate and initiate growth very close together but are clearly individual plants and should be recorded as individuals even if they are closer than 0.3 m from each other.
    3.3. If it is still difficult to distinguish individual plants using the 0.3-m rule (commonly because they are dense, contiguous patches of clonal/root sprouting/rhizomatous woody plants), assess the use classes on all the stems together within the 2.0 m x 2.5 m quadrat.

4. **Determine the available current year's growth.**
    4.1. ***Current year's leaders*** are the portion of the stems of woody plants that reflect the current year's growth or that extends from the terminal buds of 2-year-old growth. They often appear as long, thin, twig-like extensions growing from terminal buds that have not yet hardened into fibrous woody material. As leaders mature, cell walls thicken and harden into coarse, woody material in the second year. Browse on second-year and older leaders are not considered.
    4.2. Available woody plants have more than one-half (50%) of the current year's leaders below 1.5 m (5 ft), which is considered within reach of cattle, sheep, and deer. (If evaluating horse, elk, or moose browse, consider using a higher threshold of 2.1 m).
    4.3. If the first individual of a riparian woody species encountered has more than 50% of the current year's leaders above the reach of the grazing animal, the shrub is considered unavailable for grazing and the plant is not assessed for riparian woody species use. Go to the next closest plant of that species within the quadrat.
    4.4. If all individuals of a given riparian woody species are unavailable, mark "NA" in the use class column.

5. **Determine the woody species use class.**
    5.1. Woody species are classified into a "use class" (Table 14 and Figure 53). Use class descriptions are the standards by which use is judged.
    5.2. This process is repeated for the first available individual of each riparian woody or key species encountered within the quadrat.
    5.3. Review use class descriptions periodically while reading the quadrats to maintain precision and accuracy.

6. **Record the species name and use class.**
    6.1. On the data sheet, record the USDA PLANTS Database species code in the "Woody Species" column.
    6.2. Record the midpoint (Table 14) of the appropriate use class for each woody species evaluated.
    6.3. If there are multiple species, add additional rows for each additional species at the location on the transect.

7. **Record "NA" and "0" for no riparian woody or key species.**
    7.1. If there are no riparian woody species within the quadrat, mark "NA" in the "Woody Species" column and "0" in the "Use Class" column for one row of the data sheet associated with the point.

Table 14. Woody species use class and descriptions.

Class	Midpoint	Description
Unavailable	**NA**	Shrubs and trees have most (> 50%) of their leaders > 1.5 m (5 ft) tall for cattle or horse grazing. This should be adjusted if the questions to be answered involve other herbivores.
None	**0**	No browse of woody vegetation
Slight (0-20%)	**10**	Browsed plants appear to have little or no use. Available leaders may show some use, but 20% or less of the current year's leaders* have been used.
Light (21-40%)	**30**	There is obvious evidence of use of the current year's leaders. The available leaders appear cropped or browsed in patches totaling 21–40% of the available current year's leaders.
Moderate (41-60%)	**50**	Browsed plants appear rather uniformly used; 41–60% of the available current year's leaders have been browsed.
Heavy (61-80%)	**70**	The use of the browse gives the general appearance of complete search by grazing animals. Most (61-80%) of available leaders are used; some terminal buds remain on browsed plants.
Severe (81-100%)	**90**	The use of the browse gives the appearance of complete search by grazing animals; nearly all (81-100%) of available leaders are used. There may be grazing use on second and third years' leader growth. Plants may show a clublike appearance, indicating that most active leaders have been removed.

*Current year's leaders in this table means current year's branch growth.

Figure 53. Grazing utilization on shrub willow species. Use class of the individual in the left photo would be considered "moderate." Use class of the individuals in the center and right photos would be considered "heavy." Depth rod (1.5 m tall) shown in left and center photos for scale.

Quality Assurance
☐ Data sheet is complete, including plot ID, observer, recorder, visit date, transect, and azimuth. ☐ Riparian woody use is recorded for the appropriate interval along the transect, according to protocol. ☐ Use data are recorded only for the first individual of each riparian or key woody species rooted in or overhanging each quadrat as the observer is walking from the 0m transect end to the 25m end. ☐ Riparian woody use measures are consistent with plot observations

APPENDICES

Appendix A: Monitoring and Assessment Protocols

A number of monitoring protocols focused on riparian, wetland, and lotic stream systems have been developed by federal and state agencies in recent decades. Listed here are monitoring protocols that target overlapping ecosystems and/or provided source material for methods in this protocol.

Table A1. Field protocols for monitoring and assessment of riparian, wetland, stream and river (lotic), upland (terrestrial), and spring ecosystems.

Field Protocol	Citation	Target Population
AIM National Aquatic Monitoring Framework: Field Protocol for Wadeable Lotic Systems	BLM 2021	Lotic systems
Riparian Area Management: Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation	Burton et al. 2011	Riparian and lotic systems
The National Riparian Core Protocol: A Riparian Vegetation Monitoring Protocol for Wadable Streams of the Conterminous United States	Merritt et al. 2017	Riparian and lotic systems
PACFISH INFISH Biological Opinion Effectiveness Monitoring Program for Streams and Riparian Areas: 2015 Sampling Protocol for Stream Channel Attributes	Archer et al. 2015	Lotic systems
PacFish InFish Biological Opinion (PIBO) Monitoring Program: Effectiveness Monitoring Sampling Methods for Riparian Vegetation Parameters	Archer et al. 2016	Riparian and lotic systems
Field Protocol Manual: Aquatic and Riparian Effectiveness Monitoring Program	Lanigan 2010	Riparian and Lotic systems
National Rivers and Streams Assessment: Field Operations Manual	EPA 2009	Lotic systems
National Wetland Condition Assessment 2016: Field Operations Manual	EPA 2016	Wetlands
Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems. Second Edition. Volume I: Core Methods (aka Terrestrial AIM protocol)	Herrick et al. 2017	Uplands
User Guide for Wetland Assessment and Monitoring in Natural Resource Damage Assessment and Restoration	Comer et al. 2017	Wetlands
Riparian Area Management: Proper Functioning Condition Assessment for Lotic Areas	Dickard et al. 2015	Lotic systems
Riparian Area Management: Proper Functioning Condition Assessment for Lentic Areas	Gonzalez and Smith 2020	Riparian and wetland systems
Assessing Proper Functioning Condition for Fen Areas in the Sierra Nevada and Southern Cascade Ranges in California: A User Guide	Weixelman and Cooper 2009	Fen wetlands
Groundwater-Dependent Ecosystems: Level II Inventory Field Guide: Inventory Methods for Project Design and Analysis	USFS 2012	Groundwater-dependent wetlands
Springs Ecosystem Inventory Protocols	Stevens et al. 2016	Springs

Appendix B: Glossary

Absolute cover is the cover of an individual species as a percentage of the total quadrat area or total sample plot area, expressed as a percentage ranging from 0–100%. Absolute cover summed across all species within a quadrat or sample plot may exceed 100% due to overlapping canopies.

Annual use methods monitor the degree of vegetation use or soil alteration related to grazing or browsing by livestock, wild ungulates, wild horses and burros, and/or human activities.

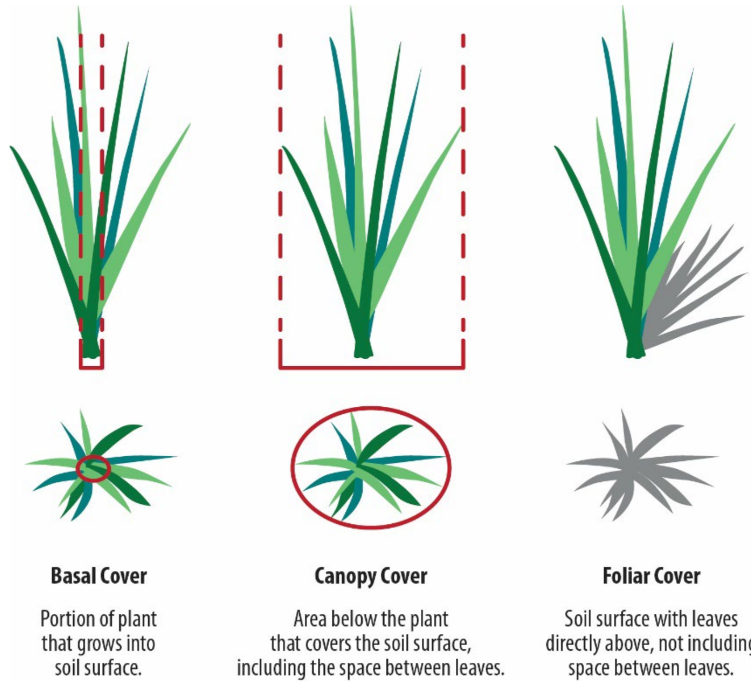


Figure B1. Diagram and definitions of different methods for estimating cover: basal cover, canopy cover, and foliar cover (adapted from the University of Idaho 2009).

Canopy cover**,** also called aerial cover, is the percentage of ground surface that is covered by the aerial portions (leaves and stems) of a plant species when viewed from above. See Figure B1. Due to overlapping canopies, the sum of canopy cover values for all species in a given sample plot may exceed 100 percent.

A ***channel*** is a linear feature formed by concentrated water flow and sediment transport between definable banks (Wohl 2018). Channel banks are discernable inflection points where the ground slope changes from relatively flat above the banks (bench or floodplain) to relatively steep on the banks and back to relatively flat between the banks (channel bed). Channels may include stable stream channels, rivulets or small channels, channels formed by headcuts, and incisions in wet meadows. Many small channels in riparian and wetland areas are not well-developed and lack a greenline, scour line, or bankfull indicators but are still considered channels if they have definable banks and there is evidence that they were formed by concentrated water flow and sediment transport. See Appendix M for types of observations that may constitute evidence of water flow and sediment transport.

Chroma is one of the three variables of soil color in the Munsell color system. Describes the relative purity, strength, or saturation of a color.

Clay is a mineral particle, less than 0.002 mm in diameter. Usually, clay particles feel sticky when rubbed between the fingers.

Contingent indicators are not universally applicable. They are only measured where present or applicable to a specific management objective.

Contingent methods measure ecosystem components with cross-program utility and consistent definitions, similar to core methods, but they are not required. Contingent methods are only used when they are important for management purposes and are not necessarily applicable in all sites.

Core indicators are measurable ecosystem components applicable across many different riparian and wetland types, management objectives, programs, and agencies.

Core methods generate data used to calculate indicators that describe key ecosystem attributes.

Covariate methods are not meant to monitor condition and trend but rather to characterize sites for the purposes of site classification, stratification, or determination of the potential natural condition.

Cowardin classification system is a hierarchical system for classifying wetlands and deepwater habitats developed by Cowardin et al. in 1979 for the U.S. Fish and Wildlife Service's National Wetland Inventory Program. The system is based on waterbody type, vegetative life form, and hydrologic regime and is applicable to all wetlands and deepwater habitats across the Unites States. At the highest level, the Cowardin classification system includes five broad types of wetlands and deepwater habitats (called systems): marine, estuarine, riverine, lacustrine, and palustrine (Cowardin et al. 1979; FGDC 2013). Most vegetated freshwater wetlands fall within the palustrine system.

Current year's leaders are the portion of the stems of woody plants that reflect the current year's growth or that extends from the terminal buds of 2-year-old growth. They often appear as long, thin, twig-like extensions growing from terminal buds that have not yet hardened into fibrous woody material. As leaders mature, cell walls thicken and harden into coarse, woody material in the second year.

Depleted matrix is a soil matrix with high value and low chroma colors due to the reduction and translocation of iron and manganese. See Appendix O (Soil Properties and Hydric Soil Indicators) for more details.

Designated monitoring area (DMA) is a permanently marked area of a riparian or wetland complex that has been selected for monitoring. DMAs are established by an interdisciplinary team of experienced personnel with knowledge of the management area. They are selected by identifying and grouping riparian and wetland areas into complexes with similar vegetation and physical characteristics. Once the riparian or wetland complex has been identified, one or more plots are established for monitoring. DMA plot locations can be established randomly within a complex to represent conditions of the larger complex (representative DMA) or hand-selected to monitor a specific location (critical DMA) or to establish reference conditions (reference DMA).

Diagonal layout is the plot layout intended for riparian and wetland areas (or zones of interest) that average between 2 m and 25 m in width. Three 25-m transects are spaced equally across the riparian or wetland area (or zone of interest), from one edge to the other edge. They may or may not be parallel, depending on the curvature of the long axis. Each transect runs diagonally across the long axis of the monitoring plot.

Facultative (FAC) species occur in both wetland and nonwetland areas.

Facultative upland (FACU) species usually occur in nonwetland areas but may occur in wetlands.

Facultative wetland (FACW) species usually occur in wetlands but may occur in nonwetland areas.

Gleying describes soil colors with bluish or greenish hues that form as a result of prolonged soil saturation and reducing conditions. See Appendix O (Soil Properties and Hydric Soil Indicators) for more details.

Histic epipedon are surface horizons with 20 cm or more of organic soil underlain by a mineral soil horizon with a chroma of 2 or less.

Histosol is a soil consisting primarily of organic content. Typically, 40 cm or more of the upper 80 cm is organic soil material. These materials include muck (sapric soil material), mucky peat (hemic soil material), and peat (fibric soil material).

Horizon is a horizontal layer of soil that differs from adjacent layers in physical, chemical, or biological properties or characteristics.

Hue is one of the three variables in the Munsell color system. Describes the chromatic composition of the color or amount of red, yellow, green, blue, or purple.

Hummocks are surface features with 10 cm (4 in) or more of microrelief from the top of the feature to the adjacent interspace or depression adjacent to the feature and that continue for 10 cm or more along the transect.

Hydric soil indicators are soil characteristics which are documented to be strictly associated only with hydric soils, such as (but not limited to) gleying, redoximorphic features, and sulfate reduction (rotten-egg smell).

Hydric soils are soils that form under conditions of saturation, flooding, or ponding long enough to periodically produce anaerobic conditions in the rooting zone, thereby influencing the growth of plants. The Natural Resources Conservation Service produced a field manual describing the features and identification of hydric soils (NRCS 2018). The NRCS also compiles a list of hydric soils by state.

Hydrogeomorphic (HGM) classification is a system for classifying wetlands developed by Brinson (1993) for the U.S. Army Corps of Engineers and further developed for wetland functional assessments (Smith et al. 1995). The HGM system of classification is based on the geomorphic or topographic position of a wetland, water sources and water transport, and hydrodynamics of wetland systems. At the highest level of hydrogeomorphic classification, wetlands are grouped into seven classes including depression, lacustrine fringe, tidal fringe, slope, riverine, mineral flat, and organic flat.

Hydrophytes or ***hydrophytic vegetation*** refers to any plant with adaptations for growing in water or on substrate that is at least periodically deficient in oxygen as a result of excessive water content. These species are designated as obligate wetland (OBL), facultative wetland (FACW), or facultative [FAC] species as defined by the National Wetland Plant List. The U.S. Army Corps of Engineers maintains regional lists of hydrophytic vegetation (USACE 2018).

Indicators are calculated from field-collected data and are structural or functional measures that either directly or indirectly provide quantitative information on the condition of critical ecosystem processes and/or attributes.

Key areas are indicator areas that reflect what is happening on a larger area as a result of on-the-ground management actions. A key area should be a representative sample of a large stratum, such as a pasture, grazing allotment, wildlife habitat area, herd management area, watershed area, etc., depending on the management objectives being addressed by the study (BLM 1996).

Key species are plant species that are identified by land managers and specialists, specific to a local management area, to assist in monitoring and application of grazing permitted uses. Key species are important (relatively common and desirable) in the plant community, are relatively palatable to livestock (or other ungulates of interest), and serve as indicators of change. Key herbaceous species within riparian and wetland areas are usually deep-rooted hydric or mesic graminoids. Key woody species within riparian and wetland areas are generally palatable facultative (FAC), facultative wetland (FACW), or obligate wetland (OBL), as defined by the National Wetland Plant List (USACE 2018), such as willow, alder, birch, dogwood, aspen, or cottonwood.

Leaders**:** See ***current year's leaders***.

Lentic areas (lentic systems) are associated with environments of still, slow, or sluggish moving water, such as seeps, fens, bogs, marshes, swamps, prairie potholes, wet and moist meadows, vegetated drainageways, oxbows, beaver complexes, and the margins of lakes, ponds, and constructed reservoirs. Lentic systems may be far from a channel, or they may be on the floodplain of a river or stream but not dominated by forces associated with the channel (fluvial processes). Wherever they are located, water within lentic systems generally does not have the requisite energy to form and maintain a scour channel. Movement of sediment may occur through dissolved or suspended transport, but bedload transport is minor and inconsequential in the development, maintenance, and function of most lentic environments.

Linear layout is the plot layout intended for riparian or wetland areas (or zones of interest) that average approximately 2 m in width. The minimum plot length is 75 m and the maximum is 200 m, even if the riparian or wetland area continues. The plot area will therefore be less than 0.3 ha. Linear layouts are applicable in narrow vegetated drainages, along the shore of a lake or pond, or when the zone of interest is a narrow band of vegetation in a larger site.

Litter is detached dead plant material from past years' stems, roots, and leaves; dung; or hay from haybales which is loose and able to blow or float away. See definitions of ***standing dead*** and ***thatch*** for comparison.

Loamy/clayey is a textural group used to describe all mineral soils with textures of sandy loam or finer (loam, clay loam, sandy loam, sandy clay loam, sandy clay, silt, silt loam, silty clay loam, silty clay, and clay).

Lotic systems are associated with environments having fast or energetic moving water, such as rivers, streams, and creeks. Moving water, concentrated in a channel, has enough shear stress to form and maintain a scour channel that is generally devoid of vegetation and capable of transporting sediment as bedload.

Management objective (or management goal) is a broad goal or desired outcome land managers are trying to achieve with land management. Management objectives and goals provide the context for why monitoring information is needed and how it will be used. Often, these are derived from planning documents and policy. Examples include maintaining forage production for livestock or high-quality habitat for big game animals.

Matrix color is the dominant soil color of a horizon. When three or more colors occur within a horizon, the matrix color may represent less than 50% of the total area.

Mesophyte or ***mesophytic species*** refers to plant species that are adapted to both wet and dry environments. These species are given a facultative (or FAC) wetland indicator status.

Mineral soil material is soil material consisting predominantly of mineral matter. Physical, chemical, and biological properties of the soil are influenced predominantly by the mineral matter (generally contain less than 12-18% organic carbon).

***Monitoring design* (or *monitoring approach*)** is the approach (e.g., random, targeted, designated monitoring area, mixed) used to select sample locations or sample sites based on management goals and monitoring objectives. This term is interchangeable with "sampling approach" and incorporates management objectives, monitoring objectives, frequency of monitoring, and types of methods included in the monitoring.

Monitoring objectives are quantitative statements that provide a means of evaluating whether management objectives or goals are being achieved. Monitoring objectives should be specific, quantifiable, and attainable based on available resources and the sensitivity of the methods. Quantitative monitoring objectives may be available in resource management plans (e.g., for sage-grouse, Clean Water Act requirements), or they may be developed in the monitoring planning process. An example monitoring objective is: Maintain native graminoid cover of greater than or equal to 75%, for 80% of riparian and wetland areas in the planning area with 95% confidence over 10 years.

Monitoring plot is the entire area around the sample location in which data are collected.

Mottles are spots or blotches of color that differ from the dominant soil matrix color, not related to soil wetness.

Muck is highly decomposed organic soil material. Organic plant parts are not recognizable. Sometimes referred to as sapric organic soil.

Mucky mineral is a modified textural class describing a mineral soil with an organic matter content between organic and mineral soil materials. Organic carbon content is between 5% and 18%, depending on clay content.

Mucky peat is a moderately decomposed organic soil material. A portion of the original plant parts are recognizable, but an equally large proportion is not. Sometimes referred to as hemic organic soil.

Munsell color system is a color designation system that specifies the relative degrees of the three color variables—hue, value, and chroma. For example, 10YR 4/2 is a soil color with hue = 10YR, value = 4, and chroma = 2.

National Wetland Inventory (NWI) is a publicly available spatial dataset provided by the U.S. Fish and Wildlife Service (USFWS) that contains detailed information on the abundance, characteristics, and distribution of wetlands in the United States. NWI mapping is created through photointerpretation of aerial photography, and data are attributed with the USFWS wetland classification system (Cowardin et al. 1979).

Obligate (OBL) wetland species almost always occur in wetlands.

Organic soil material is soil material with greater than 12-18% organic carbon, depending on clay content. The high organic matter content dominates the physical, chemical, and biological processes of the soil.

Peat is minimally decomposed organic soil material. Plant and root fibers are generally still visible. Sometimes referred to as fibric organic soil.

Peatland is a permanently saturated wetland with organic soil. For most definitions, the organic soil material must be at least 40 cm thick. Fens are peatlands that are hydrologically connected to the regional groundwater table. Bogs are peatlands that are isolated from the regional groundwater table, and the saturation is maintained by precipitation. See Appendix L for a more detailed description of fens and bogs.

Ped is a unit of soil structure such as a block, column, granule, plate, or prism, formed by natural processes (in contrast to a clod, which is usually formed artificially).

Plot: See ***monitoring plot***.

Point: See ***sample location***.

Random sample designs collect measurements and estimates of condition and trends at randomly selected sites within a study area where every member of the target population has a known probability of being selected. Results from random sample designs can be extrapolated to provide a statistically valid assessment of condition and trends across an entire population, or study area, with known levels of precision and accuracy (Gitzen et al. 2012). Random sample designs can be simple, stratified, and/or spatially balanced to ensure geographic spread across a sampling area (Stevens and Olsen 2004). Stratification ensures that different types of resources are proportionally represented according to their prevalence on the landscape. See relevant reference documents for implementing landscape-scale or population-scale random sample designs (e.g., BLM 2015, Herrick et al. 2009). Random sample designs can also be used to provide context for nonrandomly selected targeted sites.

Redoximorphic concentrations are localized zones of accumulation of iron and/or manganese oxides. Generally, they are redder in hue and have brighter (higher) chromas than the surrounding soil matrix.

Redoximorphic depletions are localized zones of low chroma color where iron and/or manganese oxides have been reduced, solubilized, and leached from the soil.

Redoximorphic features are morphological features indicating the chemical reduction and oxidation of iron and manganese compounds resulting from saturated soil conditions. Includes redoximorphic concentrations, redoximorphic depletions, and reduced matrices.

Reduced matrix is a soil matrix that has a low chroma in situ but undergoes a change in hue or chroma within 30 minutes of exposure to air due to the oxidation of iron.

Relative cover is the proportional cover of an individual species as a percentage of total plant cover, expressed as a percentage ranging from 0–100%. To calculate relative cover, measure or estimate the cover of the individual species and the cover of all species and then divide the individual species cover by total plant cover.

Riparian areas are plant communities contiguous to and affected by surface and sub-surface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have one or both of the following characteristics: (1) distinctively different vegetative species than adjacent areas, and (2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms (USFWS 2009). This definition was developed by the USFWS for the purpose of wetland mapping.

BLM has in the past, further defined riparian areas the transition between the aquatic area and adjacent upland areas that exhibit vegetation or physical characteristics reflective of permanent surface- or subsurface-water influence (BLM 2015). Lands along, adjacent to, or contiguous with perennially and intermittently flowing rivers and streams, glacial pothole, and the shores of lakes and reservoirs with stable water levels are typical riparian areas. Excluded are such sites as ephemeral streams or washes that do not exhibit the presence of vegetation dependent upon free water in the soil (BLM 1992). As transitional environments, riparian areas may include wetlands, but they also include adjacent aquatic and upland environments influenced by waterbodies (NRC 2002).

Riparian-wetland is a term used to represent areas that fit common definitions of either wetlands or riparian areas.

Rock fragments (coarse fragments) are unattached pieces of rock greater than or equal to 5 mm in diameter that are strongly cemented or more resistant to rupture.

Sample design provides information on the target population, sample size, strata definitions, and the sample selection methodology. This term is interchangeable with “sample plan,” “survey design,” “sampling plan,” or “sampling design.” See also definition of ***sampling approach***.

Sample location is the point around which monitoring occurs.

Sample point See ***sample location***.

Sampling approach is the approach (e.g., random, targeted, designated monitoring approach, mixed) used to select sample locations or sample sites based on management goals and monitoring objectives. This term is interchangeable with “monitoring approach” or “monitoring design” and incorporates management objectives, monitoring objectives, frequency of monitoring, and types of methods included in the monitoring.

Sand is a mineral particle, 0.10 to 2.0 mm in diameter. Generally, feels gritty when rubbed between the fingers.

Sandy is a soil texture group consisting of sand and loamy sand textures.

Silt is a mineral particle, 0.05 to 0.10 mm in diameter. Generally, has a smooth, nonsticky feel when rubbed between the fingers.

Site is the general riparian or wetland area within which the monitoring plot is located.

Soil profile is a vertical section of the soil through all its horizons, starting at the soil surface and extending to the unweathered parent material.

Soil structure is the arrangement of primary soil particles (e.g., sand, silt, clay) into secondary units or peds. Secondary units are described and classified based on their shape, size, and degree of distinctness.

Soil texture is the relative proportions of soil particle size categories (sand, silt, and clay) in a soil by weight. Soil textures are organized into 12 different classes for mineral soils.

Spoke layout is the standard monitoring plot configuration. It is a 30-m radius circle demarcating a 0.30-ha monitoring plot. Data collection takes place across the entire plot, at the center of the plot, andalong three 25-m transects radiating out from the center of the plot in a spoke design. Each transect starts 5 m from the center to avoid repeat data collection and sampling trampled vegetation at the center.

Standing dead is past years' stems and leaves of a plant, still attached (not loose) and not entrained. It can be considered standing dead at a less than 45° angle if it is not entrained. See definitions of ***thatch*** and ***litter*** for comparison.

Stratification refers to dividing a population or study area into subgroups or subunits called strata for the purposes of sampling or data analysis. Reasons to stratify include: (1) variability in indicators is different across types of land; (2) ensure different types of land or uncommon portions of a study area get sampled; and (3) determine differences in land potential. Examples of strata include biophysical settings, management unit boundary, and ecological sites.

Supplemental data collection can be carried out when site-specific monitoring objectives cannot be addressed with core, contingent, or annual use methods; monitoring teams should collect supplemental data that may be used for project-specific objectives. These may include macroinvertebrate sampling, longer term hydrologic monitoring, detailed water and soil chemistry analyses, or indepth investigation of wildlife use, among others. Supplemental indicators typically do not have consistent, cross-program applicability and are not covered by this protocol.

Target population refers to the resource to be described. Sample points (see ***site*** or ***monitoring plot***) are selected from within the population. The definition of the target population should contain specific information about the resource of interest, its spatial extent, its ownership status, and its size. The definition should be specific enough that an individual could determine whether a sample point is part of the target population. In some cases, membership in the target population might be determined after data have been collected at the sample point (e.g., sage-grouse seasonal habitat). Examples of target populations include: all lands within a reporting unit, all hillslope wetlands on managed land, and sage-grouse habitat on managed lands.

Targeted monitoring collects measurements and estimates condition and trends at nonrandom sites. In targeted monitoring, the sampled sites are selected using the judgment of the project manager for a specific reason. Targeted monitoring is appropriate for site-specific evaluations (treatment effectiveness or specific areas of concern) and can be used to document a reference condition, establish a repeat monitoring area, monitor known habitat of a rare plant or animal species, or track changes that result from management actions like grazing or restoration (e.g., critical designated monitoring area) (Burton et al. 2011). For targeted sample sites, statistical inference cannot be drawn beyond the sample site.

Thatch is past years' stems and leaves at < 45° angles and entrained (not loose), whether attached or not. Thatch is a tightly intermingled layer of living and dead stems, leaves, and roots that accumulates between the layer of actively growing vegetation and the soil underneath. Only occurs where species grow closely together. See definitions of ***standing dead*** and ***litter*** for comparison.

Transverse layout is the plot layout intended for riparian and wetland areas (or zones of interest) that average between 25 m and 60 m in width. The size and dimensions of the plot will be determined by the size and dimensions of the riparian and wetland area (or zone). In the transverse layout, three 25-m transects are established perpendicular to the long axis of the plot. They may or may not be parallel, depending on the curvature of the long axis.

Upland systems are not water-dominated.

Upland (UPL) species almost never occur in wetlands.

Value is one of the three variables in the Munsell color system. Describes the degree of lightness or darkness of a color.

Wetlands are those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. This definition was developed by the U.S. Army Corps of Engineers in 1977 to support regulation under the Federal Clean Water Act (NRC 2002) and has generally been adopted by the BLM (BLM 1992). For regulatory purposes, wetlands must meet the vegetation, soil, and hydrology criteria in the Corps of Engineers Wetlands Delineation Manual (USACE 1987). Multiple definitions have been developed by different agencies and for different purposes. See Appendix J for the definition used by the USFWS for the National Wetland Inventory and see NRC 1995 for an extensive discussion of wetland definitions and delineation methodologies. Under most definitions, wetlands can occur within riparian areas but may only represent a portion of the total riparian area (NRC 2002). Wetlands can also occur in non-riparian landscape positions.

Xerophyte or ***xerophytic vegetation*** refers to plant species that are adapted to upland or dry environments where water availability is limited. These species are given a facultative upland (FACU) or upland (UPL) wetland indicator status.

Zone of interest is a small area within a larger riparian or wetland complex that is of specific interest or management concern.

Appendix C: Site Selection for Representative Designated Monitoring Areas

A ***designated monitoring area*** (DMA) is a permanently marked area of a riparian and wetland complex that has been selected for monitoring. There are three types of DMAs, and the most commonly used by land managers are representative DMAs, defined as a monitoring plot in a riparian or wetland complex that is representative of a larger area (Burton et al. 2011). A representative DMA can be revisited over time to quantify resource conditions and to track trends at a specific site. The representative DMA sampling approach is based on the key area concept that is well-established in rangeland management (Elzinga et al. 1998; BLM 1996). “Key areas are indicator areas that are able to reflect what is happening on a larger area as a result of on-the-ground management actions. A key area should be a representative sample of a large stratum, such as a pasture, grazing allotment, wildlife habitat area, herd management area, watershed area, etc., depending on the management objectives being addressed by the study…Proper selection of key areas requires appropriate stratification” (BLM 1996).

Although this appendix focuses on representative DMAs, there are two other important types of DMAs. Critical DMAs are defined as manually selected DMAs chosen for a specific, localized purpose. It is not representative of a larger area but is important enough that specific information is needed at a particular site. Extrapolation of data from a critical DMA to a larger area may not be appropriate within the complex containing the critical area. A critical DMA does not have to meet the criteria for a representative DMA (Burton et al. 2011). Lastly, reference DMAs are manually selected DMAs chosen to obtain reference information that is useful for identifying potential natural conditions or to determine initial desired condition objectives for a similar riparian complex (Burton et al. 2011). A common example of a reference DMA is a grazing exclosure where livestock access to the stream is restricted and good ecological conditions and riparian or wetland functions exist. Reference DMAs should be selected to ensure that they match the geomorphic and ecological conditions of the representative or critical DMA with which they will be compared. Extrapolation of data from a reference DMA to a larger area may not be appropriate within the complex containing the reference area. However, reference DMAs can meet many of the same criteria as representative DMAs.

Selecting Representative DMAs

The process of selecting representative DMAs for riparian and wetland areas is similar to the process described by Burton et al. (2011) for selecting representative DMAs for wadeable stream reaches. Much of the guidance provided here is taken directly from Burton et al. (2011), with additional details and discussion included for practices specific to riparian and wetland areas. Establishing DMAs should be a documented, interdisciplinary exercise as most land management actions affect many resources. The process of selecting DMAs is typically informed by a review of:

- Broad-scale management objectives established in land use plans.
- Existing site information, such as a proper functioning condition assessment, baseline monitoring data, or similar information.
- Site-specific management issues or concerns related to existing resource conditions.
- An interdisciplinary evaluation of the resource values inherent in each site.
- An interdisciplinary understanding of desired resource conditions (soils, hydrology, ecology, etc.).

The process of selecting representative DMAs includes the following steps:

1. Identify and stratify sensitive riparian and wetland complexes to make the sample frame for monitoring.
2. Select plots for monitoring.
    a. If needed, determine the zone of interest.
    b. Randomly locate the monitoring plot(s).

The representative DMA approach refines the “key area” concept by decreasing the level of bias in selecting the plot locations (or key areas). This is accomplished by stratifying (grouping) riparian complexes, creating a sample frame consisting of all possible sensitive complexes (synonymous with all possible key areas), and then randomly selecting the site(s) used for monitoring from the population of sensitive complexes. As a result, this representative DMA approach has characteristics of stratified random sampling and restricted random sampling (Burton et al. 2011).

1. Identify and Stratify Sensitive Complexes

Stratification is one way a monitoring program can reduce variation among sites (Roper et al. 2002, as cited in Burton et al. 2011), and it can identify groups of sites of highest management and monitoring priority. Stratification is a process of grouping riparian and wetland sites based on similarities in their form (i.e., vegetation and physical characteristics) and their function. Riparian and wetland sites in a stratification group, or stratum, share a common set of attributes, processes, and management practices. Sites are first stratified according to riparian and wetland complexes and land uses. Riparian and wetland complexes are defined by overall geomorphology, dominant soil characteristics, hydrology (water sources and hydroperiod), and vegetation patterns (Winward 2000) (see Appendices J, K, and L for classification systems that can aid in identifying riparian and wetland complexes). Land uses and management units, such as pastures within an allotment, are also considered when creating strata to group complexes that experience similar management practices. Much of the stratification process can be completed with the aid of geographic information systems (GIS) in an office or laboratory setting. Complexes delineated in the office can be validated in the field to make sure the information adequately represents the attributes and conditions observed on the ground.

Once all riparian and wetland complexes are defined across the project area, the stratum (or strata) representing the most sensitive complexes is identified. Sensitive complexes are generally characterized by low gradient landscape positions with relatively fine sediments, stable hydrology, saturated soils or low standing water, and herbaceous vegetation (Figures C1 and C2). Complexes that are sensitive to management action should be used for representative DMAs for two reasons: (1) Sensitive complexes serve as bellwethers that are most responsive to changes in management. If insensitive complexes are monitored rather than sensitive complexes, the ability to detect positive or negative effects of management change will be low; and (2) Sensitive complexes are used because land managers should be able to implicitly assume that if management is maintaining desired or improving resource conditions in sensitive complexes, then the same management is likewise appropriate for less sensitive complexes.

Once the most sensitive stratum (or strata) is identified, a geospatial sample frame or map is created containing all complexes within the stratum. From this sample frame, one or more monitoring plots are randomly selected. The number of monitoring plots selected per project area depends on time, money, trained monitoring personnel, the degree of controversy, and the inherent resource values associated with the sensitive complex. Generally, one monitoring site per pasture (or project area) would constitute a starting point for a monitoring program (Burton et al. 2011). Qualitative assessments, such as the proper functioning condition assessment (Gonzales and Smith 2020) or supplemental DMAs with photographs only, may be dispersed through the project area to validate that the representative DMA(s) characterizes the conditions of the sensitive complex throughout the project area (Elzinga et al. 1998).

To illustrate the stratification process for riparian and wetland areas, a single pasture might have 25 springs. These could be stratified into three complexes: (1) 12 perennial high-discharge springs that support a sedge/rush-dominated community; (2) 6 seasonal low-discharge springs that support a shrub-dominated community; and (3) 7 seasonal low-discharge springs that support a grass-dominated community. Each of these complexes may respond to management action in different ways. The interdisciplinary team might identify the sedge/rush-dominated stratum as the most sensitive because livestock can easily access these sites, and livestock and wildlife are attracted by availability of water and forage throughout the grazing period. All sites within this stratum that meet other monitoring criteria (such as the criteria listed in Section 1.2 and 3.0) are included within this sensitive stratum. One or more sensitive spring sites are randomly selected to establish a representative DMA(s), depending on time, money, trained monitoring personnel, degree of controversy, and the inherent resource values associated with this complex. In this example, if 12 springs are included in the sensitive complex, each spring is assigned a number, and then a random number from 1 through 12 is selected to determine the site for a representative DMA.

Stratification and the selection of sensitive complexes should be performed by an experienced interdisciplinary team with local, indepth knowledge of the terrain, plant communities, hydrology, and land management. The process should be documented thoroughly to link management objectives with identification of sensitive complexes.

Figure C1. Stratification is important to identify priority areas for establishing representative DMAs. The riparian areas adjacent to both alpine lakes in these photos differ in their sensitivity to management. The fine-textured soils of the lacustrine fringe (right) is much more sensitive to ungulate and recreational use than the coarse-textured shoreline (left).

Figure C2. Stratification is important to identify priority areas for establishing representative DMAs. In this pair of photographs, wide, open valley bottoms support broad floodplain areas. However, the riparian area shown to the left is dominated by a dense willow community, which serves as an impediment to livestock movement. In contrast, the wet meadow shown to the right is easily accessible to livestock; therefore, it is the more sensitive complex and higher priority for monitoring with a representative DMA.

Criteria for identifying sensitive riparian and wetland complexes:

- The sensitive complexes are selected by an experienced interdisciplinary team with knowledge of local conditions and management history.
- The sensitive complexes represent and are accessible to the management activity of interest.
- The sensitive complexes have the potential to respond to the management activity of interest, and resource objectives can be achieved (i.e., the sites have the potential to respond to and demonstrate measurable trends in condition resulting from changes in grazing management or other management activities influencing the riparian and wetland vegetation) (also applicable to a reference DMA selection).
- The sensitive complexes are located outside of livestock concentration areas. Representative DMAs should not be located at water gaps or locations intended for livestock concentration or in areas where impacts are the result of site-specific conditions (such as along fences where livestock grazing use is not representative of the riparian area). The areas of concentration may be monitored to address highly localized issues if necessary (in which case they would be described as critical DMAs).
- The sensitive complexes are free from the influence of compounding activities. Representative DMAs should not be located in areas compounded by activities that make it difficult to establish cause-and-effect relations. For example, an area used heavily for recreation and grazing would not make a good representative DMA to determine the effects of livestock grazing on riparian and wetland conditions.

2. Select Plots for Monitoring

Once sites within the most sensitive complexes have been selected for monitoring, the precise location for the representative DMA monitoring plot should be established. If environmental characteristics, use levels, impact patterns, and resource conditions are fairly uniform throughout the selected riparian site, then the entire riparian and wetland site is potentially available for monitoring, and plot locations can be randomly selected. However, if the site is not uniform and is characterized by pronounced physical, hydrologic, or vegetation gradients, then there may be parts of the site that are more sensitive and more informative of various management objectives (referred to here as ***zones of interest***). Zones of interest should be identified first before establishing the monitoring plot.

A. **Zones of interest.** Zones of interest are important to consider because they may be the first to degrade under poor management practices and the first to recover with implementation of better management; or they may provide the best correlation of environmental conditions to management objectives. For example, if the interdisciplinary team wants to address the habitat conditions for a protected frog species, they might focus on the emergent vegetation zone, which provides the essential habitat for egg laying and tadpole development. Where these gradients occur, the interdisciplinary team should identify and document the zone of interest, which establishes the shape and dimensions of the potential monitoring plot.

   Four potential zones of interest are identified where monitoring efforts can be intensified to best address specific management objectives: (1) the mesic fringe; (2) the shoreline of lacustrine sites; (3) the thalweg (or deepest part) of a riparian or wetland area; and (4) the emergent vegetation zone. The zone of interest should be delineated first, and then the dimensions of the monitoring plot can be determined based on the boundaries of the zone of interest. The dimensions of the zone of interest will dictate the plot layout as described in Section 4.0. Some characteristics of the four zones of interest follow.

   1) **Representative DMAs along the mesic fringe.** In many riparian and wetland sites, the representative DMA should be located along the mesic fringe (the driest edge of a wetland). The mesic fringe is the preferred DMA location when the objective is to document:
      - Site dewatering related to water-table decline.
      - Soil disturbance related to any human, animal, or vehicle entry into a riparian or wetland area from adjacent uplands.
      - Flux of sediment from offsite sources following wildfire, timber harvest, road construction, or overgrazing that can produce excess overland flow and sheet and rill erosion.

      The mesic fringe represents that part of the riparian-wetland vegetation where there is a transition from comparatively stable upland soils that provide solid footing to large ungulates, to soft, easily displaced saturated riparian and wetland soil that cannot readily support the weight of large ungulates. The mesic fringe demarcates the general limit of intrusion by large ungulates into “soft” riparian or wetland sites.

      A DMA in the mesic fringe could follow any of the layouts described in Section 4.0, depending on the size and shape of the zone of interest. If the mesic fringe zone of interest is larger than a monitoring plot, then the plot center can be selected randomly from within the mesic fringe area using the procedure in part B. of this appendix, which follows.

Figure C3. In this fen, the mesic fringe is disproportionately impacted by livestock use. Most large animals do not walk into the central part of this fen because the organic soils and high hydrostatic pressure create unstable ground that is unable to support their weight. In this situation, changes in management impacts and evidence of recovery will be more evident along the mesic fringe than along the interior of the fen.

2) **Representative DMAs along the thalweg.** Some DMAs may target the thalweg, or the deepest or topographically lowest part of a riparian and wetland area. The thalweg may be the bottom of a vegetated drainageway, a spring brook, a gully, or incised channel. The thalweg is the preferred DMA location when:
   - It provides palatable forage and water that is sought out by livestock and wildlife.
   - Ungulates trail through or near the lowest part of the wetland.
   - There is a channel, such as a spring brook, degraded swale with a scour channel, gully, or incised channel.
   - There are concerns about dewatering of a riparian or wetland area due to gully erosion or headcut migration.

   A thalweg DMA could follow any of the layouts described in Section 4.0, depending on the shape of the zone of interest. If the thalweg zone of interest is larger than a monitoring plot, then the plot center can be selected randomly from within the thalweg area using the procedure in part B. of this appendix, which follows.

3) **Representative DMAs along a shoreline.** In some circumstances, the DMA may need to target the shoreline of lakes or ponds. Livestock and wildlife are commonly attracted to the shoreline for both water and palatable forage. Monitoring the shoreline can be done by placing the transect tape along the greenline using greenline rules, with slight modification from Burton et al. (2011) for shoreline conditions: replace “streambank” with "shoreline" and “high flows” with "high water." Establishing transects along the greenline may require many bends of the

transect. Note that monitoring within the area of water fluctuation is generally not productive, because:

- Vegetation is dominated by annual, weedy species that are not reflective of management.
- Fluctuations in water level can obliterate annual soil disturbance features.
- Murky water may obscure features of interest.

A representative DMA along a shoreline uses the greenline rules using the linear layout with the transects running along the greenline and incorporating bends as needed (Section 4.4).

4) **Representative DMA through emergent vegetation zone.** Some management questions are explicitly tied to the shallow aquatic habitat that supports emergent vegetation. This aquatic habitat is important to aquatic and semiaquatic species. For example, the amount of emergent vegetation cover is a habitat attribute measured for many listed and sensitive frog species.

   A representative DMA in the emergent vegetation zone might be tied to a specified water depth (e.g., 20-30 cm depth) or a fixed distance (e.g., 1 m) from the water's edge. In the latter case, a linear layout (Section 4.0) would be used for sampling with transects running parallel to the water's edge or specific depth zone.

B. Randomly locate the monitoring plot. Once a site has been selected for monitoring and zones of interest have been considered, the precise location of the monitoring plot is established. Placement of the monitoring plot and transects depends on the shape and dimensions of the riparian and wetland area or the zone of interest within the area. The layout possibilities for a representative DMA are the same as those for probability-based monitoring (Section 4.0).

A random plot center can be chosen using a computer algorithm, such as generalized random tessellation stratified design (Stevens and Olsen 2004), which selects coordinates from a two-dimensional polygon of a site or zone of interest. If the plot center falls near the edge of a riparian and wetland area, use plot shifting rules to move the plot center. Implement plot layout rules from Section 4.0.

Appendix D: Dominance Test for Hydrophytic Vegetation

Note: The content in this appendix is adapted from the "Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region," Version 2.0 (USACE 2008).

A set of six field criteria (Section 1.2) defines riparian and wetland ecosystems to which this protocol applies. One of these criteria is a dominance of ***hydrophytic vegetation***, which refers to any plant with adaptations for growing in water or on substrate that is at least periodically deficient in oxygen as a result of excessive water content.

Within existing cover, the vegetation of a riparian and wetland area must be dominated by hydrophytic species (i.e., obligate [OBL], facultative wetland [FACW], or facultative [FAC] species as defined by the National Wetland Plant List) (Lichvar et al. 2012, 2016; USACE 2018). For the purposes of this protocol, the upland limit of riparian and wetland environments occurs at the boundary between areas dominated by hydrophytic vegetation and areas dominated by nonhydrophytic vegetation. Some low cover of nonhydrophytic vegetation may occur within riparian and wetland areas that are sampleable, as long as hydrophytic vegetation dominates overall. Similarly, low cover of hydrophytic vegetation may occur in upland areas that are not sampleable. Discrete zones of upland vegetation, such as raised upland mounds, should be limited to 10% of the monitoring plot unless specified by monitoring objectives.

To define ***dominance*** for this protocol, the standard dominance test used for wetland delineation (USACE 1987, 2007, 2008, 2010a, 2010b) is modified. The procedure to determine dominance is the same as described in the U.S. Army Corps of Engineers (USACE) "Regional Supplement to the Corps of Engineers Wetland Delineation Manual," except that this protocol assesses dominant species for the community as a whole and not by strata.

Description of dominant hydrophytic vegetation: More than 50 percent of the dominant plant species are rated OBL, FACW, or FAC.

Procedure for selecting dominant species by the 50/20 Rule: Dominant plant species are the most abundant species in the community; they contribute more to the character of the community than do the other nondominant species present. The 50/20 rule is a repeatable and objective procedure for selecting dominant plant species and is recommended when data are available for all species in the community.

In general, dominants are the most abundant species that individually or collectively account for more than 50 percent of the total coverage of vegetation, plus any other species that, by itself, accounts for at least 20 percent of the total. For the purposes of this protocol, absolute canopy cover is the recommended abundance measure for plants in all vegetation strata.

Steps in selecting dominant species by the 50/20 rule are as follows:

1. Estimate the absolute canopy cover of all or most species in the area being considered. Species with < 1% cover do not need to be listed.
2. Rank all species from most to least abundant.
3. Calculate the total coverage of all species (i.e., add their individual percent cover values). Absolute cover estimates do not necessarily equal 100 percent.

4. Select plant species from the ranked list, in decreasing order of coverage, until the cumulative coverage of selected species exceeds 50 percent of the total coverage for the stratum. If two or more species are equal in coverage (i.e., they are tied in rank), they should all be selected. The selected plant species are all considered to be dominants. All dominants must be identified to species.
5. In addition, select any other species that, by itself, is at least 20 percent of the total percent cover in the stratum. Any such species is also considered to be a dominant and must be accurately identified.
6. Tally the number of dominant species and record the percent of dominants that are OBL, FACW, or FAC. The vegetation is considered dominated by hydrophytic vegetation if more than 50% of dominants are OBL, FACW, or FAC.

Three examples of the dominance test for hydrophytic vegetation follow:

Dominance Test Example 1

Scientific Name	Wetland Indicator Status	Absolute Canopy Cover	Dominant	Reason
Carex nebrascensis	OBL	45	Yes	Cumulative cover exceeds 50% total cover
Juncus arcticus ssp. *littoralis*	FACW	25	Yes	Individual cover exceeds 20% total cover
Ranunculus cymbalaria	OBL	5	No	
Carex lenticularis var. *lipocarpa*	OBL	2	No	
Eleocharis palustris	OBL	1	No	
Argentina anserina	OBL	1	No	
Plantago major	FAC	1	No	
Epilobium ciliatum	FACW	1	No	
Cirsium arvense	FACU	1	No	
Ericameria nauseosa	NR	1	No	
Artemisia tridentata	NR	1	No	
	Total Cover	**84**		
50/20 Thresholds	50% of total cover = 42.0% 20% of total cover = 16.8%			
Hydrophytic vegetation determination:	Total number of dominant species = 2 Percent of dominant species that are OBL, FACW, FAC = 2/2 = 100% Therefore, the vegetation is dominated by hydrophytic species			

Dominance Test Example 2

Scientific Name	Wetland Indicator Status	Absolute Canopy Cover	Dominant	Reason
Forestiera pubescens	FACU	25	Yes	Cumulative cover exceeds 50% total cover
Salix boothii	FACW	18	Yes	Cumulative cover exceeds 50% total cover
Distichlis spicata	FAC	15	Yes	Individual cover exceeds 20% total cover
Bromus tectorum	NR	7	No	
Acroptilon repens	NR	2	No	
Sporobolus airoides	FAC	2	No	
Tamarix chinensis	FAC	1	No	
Bassia scoparia	FAC	1	No	
Salix exigua	FACW	1	No	
Atriplex argentea	FAC	1	No	
Elaeagnus angustifolia	FAC	1	No	
	Total Cover	**74**		
50/20 Thresholds	50% of total cover = 37.0% 20% of total cover = 14.8%			
Hydrophytic vegetation determination:	Total number of dominant species = 3 Percent of dominant species that are OBL, FACW, FAC = 2/3 = 66% Therefore, the vegetation is dominated by hydrophytic species			

Dominance Test Example 3

Scientific Name	Wetland Indicator Status	Absolute Canopy Cover	Dominant	Reason
Pascopyrum smithii	FACU	45	Yes	Cumulative cover exceeds 50% total cover
Eleocharis acicularis	OBL	10	No	
Artemisia frigida	NR	2	No	
Hordeum jubatum	FACW	5	No	
Grindelia squarrosa	UPL	1	No	
Achillea millefolium	FACU	1	No	
Artemisia ludoviciana	UPL	1	No	
Opuntia polyacantha	NR	1	No	
	Total Cover	**66**		
50/20 Thresholds	50% of total cover = 33.0% 20% of total cover = 13.2%			
Hydrophytic vegetation determination:	Total number of dominant species = 1 Percent of dominant species that are OBL, FACW, FAC = 0/1 = 0% Therefore, the vegetation is not dominated by hydrophytic species			

Appendix E: Monitoring Altered, Developed, Artificial, or Fenced Sites

Many riparian and wetland areas in the Western United States have been altered and dewatered by human development and land use. Conversely, many artificial structures on the landscape (e.g., reservoirs, stock ponds) have created new riparian and wetland sites. Although alterations and construction activities have changed these sites to varying degrees or have created artificial wetlands, there may be management objectives tied to these areas that make them important for monitoring. Altered or artificial riparian and wetland areas can have ecological value and may offer important habitat for sensitive species.

Altered or artificial riparian and wetland areas may appear in a general population of randomly selected points, or they may be established as targeted sites. Because of the tremendous variety in the kinds of altered and artificial systems that may be encountered, it is not feasible to have a strict ruleset for how to approach these sites. However, this appendix provides a description of the most common types of altered and artificial riparian and wetland systems on the landscape and general guidance for monitoring them. In addition, fences are commonly encountered in riparian and wetland areas, either associated with water developments or in the form of allotment, pasture, or exclosure fences designed to protect sensitive sites or for study purposes. Therefore, this appendix also includes guidance on sampling fenced areas. This appendix should be used in combination with well-defined monitoring objectives and in consultation with the project leads to guide where and how any altered, artificial, or fenced sites are monitored. If project leads or monitoring teams need to determine the ecological potential of an altered riparian and wetland site, please see Appendix D in “Proper Functioning Condition Assessment for Lentic Areas,” Technical Reference 1737-16 (Gonzalez and Smith 2020) for detailed guidance on assessing the potential of altered or modified sites. Figures in this section are from Gonzalez and Smith (2020).

Spring/Seep Developments

Springs and seeps are groundwater discharge features that are common in the Western United States. Springs/seeps are of various sizes, may have a single or multiple discharge points, and the spatial extent of the associated wetland area can vary considerably. Some springs/seeps can support broad wetlands and may have vegetated drainageways or spring brooks that extend tens or even hundreds of meters below the discharge point(s). Some large springs form large stream systems, while small seeps may only surface for a meter or two from the discharge point and support very small wetland areas. One of the most common types of alterations are spring/seep developments where groundwater discharge is collected and diverted from the source. The primary purpose for most of these developments is to provide water for livestock, and they are commonly referred to as “water developments,” “range improvements,” or “spring improvements.”

Typically, spring/seep developments consist of a water collection system, either above or below ground, and a water distribution system (sometimes a storage tank(s) is also included). The water collection system is usually fenced to protect the area from livestock, and water is piped to a utility area where a water trough (usually made of metal, fiberglass, rubber, or plastic) or an earthen stock pond is located (Figures E1, E2, and E3). The utility area can be located in close proximity to the collection area or some distance from the source and sometimes includes multiple troughs or ponds served by a pipeline. If installed according to current best management practices, the utility area will be located outside the riparian/wetland area to avoid excessive impacts in the riparian and wetland zones. At sites where the source collection area is fenced, the fence may or may not encompass the entire riparian or wetland area.

Reservoirs and Constructed Ponds (Including Artificially Enhanced Natural Lakes and Ponds)

Reservoirs and constructed ponds are artificial structures of various sizes, are common in wildland settings, and serve to provide water storage for livestock use at the site and/or for downstream uses. Stock ponds are small, constructed water storage structures, such as pit tanks or dugouts, and are generally behind small earthen dams less than about 10 feet high. Stock ponds are designed to store small amounts of water from springs or seeps, collect and store surface runoff in intermittent or ephemeral drainages, or capture runoff from ditches along roadways. Sometimes a stock pond is placed in conjunction with a spring/seep development instead of a trough.

Reservoirs and constructed ponds (including stock ponds) are specifically designed to store water and/or to provide animals water on site. As such, they are concentration areas expected to sustain heavy site impacts and were not intended to provide riparian or wetland functions or values (Figure E4). Because there are usually no ecological values or resource objectives tied to these kinds of structures, they are not commonly monitored. Also, site potential may be limited at these areas, especially if the reservoir or pond is a simple surface water catchment. These sites are generally characterized by either deep water, bare ground, or a lack of perennial vegetation and are not intended to be monitored using this protocol. However, in some cases, reservoirs and constructed ponds may develop wetland attributes due to local hydrology, landscape position, and/or relatively light grazing pressure. As a result, there may be a desire to monitor such sites (Figure E5). Using this monitoring protocol on artificial sites that were designed for a utility purpose should be pursued with caution and tied to sound monitoring objectives with clear justification.

Many natural lakes and ponds have been modified or “artificially enhanced” to increase water storage capacity—usually by enlarging a dam and/or by excavating additional material. Many of these water bodies retain their original natural functions, provide riparian and wetland habitat and values, and have resource objectives linked to them. If that is the case, monitoring information may be important.

Boundary Fences and Exclosures not Associated with a Development

In addition to fenced seeps and spring developments, it is very common to encounter allotment or pasture boundary fences or exclosures in riparian and wetland areas. The monitoring objectives and sample design should determine the plot location and layout when these structures are encountered. It is often preferable to establish a monitoring plot either fully within or fully outside a fenced exclosure. Also, make sure that no part of the plot and transects are closer than 4 meters from the fence. This ensures that the data will reflect conditions either fully inside or outside of the fenced area. It is also important to consider possible differences in soils, hydrology, or vegetation pertinent to the fence location. Often fences are placed for a purpose, sometimes on ecotones. If any differences are observed in soils, hydrology, or vegetation inside and outside the fence, be sure to note these in detail in the plot description (Section 5.1).

General Guidance and Plot Layout

When applying the protocol to “altered” or “developed” systems, one needs to consider whether the location and layout of the plot will be modified. The following guidance provides answers to these questions in the context of random versus targeted sampling. Generally, no changes are made for random sampling. For targeted sampling, plot location and layout are typically modified to meet monitoring objectives. Also, many of these altered or developed systems can be very small; therefore, it is important to ensure that the site can accommodate three 25-m transects spaced at least 5 m apart.

Guidance for Random Sample Designs

1. Ensure that the point is within the target population, none of the rejection criterion are met (see Section 3.0), and that one of the five plot layouts can be successfully located in the riparian or wetland area.
2. Altered, developed, artificial, and fenced sites should always be flagged with information about the site in the plot description (Section 5.1) and the list of natural and human disturbances (Section 5.5).
3. Be aware that for random sample designs to represent the overall condition of a broad population, the random sample location may fall within the utility area, within an exclosure, or straddling an allotment, pasture, or exclosure fence. If the sample location falls where the plot would include area on either side of a fenced boundary, shift the plot to be entirely on one side of the boundary or the other, whichever has the most plot area before the shift. When adjusting the plot location, ensure that no sampling occurs within 4 meters of the fence to avoid fence line impacts. The monitoring plot associated with the point may also include different moisture zones and/or impact areas within the randomly selected plot. The monitoring objectives and sampling approach will dictate how these altered, developed, artificial, and fenced sites will be monitored. Some examples follow:
    a. If the objective of monitoring is to represent the overall riparian and wetland condition of all riparian and wetland areas within a management unit, on a landscape scale (e.g., a field office), no effort would be made to adjust the plot center or layout due to the presence of alterations or structures, unless the plot included areas on either side of a fenced boundary, and then it would be shifted onto the side of the boundary with the most area in the plot.
    b. If the objective is to determine the condition of riparian or wetland areas within an identified management unit (e.g., a single grazing allotment or pasture) and the random point occurs on a fenced allotment or pasture boundary, stay within the identified grazing allotment/pasture, on the correct side of the fence to be in the grazing allotment/pasture, and follow the procedures to adjust the plot and layout as described in Section 4.0. Ensure that no sample point is closer than 4 meters of the fence.

Guidance for Targeted Sample Designs

1. Targeted sites may be selected based on a number of different criteria and through different techniques. For example, they be selected because they contain attributes of concern or interest, they may be likely to show a response to a management action, or they demonstrate reference condition (see Section 3.4 for more details). In some cases, a ***zone of interest*** may be selected within a riparian or wetland area. If so, be careful to locate the whole plot within the zone of interest in

order to provide the most information to meet the monitoring objectives and show the most responses to management changes.

a. If allotment or pasture boundary fences (or exclosure fences) are present, ensure that the plot is entirely within the appropriate management unit and ensure that no sample point is closer than 4 meters of the fence.
b. Although utility areas for livestock water (trough/pond locations) should be placed outside the riparian or wetland area, some can be located within the riparian or wetland area. Note the presence of the trough or pond in plot description (Section 5.1) and the natural and human disturbances (Section 5.5) and discuss with the project lead whether the plot layout needs to be adjusted around the features or not. If the monitoring objective is to represent the whole riparian or wetland area, the plot can include troughs and ponds.
c. If wet meadows, vegetated wetland drainageways, or spring brooks are fenced within an exclosure, they could be effectively used as reference sites for similar unfenced sites (Figure E2).
d. If part of the wet meadow, vegetated wetland drainageway, and/or spring brook is fenced and part unfenced, plots could be installed inside and outside the exclosure in order to compare conditions at the same site (Figure E3).
e. Some concentrated impacts will likely occur in any riparian or wetland area associated with a spring/seep development that is not fenced. Do not locate the plot within small areas of very localized, concentrated impacts within a site (Figure E4) unless these concentrated use impact areas are causing damage (such as drainage) to the greater lentic riparian area and integrated riparian management has targeted these spots for monitoring objectives tied to management priorities.

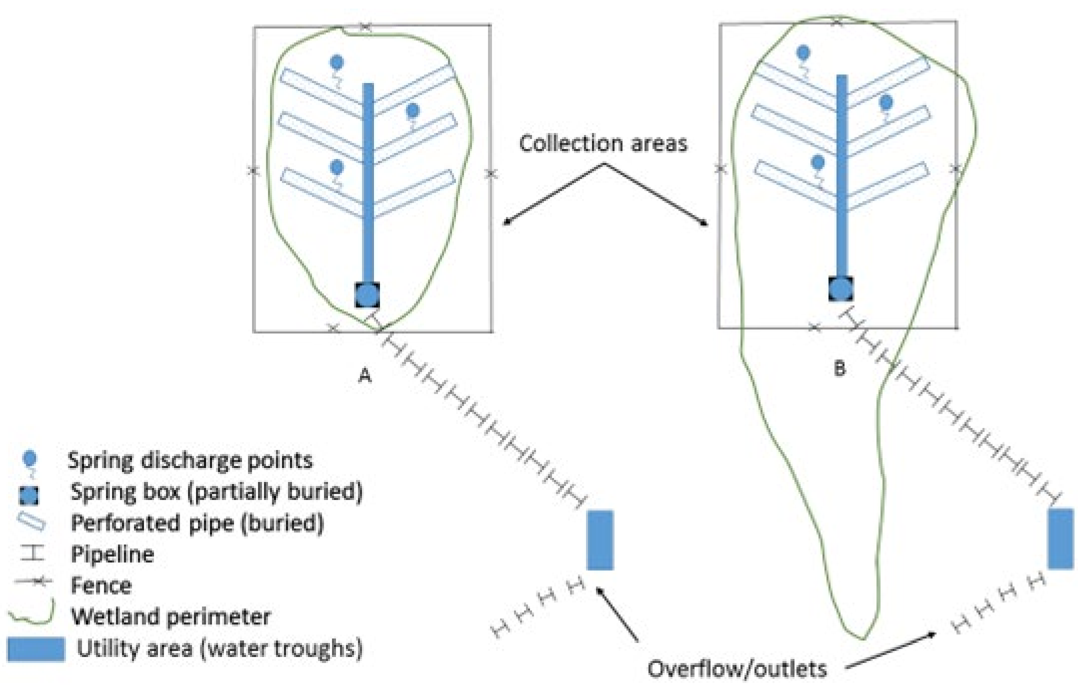


Figure E1. Schematic of a developed spring/seep showing a wet meadow (A) completely fenced and (B) only partially fenced.

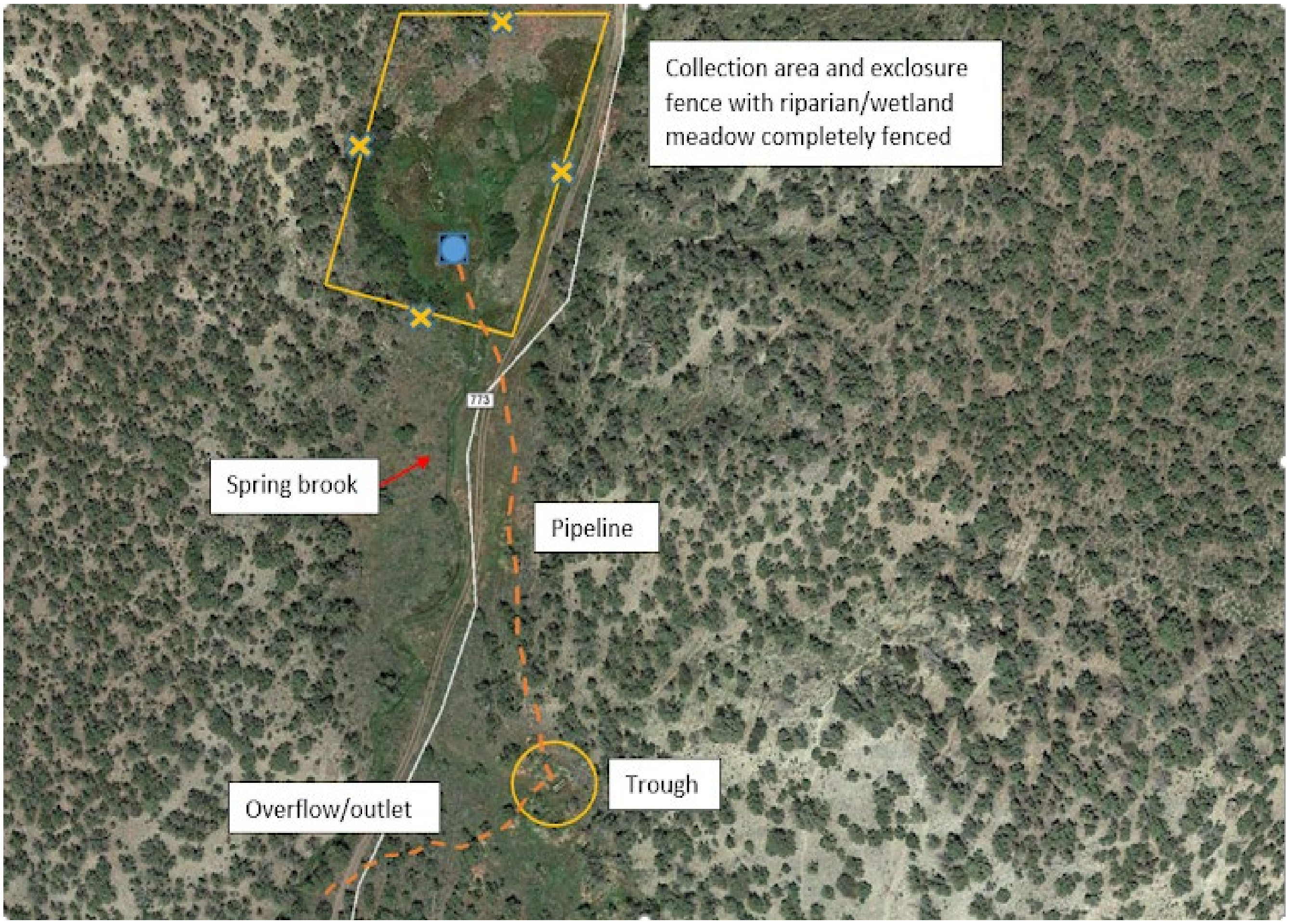


Figure E2. Overview photo of a developed spring/seep with the associated wet meadow completely fenced. This site also includes a spring brook and a trough located outside the wetland area. In this instance, the entire wetland area is fenced, and a probability-based sample point may fall anywhere within the fenced wet meadow. For targeted monitoring purposes, the wet meadow could serve as a reference for similar springs/seeps. The spring brook could be sampled with a lotic protocol, if desired.

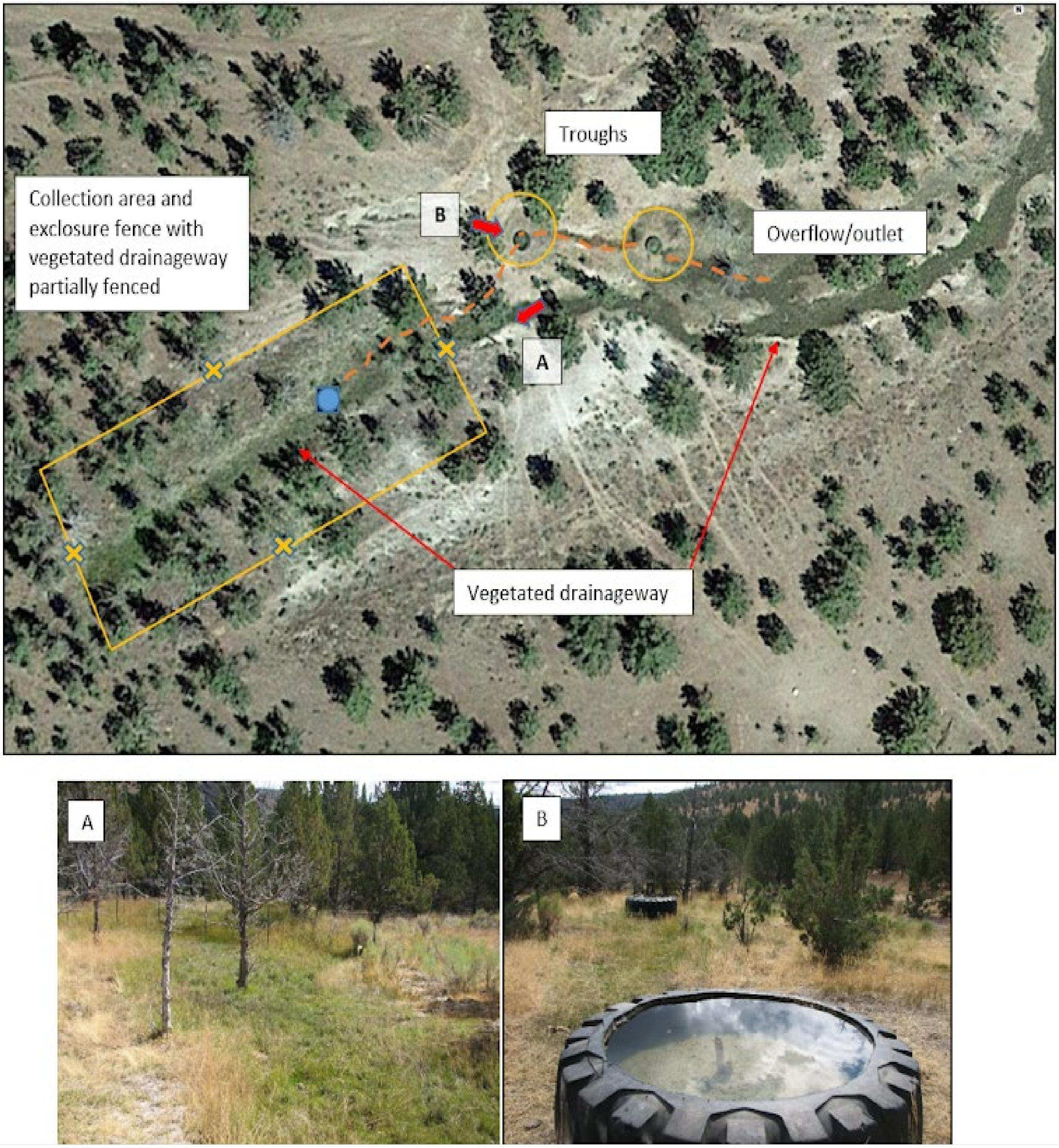


Figure E3. Developed spring/seep with the wetland (vegetated drainageway) partially fenced. The location and direction of bottom photos A and B are noted in the top photo with red arrows. Photo A shows the vegetated drainageway both outside and inside the exclosure (see fence to the rear of photo A). A probability-based sample point may fall anywhere on this site (inside or outside the fence), depending on the monitoring objective. For targeted monitoring, the plot location also depends on the monitoring objectives, and the vegetated drainageway could be sampled both inside and outside the exclosure for comparative analysis at this site.

Figure E4. Artificial stock pond constructed for livestock water. This structure was specifically designed as a livestock watering facility and, because the pond source is a combination of surface runoff and limited seasonal groundwater discharge, it has little potential to develop riparian or wetland attributes. There is a small livestock concentration zone in the vegetated drainageway between the fence and the pond. However, this small, localized impact zone is to be expected at this site. Because this pond is a designed watering facility and has little potential for developing riparian or wetland attributes, monitoring would not be recommended at this site. However, a reference plot may be installed inside the exclosure if desired to monitor the condition of the seasonally wet vegetated drainageway (provided that it meets the applicable ecosystem criteria in the Section 1.2 criteria box).

Figure E5. Small reservoir for water storage and stock water. The location and direction of the bottom photo is noted in the top photo with a red arrow. This structure was specifically designed as a water storage and livestock watering facility and is not intended to provide riparian or wetland functions or values. However, over time it has developed riparian and wetland vegetation along the shoreline. A probability-based sample point may fall anywhere along the shoreline. For targeted monitoring, the shoreline would be sampled within the vegetation community most responsive to management changes.

Appendix F: Time Estimates for Each Method

This appendix lists the estimated time requirements for each method in this protocol. Time estimates are based on averages for an experienced crew working in a variety of different riparian and wetland environments. Time requirements may vary from these ranges based on crew experience and the complexity of the plant community at a given site. Time estimates are provided for each method individually. However, some methods are carried out simultaneously. Line-point intercept (Section 6.2) and vegetation heights (Sections 6.3) are collected along the transects at the same time. Woody structure (6.4) and annual use (Section 8.0) are collected together along a separate pass of the transect. The “Where Collected” column indicates whether the method is carried out across the entire plot (P), in the center of the plot (C), along the transects (T), or in GIS. “Indicators Calculated” refers to the indicators in Table 2.

Section: Method	Method type	Where Collected	Time (hours)	# of People	Indicators Calculated
4.0: Plot Layout		P	0.5-1.5	2	NA
5.1: Plot Classification and Description	Covariate	P	0.25-0.5	1	Classification, elevation, slope and aspect
5.2: Photo Points	Covariate	P, T	0.25	2	Photo points
5.3: Hydrology and Surface Water Characteristics	Covariate	P, T	0.25-0.5	1	Water sources, aerial extent of standing water, depth of standing water, characteristics of surface water body, characteristics of channels
5.4: Soil Profile Description	Covariate	C	0.75-1.25	1	Soil color and texture, hydric soil indicators, depth of organic layer, depth to water table, depth to permafrost
5.5: Natural and Human Disturbances	Covariate	P	0.25-0.5	1	Disturbances and degree of impacts
6.1: Plant Species Inventory and Identification	Core	P	0.5-1.5	1	Species richness
6.2: Line-Point Intercept	Core	T	1.0-2.5	2	Vegetation cover and composition, ground surface attributes
6.3: Vegetation Height, Litter and Water Depths	Core	T	0.5	2	Vegetation height, litter/thatch depth, water depth
6.4: Woody Structure	Core	T	0.5-0.75	2	Woody population structure, woody canopy structure
7.1: Hummocks	Contingent	T	0.5-1.0	2	Percent cover of hummocks, hummock height, angle of side slopes, vegetation cover of side slopes
7.2: Water Quality	Contingent	C	0.25-0.5	1	pH, specific conductance, temperature, nutrients
8.2: Stubble Height	Annual Use	T	0.25	2	Stubble height
8.3: Soil Alteration	Annual Use	T	0.25	2	Soil alteration

8.4: Riparian Woody Species Use	Annual Use	T	0.5	2	Riparian woody species use
Total hours					6.5-12.25 hours
Total time for a 3-person crew[1]					4.25-7.5 hours for 2-person tasks 2.25-4.75 hours for 1-person tasks **4-8 hours total**[2]

[1] Total crew hours are based on a three-person crew. The total does not include driving and hiking time to access the site or time spent evaluating the site to verify that it is sampleable. The totals include all possible methods. In practice, it is rare that every method is carried out at one site. Sites with woody vegetation are less likely to have hummocks and vice versa. Many sites do not have surface water for water quality sampling. The total time for sampling varies widely depending on access and site conditions.

[2]Total time for completion of a site is based on the limiting factor, thus, the longer amount of time required for the 2-person tasks. It is likely the total time would actually be much less than 4-8hrs because the one crew member will complete the 1-person tasks after 2.25-4.75 hours and be able to help with the remaining 2-person tasks.

Appendix G: Field Equipment Checklist

Plot Establishment and Characterization Equipment
"Field Protocol for Lentic Riparian and Wetland Systems"
Site map(s) with monitoring points
Keys and gate combinations (as needed)
Tablet or laptop for paperless data collection (preferred) (with car and wall charger, portable USB charger, and extra battery pack or portable power bank) OR clipboard and data sheets
Mechanical pencil(s), sharpie(s), and thick dry erase marker(s)
Camera (5 megapixel minimum) with spare batteries; higher resolution may be required if photos are used for quantitative analysis (if using a tablet for data collection, the built-in camera will likely work)
Photo ID board or photo ID card on a clipboard
PVC photo pole (1.5 m long)
GPS unit with waypoints entered and spare batteries (if using a tablet for data collection, the built-in GPS function will likely work)
Pin flags (tip < 1-mm diameter) for marking plot center, transect ends, and line-point intercept method (~20)
Compass with declination adjustment
Clinometer
Chaining pins or steel stakes for tape anchors (6-10)
50-meter measuring tapes for transects (at least 1 and ideally 3 for "spoke" layout)
Metric ruler or staff gage with centimeter markings, at least 1 m long
42 x 50 cm PVC MIM frame (double Daubenmire frame) (Burton et al. 2011)
AIM monitoring multitool for height measurements (or 30-cm diameter disc)
Digital or print resources (regional plant guides and keys, guidance for field methods and soil description, maps, etc.)
[Optional] Bluetooth GPS Booster
[Optional] Range finder
Additional Hydrology, Water Chemistry, and Biota Equipment
Multiparameter water quality probe with a minimum of temperature, pH, and electrical conductivitysensors (and any accompanying cleaning and calibration materials)
Nitrile gloves (for handling water quality probe calibration supplies and first aid)
Nutrient sample bottles (if collecting water quality samples)

Water quality labels printed on Rite in the Rain paper (if collecting water quality samples)
Clear packing tape (if collecting water quality samples)
Acid stabilization materials or cooler with dry ice (if collecting water quality samples)
[Optional] Dipper cup
[Optional] Flow measurement equipment (flow meter, v-notch weir, or graduated cylinder and stopwatch)
Additional Soil Equipment
Shovel (sharpshooter or tile spade with 40-cm blade recommended)
Soft measuring tape for measuring soil horizons (in metric units)
Soil knife or trowel with a 7-inch blade
Nails, golf tees, or other markers for soil horizon boundaries
Atomizer/spray bottle with clean water
“Munsell Soil Color Book”
Ecological site descriptions and soil series/map unit descriptions (where available)
“Field Indicators of Hydric Soils in the United States: A Guide for Identifying and Delineating Hydric Soils,” Version 8.2 (NRCS 2018)
“Field Book for Describing and Sampling Soils,” Version 3.0 (Schoeneberger et al. 2012)
Additional Species Inventory, Line-Point Intercept, and Microtopography Gap Equipment
Line-point intercept pointer (a straight piece of wire, such as a long pin flag, at least 75 cm long and 1 mm or less in diameter; best if wrapped in brightly colored tape or flagging to facilitate use in dense herbaceous vegetation)
Graduated survey rod or height measuring stick with graduations in cm and m, such as an avalanche probe)
Hand lens and small ruler for plant identification
Plant press with dual straps
Blotter paper and newspaper for pressed plants
Masking tape (for labeling plant specimens)
Plastic bags and cooler (optional) for storing plant samples if they will be pressed following the field visit
[Optional] Dissecting scope for plant keying out of the field
Other Personal and Group Gear
Drinking water and snacks
Knee-high muck boots
Decontamination supplies – 25% bleach solution in spray bottle, scrub brush (with long handle), and rubber gloves, along with extra bleach (fresh), water, and a small funnel for mixing new solution

Bright flagging for all small field equipment (pencils, camera, electronics cases, etc.)
First aid kit with sufficient supplies for field crew
Sunscreen, sunglasses, hat, and other sun protection clothing
Waterproof field notebook for additional field notes
[Optional] Bug head net and bug spray
[Optional] Emergency satellite messenger with activated subscription
[Optional] Waders or hip boots (for sites with deeper water). Felt soles are strongly discouraged and are illegal in some states, as they are more likely to transport aquatic invasive species.

Appendix H: Gear Decontamination

To prevent the spread of aquatic invasive species, decontaminate all equipment that has come in contact with water after every site. Gear decontamination is needed to prevent the spread of invasive and harmful organisms such as New Zealand mudsnails, chytrid fungus, and whirling disease parasites. Decontamination should be conducted in the field with dilute solution prior to entering or sampling a new site. At the end of a hitch, gear decontamination can occur in the field or upon returning to the field office.

Materials:

- Super HDQ Neutral
- 1-gallon pump sprayer
- Scrub brush (with long handle)
- Tap water

Method:

1. The recommended disinfectant is Super HDQ Neutral. A concentration of 0.8% is required for effective spray-application decontamination. This can be obtained by diluting 6.2 ounces of Super HDQ Neutral in 1 gallon of water.
2. Prior to entering the field, mix the solution in a well-sealed 1-gallon pump sprayer (commonly used in herbicide application), labeled “toxic.”
3. After completing a site where gear has come in contact with water, lay out all exposed equipment, footwear, etc., on flat ground at least 100 feet away from any body of water.
4. Clean mud, vegetation, and any debris off equipment and footwear using scrub brush or water.
5. Apply an even layer of disinfectant to all exposed equipment (measuring tapes, shovel, muck boots). Equipment should be fully covered in disinfectant solution for at least 10 minutes. Reapplication may be necessary.
6. Allow decontaminated gear to air dry. When possible, rinse with clean tap water to prevent equipment degradation.

Safety Precautions

Concentrated Super HDQ Neutral has toxic ingredients and:

- Is harmful if swallowed.
- Is harmful if inhaled.
- Can cause severe skin burns and serious eye damage.
- May cause an allergic reaction of the skin.

When handling concentrated or diluted Super HDQ Neutral solution, be sure to wear proper personal protective equipment. It is strongly advised that concentrated Super HDQ Neutral not be taken into the field and that diluted solutions are only mixed prior to leaving for the field where running water and emergency medical care is readily accessible. Do not repackage Super HDQ Neutral; if a hazardous level of exposure occurs, the label will be readily available to provide to an emergency responder or poison control center.

Follow these guidelines to avoid harmful exposure:

- Mix concentrate prior to leaving for the field.
- Make sure to wear chemical-resistant gloves, eye protection, boots, and long sleeves when mixing concentrate and decontaminating equipment.
- Wash hands and any exposed skin thoroughly after handling.
- Do not eat, drink, or smoke when using this product.
- Use only outdoors or in a well-ventilated area.
- Do not breathe mist vapors or spray.

In case of exposure:

- If in the eyes, rinse with water for several minutes.
- If swallowed, rinse mouth. Do not induce vomiting. Contact poison control if necessary.
- If inhaled, move to fresh air, and keep at rest in a position comfortable for breathing.

Appendix I: Data Sheets

202__ BLM Riparian and Wetland AIM Photos

Site ID ________________

T-_______ / Dir ________

Date _____/_____/ 202_

R&W AIM WQ Sample
Plot ID: ____________________
State (geographic):_____________
Date: ______________________
Site Name: _________________
Original □ Blank □ Duplicate □
Tech Initials: ________________

R&W AIM WQ Sample
Plot ID: ____________________
State (geographic):_____________
Date: ______________________
Site Name: _________________
Original □ Blank □ Duplicate □
Tech Initials: ________________

R&W AIM WQ Sample
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State (geographic):_____________
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R&W AIM WQ Sample
Plot ID: ____________________
State (geographic):_____________
Date: ______________________
Site Name: _________________
Original □ Blank □ Duplicate □
Tech Initials: ________________

R&W AIM PLANT SPECIMEN LABEL

Plot ID: _____________ Visit Date: ________

Unknown Code: _______________________

State: _______ County: ________________

Temp Name:

Collector Name(s):

Abundance of Species (fill circle):

o Present o Occasional o Common

o Ubiquitous

Habitat:

Growth Habit:

R&W AIM PLANT SPECIMEN LABEL

Plot ID: _____________ Visit Date: ________

Unknown Code: _______________________

State: _______ County: ________________

Temp Name:

Collector Name(s):

Abundance of Species (fill circle):

o Present o Occasional o Common

o Ubiquitous

Habitat:

Growth Habit:

R&W AIM PLANT SPECIMEN LABEL

Plot ID: _____________ Visit Date: ________

Unknown Code: _______________________

State: _______ County: ________________

Temp Name:

Collector Name(s):

Abundance of Species (fill circle):

o Present o Occasional o Common

o Ubiquitous

Habitat:

Growth Habit:

R&W AIM PLANT SPECIMEN LABEL

Plot ID: _____________ Visit Date: ________

Unknown Code: _______________________

State: _______ County: ________________

Temp Name:

Collector Name(s):

Abundance of Species (fill circle):

o Present o Occasional o Common

o Ubiquitous

Habitat:

Growth Habit:

Appendix J: Cowardin Classification

Note: The content in this appendix is adapted from Cowardin et al. 1979, USFWS 2009, and FGDC 2013. Hints specific to the Western United States are added to the water regimes in [brackets].

There are multiple nationally recognized classification systems for riparian and wetland areas, as well as local or colloquial classification systems used in different parts of the country. For this protocol, each plot will be classified by the two most widely used wetland classification systems, the Cowardin classification system used by the U.S. Fish and Wildlife Service for National Wetland Inventory mapping and the hydrogeomorphic (HGM) classification (Appendix K).

The Cowardin classification system is a hierarchical system for classifying wetlands and deepwater habitats and is based on water body type, vegetative life form, and hydrologic regime and is applicable to all wetlands and deepwater habitats across the Unites States. At the highest level, the Cowardin classification system includes five broad types of wetlands and deepwater habitats (called systems): marine, estuarine, riverine, lacustrine, and palustrine. Most vegetated freshwater wetlands fall within the palustrine system. This appendix provides descriptions of Cowardin systems, classes, water regimes, and special modifiers and, lastly, examples of Cowardin codes.

Cowardin Systems

Palustrine (P): The palustrine system includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, regardless of their landscape position and proximity to water bodies. For the Cowardin classification, wetlands are lands where saturation influences the types of plant and animal communities living in the substrate and on its surface. The single feature that most wetlands share is a substrate that is at least periodically saturated with or covered by water, which creates severe physiological problems for plants and animals that are not specially adapted to saturated conditions.

Cowardin et al. (1979) defines wetlands as: “Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification, wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.”

Nonwetland Riparian (Rp): The riparian system is used for areas where plant communities do not meet the palustrine definition but are contiguous to and influenced by surface and subsurface hydrology of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have one or both of the following characteristics: (1) distinctly different vegetative species than adjacent areas and (2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms.

When used alongside the palustrine system for this protocol, the nonwetland riparian system should be used for areas located adjacent to water bodies that lack hydric soils and are dominated by mesophytic facultative (FAC) and upland (UPL) vegetation. One example of a nonwetland riparian system would be a cottonwood gallery forest with an upland understory located on a disconnected floodplain with nonhydric soil. The presence of the cottonwood overstory would make the site sampleable, but the upland understory would make the site nonwetland riparian (Rp) and not palustrine. Sites located adjacent to water bodies that have hydric soil or are dominated by obligate (OBL) or facultative wetland (FACW) species would be classified as palustrine.

Rp codes should be followed by a Cowardin class (only emergent, scrub-shrub, and forested apply) but no water regimes or modifiers.

Cowardin Classes

Emergent (EM): Characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants.

Scrub-Shrub (SS): Includes areas dominated by woody vegetation that is less than 6 m (20 ft) tall. Woody vegetation includes true shrubs, young trees (saplings), and trees or shrubs that are small or stunted due to environmental conditions.

Forested (FO): Wetlands dominated by woody vegetation that is 6 m (20 ft) tall or taller.

Aquatic Bed (AB): Includes wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years.

Moss/Lichen (ML): Includes areas where mosses or lichens cover substrates other than rock. This class is found in the northern regions of the conterminous U.S. and Alaska.

Unconsolidated Bottom (UB): Includes all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7 cm) and a vegetative cover less than 30%.

Unconsolidated Shore (US): Wetlands with less than 75% areal cover of stones, boulders, or bedrock AND with less than 30% vegetative cover AND are irregularly exposed due to seasonal or irregular flooding and subsequent drying.

Cowardin Water Regimes (in order from driest to wettest)

Intermittently Flooded (J): The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. **Weeks, months, or even years may intervene between periods of inundation.** The dominant plant communities under this water regime may change as soil moisture conditions change. This water regime is generally limited to the arid West. [Used for some playas and ephemeral washes. This water regime is highly stochastic. It is possible, but not likely, for most riparian and wetland areas sampled with this protocol. This is the driest water regime.]

Temporarily Flooded (A): Surface water is present for **brief periods during the growing season**, but the water table usually lies well below the soil surface for most of the season. Plants that grow both in uplands and wetlands are characteristic of the temporarily flooded regime. [Used for mesic meadows, drier floodplains, temporarily flooded playas, and prairie potholes.]

Seasonally Saturated (B): The substrate is **saturated at or near the surface** for extended periods during the growing season, but **unsaturated conditions prevail by the end of the season** in most years. Surface water is typically absent but may occur for a few days after heavy rain and upland runoff. [Used for wet meadows that are more groundwater-fed rather than flooded by a river or stream.]

Seasonally Flooded (C): Surface water is present for **extended periods especially early** in the growing season but is absent by the end of the season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface. [Used for seasonally flooded wet meadows and riparian shrublands.]

Permanently Saturated (D): The substrate is **saturated at or near the surface throughout the year** in all, or most, years. Widespread surface inundation is rare, but water may be present in shallow depressions that intersect the groundwater table, particularly on a floating peat mat. [Used for fens, bogs, muskegs, and other peatlands with perennial saturation. Can be used for some spring systems.]

Seasonally Flooded/Saturated (E): Surface water is present for **extended periods** (generally for more than a month) during the growing season but is absent by the end of the season in most years. When surface water is absent, the **substrate typically remains saturated** at or near the surface. [Used for floodplains with beaver influence or high regional groundwater discharge from surrounding slopes, particularly at higher elevations.]

Semipermanently Flooded (F): Surface water persists **throughout the growing season** in most years. When surface water is absent, the water table is usually at or very near the land surface. [Used for stable marshes and large spring systems with surface water.]

Intermittently Exposed (G): Surface water is present **throughout the year** except in years of extreme drought. This is applied to large ponds and shallow lakes where the water does not appear likely to dry up. [Used for large ponds, lakes, and large rivers. This water regime is not used for vegetated wetlands.]

Permanently Flooded (H): Water covers the substrate **throughout the year in all years**. Mostly applied to deepwater habitats such as lakes where there is no chance of drying. [Used for large ponds, lakes, and large rivers. This water regime is not used for vegetated wetlands.]

Cowardin Special Modifiers

Beaver (b): These wetlands have been created or modified by beaver (*Castor canadensis*). Dam building by beaver may increase the size of existing wetlands or create small impoundments that are easily identified on aerial imagery.

Excavated (x): This modifier is used to identify wetland basins or channels that were excavated by humans.

Partially Drained/Ditched (d): A partly drained wetland that has been altered hydrologically, but soil moisture is still sufficient to support hydrophytes. Drained areas that can no longer support hydrophytes are not considered wetland. This modifier is also used to identify wetlands containing, or connected to, ditches. This modifier can be applied even if the ditches are too small to delineate. The excavated modifier should be used to identify ditches that are large enough to delineate as separate features; however, the partly drained/ditched modifier also should be applied to the wetland area affected by the ditching.

Diked/Impounded (h): These wetlands have been created or modified by a man-made barrier or dam that obstructs the inflow or outflow of water.

Examples of Cowardin Codes

To classify riparian and wetland areas with the Cowardin classification, combine the codes for the system, class, and water regime. The following are examples of types of wetlands and how they would be coded for wetland mapping purposes.

1. Cattail marsh that has standing water for most of the year: **PEMF**
2. A prairie pothole dominated by grasses and sedges that is only wet at the beginning of the growing season: **PEMA**
3. A fen dominated by graminoids in the subalpine zone: **PEMD**
4. A small shallow pond that has lily pads and other floating vegetation and holds water throughout the growing season: **PABF**
5. A small shallow pond with less than 30% vegetation and a muddy substrate that holds water for most of the year: **PUBF**
6. A wetland dominated by willows adjacent to a stream that is periodically flooded: **PSSA**
7. Dry cottonwood gallery forest along the floodplain: **Rp1FO**

Appendix K: Hydrogeomorphic Types

Note: The content in this appendix is adapted from Hruby 2004 and Williams et al. 2010.

There are multiple nationally recognized classification systems for riparian and wetland areas, as well as local or colloquial classification systems used in different parts of the country. For this protocol, each plot will be classified by the two most widely used wetland classification systems, the Cowardin classification system (Appendix J) used by the U.S. Fish and Wildlife Service for National Wetland Inventory mapping and the hydrogeomorphic classification.

Hydrogeomorphic classification is a system for classifying wetlands developed by Brinson (1993) for the U.S. Army Corps of Engineers and further developed for wetland functional assessments (Smith et al. 1995). The hydrogeomorphic system of classification is based on the geomorphic or topographic position of a wetland, water sources and water transport, and hydrodynamics of wetland systems. At the highest level of hydrogeomorphic classification, wetlands are grouped into seven classes including slope, depressional, riverine, lacustrine fringe, tidal fringe, mineral flat, and organic flat. This appendix provides descriptions of the hydrogeomorphic classes and dichotomous key to help determine the class (Table K1).

Slope wetlands are normally found where there is a discharge of groundwater to the land surface or on sites with saturated overland flow and little to no channel formation. The predominant source of water is groundwater or subsurface flow discharging at the land surface, including from snowmelt. They normally occur on slightly to steeply sloping land, but slope wetlands can occur in nearly flat landscapes if groundwater discharge is the dominant water source. Slope wetlands primarily lose water by saturation subsurface and surface flows and by evapotranspiration. **The hydrodynamics of slope wetlands are dominated by downslope unidirectional water flow.** Slope wetlands may develop small channels, but the channels serve only to convey water away from the slope wetland.

Slope wetlands differ from riverine wetlands because they are not subject to overbank flooding. Slope wetlands are often headwater wetlands. Within a watershed, slope wetlands may transition into riverine wetlands downslope as channels form and accumulate enough flow to cause overbank flooding. Slope wetlands may also occur on the margins of stream valleys where groundwater from surrounding slopes discharges, passes through a wetland, then feeds into the stream. In these instances, slope wetlands may occur adjacent to riverine wetlands directly along the stream. Slope wetlands are distinguished from depressional wetlands by the lack of a closed topographic depression and the predominance of the groundwater/interflow water source. Though small, shallow pools may occur within the slope wetlands. Water generally leaves the wetland without impoundment. Fens and many wet meadows are common examples of slope wetlands.

Depressional wetlands occur in topographic depressions that allow the accumulation of surface water by ponding or saturation to the surface. Potential water sources are precipitation, overland flow, or groundwater flow from adjacent uplands. The direction of flow is normally from the surrounding uplands toward the center of the depression. Elevation contours are closed (though they may not be apparent on contour maps), thus allowing the accumulation of surface water. Depressional wetlands may have any combination of small inlets and outlets or lack them completely. **The hydrodynamics of depressional wetlands are dominated by vertical fluctuations of water flowing into the depression and evaporating out or discharging to the groundwater.** Depressional wetlands may lose water through intermittent or perennial drainage from an outlet, by evapotranspiration and, if they are not receiving groundwater discharge, may slowly contribute to groundwater.

Depressional wetlands differ from slope wetlands because depressional wetlands receive inputs from the entire landscape surrounding the depression while slope wetlands receive inputs from only one side (the upslope side of the landscape). Depressional wetlands grade into riverine wetlands when depressions are located near the floodplain of a perennial stream or along an ephemeral stream corridor. To be classified as depressional in these instances, the wetlands must occur at locations higher than the actual floodplain and be flooded by seasonal overbank flooding only in extreme high water years. Depressional wetlands differ from lacustrine fringe wetlands because the water body associated with lacustrine fringe wetlands must be at least 8 ha in size and must contain water 2 m or deeper. Prairie potholes, kettle ponds, and vernal pools are common examples of depressional wetlands.

Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow, backwater flow from the channel, or subsurface hydraulic connections between the stream channel and the wetland through alluvial groundwater or hyporheic flow. Additional sources may be interflow and return flow from adjacent uplands, occasional overland flow from adjacent uplands, tributary inflow, and precipitation. **The hydrodynamics of riverine wetlands are dominated by horizontal and unidirectional flow, with periodic high-energy events.** Perennial flow in the channel is not a requirement. Overbank flooding does not need to occur every year to meet the riverine classification.

Riverine wetlands can contain depressions that remain filled after the river has flooded, such as oxbows and beaver ponds. As long as these features receive surface water inputs from overbank flooding or backwater channels on a regular (~every 5 years) interval, they are considered riverine. In headwaters, riverine wetlands often are replaced by slope or depressional wetlands where the channel morphology is less distinct. Riverine wetlands differ from slope wetlands because the dominant water sources are overbank or backwater flow from the channel and not groundwater inputs. Riparian willow shrublands on floodplains and beaver ponds are examples of riverine wetlands.

Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. Additional sources of water are precipitation and groundwater discharge. However, groundwater discharge should not be the primary water source. Lacustrine fringe wetlands lose water by flow returning to the lake after flooding, by saturation surface flow, and by evapotranspiration. **The hydrodynamics of lacustrine fringe wetlands are dominated by bidirectional surface water flow, meaning water levels rise and fall with lake levels and with wave action.** Lacustrine fringe wetlands must meet all the following criteria: (a) the wetland must be on the shores of a permanent open water body at least 8 ha in size; (b) at least 30% of the open water must be deeper than 2 m; and (c) vegetation in the wetland experiences bidirectional flow as the result of vertical fluctuations of water levels due to rising and falling lake levels and/or wave action.

Lacustrine fringe wetlands differ from depressional wetlands because the water body associated with the wetlands are much larger (at least 8 ha in size and 2 m deep). Lacustrine fringe wetlands differ from slope wetlands because they have bidirectional surface water flow. Some wetlands that border lakes meeting the size requirements for lacustrine fringe wetlands are snowmelt and/or groundwater-fed, meaning they experience unidirectional flow and should be classified as slope wetlands. If they have bidirectional surface water flow, different vegetation zones along the lakeshore should be apparent. Large reservoir shores and marshes bordering lakes are common examples of lacustrine fringe wetlands.

Flat wetlands are most common on extensive relic lake bottoms or large historical floodplain terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressional and slope wetlands. **The hydrodynamics of flat wetlands are dominated by vertical fluctuations (precipitation in and evapotranspiration out).** They are distinguished from flat upland areas by their poor vertical drainage, often due to impermeable layers and hardpans, slow lateral drainage, and low hydraulic gradients. Flats can occur in settings where poor drainage and level topography cause rainwater to pond at or near the soil surface. Mineral soil flats lose water through evapotranspiration, saturated overland flow, and seepage to underlying groundwater. Large playas and greasewood flats with virtually no slope that flood due to impermeable hardpan soil (oftentimes with a saline crust) are examples of mineral soil flat wetlands in the Intermountain West region. Wetland prairies are also common mineral soil flat wetlands in the Pacific Northwest region. Organic soil flats have organic soils. Ombotrophic (rainwater-fed) peatlands (bogs) and some swamps are examples of organic soil flats. These systems differ from mineral soil flats because their elevation and topography are controlled by the vertical accretion of organic matter. They occur in relatively humid environments that are either cold (far northern climates) or warm (Southeastern Unites States). They are common in Alaska but extremely uncommon in the Western United States outside of Alaska.

Table K1. Dichotomous key to determine hydrogeomorphic class.

1a. Entire wetland unit is flat and precipitation is the primary source (> 90%) of water. Groundwater and surface water runoff are not significant sources of water to the unit. **NOTE:** *Flat wetlands are very uncommon in the Rocky Mountains and Intermountain West but can occur in the Pacific Northwest and Alaska.* .... **Flats HGM Class**

1b. Wetland does not meet the 1a criteria; primary water sources include groundwater and/or surface water ... **2**

2a. Entire wetland unit meets all of the following criteria: (a) the vegetated portion of the wetland is on the shores of a permanent open water body at least 8 ha (20 acres) in size; (b) at least 30% of the open water area is deeper than 2 m (6.6 ft); (c) vegetation in the wetland experiences bidirectional flow as the result of vertical fluctuations of water levels due to rising and falling lake levels. .... **Lacustrine Fringe HGM Class**

2b. Wetland does not meet the 2a criteria; wetland is not found on the shore of a water body, water body is either smaller or shallower, OR vegetation is not affected by lake water levels **3**

3a. Entire wetland unit meets all of the following criteria: (a) wetland unit is in a valley, floodplain, or along a stream channel where it is inundated by overbank flooding from that stream or river; (b) overbank flooding occurs at least once every 5 years; and (c) wetland does not receive significant inputs from groundwater. **NOTE:** Riverine wetlands can contain depressions that are filled with water when the river is not flooding such as oxbows and beaver ponds. However, depressions on the floodplain that are not strongly influenced by flooding would be classified as true depressions. These include depressions disconnected due to modified hydrology and channel entrenchment and impounded managed wetlands. .... **Riverine HGM Class**

3b. Wetland does not meet the 3a criteria; if the wetland is located within a valley, floodplain, or along a stream channel, it is outside of the influence of overbank flooding or receives significant hydrologic inputs from groundwater or managed hydrology.. **4**

4a. Entire wetland unit is located in a topographic depression in which water ponds or is saturated to the surface at some time during the year. **NOTE:** Any outlet, if present, is higher than the interior of the wetland. .... **Depressional HGM Class**

4b. Wetland unit meets the following criteria: (a) wetland is on a slope (slope can be very gradual or nearly flat); (b) natural groundwater is the primary hydrologic input; (c) water, if present, flows through the wetland in one direction and usually comes from seeps or springs; and (d) water leaves the wetland without being impounded. **NOTE:** Small channels can form within slope wetlands but are not subject to overbank flooding. Surface water does not pond in these types of wetlands, except occasionally in very small and shallow depressions or behind hummocks (depressions are usually < 3 ft diameter and less than 1 ft deep). .... **Slope HGM Class**

Appendix L: General Wetland Types

Note: The content in this appendix is generalized from the "User Guide for Wetland Assessment and Monitoring in Natural Resource Damage Assessment and Restoration" (Comer et al. 2003). More information on the Ecological System Classification can be found at: www.natureserve.org/products/terrestrial-ecological-systems-united-states.

Wet or Mesic Meadow. Herbaceous wetlands dominated by graminoids (sedges, grasses, and rushes) with mineral soils and a fluctuating water table. These wetlands are found throughout Western United States, including Alaska, from low elevations to the alpine. Wet meadows occupy wet sites with low-velocity surface and subsurface flows, typically on flat areas or gentle slopes, but they also may be found on slopes up to 10%. In montane and subalpine valleys, these wetlands occur as large open meadows at the base of toeslope seeps or as narrow strips bordering ponds, lakes, and streams. In the alpine, these wetlands typically occupy small depressions located below late-melting snow patches or snowbeds. In Alaska, permafrost can maintain soil saturation in wet meadows. Wet meadow soils are mineral but may have a top layer of organic matter known as a ***histic epipedon***. In either case, soils show typical hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. This system often occurs as a mosaic of several plant associations and may be found adjacent to a variety of shrub communities. Wet meadows are often dominated by graminoids such as sedges *(Carex)*, other members of the sedge family, and hydrophytic grasses, although forb cover may be substantial in areas at higher elevations. Low cover of shrubs may occur in some meadows, particularly low shrubs such as shrubby cinquefoil *(Dasiphora fruticosa),* dwarf birch *(Betula nana)*, Labrador tea (*Ledum)*, and blueberry *(Vaccinium*). Mesic meadows share similar characteristics to wet meadows but are only temporarily flooded or saturated, and the species composition is more mesic and includes more grasses and fewer sedge species. If the dimensions of the wet or mesic meadow are near or smaller than 60 m x 200 m, also consider the definitions of springs (for smaller systems) or vegetative drainageway (for long, narrow systems). However, narrow herbaceous wetland vegetation along sizable streams, lakes, or ponds fits within the wet or mesic meadow type.

- **Cowardin System and Class:** PEM, occasionally RpEM
- **Cowardin Water Regime:** A, B, C, E, occasionally J
- **HGM Class:** slope, riverine, occasionally depressional, lacustrine fringe

Marsh. Herbaceous wetlands with permanent to semipermanent standing water that support aquatic, submerged, and coarse emergent plants. Marshes may occur in depressions (impounded ponds or kettle ponds), on lake fringes, within riparian and floodplain areas (beaver ponds, backwater channels, oxbows, or sloughs), around high discharge springs, and in tidal or estuarine areas. Marshes are frequently or continually inundated, with water depths up to 2 m. Water levels may be stable or may fluctuate 1 m or more over the course of the growing season. Hydrologic inputs include direct precipitation, surface water inflows including tidal inflow, and groundwater discharge. Marshes in Alaska may occur in areas of permafrost than limit soil draining. Marshes have distinctive soil characteristics that result from long periods of anaerobic conditions in the soils (e.g., gleyed soils, high organic content, redoximorphic features). The vegetation is characterized by herbaceous plants that are adapted to saturated soil conditions. Common emergent and floating vegetation include species of bulrush (*Scirpus* and/or *Schoenoplectus*), cattail (*Typha*), rush (*Juncus*), sedge *(Carex),* pondweed (*Potamogeton*), smartweed (*Polygonum*), pondlily (*Nuphar*), and canarygrass (*Phalaris*). This system may also include areas of relatively deep water with floating-leaved plants, such as duckweed (*Lemna*), and submerged and floating plants, such as watermilfoil (*Myriophyllum*), hornwort (*Ceratophyllum*), and waterweed (*Elodea*). Marsh vegetation is occasionally bordered by woody species such as cottonwood (*Populus* spp.) and willow (*Salix* spp.).

- **Cowardin System and Class:** PEM, PAB
- **Cowardin Water Regime:** C, E, F, occasionally D
- **HGM Class:** depressional, slope, riverine, lacustrine fringe

Riparian Shrubland or Shrub Wetland.

Woody wetlands dominated (at least 25% canopy cover) by shrub species. These systems often occur adjacent to stream and river channels in a variety of geomorphic settings throughout the Western United States (riparian shrublands). They can also occur away from valley bottoms on slopes with high groundwater discharge from seeps, springs, or snowmelt (shrub wetlands). For systems located on floodplains, seasonal and episodic flooding is often the hydrologic driver and is essential to maintaining an array of plant associations. Beaver activity is often associated with the development of riparian shrublands and can profoundly change vegetation structure and alter hydrologic regimes. In boreal ecosystems such as Alaska, these systems are also called "water tracts." Vegetation in this system is variable, often characterized by a mosaic of woody shrub- and herb-dominated communities. Component plant associations vary with elevation, stream gradient, depth to groundwater, inundation durations, floodplain width, and flooding frequency. Vegetation communities usually include willows *(Salix) and* other hydrophytic shrubs. Exotic trees and shrubs such as Russian olive *(Elaeagnus angustifolia),* crack willow *(Salix fragilis),* and tamarisk *(Tamarix* spp.*)* can be common in some stands.

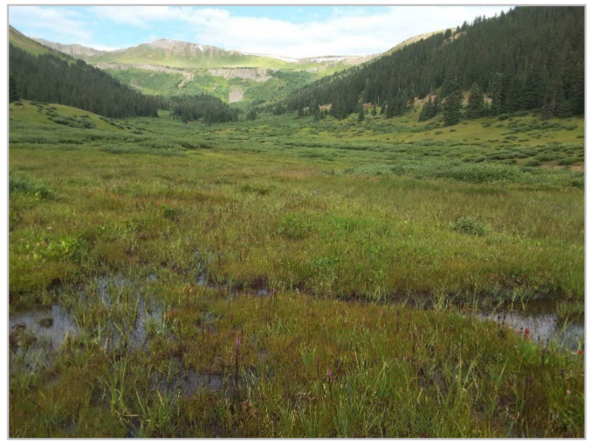
- **Cowardin System and Class:** PSS, RpSS
- **Cowardin Water Regime:** A, C, E, occasionally J, B
- **HGM Class:** riverine, lacustrine fringe, slope

Riparian Forest or Woodland.

Woody wetlands dominated (at least 25% canopy cover) by tree species. Like riparian shrublands, riparian forest or woodland systems (sometimes called "bosques") often occur adjacent to stream and river channels in a variety of geomorphic settings throughout the Western United States. Seasonal and episodic flooding and local alluvial groundwater are the hydrologic drivers of this ecosystem and essential to maintaining an array of riparian plant associations. Beaver activity is often associated with the development of riparian forests and influences vegetation structure and hydrologic regimes. Vegetation in this system is variable, often characterized by a mosaic of tree- and herb-dominated communities. Component plant associations vary with elevation, stream gradient, depth to groundwater, inundation durations, floodplain width, and flooding frequency. Vegetation communities can include cottonwood (*Populus*), boxelder (*Acer negundo*), alder (*Alnus*), and sycamore (*Platanus*). Exotic trees and shrubs such as Russian olive (*Elaeagnus angustifolia*), crack willow (*Salix fragilis*), and tamarisk (*Tamarix*) can be common in some stands.

- **Cowardin System and Class:** PFO, RpFO
- **Cowardin Water Regime:** A, C, E, occasionally J
- **HGM Class:** riverine, lacustrine fringe

Fen or Bog. Fens and bogs are two types of perennially saturated peatlands (wetlands with organic or "peat" soil that is at least 40 cm thick). Fens and bogs are differentiated by water source and connection to the groundwater table. Fens are groundwater-fed peatlands confined to specific environments where groundwater discharge is sufficient to maintain permanent saturation, which slows decomposition and leads to a buildup of organic soil. Fens form throughout the Western United States in natural depressions (basin fens) or at the base of slopes where groundwater intercepts the soil surface (slope fens). In the contiguous U.S., they are more prevalent in higher elevations where cool temperatures slow decomposition. Bogs are peatlands with no significant inflows or outflows. Bogs receive all soil moisture from precipitation rather than groundwater or surface water inflow and only occur in areas like Alaska, where precipitation is consistently high and temperatures are consistently cool during the growing season. Lacking a connection to the groundwater, which carries minerals from the surrounding landscape, bogs have relatively acidic waters and low nutrient content for plant growth. Bog vegetation is dominated by acidophilic vascular plants and mosses, particularly sphagnum. Fens and bogs are often classified by water chemistry and floristic composition into the categories of rich fens, intermediate fens, poor fens, and bogs. The latter two are floristically similar, despite hydrologic differences. Fens and bogs can be dominated by graminoids, shrubs, or trees, often occur as a mosaic of several plant associations, and can support numerous rare species and community types. The most common dominant species include water sedge (*Carex aquatilis*), beaked sedge (*Carex rostrata*), other sedge species (*Carex* spp.), as well as spikerushes (*Eleocharis* spp.), bog sedges (*Kobresia* spp.), cottongrass (*Eriophorum* spp.), and rushes (*Juncus* spp.). Common forbs include elephanthead lousewort (*Pedicularis groenlandica*), redpod stonecrop (*Rhodiola rhodantha*), marsh marigold (*Caltha leptosepala*), and felwort (*Swertia perennis*). Sites with a woody component may be dominated by shrubs, such as willow (*Salix),* birch *(Betula),* shrubby cinquefoil *(Dasiphora fruticosa),* Labrador tea (*Ledum)*, leatherleaf *(Chamaedaphne calyculata)* and sweetgale *(Myrica gale*), or even coniferous trees. Alaskan fens and bogs are commonly dominated by black spruce (*Picea mariana*) with or without tamarack (*Larix laricina*). Engelmann spruce (*Picea engelmannii*) or lodgepole pine (*Pinus contorta*) occasionally contribute cover to fens throughout the Western U.S. and Alaska. In Alaska, a common mosaic of fens and lodgepole pine (*Pinus contorta*) woodland is called a "muskeg." Bryophyte diversity is generally high and includes brown mosses and sphagnum (*Sphagnum* spp.).



- **Cowardin Class:** PEM, PSS, PFO
- **Cowardin Water Regime:** D, occasionally B, E
- **HGM Class:** slope, depressional, flat

Black Spruce Wet Forest. Forested wetlands of Alaska dominated by black spruce *(Picea mariana*), generally growing with a stunted growth form in a sparse to open canopy (10-30% canopy cover). This type has poorly drained mineral soil and does not include fens and bogs dominated by black spruce, but the soil may have a well-developed peat layer in the upper part composed of decomposing woody material (shrub and tree) and moss- or sedge-dominated peats. Black spruce wet forests are common on north-facing slopes, gentle hills, and inactive alluvial surfaces underlain by permafrost. Along with black spruce, other overstory associates may include tamarack (*Larix laricina*) or white spruce (*Picea glauca*). Tussock-forming sedges may contribute at least 25% of the vegetation cover. Common understory species include Labrador tea (*Ledum* spp.), blueberry (*Vaccinium* spp.), bog rosemary (*Andromeda polifolia),* dwarf birch (*Betula nana),* sedge (*Carex* spp.), and cottongrass (*Eriophorum* spp.). Peat moss (*Sphagnum* spp.) and splendid feather moss (*Hylocomium splendens*) dominate the bryophyte layer.

- **Cowardin System and Class:** PFO, PSS
- **Cowardin Water Regime:** B, D, E
- **HGM Class:** slope, depressional, flat

Vegetated Drainageway. Narrow, linear wetland systems within semi-arid environments that form in drainages where surface and groundwater flow concentrates. Multiple seeps, springs, diffuse groundwater discharge, and surface water runoff from the surrounding landscape provide sufficient soil moisture to support wetland vegetation that contrasts with the arid and sparsely vegetated adjacent uplands. They may have a small channel, but they lack a significant stream that would provide overbank flooding. Vegetation is typically dominated by herbaceous species, including Nebraska sedge (*Carex nebrascensis*)*,* other *Carex* species, *Juncus* species, and hydrophytic grasses and forbs. Wetter areas may contain small stands of cattails and bullrushes, while drier margins may contain shrub species. Reaches of these systems are sometimes discontinuous and may be described as drainages, swales, stringer meadows, gullies, draws, or arroyos. For this protocol, these systems must be < 60 m in width (often less than 25 m), > 200 m in length, and confined to the drainage bottom. If the wetland dimensions are close to or exceed the specified limits, consider wet meadow (for wider open systems) or spring (for smaller systems). If the hydrology is strongly influenced by a sizable stream channel that likely provides overbank flooding, consider wet meadow with a riverine HGM class.

- **Cowardin System and Class:** PEM, occasionally RpEM, PSS
- **Cowardin Water Regime:** A, B, C, E, occasionally J
- **HGM Class:** slope

Spring or Seep. Localized area of groundwater discharge. In general, springs have more flow than seeps. Springs and seeps are various in size, they may have single or multiple discharge points, and the spatial extent of the associated riparian or wetland area can vary considerably. These systems vary greatly depending on regional location, seasonality, discharge rates, and surrounding geology. Some springs may have a stable groundwater component and do not fluctuate greatly over the course of the season, while others may only maintain surface water during spring runoff. Vegetation communities vary and can range from robust communities of woody and/or herbaceous hydrophytes to sparse areas of ***mesophytic species***. Springs and seeps are common water sources for many different wetland types in the Western U.S. For this protocol, sites should only be classified as spring or seep if they are highly localized and do not meet the definitions of other, larger wetland types. The wetland area must be < 60 m in width (often less than 25 m), < 200 m in length, and immediately surrounding or adjacent to a springhead. If the wetland area is larger or longer than these dimensions, consider the definitions of a wet meadow or vegetated drainageway.

- **Cowardin System and Class:** PEM, PSS
- **Cowardin Water Regime:** B, C, E, occasionally D
- **HGM Class:** slope

Playa. A barren or sparsely vegetated flat or basin found throughout the Intermountain West. These systems are intermittently flooded by surface runoff from large precipitation events. Water is typically prevented from percolating through the soil by an impermeable soil subhorizon and is left to evaporate. Some are affected by high groundwater tables. Soil salinity varies with soil moisture and greatly affects species composition. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. Characteristic species may include greasewood (*Sarcobatus vermiculatus*), spiny hopsage (*Grayia spinosa*), Lemmon's alkaligrass (*Puccinellia lemmonii*), basin wildrye (*Leymus cinereus*), saltgrass (*Distichlis spicata*), and species of saltbush (*Atriplex* spp.). These wetlands are particularly important to waterfowl and shorebirds and also support many rare and unique species.

- **Cowardin Class:** PEM
- **Cowardin Water Regime:** J, A, B, C
- **HGM Class:** depressional, occasionally flat, slope

Prairie Pothole. Depressional wetlands and small lakes formed by glaciers scraping the landscape during the Pleistocene era and found primarily in the glaciated northern Great Plains of the United States and Canada. Prairie potholes are variable depending on topography, soils, and hydrology. Many prairie potholes are closed basins and receive irregular inputs of water from their surroundings (groundwater and precipitation), and some export water as groundwater. Hydrology of the potholes is complex. Precipitation and runoff from snowmelt are the principal water sources, with groundwater inflow secondary. Evapotranspiration is the major water loss, with seepage loss secondary. Most of the wetlands and lakes contain water that is alkaline (pH > 7.4). The concentration of dissolved solids results in water that ranges from fresh to extremely saline. The flora and vegetation of potholes are a function of the topography, water regime, and salinity. In addition, because of periodic droughts and wet periods, many potholes undergo vegetation cycles. These wetlands include elements of aquatic vegetation, emergent marshes, and wet meadows that develop into a pattern of concentric rings. Potholes provide habitat for more than 50% of North America's migratory waterfowl, with several species reliant on this system for breeding and feeding. Much of the original extent of this system has been converted to agriculture, and only approximately 40-50% of prairie potholes remains undrained.

- **Cowardin System and Class:** PEM
- **Cowardin Water Regime:** A, B, C
- **HGM Class:** Depressional

Vernal Pool. A type of wetland that occurs in topographic depressions that collect water during the winter and spring rains, changing in volume in response to weather patterns. Vernal pools range in size from small puddles to shallow lakes. Depending on the season, they may be completely inundated, dominated by herbaceous vegetation, or dry and barren. In the Western United States, vernal pools are more common in the Pacific Coast states of California, Washington, and Oregon.

- **Cowardin System and Class:** PEM
- **Cowardin Water Regime:** A, B, C
- **HGM Class:** Depressional

Other. Describe any other wetland type encountered if the monitoring plot does not fit any of the previous descriptions.

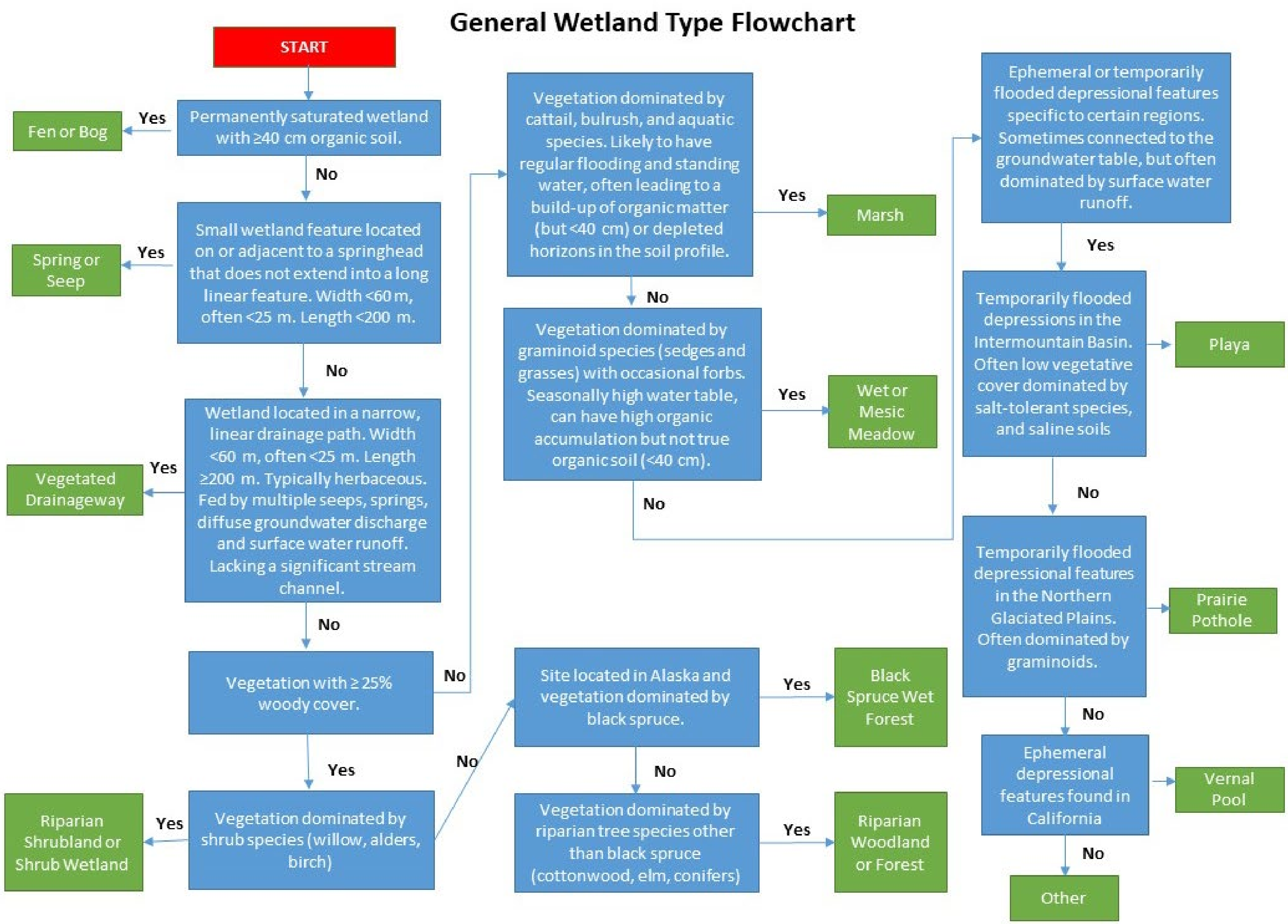


Figure L1. Flowchart to determine general wetland type.

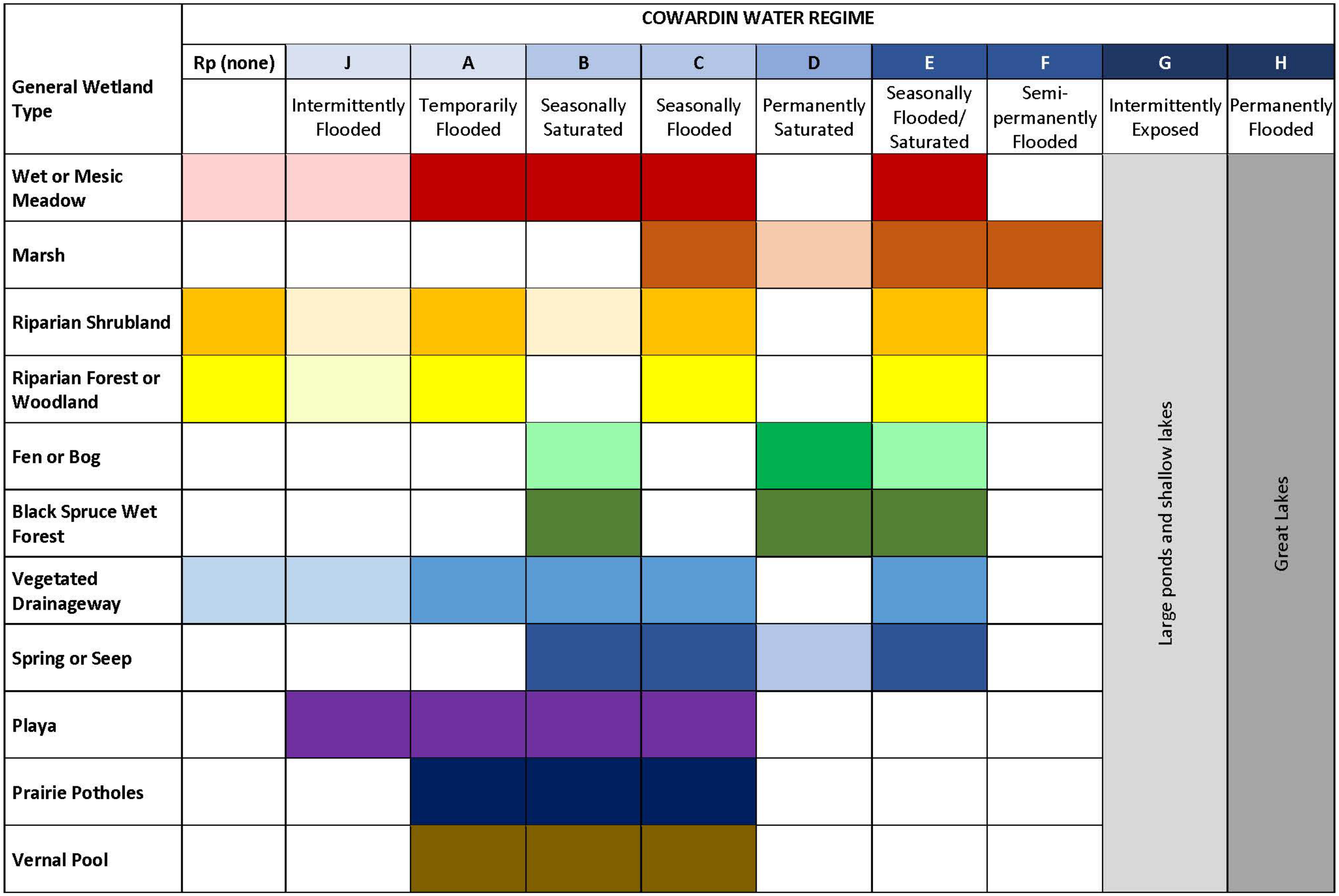


Figure L2. General wetland types and their accepted Cowardin water regimes. Darker shades represent more common water regimes for each general wetland type. Lighter shades are less common water regimes.

Appendix M: Wetland Hydrology Indicators

Note: The content in this appendix is adapted from EPA 2016 and USACE 1987.

This appendix describes U.S. Army Corps of Engineers wetland hydrology indicators, which are used in this protocol to document evidence of hydrology influenced by current or past surface or groundwater. Photos of many of the indicators are provided after all of the descriptions.

Group A – Observation of Surface Water or Saturated Soils

A1. **Surface Water** – direct, visual observation of surface water (flooding or ponding) during a site visit.

A2. **High Water Table** – direct, visual observation of the water table within 30 cm of the soil surface in a pit, auger hole, or monitoring well; includes water tables derived from perched water, throughflow, and discharging groundwater (e.g., in seeps) that may be moving laterally near the soil surface.

A3. **Saturation** – visual observation of saturated soil conditions within 30 cm of the soil surface as indicated by water glistening on surfaces and broken interior faces of soil samples removed from a pit or auger hole; must be associated with an existing water table immediately below the saturated zone unless there is a restrictive soil layer or bedrock within 30 cm of the soil surface.

Group B – Evidence of Recent Inundation

B1. **Water Marks** – discolorations or stains on the bark of woody vegetation, rocks, bridge supports, buildings, fences, or other fixed objects as a result of inundation.

B2. **Sediment Deposits** – thin layers or coatings of fine-grained mineral (e.g., silt, clay) or organic material, sometimes mixed with other detritus, remaining on tree bark, plant stems or leaves, rocks, and other objects after surface water recedes.

B3. **Drift Deposits** – rafted debris that has been deposited on the ground surface or entangled in vegetation or other fixed objects; debris consists of remnants of vegetation (e.g., branches, stems, leaves), man-made litter, or other waterborne materials; drift may be deposited at or near the high water line in ponded or flooded areas, piled against the upstream side of trees, rocks, and other fixed objects, or widely distributed within the dewatered areas.

B4. **Algal Mat or Crust** – mat or dried crust of algae, perhaps mixed with other detritus, left on or near the soil surface after dewatering.

B5. **Iron Deposits** – thin orange or yellow crust or gel of oxidized iron on the soil surface or on objects near the surface.

B6. **Surface Soil Cracks** – shallow cracks that form when fine-grained mineral or organic sediments dry and shrink, often creating a network of cracks or small polygons.

B8. **Sparsely Vegetated Concave Surface** – on concave land surfaces (e.g., depressions, swales), the ground surface is unvegetated or sparsely vegetated (> 5% ground cover) due to long-duration ponding or flooding during the growing season; sparsely vegetated concave surfaces should contrast with vegetated slopes and convex surfaces in the same area.

B9. **Water-Stained Leaves** – fallen or recumbent dead leaves that have turned grayish or blackish in color due to inundation for long periods.

B10. **Drainage Patterns** – flow patterns visible on the soil surface or eroded into the soil, low vegetation bent over in the direction of flow, absence of leaf litter or small woody debris due to flowing water, or similar evidence that water flowed across the ground surface.

B11. **Salt Crust** – hard, brittle deposits of salts formed on the ground surface due to the evaporation of saline surface water.

B12. **Biotic Crust** – presence of ponding-remnant biotic crusts, benthic microflora, or dried remains of free-floating algae left on or near the soil surface after dewatering.

B13. **Aquatic Invertebrates (or "fauna")** – presence of live individuals, diapausing insect eggs or crustacean cysts, or dead remains of aquatic fauna, such as, but not limited to, sponges, bivalves, aquatic snails, aquatic insects, ostracods, shrimp, other crustaceans, tadpoles, or fish, either on the soil surface or clinging to plants or other emergent objects.

B14. **True Aquatic Plants** – presence of live individuals or dead remains of true aquatic plants; true aquatic plants are species that are normally submerged, have floating leaves or stems, require water for support, or desiccate in the absence of standing water.

B15. **Marl Deposits** – presence of marl on the soil surface; marl deposits consist mainly of calcium carbonate ($CaCO_3$) precipitated from standing or flowing water through the action of algae or diatoms; appears as a tan or whitish deposit on the soil surface after dewatering and may form thick deposits in some areas.

B16. **Moss Trim Lines** – presence of moss trim lines on trees or other upright objects in seasonally inundated areas; moss trim lines are formed when water-intolerant mosses growing on tree trunks and other upright objects are killed by prolonged inundation forming an abrupt lower edge to the moss community at the high water level.

Group C – Evidence of Current or Recent Soil Saturation

C1. **Hydrogen Sulfide Odor** – a hydrogen sulfide (rotten egg) odor within 30 cm of the soil surface.

C2. **Dry-Season Water Table** – visual observation of the water table between 30 and 60 cm below the surface during the normal dry season or during a drier than normal year.

C3. **Oxidized Rhizospheres along Living Roots** – presence of a layer containing 2% or more iron oxide coatings or plaques on the surfaces of living roots or iron oxide coatings or linings on soil pores immediately surrounding living roots within 30 cm of the soil surface.

C4. **Presence of Reduced Iron** – presence of a layer containing reduced (ferrous) iron in the upper 30 cm of the soil profile, as indicated by a ferrous iron test or the presence of a soil that changes color upon exposure to the air.

C5. **Salt Deposits** – whitish or brownish deposits of salts that accumulate on the ground surface through the capillary action of groundwater.

C6. **Recent Iron Reduction in Tilled Soils** – presence of a layer containing 2% or more redox concentrations as pore linings or soft masses in the tilled surface layer of soils cultivated within the last 2 years; layer containing redox concentrations must be within the tilled zone or within 30 cm of the soil surface, whichever is shallower.

C7. **Thin Muck Surface** – layer of muck 2.5 cm or less thick on the soil surface.

C8. **Crayfish Burrows** – presence of crayfish burrows, as indicated by openings in soft ground up to 5 cm in diameter, often surrounded by chimney-like mounds of excavated mud.

C10. **Fiddler Crab Burrows** – presence of fiddler crab (*Uca* spp.) burrows, as indicated by openings in soft soil or sand approximately 1-2 cm in diameter, often associated with excavated balls of mud or sand.

Group D – Evidence from Other Site Conditions or Data

D1. **Stunted or Stressed Plants** – individuals of the same species are clearly of smaller stature, less vigorous, or stressed compared to individuals growing in nearby nonwetland or drier landscape situations.

D2. **Geomorphic Position** – area is located in a depression, concave position within a floodplain, at the toe of a slope, on an extensive flat, on the low-elevation fringe of a pond or other water body, or in an area where groundwater discharges.

D3. **Shallow Aquitard** – presence of an aquitard (a relatively impermeable soil layer or bedrock that slows the downward infiltration of water) within the soil profile that is potentially capable of perching water within 30 cm of the surface; occurs in and around the margins of depressions and in flat landscapes.

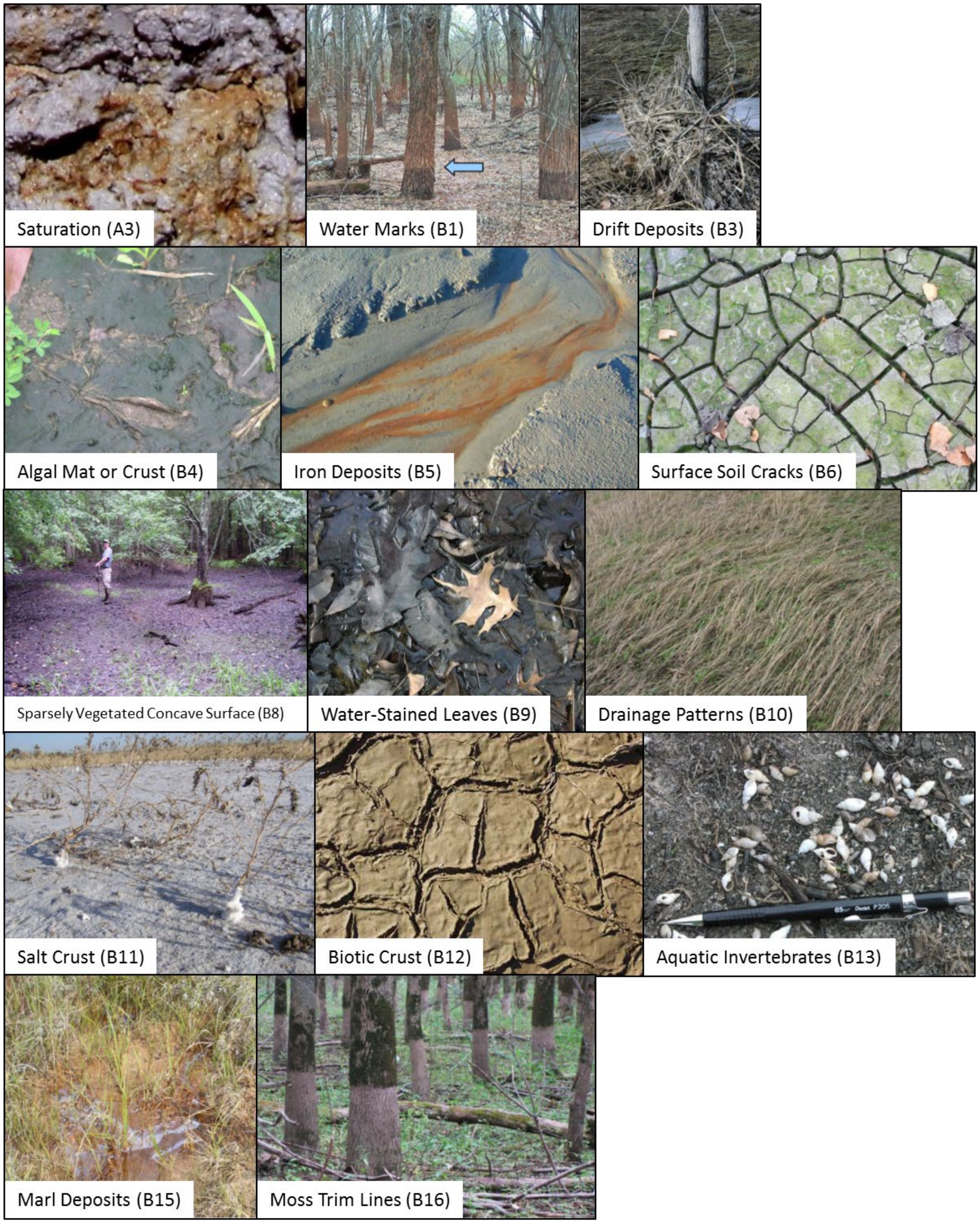
D4. **Microtopographic Relief** – presence of microtopographic features that occur in areas of seasonal inundation or shallow water tables, such as hummocks and tussocks.

D6. **Raised Ant Mounds** – presence of elevated ant mounds 15 cm or more in height built in response to seasonal flooding, ponding, or high water tables.

D7. **Frost-Heave Hummocks** – presence of hummocky microtopography produced by frost action in saturated wetland soils.

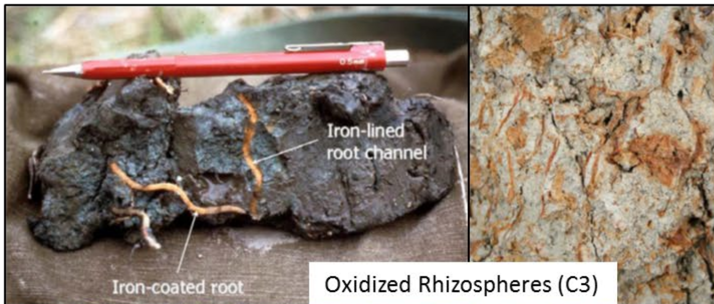
D8. **Sphagnum Moss** – presence of peat mosses (*Sphagnum* spp.).

Examples of Wetland Hydrology Indicators



Saturation (A3)
Water Marks (B1)
Drift Deposits (B3)
Algal Mat or Crust (B4)
Iron Deposits (B5)
Surface Soil Cracks (B6)
Sparsely Vegetated Concave Surface (B8)
Water-Stained Leaves (B9)
Drainage Patterns (B10)
Salt Crust (B11)
Biotic Crust (B12)
Aquatic Invertebrates (B13)
Marl Deposits (B15)
Moss Trim Lines (B16)

Examples of Wetland Hydrology Indicators



Oxidized Rhizospheres (C3)

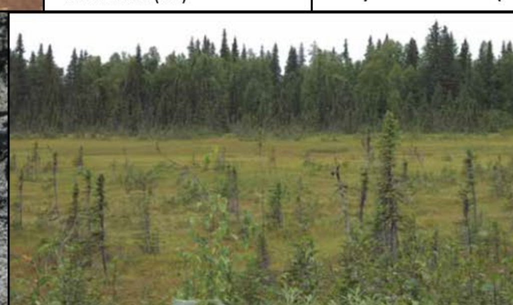
Presence of Reduced Iron (C4): freshly exposed soil sample (left side); color change after exposure to air for several minutes (right side)

Salt Deposits (C5)

Recent Iron Reduction in Tilled Soils (C6)

Crayfish Burrow (C8)

Fiddler Crab Burrows (C10)



Stunted or Stressed Plants (D1): black spruce in the wetland (foreground) are stressed and stunted compared with spruce in the adjacent non-wetland (background)

Geomorphic Position (D2)

Microtopographic Relief (D4)

Raised Ant Mounds (D6)

Frost-Heave Hummocks (D7)

Sphagnum Moss (D8)

Appendix N: Decision Tree for Identifying Groundwater-Dependent Wetlands

Note: The content in this appendix is adapted from "Groundwater-Dependent Ecosystems: Level II Inventory Field Guide: Inventory Methods for Project Design and Analysis" (USFS 2012a)

The purpose of this decision tree is to assist in determining water sources in riparian and wetland areas. Answer the questions in sequence. A bold answer indicates likely groundwater dependence, and subsequent questions need not be answered.

1. Is the wetland seasonal?
   Yes—Low likelihood of groundwater dependence.
   No—Go to next question.
2. Does the wetland occur in one of these landscape settings:
   a. slope break
   b. intersection of a confined aquifer with a slope
   c. stratigraphic change, or
   d. along a fault?
   Yes—High likelihood of groundwater dependence.
   No—Go to next question.
3. Is the wetland associated with a spring or seep?
   Yes—High likelihood of groundwater dependence.
   No—Go to next question.
4. Does the wetland have signs of surface inflow?
   No—High likelihood of groundwater dependence.
   Yes—Go to next question.
5. Are the wetland soils organic, muck, or peat?
   Yes—High likelihood of groundwater dependence.
   No—Go to next question.
6. Is the wetland saturated even after surface inputs become dry and during extended periods with no precipitation?
   a. Yes—Are the wetland soils clay, hardpan, or impermeable?
      i. No—High likelihood of groundwater dependence.
      ii. Yes—Low likelihood of groundwater dependence.
   b. No—Low likelihood of groundwater dependence.

Appendix O: Soil Properties and Hydric Soil Indicators

Note: The content in this appendix is adapted from "National Wetland Condition Assessment 2016: Field Operations Manual" (USEPA 2016).

This appendix provides information to assist in describing soils in riparian and wetland areas, including the soil profile, soil matrix color, soil texture, and hydric soil indicators. Suggested soil reference materials and websites are provided at the end of this appendix.

Soil Profile Description

The soil profile description identifies and describes distinct horizons of the soil core. Soil horizons are distinguished based on differences in:

- Color, measured using the "Munsell Soil Color Book"
- Presence of organic soils (fibric, hemic, or sapric)
- Texture or the proportion of sand, silt, and clay
- The presence and type of redoximorphic features, including concentrations and depletions
- The presence of rock fragments, roots, or other prominent features

See the following resources for more information, as needed:

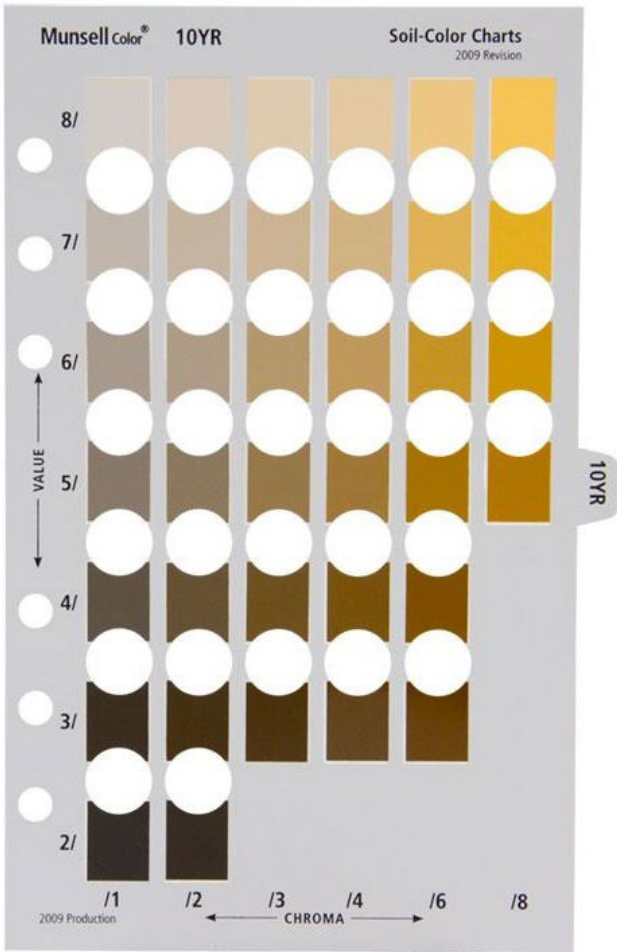
- "Keys to Soil Taxonomy" (Soil Survey Staff 2022)
- "Field Indicators of Hydric Soils in the United States: A Guide for Identifying and Delineating Hydric Soils," Version 8.2 (NRCS 2018)
- "Field Book for Describing and Sampling Soils" (Schoeneberger et al. 2012)

Soil Matrix Color

Soil color can provide important information on hydrology, soil parent materials, weathering processes, and organic carbon content. In soil science, the Munsell color system is used to describe colors in a standardized, reproducible format. The "Munsell Soil Color Book" contains charts of color chips, which are used to determine soil color in the field. The Munsell color system has three components—hue, value, and chroma (Figure O1). When determining matrix color in the field, begin at the 10YR page. Hues are progressively redder moving toward the front of the book and yellower toward the back of the book (see the color ramp displayed below). Gley pages at the very back of the book are specifically for coloring soils with neutral or blueish-green colors (Figure O2).

10R 2.5YR 5YR 7.5YR 10YR 2.5Y 5Y

For each soil horizon, record the dominant color of the horizon as the matrix color. Also record the color of any primary and secondary redoximorphic (redox) features using the "Munsell Soil Color Book." Redox features are color patterns that differ from the soil matrix and are formed as iron and/or manganese are changed chemically and translocated in the soil due to reduction and oxidation associated with wetting and drying cycles (Figures O3 and O4).



Value: Degree of lightness or darkness of color. Values are listed on the left side of the page, decreasing in value (darker) in rows going down the page.

Hue: Measure of chromatic composition (red, yellow, green, blue, etc.).

Chroma: Relative purity or strength of color (brightness). Chroma is organized in columns listed at the bottom of the page.

Figure O1. Descriptions of soil hue, value, and chroma for the "Munsell Soil Color Book." The soil color in the red box would be written 10YR 4/2. This figure is provided only as an example and should not be used for measuring soil color in the field.

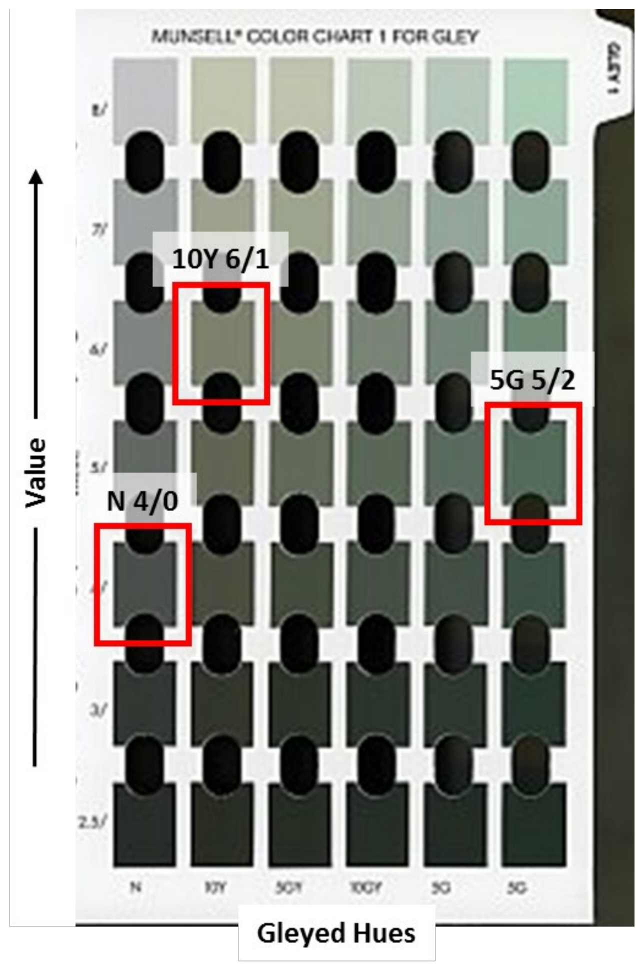


Figure O2. Example of a gley page, which differs from most pages in the "Munsell Soil Color Book." Soils with neutral hues (N) have a chroma of 0. For all other gleyed hues (10Y, 5GY, 10GY, 5G, 10G, 5BG, 5B, 10B, 5PB) the chroma is 1 for the first column, and the chroma is 2 for the second column of the hue (5G is the only hue on the gleyed pages to have a chroma of 2). This figure is provided only as an example, and should not be used for measuring soil color in the field.

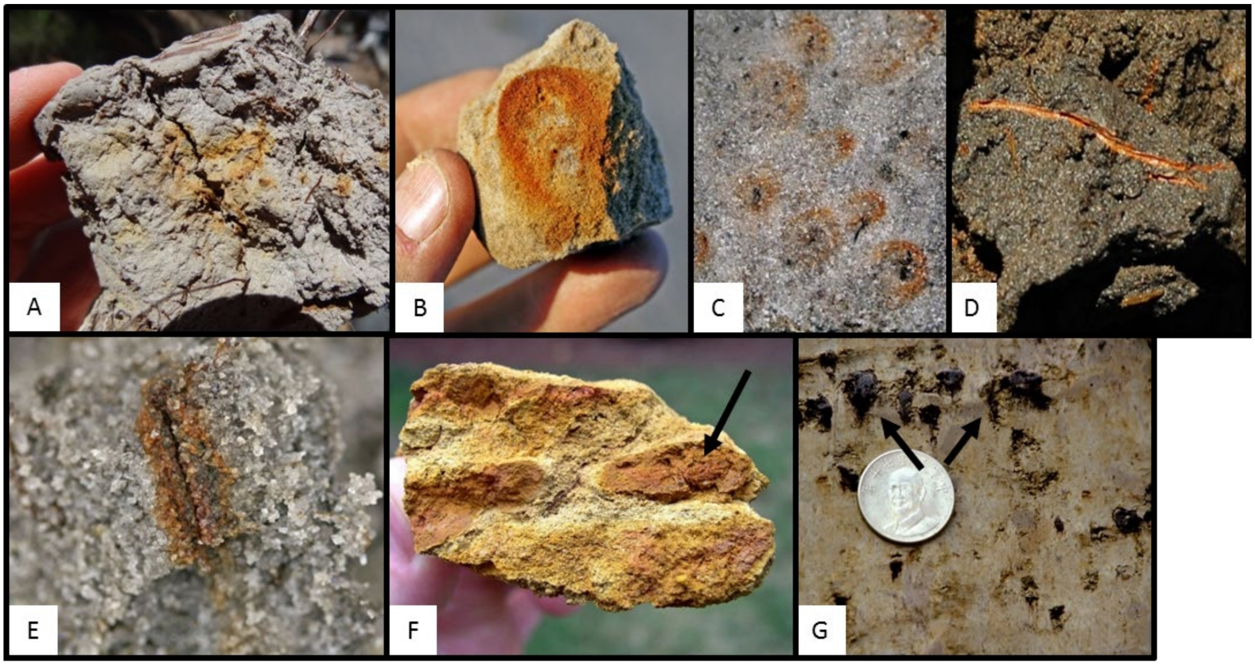


Figure O3. Examples of redoximorphic concentrations. (A) Redox concentrations occurring as soft masses and porelinings (photo by Ann Rossi). (B and C) Redox concentrations occurring as soft masses. (D and E) Redox concentrations occurring as pore linings. (F) Iron nodules (indicated by arrow). (G) Manganese concretions.

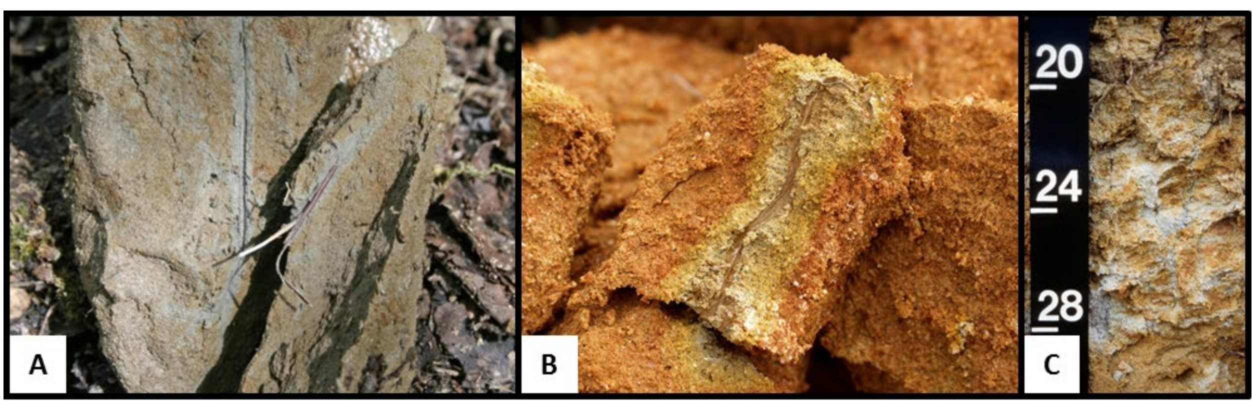


Figure O4. Examples of redoximorphic depletions. (A) Depletion occurring along root channel. (B) Depletion along root channel. (C) Depletions (gray zones) in an oxidized soil matrix (red areas).

Soil Texture

Soils vary in the proportion of organic and mineral material they contain. ***Mineral soil*** horizons are dominated by inorganic mineral materials. The texture of a mineral soil is determined by the distribution of sand, silt, and clay particles. ***Organic soil*** horizons (Figure O5) have greater than 12-18% organic carbon by weight, depending on clay content. Organic soils can be further distinguished by the degree of decomposition. Distinguishing between organic and mineral horizons and noting the changes in soil texture can help identify horizons and explain soil processes occurring within the soil. Soil texture influences a number of functions performed by soils, including water and nutrient holding capacity.

Soil texture can be determined by hand. First, determine if the soil is primarily organic or mineral. This can be done by gently rubbing a pinch of moist soil between the forefingers and thumb. Remember that organic soils have greater than 12-18% organic carbon by weight. Organic carbon represents roughly 50% of total organic matter, meaning that organic soils have greater than 24-36% organic matter by weight. Because organic matter is far less dense than mineral soil material, organic matter must represent a very large share of the soil by volume.

If the soil has any of the following characteristics, it is likely an organic soil:

- The soil feels greasy.
- The soil is very light (low bulk density) compared to equal amounts of mineral soil.
- You can discern visible organic particles.
- You can feel or see little to no mineral particles (grittiness of sand grains, silt coating on hands, stickiness of clay particles).
- The soil leaves little to no residue on your hands or stains your hands slightly brown.

If the soil does not feel greasy, but feels heavy, gritty, sticky, or stains your hand grey as it dries, the soil is a mineral soil.

Texturing Organic Soils. Organic soil horizons are common in wetlands with a consistently high water table, permanent saturation, or soils influenced by permafrost. Organic soils are classified by the degree of decomposition rather than particle size distribution. Organic soil materials are categorized as fibric (peat), hemic (mucky peat), or sapric (muck). To determine the type of organic soil material, take a fresh golf ball-sized sample of moist soil and rub the sample between the thumb and fingers 10 times. Visually estimate the percent volume of plant fibers and dead roots remaining after rubbing. Use Table O1 to determine the type of organic soil material.

Fibers are pieces of plant tissue in organic soil materials (excluding live roots) that:

- Are large enough to be retained on a 100-mesh sieve (openings 0.15 mm across) when the materials are screened.
- Show evidence of the cellular structure of the plants from which they are derived.
- Either are 20 mm or less in their smallest dimension or are decomposed enough to be crushed and shredded with the fingers.

Wood fragments are larger than 20 mm in cross section and so undecomposed that they cannot be crushed and shredded with fingers; they are not considered fibers.

Figure O5. Photographs of organic soil.

Table O1. Characteristics of organic material by soil texture class and degree of decomposition (humification) (adapted from USACE 2008).

Soil Texture	**Volume of Fibers**		**Degree of Humifiction**	**Nature of Water Expressed on Squeezing**	**Material Extruded between Fingers**	**Nature of Plant Structure in Residue**
	Unrubbed	**Rubbed**				
Fibric (Peat)	> 67%	> 40%	H1	Clear, colorless water	No organic solids squeezed out	Unaltered, fibrous, undecomposed
			H2	Yellowish water	No organic solids squeezed out	Almost unaltered, fibrous
			H3	Brown, turbid water	No organic solids squeezed out	Easily identifiable
Hemic (Mucky Peat)	33-67%	20-40%	H4	Dark brown, turbid water	No organic solids squeezed out	Visibly altered but identifiable
			H5	Turbid water	Some organic solids squeezed out	Recognizable but vague, difficult to identify
			H6	Turbid water	1/3 of sample squeezed out	Indistinct, pasty
Sapric (Muck)	< 33%	< 20%	H7	Very turbid water	1/2 of sample squeezed out	Faintly recognizable; few remains identifiable, mostly amorphous
			H8	Thick and pasty	2/3 of sample squeezed out	Very indistinct
			H9	No free water	Nearly all of sample squeezed out	No identifiable remains
			H10	No free water	All of sample squeezed out	Completely amorphous

Texturing Mineral Soils. Mineral soil textural classes are distinguished based on the relative proportion (by weight) of sand, silt, and clay particles (see Figure O6). Rock (coarse) fragments, gravels, or rocks greater than 2 mm in diameter are not included when determining the textural class. Soil texture determinations will be used to identify the appropriate hydric soil field indicators to consider for the soil profile. Mineral soils can be textured by hand using the flowchart (Figure O7).

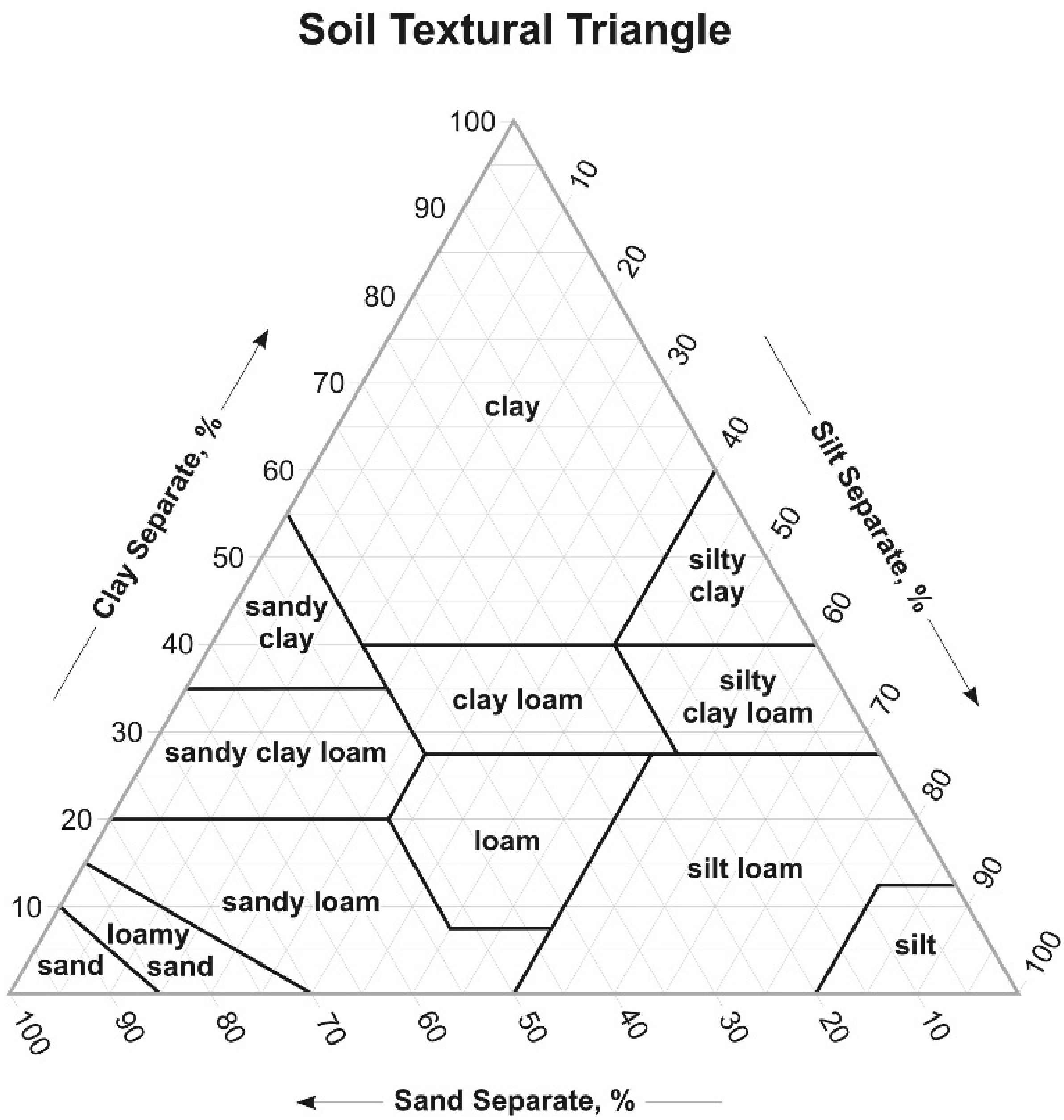


Figure O6. Soil textural triangle for determining the textural class of soil (adapted from Thien 1979).

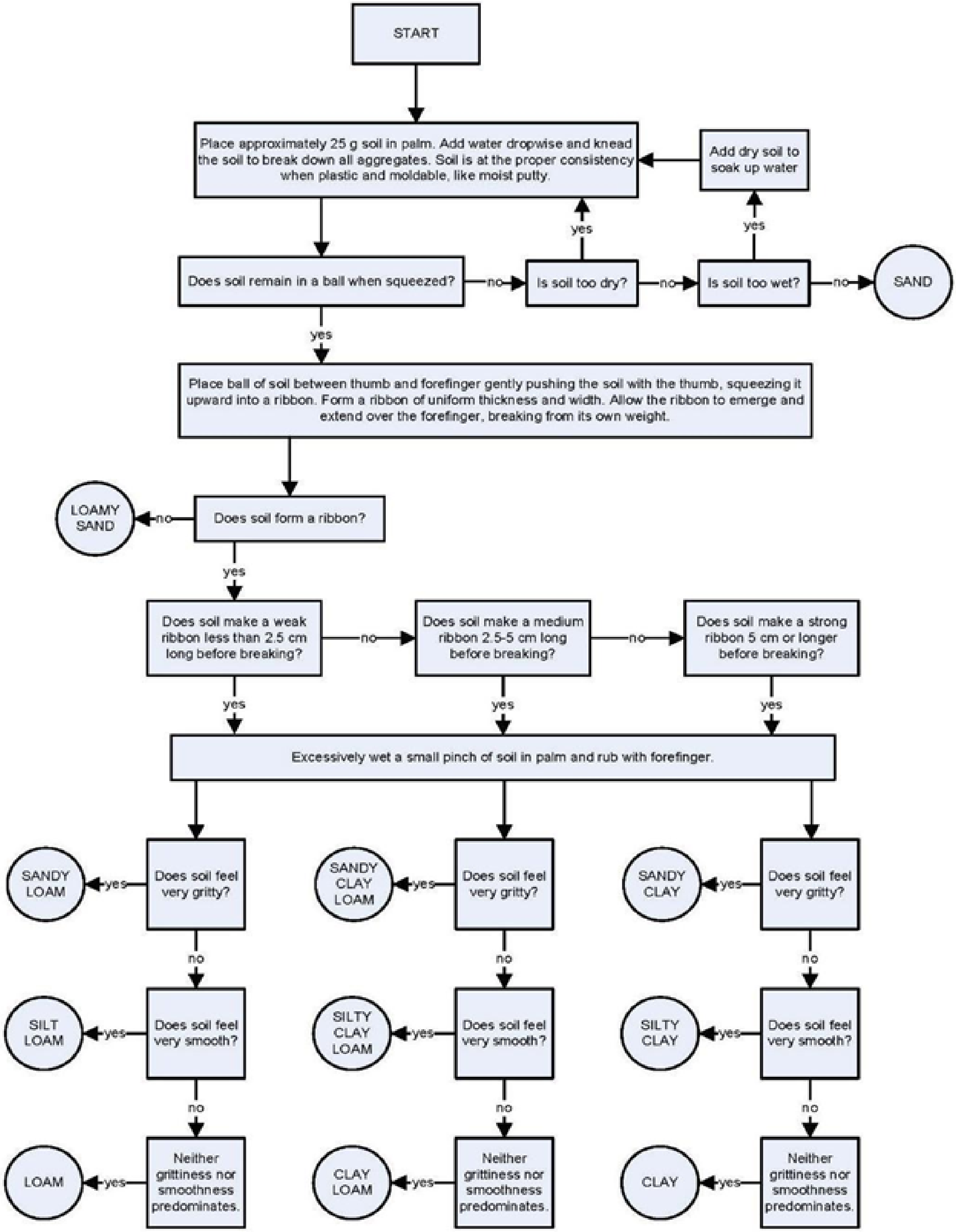


Figure O7. Flow chart for texturing mineral soils by hand (adapted from Thien 1979).

Hydric Soil Indicators

A ***hydric soil*** is defined as a soil that formed under conditions of saturation, flooding, or ponding long enough to periodically produce anaerobic conditions in the rooting zone, thereby influencing the growth of plants. Hydric soils indicate that a site has experienced periods of saturation or inundation combined with microbial activity in the soil that depletes available oxygen. Once oxygen is no longer available, soil microbes shift to using different electron receptors in their metabolic pathways, leading to anaerobic conditions.

During prolonged and/or repeated period of anaerobic conditions, certain biogeochemical processes may occur and produce hydric soil features (NRCS 2018). Common anaerobic biogeochemical processes and the resulting hydric soil features can be grouped into a few major categories:

1. **Organic matter accumulation.** Soil microbes generally use carbon compounds as an energy source and rely on oxygen to facilitate the breakdown of those compounds. However, in saturated soil with less available oxygen, microbial respiration is retarded and organic matter may accumulate faster than it is decomposed. Consequently, thick organic horizons, such as peat, mucky peat, and muck, or dark organic-rich mineral surface layers may form in riparian or wetland environments. In boreal and arctic zones of Alaska, the active layers above "permafrost" (permanently frozen soil material within 2 meters of the surface) experience freeze-thaw cycles and can accumulate significant organic material. Organic soil horizons, including those influenced by permafrost, are identified using the rubbed fiber test to distinguish peat, mucky peat, and muck (see previous information under Soil Texture).
2. **Sulfate reduction.** Microbes can convert sulfate (SO_4^{2-}) to hydrogen sulfide gas (H_2S) to produce a "rotten egg" odor. Do not confuse the characteristic "rotten egg" odor with rotting organic matter. Sulfate reduction occurs only in soil that contains sulfur-bearing compounds and that is very wet. Hydrogen sulfide gas escapes rapidly, so detection of its presence should be noted as the soil pit is being excavated.
3. **Iron and manganese reduction, translocation, and accumulation.** Under anoxic (oxygen-depleted) conditions, anaerobic soil microbes use elements other than oxygen in their metabolic pathways, including iron and manganese. These anaerobic microbes reduce iron from the ferric (Fe^{3+}) to the ferrous (Fe^{2+}) form and manganese from the manganic (Mn^{4+}) to the manganous (Mn^{2+}) form. Iron reduction is generally more visible than manganese reduction in soils. Iron and manganese reduction, translocation, and accumulation produces a range of soil features, including:
   - **Redox concentrations** – zones of apparent accumulation of Fe-Mn oxides (Figure O3), including:
     - **Concretions,** which are cemented bodies with concentric layers visible to the eye.
     - **Nodules**, which are cemented bodies with no visible organized internal structure.
     - **Masses**, which are noncemented concentrations within the soil matrix.
     - **Pore linings**, which include zones of accumulation that fill pores, coat pore surfaces, or impregnate the matrix adjacent to the pores.
   - **Redox depletions** – zones of low chroma where Fe-Mn oxides or Fe-Mn oxides and clay have been removed (Figure O4).

- **Depleted matrix** – a soil matrix with high value and low chroma colors due to the reduction and translocation of iron and manganese that meets one of the following combinations of characteristics (Figure O8):
    - Matrix value ≥ 5 and chroma ≤ 1, with or without redox concentrations occurring as soft masses or pore linings.
    - Matrix value ≥ 6 and chroma ≤ 2, with or without redox concentrations occurring as soft masses or pore linings.
    - Matrix value of 4 or 5 and chroma of 2, and 2% or more distinct or prominent redox concentrations occurring as soft masses or pore linings.
    - Matrix value of 4 and chroma of 1, and 2% or more distinct or prominent redox concentrations occurring as soft masses or pore linings.
- **Reduced matrix** – a soil matrix that has low chroma in situ but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air. In the Soil Data Sheet, document color change by recording initial color in the "Matrix Color" column and the 30-minute color in the "Dominant Redox Features" color column.
- **Gleyed matrix** – a soil matrix with blue or grey colors located on the gley pages of the "Munsell Soil Color Book" and values of 4 or more (Figure O9). In some places, the gleyed matrix may change color upon exposure to air and would also be considered a reduced matrix.

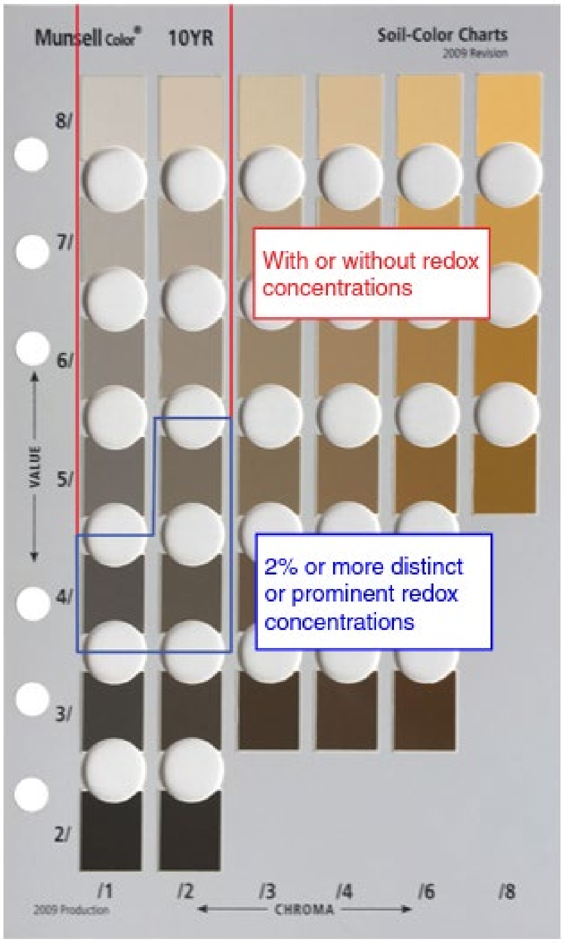


Figure O8. Illustration of values and chromas that require 2 percent or more distinct or prominent redox concentrations and those that do not, for hue 10YR, to meet the definition of a depleted matrix (NRCS 2018).

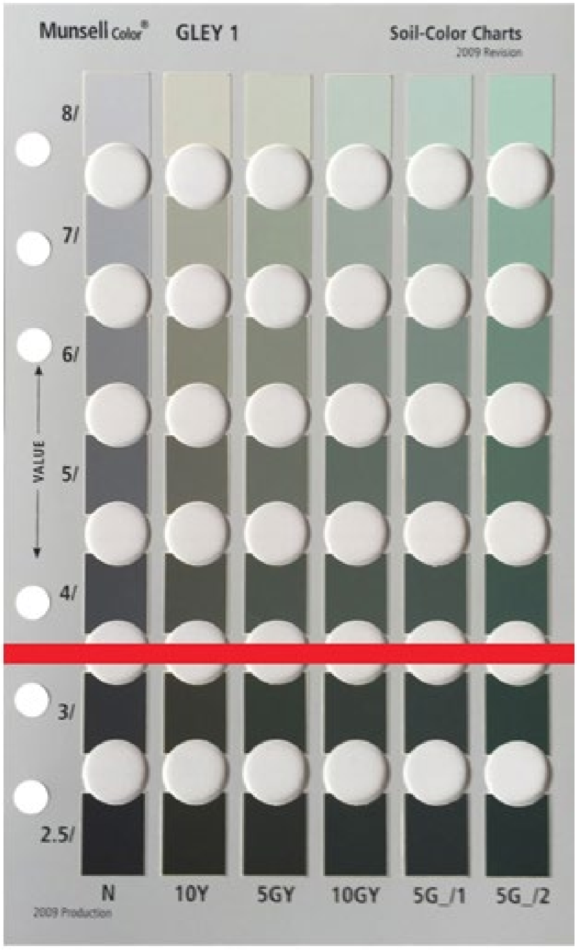


Figure O9. A gleyed matrix must have the colors on one of the two pages showing gleyed colors in the "Munsell Soil Color Book." Values are 4 or more (above the red line) (NRCS 2018).

Hydric soil indicators are regionally specific and are designed for use in specific U.S. Department of Agriculture land resource region (Figure O10). Hydric soil indicators are also texture-specific, meaning different indicators apply to different soil textures. The three soil texture groups for hydric soil indicators are: All Soils (A), Sandy Soils (S), and fine-textured Loamy and Clayey Soils (F). Once the soil profile description has been recorded in the Soil Data Sheet, identify the land resource region in which the sample plot is located and use the "Field Indicators of Hydric Soils in the United States: A Guide for Identifying and Delineating Hydric Soils," Version 8.2 (NRCS 2018) to determine if the soil is a hydric soil indicator.

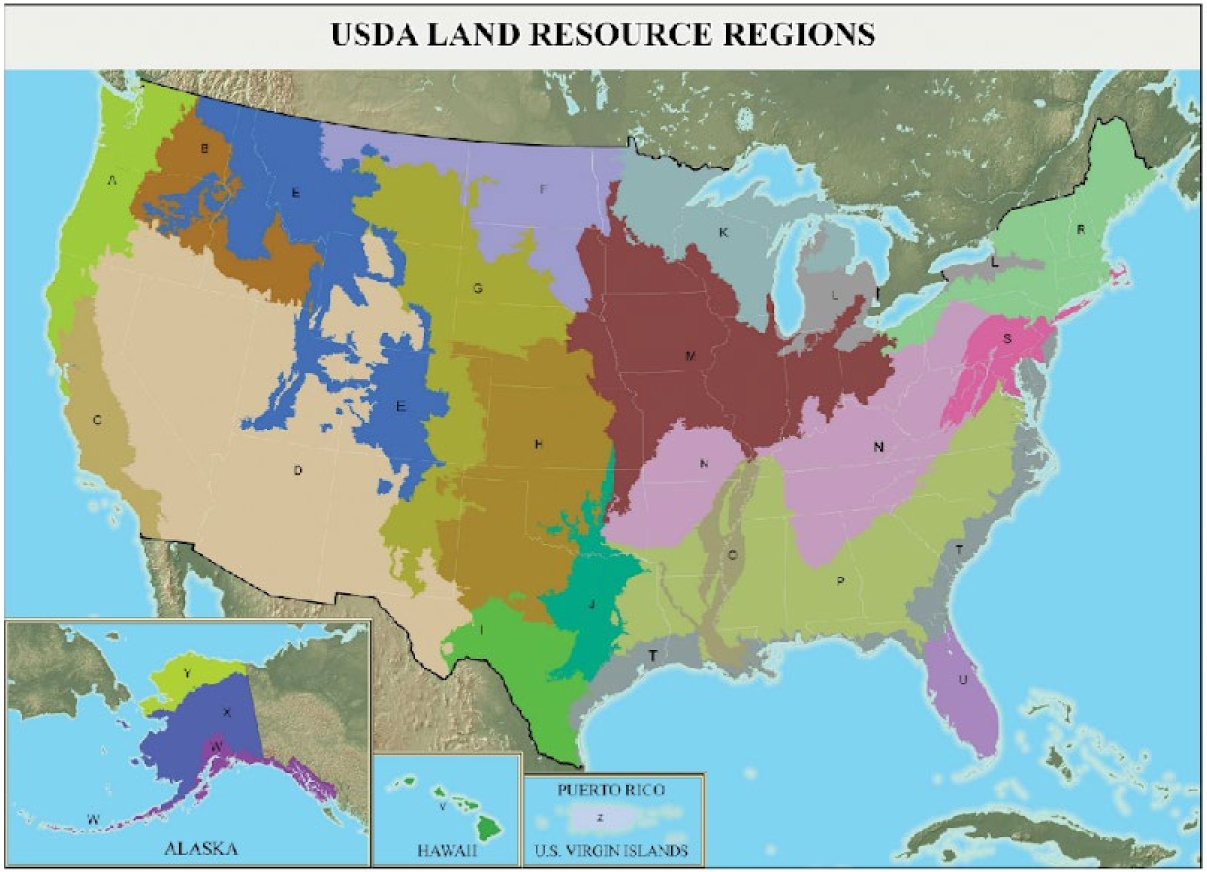


Figure O10. Map of U.S. Department of Agriculture land resource regions for determining hydric soil indicators.

Key to Western U.S. land resource regions:

- A. Northwestern Forest, Forage, and Specialty Crop Region
- B. Northwestern Wheat and Range Region
- C. California Subtropical Fruit, Truck, and Specialty Crop Region
- D. Western Range and Irrigated Region
- E. Rocky Mountain Range and Forest Region
- F. Northern Great Plains Spring Wheat Region
- G. Western Great Plains Range and Irrigated Region
- H. Central Great Plains Winter Wheat and Range Region
- W. Southern Alaska and Aleutian Alaska
- X. Interior Alaska and Western Alaska
- Y. Northern Alaska

Suggested Reference Materials

The following reference materials (or their most recent updates) provide detailed technical discussion and field sampling techniques for soils, especially riparian and wetland soils. Not all U.S. Army Corps of Engineers (USACE) regional supplements to the wetland delineation manual (e.g., USACE 2007) are included; additional supplements are available from the USACE website that follows.

Lewis, L., L. Clark, R. Krapf, M. Manning, J. Staats, T. Subirge, L. Townsend, and B. Ypsilantis. 2003. Riparian Area Management: Riparian-Wetland Soils. Technical Reference 1737-19. U.S. Department of the Interior, Bureau of Land Management, Denver, CO.

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field Book for Describing and Sampling Soils, Version 3.0. U.S. Department of the Interior, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Soil Survey Staff. 1999. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys, Second Edition. Agriculture Handbook Number 436. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, DC.

Soil Survey Staff. 2022. Keys to Soil Taxonomy, Thirteenth Edition. U.S. Department of Agriculture, Natural Resources Conservation Service.

Sprecher, S.W. 2008. Installing Monitoring Wells in Soils, Version 1.0. U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Thien, S.J. 1979. A flow diagram for teaching texture by feel analysis. Journal of Agronomic Education 8 (1): 54-55.

U.S. Army Corps of Engineers). 2007. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Alaska Region (Version 2.0). ERDC/EL TR-07-24. U.S. Army Corps of Engineers, Engineer Research and Development Center, Vicksburg, MS.

U.S. Army Corps of Engineers. 2008. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region (Version 2.0). ERDC/EL TR-08-28. U.S. Army Corps of Engineers, Engineer Research and Development Center, Vicksburg, MS.

U.S. Army Corps of Engineers. 2010. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region (Version 2.0). ERDC/EL TR-10-1. U.S. Army Corps of Engineers, Engineer Research and Development Center, Vicksburg, MS.

U.S. Army Corps of Engineers. 2010. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0). ERDC/EL TR-10-3.U.S. Army Corps of Engineers, Engineer Research and Development Center, Vicksburgh, MS.

Natural Resources Conservation Service. 2018. Field Indicators of Hydric Soils in the United States: A Guide for Identifying and Delineating Hydric Soils, Version 8.2. U.S. Department of Agriculture, Natural Resources Conservation Service.

Winward, A.H. 2000. Monitoring the Vegetation Resources in Riparian Areas. Gen Tech Rep RMRS-GTR-47. U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Ogden, UT.

Websites. Links to websites are subject to change. If any website address no longer functions, conduct a web search using appropriate keywords to reestablish links.

NRCS Ecological Site Descriptions
https://www.nrcs.usda.gov/getting-assistance/technical-assistance/ecological-sciences/ecological-site-descriptions

NRCS Technical References for Soils
https://www.nrcs.usda.gov/resources/guides-and-instructions/technical-references-for-soils

NRCS Web Soil Survey
https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

USACE Regional Supplements to Corps Delineation Manual
http://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/reg_supp/

Appendix P: Cover Estimate Guides

Estimating vegetation cover is required for each plant species identified on the plot for the core method Plant Species Inventory (6.1). Cover may also be required to conduct a dominance test, as shown in Appendix D. Estimating vegetation cover across a plot can be challenging and requires some practice. Below are examples of specific percent covers of vegetation in an idealized grid which can be helpful for data collectors learning how to estimate cover.

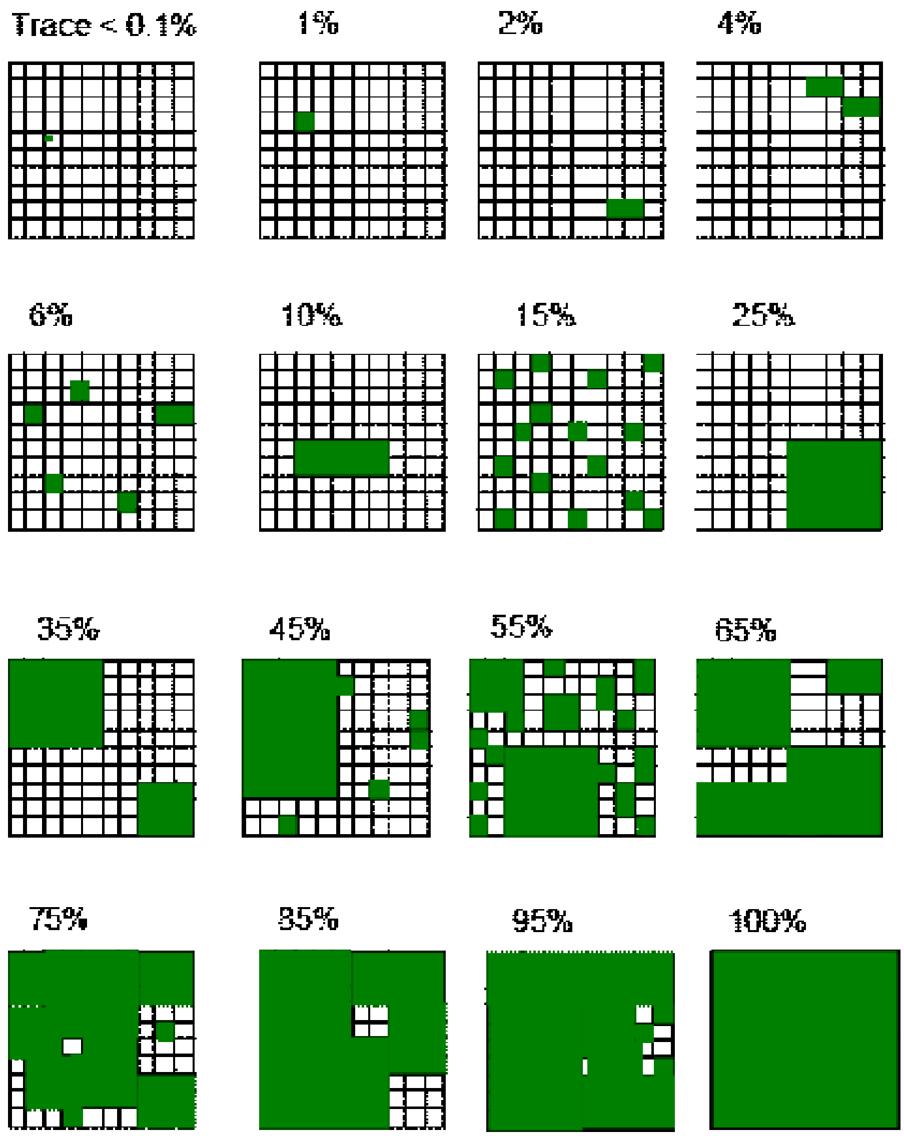


Chart 1. Examples of Percent Cover Estimates. Each large square = 100 m^2 module, grid squares = 1 m^2 (i.e., one grid square = 1% cover in a module), shaded areas represent cover of a vegetation stratum or of an individual species.

Figure P1. Examples of exact percent covers illustrated in 100-square grids.

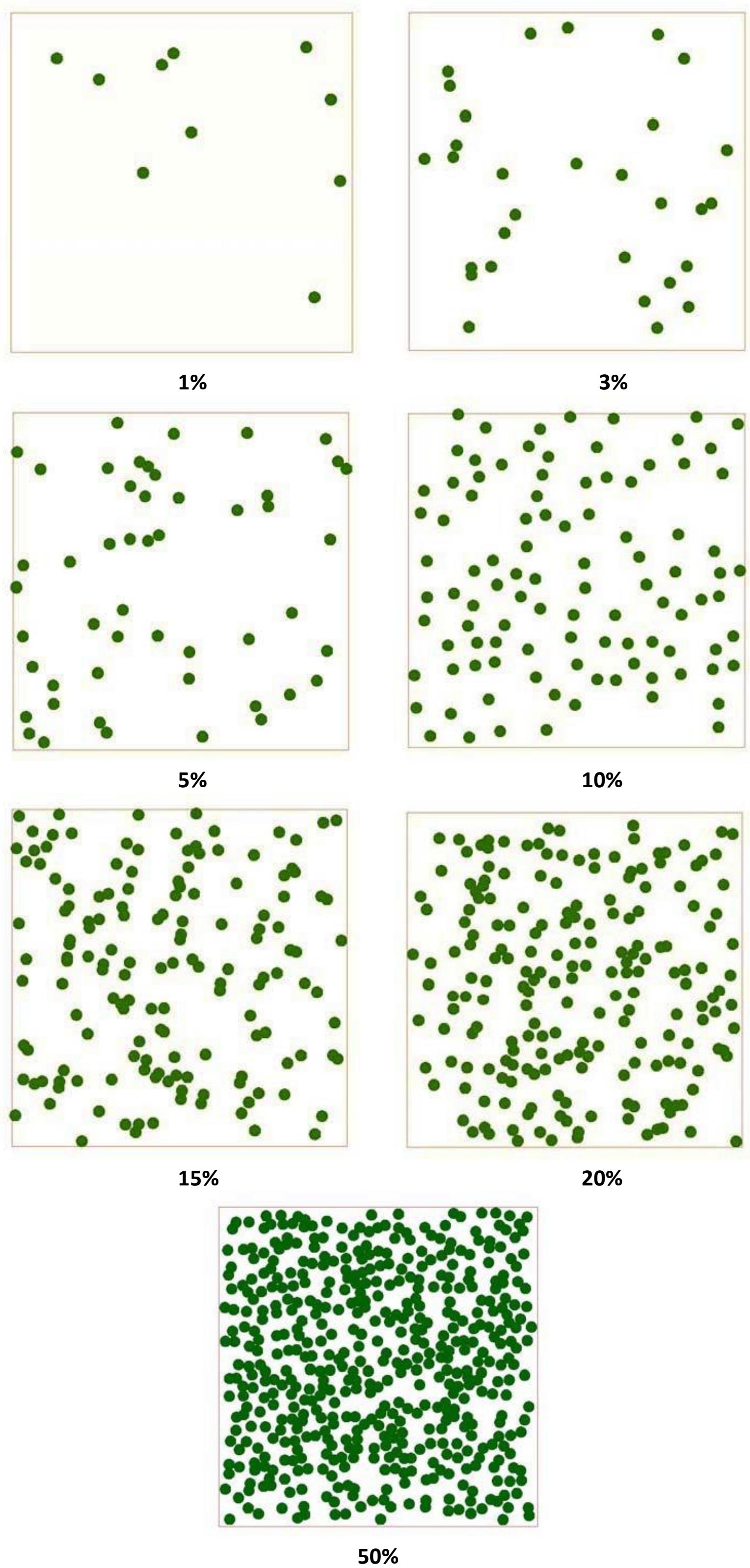


Figure P2. Examples of exact percent covers illustrated with dots as the plant vegetation cover.

Appendix Q: Common Rhizomatous and Dwarf Shrub Species

In the woody structure method (6.4), data collectors are required to identify whether a woody species is a tree, a shrub, or a rhizomatous or dwarf shrub species. This appendix includes a list of common rhizomatous and dwarf shrub species that data collectors may encounter. Dwarf shrubs can also be called subshrubs, and are usually < 0.5 m at maturity. Some shrub species are both rhizomatous and dwarf. The following list of common rhizomatous and/or dwarf shrubs is provided for consistency but data collectors should consult local botanical experts for other potential species in the state.

Table Q1. Common rhizomatous and dwarf shrubs. In general, all subordinate taxa of the listed species should also be considered rhizomatous or dwarf shrubs. A primary designation is given, but some species can be both rhizomatous and dwarf.

Family	Scientific Name	Common Name	Designation
Ericaceae	*Andromeda polifolia*	bog rosemary	Dwarf Shrub
Ericaceae	*Arctostaphylos alpina*	alpine bearberry	Dwarf Shrub
Ericaceae	*Arctostaphylos rubra*	red fruit bearberry	Dwarf Shrub
Ericaceae	*Arctostaphylos uva-ursi*	kinnikinnick	Dwarf Shrub
Asteraceae	*Artemisia arctica*	boreal sagebrush	Dwarf Shrub
Asteraceae	*Artemisia cana*	silver sagebrush	Rhizomatous
Asteraceae	*Artemisia frigida*	prairie sagewort	Rhizomatous
Betulaceae	*Betula glandulosa*	resin birch	Dwarf Shrub
Betulaceae	*Betula nana*	dwarf birch	Dwarf Shrub
Ericaceae	*Cassiope lycopodioides*	clubmoss mountain heather	Dwarf Shrub
Ericaceae	*Cassiope mertensiana*	western moss heather	Dwarf Shrub
Ericaceae	*Cassiope tetragona*	white arctic mountain heather	Dwarf Shrub
Ericaceae	*Chamaedaphne calyculata*	leatherleaf	Rhizomatous
Pyrolaceae	*Chimaphila umbellata*	pipsissewa	Rhizomatous
Thymelaeaceae	*Daphne mezereum*	paradise plant	Dwarf Shrub
Rosaceae	*Dasiphora fruticosa*	shrubby cinquefoil	Rhizomatous
Diapensiaceae	*Diapensia lapponica*	pincushion plant	Dwarf Shrub
Rosaceae	*Dryas drummondii*	Drummond's mountain-avens	Dwarf Shrub
Rosaceae	*Dryas integrifolia*	entireleaf mountain-avens	Dwarf Shrub

Rosaceae	*Dryas octopetala*	eightpetal mountain-avens	Dwarf Shrub
Empetraceae	*Empetrum nigrum*	black crowberry	Dwarf Shrub
Ericaceae	*Gaultheria hispidula*	creeping snowberry	Dwarf Shrub
Ericaceae	*Gaultheria humifusa*	alpine spicywintergreen	Dwarf Shrub
Ericaceae	*Gaultheria miqueliana*	Miquel's spicywintergreen	Dwarf Shrub
Ericaceae	*Gaultheria ovatifolia*	western teaberry	Dwarf Shrub
Ericaceae	*Gaultheria shallon*	salal	Rhizomatous
Ericaceae	*Harrimanella stelleriana*	Alaska bellheather	Dwarf Shrub
Clusiaceae	*Hypericum calycinum*	Aaron's beard	Rhizomatous
Ericaceae	*Kalmia microphylla*	alpine laurel	Dwarf Shrub
Ericaceae	*Kalmia polifolia*	bog laurel	Dwarf Shrub
Ericaceae	*Ledum groenlandicum*	bog Labrador tea	Dwarf Shrub
Ericaceae	*Ledum palustre*	marsh Labrador tea	Dwarf Shrub
Caprifoliaceae	*Linnaea borealis*	twinflower	Dwarf Shrub
Ericaceae	*Loiseleuria procumbens*	alpine azalea	Dwarf Shrub
Rosaceae	*Luetkea pectinata*	partridgefoot	Dwarf Shrub
Berberidaceae	*Mahonia aquifolium*	hollyleaved barberry	Rhizomatous
Berberidaceae	*Mahonia nervosa*	Cascade barberry	Rhizomatous
Myricaceae	*Myrica gale*	sweetgale	Dwarf Shrub
Ericaceae	*Phyllodoce aleutica*	Aleutian mountainheath	Dwarf Shrub
Ericaceae	*Phyllodoce breweri*	purple mountainheath	Rhizomatous
Ericaceae	*Phyllodoce caerulea*	blue mountainheath	Dwarf Shrub
Ericaceae	*Phyllodoce empetriformis*	pink mountainheath	Dwarf Shrub
Ericaceae	*Phyllodoce glanduliflora*	yellow mountainheath	Dwarf Shrub
Asteraceae	*Pluchea sericea*	arrowweed	Rhizomatous
Rosaceae	*Prunus virginiana*	chokecherry	Rhizomatous
Ericaceae	*Rhododendron camtschaticum*	Kamchatka rhododendron	Dwarf Shrub

Ericaceae	*Rhododendron lapponicum*	Lapland rosebay	Dwarf Shrub
Anacardiaceae	*Rhus glabra*	smooth sumac	Rhizomatous
Anacardiaceae	*Rhus trilobata*	skunkbush sumac	Rhizomatous
Grossulariaceae	*Ribes aureum*	golden currant	Rhizomatous
Fabaceae	*Robinia hispida*	bristly locust	Rhizomatous
Rosaceae	*Rosa pinetorum*	pine rose	Rhizomatous
Rosaceae	*Rosa rugosa*	rugosa rose	Rhizomatous
Rosaceae	*Rosa woodsii*	Woods' rose	Rhizomatous
Rosaceae	*Rubus idaeus*	American red raspberry	Rhizomatous
Rosaceae	*Rubus parviflorus*	thimbleberry	Rhizomatous
Salicaceae	*Salix arctica*	arctic willow	Dwarf Shrub
Salicaceae	*Salix arctophila*	northern willow	Dwarf Shrub
Salicaceae	*Salix barclayi*	Barclay's willow	Dwarf Shrub
Salicaceae	*Salix chamissonis*	Chamisso's willow	Dwarf Shrub
Salicaceae	*Salix eriocephala*	Missouri River willow	Rhizomatous
Salicaceae	*Salix exigua*	narrowleaf willow	Rhizomatous
Salicaceae	*Salix fuscescens*	Alaska bog willow	Dwarf Shrub
Salicaceae	*Salix hookeriana*	dune willow	Rhizomatous
Salicaceae	*Salix ovalifolia*	oval-leaf willow	Dwarf Shrub
Salicaceae	*Salix phlebophylla*	skeletonleaf willow	Dwarf Shrub
Salicaceae	*Salix polaris*	polar willow	Rhizomatous
Salicaceae	*Salix pseudomonticola*	false mountain willow	Rhizomatous
Salicaceae	*Salix pulchra*	tealeaf willow	Dwarf Shrub
Salicaceae	*Salix reticulata*	netleaf willow	Dwarf Shrub
Salicaceae	*Salix rotundifolia*	least willow	Dwarf Shrub
Salicaceae	*Salix sessilifolia*	northwest sandbar willow	Rhizomatous
Salicaceae	*Salix setchelliana*	Setchell's willow	Dwarf Shrub

Salicaceae	*Salix sphenophylla*	wedgeleaf willow	Dwarf Shrub
Salicaceae	*Salix stolonifera*	sprouting leaf willow	Dwarf Shrub
Rosaceae	*Spiraea douglasii*	rose spirea	Rhizomatous
Rosaceae	*Spiraea tomentosa*	steeplebush	Rhizomatous
Caprifoliaceae	*Symphoricarpos albus*	common snowberry	Rhizomatous
Caprifoliaceae	*Symphoricarpos orbiculatus*	coralberry	Rhizomatous
Caprifoliaceae	*Symphoricarpos oreophilus*	mountain snowberry	Rhizomatous
Oleaceae	*Syringa vulgaris*	common lilac	Rhizomatous
Ericaceae	*Vaccinium cespitosum*	dwarf bilberry	Dwarf Shrub
Ericaceae	*Vaccinium myrtilloides*	velvetleaf huckleberry	Dwarf Shrub
Ericaceae	*Vaccinium myrtillus*	whortleberry	Dwarf Shrub
Ericaceae	*Vaccinium oxycoccos*	small cranberry	Dwarf Shrub
Ericaceae	*Vaccinium scoparium*	grouse whortleberry	Rhizomatous
Ericaceae	*Vaccinium uliginosum*	bog blueberry	Dwarf Shrub
Ericaceae	*Vaccinium vitis-idaea*	lingonberry	Rhizomatous

Appendix R: Instructions to Construct a Multiple Indicator Monitoring Frame

This appendix provides instructions for constructing a Multiple Indicator Monitoring (MIM) frame for completing the stubble height method and soil alteration method. Monitoring frames may be constructed of various materials including metal (usually aluminum) or 1/2-inch PVC schedule 40 pipe. Metal frequency plot frames (typically 40 by 40 cm) may be used by extending the tines to 50 cm in length and marking the four incremental segments with lines or alternating colors.

Schedule 40 PVC is rigid and does not warp as much as lighter pipe. This material is inexpensive, light, and easy to use to make the frames. Table R1 provides a list of materials needed for constructing a MIM frame. Carefully measure each of the parts before they are glued together, as fittings (tees) are not uniform among manufacturers. To construct a MIM frame using 1/2-inch PVC pipe, see Figure R1 and follow these steps:

a. Cut pipe to the appropriate lengths (see Table R1).
b. Apply PVC cement to one end of pipe part B and the tee (part A) and slide them together. Repeat the procedure on the opposite end of the tee. Repeat the process on the second tee (part A). Remember PVC cement cures rapidly (within a few seconds). There are no second chances.
c. Apply cement to the short pipe (part E) and the tee of one of the previously constructed parts (see step b). Slide them together.
d. Apply cement to the tee (part C) and the end of part E. Slide the two parts together, making sure the tee is perpendicular to part A so that the handle can be used properly.
e. The center pipe (part D) may or may not be glued into place between the previously constructed parts. If the center pipe is glued, make sure the two ends are level. Not gluing the center pipe allows the frame to be taken apart and transported. On the other hand, it may come apart occasionally when being used.
f. Construct the handle by cementing the male threaded coupler (part G) to one end of the pipe (part F). Put Teflon tape on the threads prior to screwing the parts together, which makes it much easier to remove the handle when needed.
g. Screw the handle into the frame (part C) and mark the handle in 1-in (or 2-cm) increments beginning at ground level. Proceed up the handle for 1 m. Cut off excess material.
h. The markings on the frame provide references for observers to project lines and estimate the amount of vegetation in the quadrat. Electrical tape wrapped around the pipe is a good material for marking the alternating colors. Tape does not come off the pipe as easily as paint does.

Table R1. Parts list for constructing a MIM frame. To ensure the handle is the proper length, first assemble the frame. Then, measure from the base of the frame to one meter and cut the handle at that location.

Item	**Part Label**	**No.**	**Length**	
			Inches	**cm**
PVC cement	NA	1	--	--
½ inch tee fitting	A	3	--	--
PVC pipe (schedule 40)	B	4	7.75	19.7
½ inch tee with threaded riser	C	1	--	--
PVC pipe (schedule 40)	D	1	16.9	43
PVC pipe (schedule 40)	E	1	1.25	3.2
PVC pipe (schedule 40)	F Handle	1	39	100
½ inch male threaded coupler	G on Handle	1	--	--

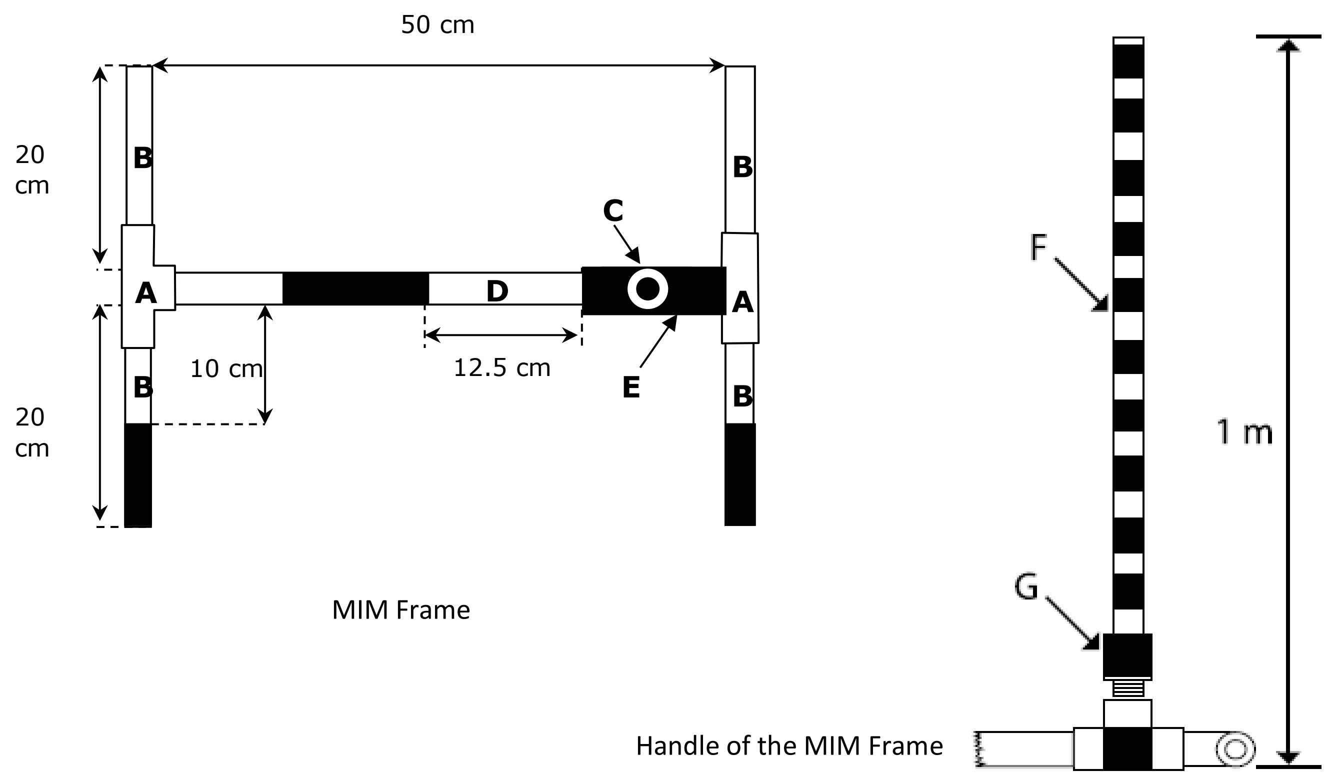


Figure R1. Schematic diagram of the MIM frame and handle.

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