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RIPARIAN AREA MANAGEMENT

Proper Functioning Condition Assessment for Lentic Areas

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Abbreviations

BLM – Bureau of Land Management
DMA – designated monitoring area
EC – electrical conductivity
ESP – exchangeable sodium percentage
FAC – (see WIC)
FACU – (see WIC)
FACW – (see WIC)
FAR – functional–at risk
GIS – geographic information system
GPS – global positioning system
HGM – hydrogeomorphic
ID – interdisciplinary
IRMP – integrated riparian management process
LIDAR – light detection and ranging (data)
MIM – multiple indicator monitoring
NA – not applicable
NF – nonfunctional
NRCS – Natural Resources Conservation Service
NWI – National Wetlands Inventory
  NWI+ – National Wetlands Inventory Plus
  NWIPlus – National Wetlands Inventory Plus
OBL – (see WIC)
PFC – proper functioning condition
PNC – potential natural condition
TR – technical reference
UAV – unmanned aerial vehicle
UPL – (see WIC)
USGS – U.S. Geological Survey
WIC – wetland indicator category (arranged wettest to driest)
  OBL – obligate
  FACW – facultative wetland
  FAC – facultative
  FACU – facultative upland
  UPL – upland

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1. Introduction

Riparian areas and **wetlands** are areas that exhibit vegetation or physical characteristics reflective of permanent surface- or subsurface-water influence. Though there is not a single, consistently used definition for riparian areas, this description includes qualities common in many current definitions (National Research Council 2002). Riparian and wetland areas are influenced and supported by the presence of plant-available water above or within the rooting zone, often as a result of surface inundation or soil saturation. To support riparian and/or wetland vegetation, this water must be available for a substantial part of the growing season. Though this duration is not fixed, the common understanding is that the water should be available for at least 15 consecutive days to support the types of vegetation expected in wetland environments (National Research Council 1995); some riparian and wetland areas can be supported with shorter periods of water availability. Due to the overlapping and potentially confusing definitions of riparian and wetland, the term **riparian-wetland** is used here to encompass both concepts. Finally, riparian-wetland areas as defined here include not only areas that the U.S. Army Corps of Engineers defines as jurisdictional wetlands (USACE 1987), but also nonjurisdictional areas.

The upland limit of riparian-wetland area occurs at the boundary between hydrophytic (obligate (OBL), facultative wetland (FACW), and facultative (FAC)) and nonhydrophytic (facultative upland (FACU) and upland (UPL)) vegetation, as defined by the National Wetland Plant List (Lichvar et al. 2016). The proper functioning condition (PFC) protocol is primarily intended for plant communities that are dominated by OBL, FACW, and FAC species.

Riparian-wetland areas are divided into two systems: lotic and lentic. **Lotic systems** are associated with environments having fast or flowing water, such as rivers, streams, and creeks. Flowing 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. Lotic systems are assessed using the PFC protocol for lotic systems (Dickard et al. 2015).

In contrast to lotic systems, **lentic systems** are characterized by still or very slow-moving water. Lentic riparian-wetland systems include but are not limited to seeps, springs, marshes, swamps, bogs, fens, muskegs, prairie potholes, wet and moist meadows, vegetated drainageways, oxbows, beaver complexes, shallow (i.e., typically a depth of 2 meters or less) lakes and ponds, and constructed reservoirs. Lentic systems may be independent of 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 lentic systems are located, water within them generally does not have the requisite energy to form and maintain a scour channel when functioning properly or at the system's potential. Movement of sediment and organic matter may occur through dissolved or suspended transport, but bedload transport is minor and inconsequential in the development, maintenance, and function of most lentic environments.

This document provides guidance for completing PFC assessments on lentic areas. The distinction between lotic and lentic systems, however, is not always readily apparent. Sometimes functions vary by season such that the site behaves or resembles a lotic site for part of the year and a lentic site at other times. Although two discrete systems are described, the boundary between them can be blurry in some situations. When there is a degree of ambiguity, assessment items from the lotic and lentic protocols may be blended to create a customized or hybridized protocol that best fits an unusual and specific situation.

Riparian-wetland areas are complex, dynamic ecosystems incorporating biological, physical, and chemical processes. The PFC assessment method was created to evaluate the foundation of these processes qualitatively—specifically, the functionality of the physical processes occurring in a riparian-wetland area. These physical processes include the interactions of hydrology, stabilizing vegetation, and geomorphology (soils and landforms). A quality assessment requires that an interdisciplinary (ID) team with expertise in these subjects assess the riparian-wetland area together. Because the PFC assessment compares each site to its own potential, it is universally applicable to all but the most highly modified lentic areas.

This document uses the abbreviation "PFC" to describe both the assessment method and a defined, on-the-ground condition of a lentic riparian area. First, PFC describes an assessment protocol that, using a consistent approach, considers hydrologic, vegetative, and soil/geomorphic attributes and processes to assess the condition of riparian-wetland areas at a point in time. Second, the on-the-ground condition of PFC indicates how well the physical processes on the ground are functioning. In this regard, once a lentic riparian-wetland site has been assessed and rated as PFC, it is in a state of resiliency that will allow it to resist impairment from energy stressors, including overland flow events and wind and wave action, as well as direct physical stressors from human activities and wild and domestic ungulates. This resiliency allows an area to then produce desired values, such as waterfowl habitat, neotropical bird habitat, or forage over time. Riparian-wetland areas that are not functioning properly cannot sustain these values. A condition rating of PFC is not synonymous with potential natural condition but is generally a prerequisite for achieving and maintaining habitat quality and other values.

Information pertaining to 20 attributes and processes of a lentic riparian-wetland system is foundational to determining its physical function and is synthesized on an assessment form (appendix A). Based on the responses and comments on the assessment form, the ID team places the lentic area in one of three rating categories:

Proper functioning condition (PFC): A lentic riparian-wetland area is considered to be in PFC, or functioning properly, when adequate vegetation, soil and landform, or woody material is present to:

- Dissipate energies associated with overland flows (e.g., storm and snowmelt events) and wind and wave action, thereby reducing erosion.
- Protect/stabilize shorelines, islands, and soil surfaces from erosion and direct physical alteration from human and animal activities.
- Improve floodwater retention as well as ponding, storage, and retention of surface water.
- Saturate soil and retain soil moisture.
- Maintain or improve groundwater recharge.
- Capture sediment.
- Maintain soil attributes (e.g., organic matter, pore space, structure, soil chemistry).

A riparian-wetland area in PFC will, in turn, provide associated values, such as wildlife habitat, recreational opportunities, and good water quality.

Functional–at risk (FAR): These riparian-wetland areas are in limited functioning condition; however, one or more existing hydrologic, vegetative, or soil/geomorphic attributes make them susceptible to impairment.

Nonfunctional (NF): These riparian-wetland areas clearly are not providing adequate vegetation, soil and landform, or woody material to dissipate energies associated with overland flows and wind and wave action, and thus are not reducing erosion, improving water quality, protecting soil surfaces, stabilizing the site from physical alterations, and otherwise supporting PFC.

The minimum acceptable management goal for a riparian-wetland area is at least the condition of PFC because any rating below PFC indicates a condition that is not sustainable. If a riparian-wetland area is functioning properly, then processes are in place to create and maintain values associated with the potential of the site, such as quality habitat and clean water. If, on the other hand, the riparian-wetland area is not functioning properly, it is likely that these values will be impaired (Harman et al. 2012). However, attaining PFC does not necessarily mean that chemical and biological processes are unaffected. For example, sediment, thermal, or nutrient regimes could remain impaired because of offsite impacts that are transmitted into the lentic area. Protocols that assess or monitor chemical or biological functions can be used to understand these parameters in conjunction with the PFC assessment.

ID team members must understand site dynamics and potential and use their professional experience and judgment to complete a quality assessment accurately. Although a PFC assessment relies on basic concepts of lentic area function, it cannot be completed by personnel who lack specific subject-matter training, relevant experience, or firsthand knowledge of local riparian-wetland systems. It requires thoughtful observation of various site conditions and their current state in quantitative measurements. A PFC assessment involves both the art and the science of "reading the landscape," and a working understanding of each requires time and experience.

Purpose of This Technical Reference and Changes from Earlier Editions

This technical reference (TR) provides instructions for the application of the lentic PFC protocol. It is not intended to serve as a textbook addressing every aspect of lentic area and riparian-wetland function and ecology. The lentic PFC protocol addresses the physical functioning of perennial or intermittent lentic riparian-wetland systems, such as swamps, ponds, or marshes. Lotic riparian-wetland systems, such as rivers or streams, are addressed in a separate TR (Dickard et al. 2015). The PFC assessment protocol is not intended for use on ephemeral systems, which do not support the vegetation, riparian-wetland functions, and values that depend on extended periods of available free water in the soil.

The PFC method is a qualitative assessment based on quantitative science. For example, item 13 on the lentic PFC assessment form asks whether there is an adequate amount of stabilizing riparian-wetland vegetation present to protect soil surfaces and shorelines and to dissipate energy from overland flows and wind and wave actions. Visual evidence of erosion would provide the qualitative information that there is not enough cover of stabilizing riparian-wetland vegetation. If compelling visual evidence was absent or if the amount of stabilizing vegetation needed to be quantified or tracked over time, other monitoring tools would provide the rigorous methods to do so. A similar kind of quantification or monitoring can be produced for almost all assessment items.

Use of quantitative techniques is encouraged in conjunction with the PFC assessment when deemed necessary; most commonly ID teams use quantitative data for individual or ID team calibration or where quantitative data can provide additional documentation for highly controversial or complicated sites. PFC is also an appropriate starting point for determining and prioritizing the type and location of quantitative inventory or monitoring needed, and it can provide context for quantitative data.

TR 1737-11, Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas (Prichard et al. 1998), describes the PFC protocol for lentic areas, which was first presented in an earlier edition in 1994. In 1999, TR 1737-11 was rewritten as TR 1737-16. It included more detail on how to apply the PFC protocol; this version was then revised in 2003. The 2003 revision, A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lentic Areas (Prichard et al. 2003), incorporated input from resource specialists in the Bureau of Land Management (BLM), Forest Service, Natural Resources Conservation Service (NRCS), and state riparian-wetland teams in the Creeks and Communities Network. Since that revision the PFC method has been further implemented by the BLM and several other agencies and has been widely used on numerous riparian-wetland systems in the United States. This widespread application of the tool has helped practitioners identify several needed updates and improvements.

This third edition of TR 1737-16 does not alter the overall approach from the 2003 document. Most of the changes address the need to include new science, provide better examples, clarify the wording of some of the assessment items and sections, provide additional detail where needed, and add a quick-reference matrix of items that commonly correlate (appendix B). Because many new quantitative and semiquantitative procedures have been developed since 2003, the procedures available to validate PFC assessments of lentic areas have been updated (appendix C). This edition also includes examples to describe how PFC fits into an overall integrated riparian management process (IRMP) and to emphasize the work required before and after conducting a field assessment of a site.

The definition of lentic PFC has been slightly modified from earlier versions to emphasize physical stressors in addition to energy stressors that are common in lentic riparian-wetland areas. Lotic PFC places a significant emphasis on energy stressors; namely, stream energy in the context of a system's ability to withstand moderately high-flow events. The corresponding energy stressors in lentic areas are overland flows and wind and wave action. *Some lentic riparian-wetland sites do not experience significant exposure to overland flow or wind and wave action. Many lentic riparian-wetland areas, however, experience direct physical stressors from human activity, wild and domestic ungulates, and vehicles or machinery. These physical stressors can significantly affect riparian-wetland area function.*

Examples of the physical effects of these stressors are off-highway vehicle impacts, soil compaction, trailing, soil pugging, and hoof shear/hoof slide. Lentic riparian-wetland areas that develop plants with stabilizing properties are able to withstand the effects of these physical stressors. This resistance to physical alteration protects the site from erosion and soil compaction and promotes many beneficial functions (e.g., organic-matter production, soil moisture retention, sediment capture, effective nutrient cycling).

The process for applying potential and capability to the PFC assessment has been refined to improve the consistent use of these concepts. Potential is described in detail, and the specific term "capability," used in the 2003 version to describe limiting factors as a result of human changes, is no longer used. The concept for addressing the same limiting factors in a unique way still applies; however, **altered potential** (a more direct term) is now used, and a set of guidelines has been developed to help users evaluate how human alterations affect potential.

Lastly, the order of items 8 and 9 has been reversed on the lentic assessment form from previous versions to create a more logical flow to the assessment process. This reversal will need to be considered in database management.

Intended Applications

The lentic PFC assessment protocol *is* designed to:

- **Assess the function of perennial and intermittent lentic riparian-wetland areas.** The attributes and processes developed for the lentic PFC assessment are specific to perennial and intermittent systems. Other protocols could be used to focus specifically on the assessment of fens (Weixelman and Cooper 2009), lotic riparian systems (Dickard et al. 2015), or ephemeral systems (e.g., Pellant et al. 2020). Lentic PFC assessments apply to:
    - **Most lentic areas, regardless of size.** Because each riparian-wetland area is assessed against its own specific potential, the PFC protocol can essentially be used on any size lentic system provided that the ID team fully understands the attributes and processes influencing the function of that system.
    - **Most lentic areas that have been created** (e.g., reservoirs) **or modified** (e.g., developed seeps and springs) unless they have been altered so extensively that they are no longer expected to provide natural riparian-wetland functions. Appendix D provides guidance on how to consider the potential of systems with modifications or relatively permanent human alterations. Although PFC *can be used* to assess many created and modified systems, the land use plan, goals, and policy of the management agency or landowner will dictate *if* PFC is appropriate.

- **Be conducted by an ID team of experienced resource specialists.** Because PFC is a qualitative assessment of indicators of riparian-wetland area function, most resource specialists completing the PFC assessment should have a strong technical background and experience collecting, analyzing, and interpreting quantitative data related to the assessment items specific to their discipline. In addition, most ID team members should have local experience in the watershed(s) being assessed. The PFC assessment provides a good communication tool to discuss riparian functions with stakeholders; however, on federal lands, the agency's ID team is responsible for answering evaluation items and determining final ratings (see discussion on assembling an ID team in chapter 3).

- **Provide a consistent approach for assessing the physical functioning of riparian-wetland areas** through consideration of hydrologic, vegetative, geomorphic, and soil attributes relative to the potential of the site being assessed. The PFC assessment synthesizes information that is foundational to determining the overall health of a riparian-wetland area.

- **Provide a focused and effective foundation for determining resource values and developing management goals** by identifying attributes and processes that are out of balance for the landscape setting. See examples provided in appendix E.

- **Help establish and prioritize management, monitoring, and restoration activities.** The PFC assessment can provide an early warning of problems and point to opportunities by helping to identify key management issues, focus monitoring activities to maximize efficiency, and prioritize restoration actions on the "at-risk" systems of highest resource value.

- **Communicate fundamental riparian concepts** to a wide variety of audiences. This process forms a "common vocabulary" for discussing physical riparian-wetland functions as the basis for developing common understanding and vision for long-term, desired conditions.

The PFC assessment protocol *is not* designed for:

- **Assessments of the function of ephemeral systems.**

- **Use by inexperienced personnel.** Because PFC is an observational assessment, personnel must have enough experience to recognize and interpret visual indicators of function.

- **Assessments completed without an ID team.** While *individuals* may learn about riparian-wetland areas by studying and using the PFC concepts and thought process, the assessment must be completed by an ID *team. A study of riparian function that is not completed with an ID team is inconsistent with this protocol and is not considered a PFC assessment.*

- **Monitoring of resource conditions and trends.** PFC is an assessment and is not intended to be a monitoring tool, because it generally lacks the sensitivity to detect incremental changes in riparian-wetland condition.

- **Assessments of specific resource values or as the sole method for assessing the health of the aquatic or terrestrial components of a riparian-wetland area.** The PFC assessment is not a replacement for inventory, assessment, or monitoring protocols designed to yield information on the biology of the plants and animals or other habitat parameters.

- **Assessments of the function of systems where relatively permanent human alterations have created artificial conditions for a substantial part of the site.** Instructions for how to consider modified and altered sites are included in appendix D.

2. Managing Riparian-Wetland Areas Using an Integrated Process

A PFC assessment is most useful if implemented as part of a comprehensive adaptive management framework. The integrated riparian management process, or IRMP, is an adaptive management framework that ensures riparian assessments (PFC), monitoring, and management efforts are effective and efficient (figure 1). The IRMP provides a logical, sequential progression of actions designed to ensure that key activities are completed, priorities are considered, goals and objectives are properly described, and monitoring actions are focused and informative—all of which are necessary for effective land management decisions.

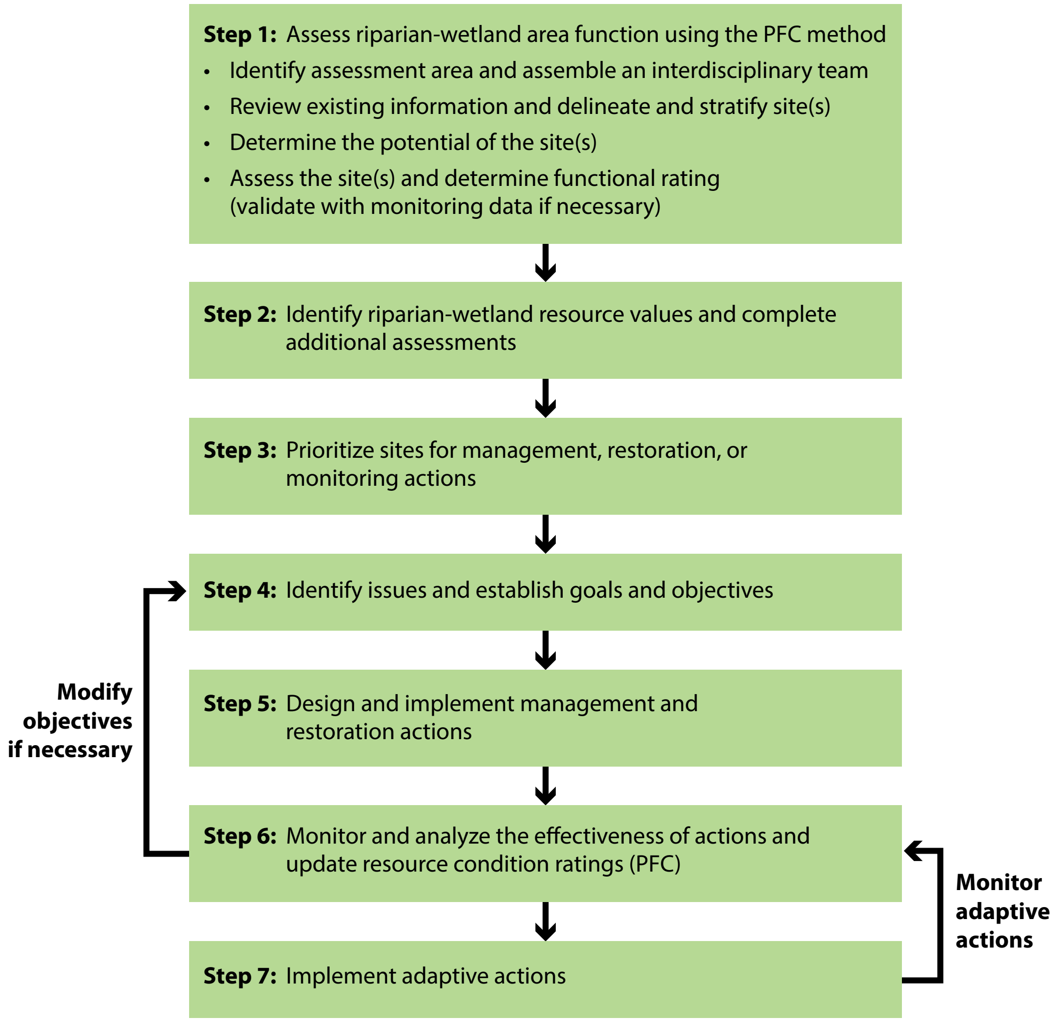
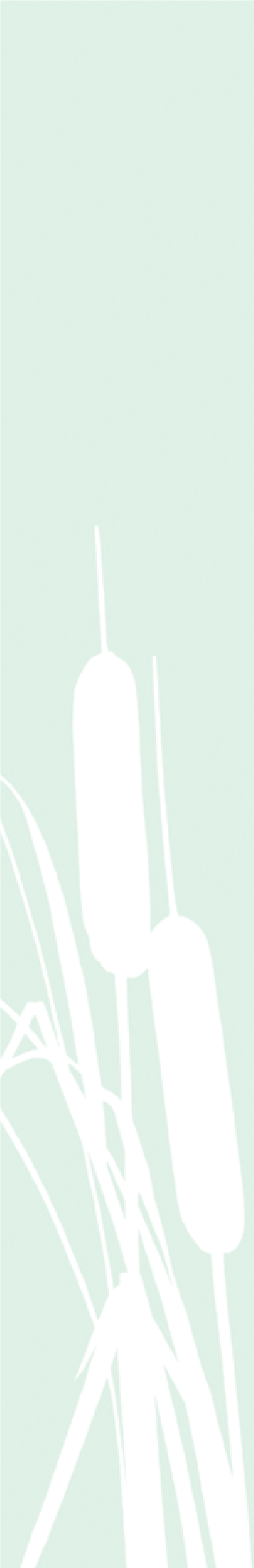


Figure 1. Recommended steps in the integrated riparian management process. After effectiveness monitoring has been done (step 6), initial objectives are validated and modified if necessary. After adaptive actions are implemented, step 6 is repeated to monitor the effectiveness of those actions.



Step 1: Assess Riparian-Wetland Area Function Using the PFC Method

Completing a PFC assessment is an effective way to initiate a comprehensive and integrated riparian management process because it provides fundamental information for subsequent management, restoration, or monitoring actions. Chapters 3-8 provide detailed instructions for conducting a PFC assessment, which consists of the following tasks:

- Identify the assessment area and assemble an ID team (any number of management, regulatory, or resource issues could drive the decision to select or prioritize an area to assess).

- Review existing information, and delineate and stratify sites.

- Determine the potential of each site in terms of hydrology, vegetation, and soil/geomorphic characteristics.

- Assess each site and determine its functional rating (validate with monitoring data if necessary). Document the findings of the assessment with completed assessment forms, riparian-wetland plant lists, and photo documentation of key findings.

Step 2: Identify Riparian-Wetland Resource Values and Complete Additional Assessments

Within the assessment area, identify resource values for the various sites. These will later be used to help establish priorities for management, restoration, and monitoring. Values include fish and wildlife habitat, recreational opportunities, livestock forage, sensitive plants, water quality, Endangered Species Act requirements, species of concern, special interest areas, etc. Although resource values are usually established at some level in a land use plan, values should generally be validated or refined at the site scale.

Once values are identified, they may require additional assessment. A PFC assessment provides fundamental information regarding the physical function and condition of the riparian-wetland area; however, PFC represents a basic level of function and resiliency only. Desired conditions often require additional ecological attributes or an advanced ecological condition—beyond PFC. Therefore, additional information is often needed to obtain a comprehensive assessment of riparian-wetland condition. Fish or wildlife habitat and water quality assessments are examples of additional resource assessments that may be needed to characterize overall riparian-wetland condition in preparation for subsequent activities. Often these assessments can be done simultaneously with the PFC assessment.

Step 3: Prioritize Sites for Management, Restoration, or Monitoring Actions

Once resource values are identified, those values, along with the PFC assessment results, provide a basis for prioritizing sites for management, restoration, or monitoring actions.

Although restoring function is a fundamental priority, some lentic sites at PFC may not be meeting other habitat or desired condition objectives and may also be a high priority for management, restoration, or monitoring due to legal mandates or other needs. These needs are factored into the prioritization process along with the needs associated with NF and FAR sites and their corresponding values.

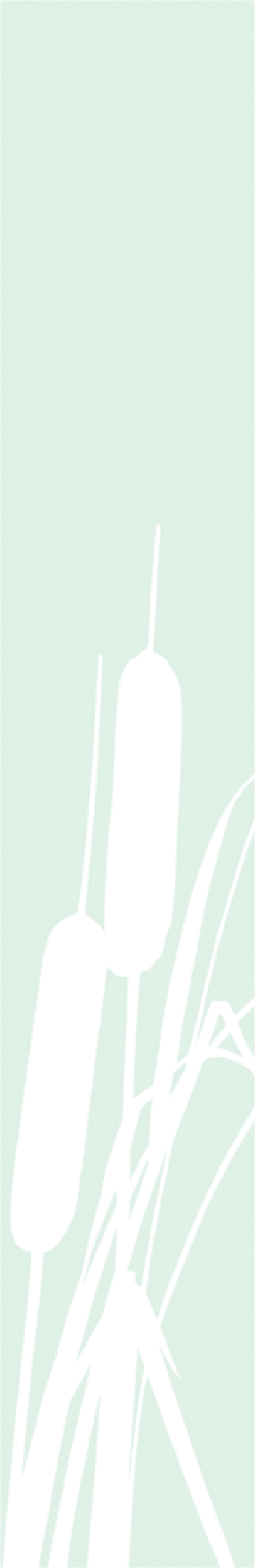
By concentrating on the sensitive, at-risk areas that may be near the threshold of rapid degradation into an NF condition, timely management changes or restoration activities can halt the decline and begin the recovery process before deterioration progresses further and recovery actions become expensive. Often, once an area is nonfunctional, the effort, potential for failure, cost, and time required for recovery dramatically increase. There are also instances where neither management nor restoration actions are necessary, but the area is a high priority for monitoring due to a need to document condition or track changes (trend).

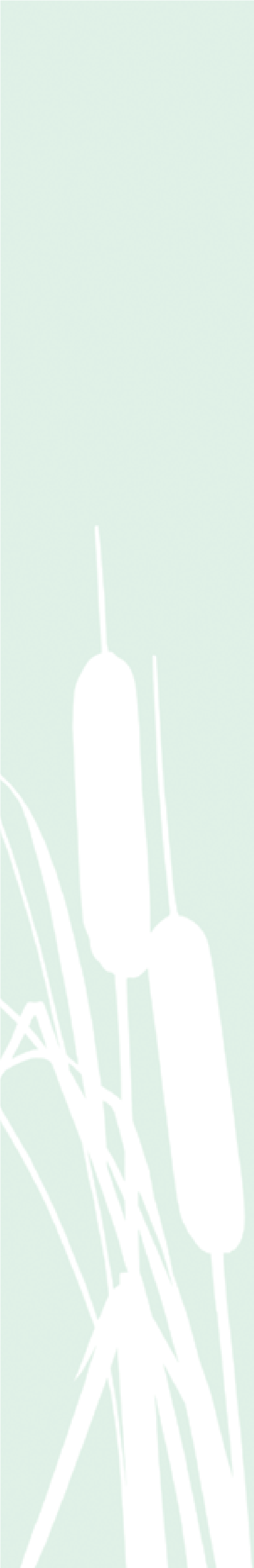
Restoration of most NF systems should be reserved for those situations in which the riparian-wetland area has reached a point where recovery is possible, efforts are not at the expense of at-risk systems, or unique opportunities exist. NF systems should not be ignored, but the cost to restore function may be prohibitive; natural evolution may be the best course of action for these systems. At the same time, areas that are functioning properly are often not the highest priorities for additional restoration work towards potential because they are more resilient than the at-risk areas. However, it is critical to manage these areas to retain their resilience and further progress towards desired condition.

Because not all at-risk sites have the same resource values, information from the PFC assessment should be combined with site-specific resource values to establish reasonable priorities. For example, sites that are FAR with high resource values would be a higher priority than FAR sites with low resource values.

The PFC assessment can also help determine the appropriate timing and focus for riparian-wetland restoration projects (including structural and management changes). Because PFC evaluates attributes and processes of function, the assessment results can be used to inform the design of restoration actions that address the causal factors of impairment. The PFC assessment can also identify situations where structures are either entirely inappropriate or premature (e.g., stabilizing a headcut would be necessary before downslope restoration projects are initiated).

The results of the PFC assessment can be used to identify watershed scale (or allotment or other management unit scale) problems and suggest management remedies and priorities. Whereas the methods and data are site-based, the ratings can be aggregated and analyzed at larger scales. This simple aggregation would include the number of sites assessed, their acreage, and their functional rating within a project area. Information from the PFC assessment, along with other watershed and habitat condition information, helps provide a good picture of the watershed or management unit and the probable causal factors affecting the health of the watershed or unit.





For example, an ID team, working on an environmental assessment for a group of allotments, might note the riparian functional status of all the lentic areas in the project areas as: 80 acres (50 percent) PFC, 40 acres (25 percent) FAR–upward trend, 20 acres (12 percent) FAR–no trend apparent, 15 acres (10 percent) FAR–downward trend, and 5 acres (3 percent) NF.

See the Lentic Riparian-Wetland Area Prioritization Guide (Smith 2008) for guidance on evaluating management and restoration priorities in lentic areas.

Step 4: Identify Issues and Establish Goals and Objectives

The completed PFC assessment, combined with additional resource assessments, not only provides comprehensive information about both physical function and attendant resource values, it also highlights specific resource issues (by site) that need to be addressed. Because PFC is a systematic assessment throughout an entire project area, it is very effective in identifying issues that may have been missed during field inspections conducted sporadically or from the limited perspective of examining scattered monitoring plots. For example, the PFC assessment may reveal that although vegetative cover at a site is high, the cover of stabilizing species is low. This situation may be preventing the site from achieving PFC and desired habitat values.

The information obtained from the PFC assessment can be used to develop goals (which are general, unquantified statements of planned results), such as increasing the cover of stabilizing species. The ID team should describe goals that are tied to the findings of the PFC assessment (and other assessment or monitoring information) and that can be refined into quantifiable objectives later if data are collected.

Information from the PFC assessment will allow the ID team to focus on key attributes (e.g., stabilizing vegetation) that need to improve and to be monitored subsequently to determine if improvement has occurred. Low-priority sites may require the creation of only broad goals, and thus, may often need only infrequent qualitative monitoring. Other sites may need specific, quantitative objectives and subsequent quantitative monitoring.

Baseline data are usually necessary to establish quantifiable resource objectives for priority sites identified during the PFC assessment. The term "baseline data" refers to the initial collection of data, which serves as a basis for comparison with the subsequently acquired data. Some baseline data may already have been collected for sites (e.g., where validation monitoring was done to support the PFC assessment) and may relate directly to the attainment of the overall goals.

Good objectives should be based on the potential of the site, relate directly to the attainment of the overall goals, and include components illustrated by the acronym "SMART" (Adamcik et al. 2004):

- **S**pecific
- **M**easurable
- **A**chievable
- **R**esults-oriented
- **T**ime-fixed

Writing effective quantitative objectives involves determining the current state of an attribute, how much it may need to change, and the timeframe necessary to achieve the desired change. Other quantitative techniques can be used as appropriate to collect baseline resource and habitat data as well (see appendix C for additional techniques tied to the PFC assessment). If, for example, the cover of stabilizing plant species is found to be lacking at a site and bare ground is high ("no" response to item 13), a *goal* would be to increase the amount of cover of stabilizing plant species and decrease bare ground. Related *SMART objectives* tied to those goals would be to increase the amount of cover of stabilizing riparian-wetland species by at least 30 percent (e.g., 55 to 85 percent) and decrease bare ground by at least 10 percent (e.g., 15 to 5 percent) within a fixed time (e.g., 7 years) at a specific location (e.g., Side Hill Spring).

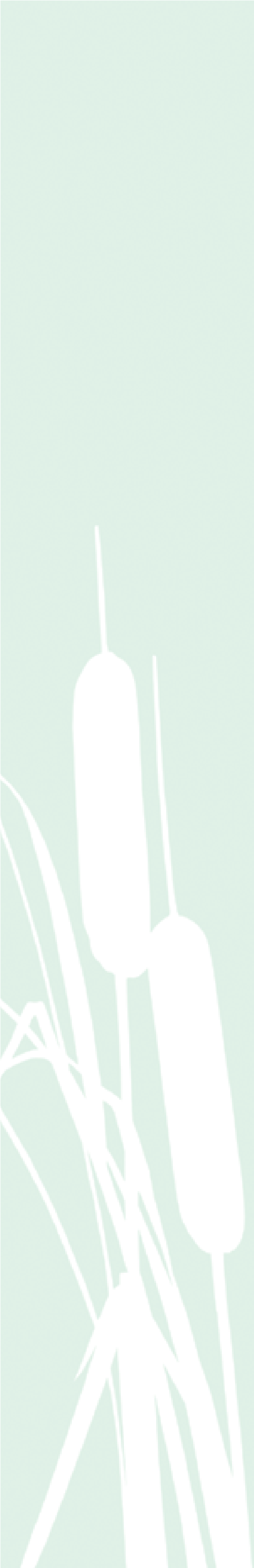
Most lentic sites will have a short list of objectives. The objectives described above are largely tied to functionality; however, other resource objectives should be included on this list as well (e.g., the percent cover of threatened, endangered, or sensitive plants on a site). It is sometimes advantageous to establish intermediate objectives (3-7 years) and long-term objectives (more than 7 years) for sites that need considerable time to recover. Progress towards management objectives is partly a function of management actions and partly controlled by environmental circumstances, such as the timing of floods, droughts, fire, and other watershed disturbances. Consequently, objectives may need to be modified as part of the adaptive management process.

Step 5: Design and Implement Management and Restoration Actions

Once the preceding steps have been completed, management and restoration actions can be designed and effectively set in motion. Management and restoration actions for selected sites, or units within the assessment area (e.g., grazing allotments), are planned and implemented specifically to address SMART objectives.

Step 6: Monitor and Analyze the Effectiveness of Actions and Update Resource Condition Ratings (PFC)

Two types of monitoring are commonly done for land management purposes: (1) implementation monitoring and (2) effectiveness monitoring. Implementation monitoring is often referred to as short-term monitoring and is necessary to evaluate whether a management action was implemented properly. Monitoring annual forage use is an example of implementation monitoring. To document actions and to help establish cause-and-effect relationships when evaluating trend, some level of implementation monitoring should be done periodically for ongoing activities, such as grazing by livestock or wildlife. Monitoring the results of management or restoration actions is effectiveness monitoring. Effectiveness monitoring is often referred to as long-term monitoring and is necessary to evaluate trend or progress towards the achievement of objectives and to determine if key attributes and processes evaluated during the PFC assessment have changed. The most appropriate way to monitor the effectiveness of actions is to reassess the site using the same techniques employed to obtain the previous data. Long-term effectiveness monitoring should generally



be completed at intervals appropriate to evaluate the achievement of objectives (3-7 years).

Measurements at a reference monitoring site can be an effective way to establish quantitative objectives for the managed site. Quantitative monitoring should take place at established monitoring sites (plots or designated monitoring areas (DMAs)). DMAs are permanently marked sites that serve as the locations where monitoring data are collected for developing and tracking the achievement of riparian-wetland objectives (Archer et al. 2016; Burton et al. 2011). Although DMAs were initially established for lotic monitoring sites, the same sampling concepts can be adapted for use in lentic areas. Elzinga et al. (1998) also provided detailed information about sampling design and quantitative monitoring. Monitoring sites are often selected to represent FAR sites where the PFC assessment identified a need for a management change or a monitoring focus.

Monitoring sites can be selected as part of the PFC assessment. Because an experienced ID team has been assembled to do the PFC assessment, which involves delineation and stratification of sites/complexes, an appropriate time to locate new reference locations or DMAs or to validate the locations of existing DMAs is either during or immediately following a PFC assessment.

Monitoring may indicate a need to update resource condition ratings. PFC assessment ratings commonly need to be updated for various purposes (such as for completing a National Environmental Policy Act analysis). For example, if a site is rated less than PFC during the initial assessment and a management change is implemented, the assessment will eventually need to be updated. Because PFC is not a monitoring tool, however, repeating a complete PFC assessment to detect improvement (or deterioration) is usually not necessary or particularly useful in most cases. PFC is a coarse assessment tool that is not precise enough to detect small changes in condition. The more efficient way to update a PFC assessment is to use monitoring data, which have higher resolution and can be targeted to specific sites that require the most scrutiny.

If the management steps presented in this chapter are used, and a monitoring site has been established, some level of monitoring (qualitative or quantitative) will have been done. An ID team can use monitoring data to help update a PFC assessment because most of the assessment items are quantifiable. Some assessment items, however, cannot be quantified. These include item 7 (impoundment structure accommodates safe passage of flows) and item 12 (riparian-wetland plants exhibit high vigor). In addition, some of the quantifiable assessment items may not have any data associated with them at the time of the PFC update. To update the PFC assessment, the ID team should use the available quantitative data as appropriate and assess items that were not quantified (using remote sensing and field reconnaissance) to analyze any change in condition for those items. As with the original assessment, interpreting monitoring data and updating the PFC assessment in this manner must be done by an experienced ID team.

Reassessing a site using the complete PFC protocol (rather than just using monitoring data to update conditions and ratings as described above) is necessary in some circumstances, such as where a fire, flood, or other dramatic ecological disturbance has significantly changed the site. Also, if considerable time has elapsed since the initial assessment or if the quality of the original PFC assessment is suspect, the ID team may determine that a complete and comprehensive PFC assessment needs to be repeated.

The following example illustrates an effective way to update the status of PFC assessments where quantitative monitoring has been done:

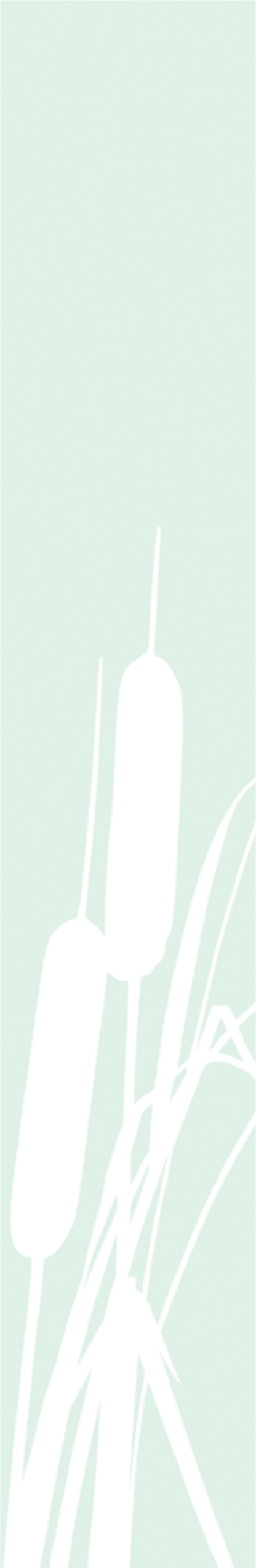
1. The site (Side Hill Spring) was rated FAR primarily due to a lack of adequate stabilizing riparian-wetland vegetative cover.
2. Baseline data collected shortly after the PFC assessment revealed that the amount of cover of stabilizing riparian-wetland species was 55 percent.
3. Five years after the PFC assessment, effectiveness monitoring is completed on Side Hill Spring. Comparison of the monitoring data and the baseline data reveal that the amount of cover of stabilizing riparian-wetland species has improved from 55 percent to 85 percent, and bare ground has decreased from 15 percent to 5 percent.
4. The ID team may consider that both 85 percent cover of stabilizing riparian-wetland plants and bare ground of 5 percent are now adequate for the site.
5. The ID team would then observe the rest of the site to determine if the remainder of the assessment is still valid, and if so, would now consider the site to be in PFC.

If monitoring sites are not established and quantitative baseline monitoring is not completed following the PFC assessment, high-quality photopoints or other qualitative monitoring information can be used to help update the PFC assessment. This method generally works best where quantitative baseline data were not collected because the site was a low priority for monitoring (e.g., the site was located in a complex that is not sensitive to management and was rated as PFC). If an assessment is updated, the ID team may also need to update related management objectives (see IRMP loop back to step 4, figure 1).

Monitoring data may also reveal a need to modify goals or objectives. For example, despite the best efforts to predict ecological pathways and recovery rates, the expectation described in the objective statement may not always be accurate or achievable. If this is the case, step 4 will need to be revisited (see IRMP loop back to step 4, figure 1).

Step 7: Implement Adaptive Actions

If monitoring shows that the actions implemented are not making acceptable progress towards meeting the established goals or objectives, those actions should be modified. Monitoring would then be repeated to determine the effectiveness of those modified or adapted actions. In some cases, the original objectives may need to be modified to incorporate knowledge acquired from monitoring and adaptive actions or to address other changes to the site.



3. Preparing for a PFC Assessment

Identify the Assessment Area

The PFC assessment can be conducted at various scales depending on information needs. It can be done at the landscape or watershed scale by assessing riparian-wetland sites within the area of interest; for example, a single lentic site, a single allotment, grouping of allotments, a single watershed (fifth-order hydrologic unit code), grouping of watersheds, or resource management area. PFC assessments are conducted to obtain information to answer specific management questions. A manager and ID team should determine what an assessment is to be used for and select an assessment area appropriate for the information needs.

Assemble an Interdisciplinary Team

The assessment is intended to be performed by an ID team with knowledge of the attributes and processes occurring in the riparian-wetland areas being assessed. Team members should have strong observational and interpretive skills, experience collecting and evaluating quantitative monitoring data related to the attributes and processes addressed in the PFC assessment, and experience working productively and effectively with other specialists. They must be able to interpret the appearance of physical attributes to assess the functionality of each system correctly. The ID team is required because different disciplines must work together to accurately interpret existing information about the dynamic nature of riparian-wetland areas and how riparian attributes and processes change over time in response to management, climate, and various natural processes that affect watershed conditions. The ID team needs to have an understanding of riparian function attained from education, training, literature, time spent in the field with experienced personnel, and interpretation of the available information. The BLM provides several technical references (the 1737 series) for ID teams that are helpful for developing an understanding of riparian concepts.

ID team members should attend PFC assessment training before completing a PFC assessment. If untrained personnel serve on an ID team, they should be mentored by trained and experienced team members. A broad set of skills are necessary (collectively within the team) to conduct a PFC assessment:

- Knowledge of quantitative sampling methods that support the PFC assessment.

- Ability to gather information pertinent to the assessment: geographic information system (GIS) data, remote sensing products, maps, monitoring data, etc.

- Knowledge of a watershed’s geology, size, landforms, climate and weather patterns, hydrologic processes, sediment dynamics, and how each feature affects riparian-wetland sites in the region.

- Knowledge of reference conditions for assessment sites, whether based on data or professional judgment.

- Ability to identify riparian-wetland plant species/communities of the region, including common riparian trees, shrubs, grasslike plants, grasses, and forbs, and the ability to use taxonomic plant keys.

- Knowledge of riparian-wetland vegetation (reproductive strategies, rooting characteristics, disturbance response and recovery, ecological amplitude, soil water/moisture tolerance and dependence on groundwater depths, expected distribution, structure, and abundance in different riparian-wetland types, and flooding/ponding and saturation regimes).

- Ability to determine soil texture, interpret soil features (particularly hydric soil features), recognize organic soils, and relate soil texture and soil-water states to expected potential vegetation.

- Knowledge of geomorphic processes, including sediment sources and storage/transport dynamics.

- Knowledge of regional hydrology and the hydrodynamics of the site.

- The ability to use climate and groundwater data and appropriate publications to determine timing, frequency, and duration of soil saturation and surface flooding/ponding or inundation.

- General knowledge of surface-water/groundwater interactions within different riparian-wetland types.

- General knowledge of water-table dynamics, capillary fringe, and hyporheic zones.

- Ability to communicate concepts and findings with teammates and stakeholders, to document assessment results in a report, to make recommendations, and to use PFC assessment results to inform collaborative adaptive management and monitoring.

Gather and Review Existing Information

Considerable information can be obtained by gathering, assembling, and reviewing past work, where available. PFC is a qualitative assessment, but quantitative data, photographs, and information from many different sources help the ID team recognize key attributes and interpret field observations correctly. Knowledge of historical conditions and interpretation of current information, combined with field observation of visual indicators (i.e., "reading the land"), lead the ID team towards a determination of potential, appropriate responses on assessment items, a rating and trend determination, and an understanding of any current deterioration and expected recovery for the riparian-wetland area being assessed.

Each member of the ID team should review files relevant to his or her area of expertise (and other known sources of information about the areas under investigation) and share that information with the entire ID team. This review of

existing information is critical to the process of delineating and stratifying riparian-wetland areas and initiating a discussion of the potential of each riparian-wetland type. A file, which includes summaries of the pertinent information, is then developed for each assessment site, or a set of sites, within a project area.

The following sources may provide valuable information as the ID team prepares to complete a PFC assessment:

- A time series of aerial photographs (or other remote sensing products). For example, normalized difference vegetation index data can provide evidence of riparian-wetland area extent and fluctuations as related to changes in land management or climate. Historical trends in such data can be tracked and evaluated using remote-sensing tools.

- Photopoints, historical photos, and any pertinent photos of past conditions.

- GIS data and other information that will help with delineation and stratification (ecoregions, geology maps, watershed mapping, general patterns of soil and riparian-wetland vegetation, management unit boundaries such as allotments and pastures).

- Topographic maps and three-dimensional topographic data, such as LIDAR (light detection and ranging).

- Soil surveys and ecological site descriptions produced by the NRCS.

- Riparian-wetland classifications and mapping (e.g., wetland inventory data from state natural heritage programs).

- National Wetlands Inventory (NWI) maps produced by the Fish and Wildlife Service.

- National and regional hydrogeomorphic (HGM) model guidebooks (available online from U.S. Army Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory).

- Data from nearby weather stations and water-level gages to understand long-term precipitation and runoff patterns and potential effects of recent weather events. Weather and climatic data are available online from PRISM (Parameter-elevation Regressions on Independent Slopes Model) climate group, and from regional climate centers and regional climate service directors of the National Oceanic and Atmospheric Administration, National Climatic Data Center. Water-level data may be derived from piezometers, groundwater monitoring wells, staff gages, state water resources departments and/or state engineer's offices, and the U.S. Geological Survey (USGS), including its many water resources databases and websites, such as the National Water Information System and StreamStats.

- Riparian-wetland plant lists. Dominant vegetation, stabilizing species, and diagnostic species for ecological site descriptions or other classifications should be assembled to help indicate or refine potential and to prepare for addressing the vegetation items. This information can be recorded using the "Lentic PFC Riparian-Wetland Plant List Form" in appendix A. The wetland indicator categories are found in Lichvar et al. (2016); the greenline stability ratings can be found in Winward (2000), Burton et al. (2011), and Lorenzana et al. (2017).

- Riparian-wetland plant community classifications.
- Watershed assessment documents.
- Groundwater reports.
- Species (animal and plant) lists (such as special status species lists and reports), which could be used to determine species' habitat needs and to shed light on riparian conditions that support or once supported those species.
- Land survey notes (many are archived under General Land Office Records, which is administered by the BLM) or other documentation of past/historical conditions.
- Previous assessment, inventory, or monitoring data, including interpretations/results concerning soil, water, vegetation, and wildlife, and other agencies' (e.g., state fish and wildlife) files for similar data.
- Information on reference areas (exclosures, preserves, slightly disturbed areas, well-managed areas with reference communities).
- Management records, including land use plans, allotment management plans, annual operating instructions, actual-use records, range inspection records, or other activity records of the assessment area.

Delineate and Stratify Assessment Sites

Delineation is a process performed by the ID team to identify the extent of individual riparian-wetland sites or riparian complexes. Delineation is based on observable differences in geomorphology, hydrology, soils, and vegetation (type and pattern of riparian-wetland plant communities) (USDA Forest Service 1992; Maxwell et al. 1995).

In contrast to delineation, **stratification** is a process of finding similarities among riparian-wetland sites (or riparian complexes), grouping sites by commonalities, and classifying riparian-wetland sites into similar functional groups or strata that share a common set of attributes, processes, and management practices. For the purposes of PFC assessments, stratification is used to identify potential and to use that potential to inform the evaluation of the 20 lentic assessment items. Stratification is not intended here for statistical extrapolation beyond the assessed sites.

Stratification is critical in the assessment and monitoring process because of the natural variability exhibited in the characteristics, properties, attributes, and functions of different riparian-wetland areas. Stratification is one way to reduce the range of variability and to improve evaluations of functionality and condition. For example, what might be considered evidence of poor condition in a perennially flooded lentic site might be interpreted as evidence of good condition in a seasonally dry site.

Sites are typically stratified in groups based on riparian complexes (see Winward 2000), wetland classification (e.g., Cowardin et al. 1979; FGDC 2013; appendix F), and/or HGM classes and subclasses (appendix G; Brinson 1993; Smith et al. 1995, 2013; Weixelman et al. 2011). If one broadens Winward's definition of a riparian complex (Winward 2000) to include not only lotic but also lentic systems, a **riparian complex** may be described as follows: A unit of land with a unique set of biotic and abiotic factors. Complexes are identified by their overall geomorphology, substrate or soil characteristics, gradient and associated hydrologic features, and general vegetation patterns.

A riparian complex supports or may potentially support a similar grouping of multiple community types (Winward and Padgett 1989). The riparian complex is analogous to the ecological site concept in rangelands. Riparian complexes occur in both lotic and lentic settings and encompass the full width of the riparian-wetland area (Winward 2000). Finally, riparian complexes serve as a basic mapping unit of riparian-wetland areas (USDA Forest Service 1992).

Similarly, HGM classes and subclasses are differentiated by geomorphic setting (e.g., landscape setting, landform, slope/gradient), hydrologic source (groundwater, surface water), and hydrodynamics (directional flow of water; Brinson 1993; Smith et al. 1995). The developers of the HGM classification (Brinson 1993) and the HGM approach (Smith 1993; Smith et al. 1995) recognized the tremendous diversity of HGM subclasses at the continental scale and, therefore, noted that HGM subclasses should be defined regionally. Illustrating the regional diversity within just the depression wetland class, Smith et al. (1995) included various ecosystems, such as vernal pools in California, prairie potholes in the Dakotas, rainwater basins in Nebraska, playa lakes in the Texas High Plains, kettles in the glaciated Midwest and New England states, and cypress domes in Florida.

The Cowardin classification serves as the national mapping standard for the National Wetlands Inventory (Cowardin et al. 1979; FGDC 2013), which maps and classifies wetlands at a broad scale (initially at about 1:100,000 scale; Cowardin et al. 1979). In addition, the information used to subdivide the wetland systems into finer units (subsystems, classes, subclasses, dominance types, and modifiers) speaks to a process of stratifying riparian-wetland areas on similar basis of substrate (or soil), hydrologic properties of water depth, depth to water table, seasonality and period of inundation or flooding, and dominant vegetation life-forms (Cowardin et al. 1979; FGDC 2013). These stratification concepts are particularly useful in stratifying riparian complexes throughout a project area; however, the scale of NWI mapping is quite broad in many areas for detailed PFC assessments. Some areas have recently been remapped or are currently being mapped at a finer scale (1:24,000), which provides a sufficiently detailed base map and inventory of riparian-wetland areas for PFC assessments. In addition, other recent updates include the mapping, classification, and characterization of wetlands using a process referred to as NWI+ (or NWIPlus) (Tiner 1997a, 1997b, 2010, 2014), which combines the Cowardin classification with HGM-type descriptors to facilitate the prediction of wetland functions. These additional HGM-type descriptors include **L**andscape position, **L**andform, **W**ater flow path, and **W**ater body type, collectively referred to as LLWW.

Riparian complexes, HGM classes and subclasses, and Cowardin classifications (NWI) may be defined for lotic or lentic areas. For convenience, this TR generally refers to a riparian complex, Cowardin system, or HGM class or subclass, though in many instances the matter could easily apply equally to any and all classification systems.

PFC assessments do not require formal and comprehensive inventories of riparian complexes; however, it is useful to understand how riparian complexes are identified and labeled. Riparian complexes typically follow a formalized naming convention based on common or prominent overstory/understory community type(s), soil group, and landform (see Winward 2000); an example would be a bog blueberry (*Vaccinium uliginosum*)/Sitka sedge (*Carex sitchensis*)—sphagnum peat—wet shrub meadow complex.

Both riparian-wetland sites and riparian complexes are identified by the same set of biotic and abiotic factors. The "assessment site" in a PFC assessment may be part of a riparian complex (e.g., when an individual complex is divided by fences or land-ownership boundaries into different management units), may coincide entirely with the extent of a riparian complex, or may be more than one riparian complex, depending on management issues and environmental complexity.

Purposes and Objectives of Delineation and Stratification

The ID team must work through the delineation and stratification process to create the foundation for the assessment. Much depends on the delineation and stratification process, including (1) identification of potential natural condition of lentic areas (which greatly improves interpretation, understanding, and evaluation of assessment and monitoring data), (2) determination of assessment approaches, (3) prioritization of the work plan, and (4) selection of sites for subsequent monitoring of riparian-wetland areas.

Identification of potential natural condition. The condition of a riparian-wetland area is evaluated with respect to its potential (see chapter 4 for additional information). The physical and ecological characteristics used to delineate and stratify sites can provide information to develop descriptions of potential natural condition.

Determination of assessment approaches. The ID team evaluates the assessment area and determines the type and degree of inspection a riparian-wetland area receives, dependent on time, budget, and availability of qualified ID team members. Other factors influencing the assessment approach include level of controversy, values at risk, sensitivity to management impacts, history and legacy effects of management practices and natural processes (e.g., floods, droughts, and wildfire), current practices and expected conditions, and accessibility of riparian-wetland sites. The ID team may decide to:

- Conduct a complete reconnaissance by field inspection of all lentic areas within a project area.

- Conduct aerial inspection (e.g., with aerial photography, satellite imagery, or low-elevation photography and videography from unmanned aerial vehicle (i.e., drone)) of lentic areas followed by field validation of a subset of areas.

- Concentrate on only those riparian complexes or strata that are most sensitive to management actions.

Prioritization. Stratification permits prioritization of assessments as well as subsequent management activities and monitoring efforts. Prioritization parameters could include (but are not limited to) current success of management, applicability of federal and state laws and regulations, presence of or potential habitat for special status flora and fauna, values inherent in a riparian-wetland area, time since last assessment or until next planning effort, and amount of monitoring data and management information for the stratum. Additional guidance on prioritization techniques is provided in Smith (2008).

One example of prioritization among sites from different strata is a practice in which the ID team thoroughly inspects the complex that is most sensitive to the management activity within a pasture, allotment, or other management unit. Generally, ID teams might concentrate an assessment on sensitive complexes for two reasons: (1) Sensitive complexes may serve as bellwethers, since they are commonly the most responsive to changes in management. If management is changed, but highly unresponsive or insensitive complexes are assessed and monitored, then the ability to detect positive or negative effects of the management change may be low. (2) Land managers may be able to assume that if management is maintaining desired conditions or improving resource conditions in sensitive complexes, then management is appropriate for less sensitive complexes. Consequently, riparian-wetland areas in less sensitive strata might justifiably receive less attention than areas in the most sensitive strata.

Identification of the sensitive complex(es) leads to efficient assessment and monitoring of project areas. Although local factors and specific management objectives can change the criteria by which sensitive complexes are identified, some common criteria include:

- Soil texture and organic-matter content. Finer-textured soils and organic soils are typically more sensitive than coarser-textured mineral soils are to hoof action, compaction, soil pugging, and oxidation.

- Depth to water table.

- Type of plant community. Herbaceous communities typically are more sensitive to grazing and recreational activities than dense, impenetrable shrub communities. If livestock or people cannot access a site because of dense vegetation, then there is typically little impact from grazing or such recreational activities as camping, off-highway vehicle use, and equestrian or packstock use.

Selection of DMAs. Stratification also serves to target the most sensitive, highest value, or the most representative riparian-wetland areas for future monitoring. Details on the stratification process for DMA selection are provided in the multiple indicator monitoring (MIM) protocol (Burton et al. 2011).

Delineation Process

Riparian-wetland delineation is a process that distinguishes riparian-wetland areas from all other adjacent upland areas. Generally, the delineation of riparian-wetland areas is a two-step process. First, the ID team tentatively delineates the extent of riparian-wetland areas based on office reference materials (e.g., aerial photography, topographic maps, NWI maps, soil maps, and any other physiographic and biotic information that delineates riparian-wetland areas). Tentative delineations are marked on a base map. Second, the ID team uses field observations to validate or modify the extent of each riparian-wetland area. Delineations may be modified if office evidence does not conform to physiographic and ecological observations made in the field. Recently, there have been advances in riparian-wetland mapping products and web-based databases (e.g., NWI, NWIPlus, state natural heritage programs) where delineation and stratification of sites have already been completed. In these cases, the ID team should review the existing delineation mapping to see if it is accurate at the appropriate scale and properly stratifies riparian-wetland sites throughout the project area.

Typically, delineation of riparian-wetland areas is based on:

- Vegetation indicators of wetlands. Most riparian-wetland areas are dominated by hydrophytic vegetation, also known as hydric species (species with a wetland indicator class of OBL or FACW) or in some cases by mesic vegetation (plants of moist soils that might include species with a wetland indicator class of FAC).

- Soil indicators of wetlands. Most riparian-wetland areas contain hydric soils (USDA-NRCS 2017).

- Hydrologic indicators of wetlands. Most riparian-wetland areas contain evidence of current or recent inundation and/or saturated soils.

There are numerous methods for delineating wetlands. There is a formal process for Jurisdictional Wetland Delineations that are performed on a property in order to delineate which waters are Waters of the United States and are therefore subject to Section 404 of the Clean Water Act. The tools and approach for delineating jurisdictional wetlands are useful for delineating wetlands for PFC assessments; however, the delineations done for PFC are not used for designating jurisdictional wetlands. Designating jurisdictional wetlands is done under the purview of the U.S. Army Corps of Engineers. The Corps of Engineers Wetlands Delineation Manual (USACE 1987), hereinafter referred to as Wetlands Delineation Manual, and associated regional supplements (USACE 2007, 2008, 2010a, 2010b, 2010c, 2010d, 2011, 2012a, 2012b, and 2012c) are the most widely used manuals for delineation of regulatory wetlands.

Alternatively, the primary indicators method (Tiner 1993) provides a nonregulatory, rapid assessment approach for delineating vegetated wetlands in areas without significant hydrologic modification, a situation that occurs on a vast majority of federally managed public lands administered by the BLM and the Forest Service. The primary indicators method is commonly used by the Fish and Wildlife Service and differs notably from the Corps methodology in intentionally omitting observations of water or indirect evidence of water-carried debris, water-stained leaves, or other signs of hydrology. That is because these ephemeral signs can indicate that an event has happened but do not necessarily provide information about the duration or frequency of these events. Furthermore, it is recognized that many of these hydrologic indicators can occur in nonwetland areas as a consequence of rare flooding or ponding from large-magnitude, extreme events (Tiner 2017).

The ID team should become familiar with the Wetlands Delineation Manual (USACE 1987) and/or the primary indicators method (Tiner 1993) to facilitate quick and accurate delineation of riparian-wetland areas. The ID team must also collectively possess a strong working knowledge of hydrophytic vegetation and hydric soils associated with wetland delineation.

Delineation is typically performed once and never repeated. Once riparian-wetland areas have been mapped and delineated, it is customary to continue using the existing delineation. ID teams may want to validate previous mapping, however. Mapping of riparian-wetland areas may be modified if a major change in management (e.g., elimination or addition of fence lines) or the environment (e.g., construction of a new, major dam, drainage structure, or water-diversion structure) creates a need to adjust the maps. These types of changes, however, would be exceptions to the general rule.

Management practicality. The delineated riparian-wetland site should be a manageable unit. Generally, it should be at least 0.1 hectare (1,000 square meters or about 1/4 acre), as smaller areas are generally impractical to assess and manage individually. However, ID teams can assess smaller riparian-wetland areas if the areas have significant values or special management needs.

Ownership and management boundaries. Boundaries dividing land ownership, allotments and pastures, or other management units can and typically do serve as boundaries of assessment sites. Even if the management is the same on opposite sides of a pasture fence, the fence may delineate an assessment area for several reasons (e.g., different managers with different management objectives or practices, different livestock with different behavior, or different sources or amounts of off-stream water supplies).

Repeating complexes. Sometimes alternating lotic and lentic sections are located within one valley, such as where beaver ponds or wet meadows alternate with discrete channels that flow between ponds/meadows (figure 2). In this example, the ID team could complete one lotic assessment form to describe the condition of all "A" (willow trough floodplain) complexes and one lentic assessment form to describe all "B" (sedge wet meadow) complexes within a valley or management unit. Many different combinations of lotic and lentic sections are possible, and teams must decide which assessment approach best suits their particular situation.

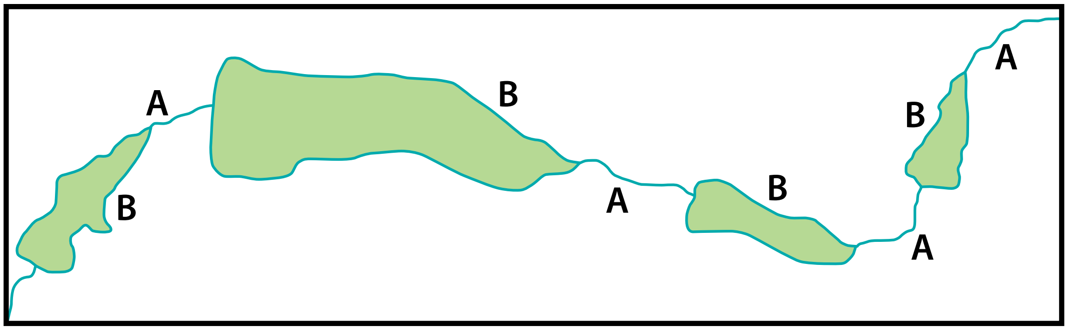


Figure 2. Lotic (complex A—willow trough floodplain) and lentic (complex B—sedge wet meadow) complexes can alternate and repeat within a reach or assessment area.

Ambiguous or complicated complexes. In some cases, the complex may contain both lotic and lentic features (e.g., a spring brook, a beaver-affected complex, a degraded vegetated drainageway, or a vegetated drainageway transitioning to a low-order stream channel). Other cases exist where the site functions as a lentic site at some times of the year (e.g., water supply is from groundwater discharge), but at other times, surface water moves through the site in discrete channels. In these complicated situations, the ID team may choose to create a customized, hybrid assessment form that uses the pertinent items from the lotic (Dickard et al. 2015) and the lentic (this volume) PFC protocols.

Ecotones and gradational areas. Transition areas (ecotones) can exist between riparian complexes. An assessment should not focus on conditions within an ecotone to make interpretations for the entire riparian complex. Also, the hydrologic, vegetative, and soil/geomorphic attributes and processes might change gradually throughout a riparian-wetland area such that there is no distinct starting and ending point to subdivide the complex. For example, in a vegetated headwater drainageway, the hydrology may gradually change from perennial groundwater discharge to intermittent surface water, and the point in space and time where intermittent flow begins is not fixed. The ID team might establish a downvalley break where intermittent flow is obvious and reflected in the composition of the riparian-wetland plant community; however, the team would need to note the gradational nature of diminishing streamflow and the gradual drying along the entire drainageway. The ID team should also incorporate a gradational concept of potential when assessing this type of riparian-wetland area.

Stratification Process

To stratify riparian-wetland areas into distinct groups, or strata, the ID team notes similarities and differences among all the riparian-wetland sites in the project area. For example, riparian-wetland areas can be stratified by slope, with low-gradient complexes segregated from steep ones. Similarly, complexes can be stratified by substrate (bedrock versus fine-textured soils) to discriminate low versus high vulnerability to soil alteration. Also, complexes dominated by communities of riparian shrubs should be differentiated from those that are dominated by herbaceous communities, because livestock, wildlife, and human access and use differ between these types of plant communities.

Whereas the delineation process emphasizes division of the riparian-wetland system into small, discrete assessment areas, the stratification process works in reverse by aggregating complexes with similar biotic and abiotic characteristics into discrete strata. The stratification process can aggregate complexes within a single valley and then build to progressively larger areas of interest, such as the subwatershed, watershed, ecoregion, or resource management area. The ID team should stratify the riparian complexes on the basis of geology, climate, ecology, hydrology, vegetation, soil, geomorphology, and land management characteristics throughout the project area (table 1). USDA Forest Service (1992), Burton et al. (2011, pp. 5-6), and USDI (2015, pp. 17-24) provide additional guidance on the stratification process. Managers can then use the stratified information to make rational comparisons and objective determinations about prioritization of assessments or restoration activities, location of DMAs, etc. For the purposes of PFC assessments, stratification is used to identify potential and to use that potential to improve evaluation of the 20 lentic assessment items. Stratification is not intended here for statistical extrapolation beyond the assessed sites.

Table 1. Common attributes used in stratification of lentic sites.

Category	Attributes: Examples
Geology, Climatology, and Ecology	Geology: Bedrock geology, structural controls on groundwater, regional aquifers Climatology: Elevation, aspect, and orographic controls on climate Ecoregion: Ecoregions (Bailey et al. 1994; McNab and Avers 1994), available from USDA Forest Service and Environmental Protection Agency (Omernik 1987) or with an interactive mapmaker at the National Map website. Alternatively, see Land Resource Regions or Major Land Resource Areas (USDA-NRCS 2006).
Hydrology	Duration: Perennial, intermittent, seasonal, temporary Quantity: Volume and discharge/flux rate Energy/Pressure: Kinetic, potential, hydraulic head Water chemistry: Salinity, electrical conductivity, dissolved oxygen, pH, carbonates Water sources and flow paths: Groundwater, surface water, lateral/throughflow, or combination
Vegetation	Structural-functional groups Community types Life cycle: Annual, perennial Life-form: Trees, shrubs, graminoids, and forbs Age structure, recruitment, and successional pathways Wetland indicator class: Obligate (OBL), facultative wetland (FACW), facultative (FAC), facultative upland (FACU), upland (UPL)
Soils and Geomorphology	Geology and surrounding topography (landform and landscape position), including gradient of riparian-wetland area Soil texture/substrate properties Organic matter: Type and amount/thickness Soil chemistry: Salinity, sodicity, redox potential, pH, heavy metals, etc. Water table: Depth to and natural range of seasonal fluctuation Hydric soil indictors

Category	Attributes: Examples
Land Management	Land ownership: Private, state, tribe, public Dominant activity: Grazing, recreation, logging, combination Grazing system: Year-long, season-long, rest-rotation, deferred-rotation, fixed-rotation, etc. Modified/altered systems

Classification of Riparian-Wetland Sites

A constructive product of stratification is the classification of individual sites into map units (e.g., NWI or NWIPlus), riparian complexes (see Winward 2000), or HGM classes and subclasses (e.g., Brinson 1993; Smith et al. 1995). When individual sites are stratified and classified, ID teams can work with populations of sites that share common processes, attributes, and functions. This facilitates the assessment, management, restoration, and monitoring of sites that share common features.

Where detailed (1:24,000 scale or larger) wetland mapping already exists and classification of sites has already been completed, the ID team may be able to omit the steps to delineate and stratify sites and instead may simply validate the existing mapping and prepare for assessments.

Plan and Time the Assessment Approach

The PFC assessment, in most cases, requires the ID team to physically inspect the assessment area in the field or at least to sample various locations within an assessment area (if the assessment area is extremely large). The most effective way to accomplish a PFC assessment is for an ID team to do a complete reconnaissance of the site by walking or boating the shorelines or extent of the riparian-wetland area. However, depending on the availability and quality of remote sensing tools, such as digital photos, aerial photos, GIS data, very large scale aerial photos (e.g., photos and video from unmanned aerial vehicles (drones)), LIDAR data, some sites may be analyzed in the office using one or more of these tools followed by inspections of selected representative sites. In addition, photography and videography collected by unmanned aerial vehicles can provide high-resolution images of areas that are physically difficult or time-consuming to walk. For example, a PFC assessment of a remote vegetated drainageway in a deep, narrow canyon that is difficult to access and inspect physically could effectively combine remote sensing tools with ground inspections of selected representative sites as needed to complete the assessment. As a general rule, an ID team should conduct random field verification on 25 percent of the sites assessed by remote sensing (Clemmer 2001).

Other factors may influence the assessment approach, including, for example, level of controversy, resource values, and sensitivity to management impacts. All these factors should be considered by the ID team to establish priorities for PFC assessments and to select the most suitable assessment approach. The ID team should document the tools and approach used to complete the assessment. ID teams using remote imagery should have the appropriate experience using these tools.

The ID team should begin the assessments from the top of the site or watershed and work downslope/downstream. Starting at the top allows for a more accurate assessment of the downstream/downgradient sites that may be affected by those higher in the watershed, since the ID team will have already observed upslope conditions. This approach helps the ID team assess factors that may be influencing downslope/downgradient sites. Also, the team should try to view the site from an elevated area to get an overall, bird's-eye picture of the site.

The optimal time to complete the PFC assessment is during the growing season when annual flooding has receded and vegetation is most easily identified and evaluated; however, the PFC assessment can be completed effectively at any time of year when the vegetation, hydrology, and soils and landforms can be readily identified. The assessment may be more challenging to complete during the dormant season or before leaf-out, when the site is flooded, soon after a wildfire, or when the area has been recently grazed. In these cases, ID teams must be cautious to avoid allowing transient, superficial appearances of the riparian-wetland area to bias the assessment. If necessary, teams may need to postpone assessments until assessment items can be properly observed and interpreted.

ID teams should also use caution when completing the PFC assessment immediately following high-magnitude flood events. In most cases, it is best to allow sites to at least start to adjust to these events before completing the assessment, if possible.

4. Conducting a PFC Assessment

Determine the Potential of the Assessment Area

In the PFC assessment method, the condition of a riparian-wetland area is evaluated in consideration of the area's potential. **Potential** is defined here as the highest ecological status a riparian-wetland area can attain in the present climate. This status is sometimes referred to as **potential natural condition,** or PNC, and is not to be confused with potential natural community, which is specific to the plant community. The potential natural condition accounts for the hydrologic regime, the plant communities, and the geomorphic and soil characteristics of the riparian-wetland area that exist at potential.

The assessment items in chapters 5, 6, and 7 cite several references that can assist ID teams in estimating potential.

Ecological status is defined here as the degree of similarity between existing hydrologic, vegetative, geomorphic, and soil conditions and the potential of a site; the higher the ecological status, the closer the riparian-wetland site is to potential.

A determination of the potential of a site can be challenging and often represents an "educated estimate." A detailed description of every attribute of potential can be very difficult (often impossible) and may be unnecessary for completing a PFC assessment. However, to complete a reliable PFC assessment, the ID team must have a reasonable idea of the attributes and processes that are possible within the assessed site to ensure that the system will be gauged against what it can actually be. At a minimum, descriptions of potential must include an estimate of the three basic factors used to define riparian-wetland area: hydrology, vegetation, and soils. In addition, an ID team should consider geomorphic and geologic factors because landscape position and geology provide the physical foundation that dictate the location and essential function of riparian-wetland areas. The primary attributes and processes of these four factors (hydrology, vegetation, soils, geomorphology/geology) are summarized in table 2.

When completing a PFC assessment, potential is identified for each assessment area. Because the rationale for delineating and stratifying riparian complexes is based on physical and ecological uniqueness, the ID team should use information from the delineation and stratification process to develop descriptions of potential. Because a suite of plant communities (by definition) exists within a riparian complex and more than one landform or soil type can occur within that complex (especially on larger riparian-wetland areas), potential will commonly reflect a range of natural conditions that can exist when riparian landforms are highly resilient and stable and when dominant vegetation is composed of late-seral plant communities. There may be more than one community type or phase that represents potential. For example, a valley segment could be represented by willow communities or by a beaver complex at potential. Both may be reasonable approximations of potential, and over time the "potential" conditions may oscillate between willow communities and beaver complex.

The identified potential should reflect what is possible within a reasonable timeframe in the present climate (generally no more than 50 years). Attempting to gauge current conditions against site attributes and processes that may occur several decades or centuries (or more) in the future is conjectural and impractical for this assessment. For example, sedimentation of prairie potholes can drastically change riparian-wetland area potential, but this process usually occurs over hundreds to thousands of years in properly functioning systems.

The ID team considers all the physical attributes and processes that affect riparian-wetland function and identifies those that are most relevant to the riparian-wetland area being assessed. If the ID team does not develop an understanding of the attributes and processes that principally affect an assessment site, the team's judgment about PFC will be incomplete and may be incorrect. A partial list of physical attributes and processes that most affect any given riparian-wetland area and, therefore, influence a description of potential is included in table 2.

An ID team with extensive experience in a particular riparian-wetland type might be able to determine the soil characteristics and dominant vegetation at potential by walking the assessment area and carefully noting the most relevant attributes and processes. When the ID team encounters a riparian complex with which they have little experience, they should use a combination of literature review, GIS analysis, and field reconnaissance to determine potential. Riparian-wetland vegetation classifications, where available, are a great source for much of the needed information. Riparian ecological site descriptions with state-and-transition models, where developed, can provide additional insight on the attributes and processes that affect the potential of a site.

Table 2. Physical attributes and processes affecting riparian-wetland function.

Hydrology and Climate	Vegetation and Ecology	Soils	Geomorphology and Geology
Hydrologic regime	Plant community types	Parent material	Topography
Duration	Structural/ functional groups	Soil texture	Lithology and sedimentology
Timing	Wetland indicator categories of plants	Saturated hydraulic conductivity	Structural geology
Frequency	Disturbance dynamics and successional tendencies of plants	Soil organic matter	Groundwater/ surface-water interactions
Water balance: Water sources, storage locations, and flow paths	Recruitment/ reproduction methods	Soil chemistry	
Runoff/Run-on	Root characteristics	Oxidation-reduction	
Throughflow		Soil physics	
Infiltration		Soil-moisture regime	
Evapotranspiration			
Groundwater discharge			
Groundwater recharge			
Energy			
Depth to water table			
Hydrodynamics			
Weather			
Precipitation			
Temperature			
Extreme event			

Hydrology and Climate

Hydrology is the principal driver that creates and maintains riparian-wetland areas. Without water in sufficient quantity and for sufficient time, there would be no riparian-wetland area. Climate (the prevailing weather conditions and patterns over many years) dictates the availability of water. Hydrology and climate influence the production of vegetation, the formation and chemistry of soils, and the energy related to the production, transportation, and deposition of sediment. Consequently, hydrology and climate affect potential natural condition in many ways, by controlling or affecting:

- The type, annual amount, and variability of *precipitation*, which in turn affects the *hydrologic regime* (duration, timing/seasonality, and frequency) of surface inundation and soil saturation.

- The *water balance*, including the relative proportion of precipitation, surface runoff, run-on, throughflow, infiltration, groundwater discharge, groundwater recharge, and evapotranspiration throughout the contributing area and within the riparian-wetland site.

- The *water source*, since groundwater-dependent sites can differ substantially from surface-water sites. Also, hot springs create different water chemistry, geology, and potential plant communities than cold springs.

- The depth to *water table*, including the seasonal fluctuations in water table, and the availability of water to hydrophytic plants.

- The *hydrodynamics* of a site. Hydrodynamics deals with the motion of water (i.e., vertical fluctuations, unidirectional flow, bidirectional (oscillating) flow), and the energetics of flow (i.e., the capacity to transport sediments, nutrients, and chemicals) (Brinson 1993).

- The annual range in *temperature*, particularly as temperature affects the freeze-thaw cycle; the storage and release of precipitation in the forms of snow, snowmelt, and runoff; the evapotranspiration rate; and the production and decomposition rates of organic matter.

- The typical *weather patterns* that maintain ordinary hydrologic conditions and the sensitivity of some systems to *extreme values* in temperature and precipitation, which can stress and destabilize riparian-wetland systems.

Hydrology and climate are affected by latitude, elevation, general circulation patterns, distance from marine influences, and orographic effects, among other factors. Microclimatic controls can be especially pronounced in mountainous or hilly terrain, where insolation (incoming solar radiation) varies significantly between north- and south-facing slopes. Differences in insolation can result in different plant communities, which are adapted to different soil-moisture conditions, evapotranspiration rates, and drought tolerances. An understanding of hydrologic and climatic processes is vital to understanding which plant communities can occupy and thrive in different riparian-wetland areas or various parts of a riparian complex.

Vegetation and Ecology

Plants dissipate energy, resist physical alteration, capture sediment, build and bind soils, and provide forage and habitat to many species of animals. Determination of potential riparian-wetland vegetation and of the ecological requirements of riparian-wetland species requires knowledge of:

- *Types of plant communities,* present and possible successional pathways.
- Moisture requirements (i.e., the wetland ratings or *wetland indicator categories*) of individual plant species and the distribution of community types in relation to water availability and soil characteristics. The ID team must know which plants are adapted to flooding, waterlogging, and anaerobic conditions. See item 10 (species present indicate maintenance of riparian-wetland soil-moisture characteristics) for details.
- Plant responses to ecological *disturbances* and processes, such as flooding, deposition, defoliation, and soil saturation.
- Patterns of plant establishment, *colonization, recruitment and reproduction,* and successional tendencies of riparian-wetland plants.
- *Root characteristics,* particularly root strength, density, and depth and the ability of different types of roots to stabilize soil.

Many riparian-wetland vegetation classifications are available for various states and regional areas. Riparian-wetland plant communities are best understood for perennial systems and for those intermittent systems that are slightly drier than perennial systems. In those systems that are slightly wetter than uplands, riparian-wetland plant communities are more highly variable and less understood. Determination of the potential plant communities of a given riparian-wetland site is an ecological exercise that requires integration of the physical, chemical, and biological properties of the site.

Ideally, the ID team identifies and inspects the riparian complexes of reference areas to establish the natural variability in potential. Some reference areas might be within natural areas, within livestock or wildlife exclosures, or in administrative units, such as guard stations, which are undisturbed by grazing. However, areas protected from grazing, recreation, or other uses are not always appropriate reference areas. The initial reason for protecting the area might have been to restore a severely deteriorated site, and that site may still be in the process of recovering; or the protected area may have been a site with the highest potential for wetland expression and riparian habitat (and, therefore, not necessarily comparable to other areas). Conversely, areas that have been grazed properly can provide an understanding of potential. Livestock grazing varies greatly in intensity, duration, and opportunities for recovery and, consequently, in its influence on plant communities and riparian functions. Therefore, the ID team should select and use reference areas with care. The reference conditions for potential can be based on data or professional judgment and should be documented on the "Lentic Riparian-Wetland Assessment Area Information Form" (see appendix A).

Soils

Soil properties greatly influence the distribution and potential of riparian-wetland plant communities. The distribution of riparian-wetland plant communities is tied to various soil properties, including:

- *Parent material,* which establishes the basic physical and chemical properties of the soil.
- *Soil texture,* especially in terms of water-holding capacity and its influence on the capillary zone immediately above the water table.
- *Saturated hydraulic conductivity,* which measures the ability of saturated soil to transmit water when subjected to a hydraulic gradient.
- *Soil organic matter* and its effects on bulk density, cation-exchange capacity, soil-moisture storage, infiltration capacity, and pH.
- *Soil chemistry,* especially pH, oxidation-reduction potential, salinity, sodicity, alkalinity, and cation-exchange capacity.
- *Oxidation-reduction potential* and its effects on chemical reactions and plant distribution (e.g., with respect to aerobic versus anaerobic conditions).
- *Soil physics,* including bulk density and its effects on root growth, soil-moisture volume, and gas and water movement through soil.
- *Soil-moisture regimes* and the annual pattern of soil-water and oxidation-reduction states.

Geomorphology and Geology

The geomorphic and geologic characteristics of a drainage basin strongly influence the transport of sediment, water, and energy to and through riparian-wetland areas; the places where sediment, water, and energy can be stored or attenuated; and the potential function and primary processes of riparian-wetland areas. The principal geomorphic and geologic attributes and process that affect potential of riparian-wetland systems include:

- *Topography,* including valley bottom width, valley confinement, hillslope position, slope shape, water-flow patterns, and landscape position relative to recharge, discharge, and ponding locations.
- *Lithology and sedimentology,* for example, type and location of hydrologic restrictive layers, type of bedrock geology and surficial deposits, including their hydraulic properties, pore volume, and thicknesses.
- *Structural geology,* including locations where fault planes intersect the ground surface and give rise to springs, and orientation of geologic formations, which can predict where aquifers discharge to the surface.

- *Groundwater and surface-water interactions,* including establishment of groundwater recharge and discharge areas and identification of the sources of water that supply a riparian-wetland area.

Assess the Riparian-Wetland Area

Delineation, stratification, and determination of potential initially take place in the office. However, the ID team should use field observations to validate or modify riparian-wetland delineations or to update a description of site potential. The location and description of each assessment site, as well as a description of its potential, should be recorded on the "Lentic Riparian-Wetland Assessment Area Information Form" as part of the assessment. Observations pertaining to attributes and processes used to determine functionality are recorded on the "PFC Assessment Form (Lentic)." Creation of a plant list, using the "Lentic PFC Riparian-Wetland Plant List Form" (or a similar form) is also recommended. These forms, as well as detailed instructions for completing them, are included in appendix A.

The lentic PFC assessment protocol uses 20 assessment items to determine the condition and functional rating category for each lentic assessment area. These items are grouped into three categories—hydrology, vegetation, and soils/geomorphology—and discussions are provided for each item as it relates to the PFC assessment in chapters 5-7. The following information is also provided for each assessment item:

- The purpose of the assessment item.
- Observational indicators and examples useful for addressing the item.
- The supporting science used to derive the response to the item.
- Correlation with other items on the assessment form (appendix B).

The assessment items are designed to address the common attributes and processes that should be in working order for a riparian-wetland area to function properly. A "yes" response for an item on the form indicates that the attribute or process is working, a "no" response indicates that it is not working, and an "NA" response means that the item is not applicable to that particular site. Example assessments can be found in appendix E.

Many of the assessment items are closely related, providing a system of checks and balances and requiring users to consider related responses closely to ensure that they are consistent (see appendix B). For example, if item 1 (riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events) is answered "yes," item 17 (saturation of soils is sufficient to compose and maintain hydric soils) will most likely (though not always) be answered "yes," too, because the hydrology and soil indicators of riparian-wetland areas are commonly interdependent. The items are numbered for the purpose of cataloging the comments; the numbers do not declare importance. *The importance of any one item will vary relative to a riparian-wetland area's particular attributes and processes.*

The PFC assessment requires that the effects of high-magnitude, low-frequency events be taken into account. Although PFC is a barometer of how well a riparian-wetland area may resist degradation when subjected to a high-energy event or physical stressors, even the most highly functional systems may experience major adjustments as a consequence of large, rare events (i.e., those with a return interval greater than 25 years). Knowledge of historical riparian conditions is helpful to distinguish between acute responses to rare events and changes resulting from chronically poor riparian conditions and poor land management.

The ID team should do a thorough job of completing each item and should not dismiss the importance of an individual item just because it may not significantly influence the final rating. *How thoroughly an individual item is addressed* often has a significant effect on future management, restoration, and monitoring actions regardless of functional rating.

The supporting science for some of the items is the same or overlapping. Explanations are provided with the most appropriate items, but some cross-referencing among items may be required.

If ID teams have difficulty resolving some "yes" and "no" responses, the assessment item(s) can be quantified to help resolve the issue. In some cases, a team may simply want to validate an item by collecting quantitative data. Appendix C describes techniques that are effective in quantifying the assessment items.

Apply Potential to the PFC Assessment

Potential is applied to the PFC assessment by considering each item on the assessment form relative to what it can possibly attain. When a "yes" response does not exist within the system's potential, the item is answered not applicable ("NA"). When the possibility does exist for a "yes" response, the ID team determines whether the item should be answered "yes" or "no" based on current conditions. A lentic area does not have to be at potential for an item to be answered "yes." The answer depends on the condition required to meet the definition of PFC and to maintain stability within an expected natural range of variation.

For example, item 8 states, "There is adequate diversity of stabilizing riparian-wetland vegetation for recovery/maintenance." If the potential of a particular site is multiple sedge species, and the existing condition is limited to a dominance of just a few, the item should be answered "yes." This is because even though the site has the potential for more sedge species than what is currently present, the composition of stabilizing plants is adequate for recovery/maintenance of the site.

Applying Potential to the Assessment of (Permanently) Altered Lentic Riparian-Wetland Areas

Instructions (including examples) for addressing potential for permanently altered lentic riparian-wetland systems can be found in appendix D. An "Altered Potential Attachment" is included in appendix A to enable ID teams to determine and document altered potential conditions.

Applying Potential in the Context of Site Evolution and Legacy Effects

Many lentic riparian-wetland areas show the legacy of past environmental events or past management effects. Rare, high-magnitude natural disturbances (e.g., extreme climatic and hydrologic events or catastrophic wildfires) and management stressors (e.g., roads, grazing, logging, irrigation structures, and culverts) can significantly affect lentic riparian-wetland areas. These events and stressors can destabilize lentic sites and transform them (sometimes rapidly) into an impaired condition that might last for decades to centuries. Some systems may cross a functional threshold for which physical restoration is required. Because there are various types of lentic sites, impairment and recovery processes are extremely variable and often complex; the process may occur in many ways, at different rates, and at different times.

A degradation/impairment scenario for one type of wet meadow is depicted in figures 3 and 4. This kind of degradation process, in which a wet meadow develops concentrated flow patterns ultimately resulting in the formation of one or more gullies, is common in the western United States. *The purpose of this scenario is to show how the attributes and processes assessed in the PFC protocol can change on a specific kind of lentic riparian-wetland area when it becomes impaired and to demonstrate how the site's overall functional condition would be characterized at various stages.*

In this scenario, **State 1** represents a high degree of site stability, the water table is almost constantly at or near the surface, overland flows are dispersed over the surface of the meadow, stabilizing hydric riparian-wetland plants dominate the site, and the meadow has achieved its potential extent. This site would be assessed as PFC.

State 2 would be assessed as FAR. A channel is starting to form at the lowest point in the meadow—causing overland flow to become more concentrated. The hydric zone is contracting as water movement in the soil is directed towards the channel. Stabilizing riparian-wetland vegetation is not adequately dominant as mesic species begin to replace hydric plants. Excess soil disturbance may be evident (e.g., formation of displaced soil, bare soil, small concentrated flow patterns, trampling, or vehicle use), or an incised gully with an advancing headcut may have formed.

State 3 would be assessed as NF because a gully has formed, the water table has dropped, groundwater movement is towards the deepening channel, and the site is draining. Stabilizing riparian-wetland vegetation is contracting inward towards the lowest point as dewatered parts of the meadow become colonized by xeric (dry/upland) species. ID teams would have to examine the extent of incision to determine if the meadow should be assessed with the lentic protocol or the lotic protocol. If the incision runs the entire length of the meadow or assessed area, the lotic protocol (or a customized assessment drawing pertinent items from both lotic and lentic protocols) may be more appropriate. The ID team should document the rationale for the protocol used in areas in this state.

State 4 is clearly NF, and the riparian-wetland function is essentially lost. The gully has cut through the stratified soil material to the fragmental substrate, causing the water table to drop significantly and contract further than in state 3. Vegetation is almost entirely xeric species as the meadow has become mostly drained. Because of the presence of a gully channel, the site is now defined as a lotic site instead of the functional wet meadow (lentic site) that it once was.

Depending on several site variables and the kind of management implemented at the site, this new "stream" may or may not be able to achieve lotic functionality. *The site has crossed a threshold from a lentic state to a lotic state, and restoration back to a functional lentic riparian-wetland site would usually require some form of physical restoration treatments (or decades of time for gully width expansion) to restore lentic riparian-wetland function.* Even after restoration, while it may be possible to restore the site to proper functioning condition, the area may not exhibit the same level of function or habitat quality as in the past (e.g., overland flow patterns and wetland extent may not be as optimal as they were in state 1).

State 4 would be assessed using the lotic PFC protocol; however, it is important that the evidence of this kind of change (from a lentic site to a lotic site) is adequately documented. To accomplish this, the ID team must be able to detect the attributes and features that provide evidence of this kind of change. Chapter 4 provides a discussion of the indicators used to determine if this process has occurred at the site being evaluated.

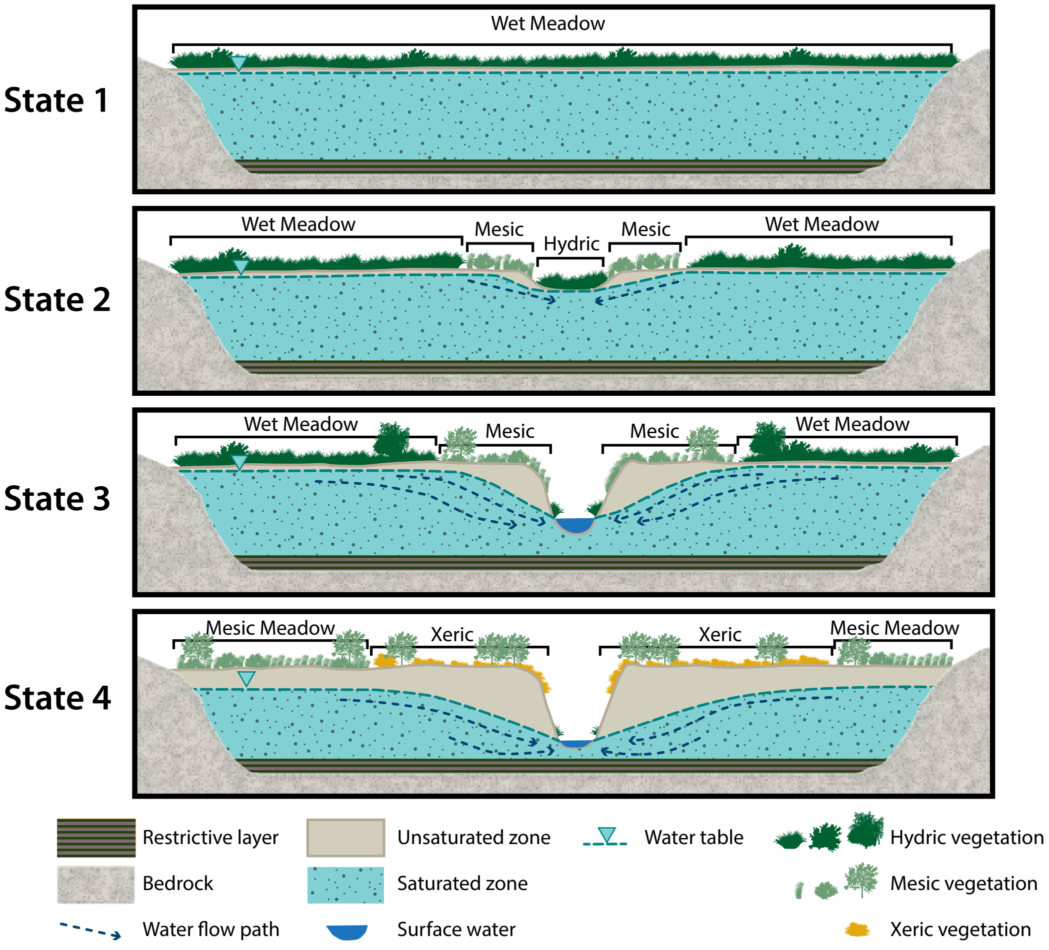


Figure 3. Degradation of one kind of riparian-wetland system (lentic wet meadow) to an incised stream system (lotic).

Figure 4. State 1: Intact wet meadow. **State 2:** Wet meadow with a small, concentrated rill channel starting to form. **State 3:** Wet meadow with a gully and an advancing headcut. **State 4:** Deep gully in former wet meadow. Wetland is now drained, and meadow is mesic/xeric.

5. Assessing Hydrology Attributes and Processes

Hydrology is a fundamental aspect of riparian-wetland areas. Hydrologic attributes and processes are addressed relative to presence, extent, and function. The term "wetland hydrology" encompasses all hydrologic characteristics of lentic areas that are periodically inundated or have soils saturated to the surface at some time during the growing season. Areas with evident characteristics of wetland hydrology are those where the presence of water has an overriding influence on characteristics of vegetation and soils due to anaerobic conditions and reducing conditions, respectively. Such characteristics are usually present in areas that are inundated or saturated to the surface for sufficient duration to develop hydric soils and support vegetation typically adapted for life in periodically anaerobic soil conditions. Indicators of wetland hydrology can sometimes be the most difficult to identify in the field, as they can vary greatly seasonally or annually and may not even be visible on the day of the assessment. However, it is essential to establish that a wetland area is periodically inundated or has saturated soils during the growing season (Prichard et al. 1998).

Hydrology provides the water that sustains riparian-wetland vegetation and forms hydric soils. Items 1-7 on the PFC assessment form address hydrologic attributes and processes that must be in working order for a riparian-wetland area to function properly. In summary:

- Item 1 addresses the presence and frequency of saturated or flooded conditions. This item evaluates the water regime, which addresses the temporal duration (e.g., perennial, seasonal, temporary) and timing of plant-available water, either held in saturated soils or inundating the ground surface. It includes temporal and spatial patterns of the water table in relation to intersection of the ground surface and/or persistence within the rooting zone of riparian-wetland plants.

- Item 2 assesses the degree to which water levels fluctuate and what effect those fluctuations have on riparian-wetland function. Water-level fluctuations are related to water regime and changes in water quantity throughout the growing season.

- Item 3 focuses on the aerial extent of the riparian-wetland area. Degraded or dewatered riparian-wetland areas contain evidence of contraction, whereas stable and recovering riparian-wetland areas typically show maintenance or expansion of the riparian-wetland extent.

- Item 4 addresses whether conditions in the adjacent upland drainage area are contributing to impairment of the riparian-wetland area. It is not asking about the impairment of conditions of the uplands. To address item 4 properly, the ID team should have a good understanding of the hydrologic cycle or water balance; that is, the ID team needs to know the sources of water in the riparian-wetland area, how water moves on the surface, through the subsurface, and in and out of the riparian-wetland area.

- Item 5 examines the effects of water quality on riparian-wetland vegetation. Water quality deals with water contaminants and their potential effect on riparian-wetland flora and fauna.

- Item 6 determines if disturbances have resulted in alteration of surface- or subsurface-flow patterns. Item 6, like item 4, concerns the hydrologic cycle and how water moves across the surface and through the subsurface. Item 6 is an examination of how various infrastructure (e.g., dams, dikes, levees, spring boxes, diversions, ditches, and drains), management activities (e.g., grazing, logging, road development and maintenance), or hydrogeomorphic processes (rill and gully erosion) might alter surface and subsurface hydrologic processes.

- Item 7 assesses the ability of a structure to convey flow safely (i.e., the structure does not create erosion or otherwise impair the site).

The ID team needs to collect background information (see chapter 3) and to understand key concepts before completing the hydrology section of the assessment form. Information gathered in the office can help with the field assessment. For example, the ID team should have a reasonable understanding of the degree to which a lentic area is supported by groundwater versus surface-water sources. Also, information on climatic patterns and the timing, duration, intensity, and quantity of surface water delivered to different types of riparian-wetland areas will help the ID team determine the level of departure, if any, that would be qualitatively documented in the field. Similarly, an understanding of the role of groundwater in different types of riparian-wetland areas is essential to addressing the hydrology items properly.

Site information must be gathered and reviewed before fieldwork, leading to (at least) the following:

- A calculation of the contributing drainage area from topographic maps, GIS, the StreamStats program of the USGS, or other appropriate means.

- A review of a riparian-wetland map (e.g., NWI, NWIPlus, or inventories compiled by state natural heritage programs).

- A determination of the depth to the water table and characteristics (e.g., water volume, water chemistry, and annual/seasonal variation in water supply) of local and regional aquifers.

- An inventory of dams, water diversions, groundwater wells, dikes, and all other surface and groundwater infrastructure in the project area.

- An annual/seasonal summary of climate, including average and recent precipitation, average and recent snowpack, and source of precipitation events.

Specific information that may help the ID team address the hydrology items includes:

- A determination of the hydroperiod (perennial, intermittent, temporary) for parts or all of the assessed riparian-wetland area.

- Timing (seasonality), frequency, and duration of flood events (e.g., related to spring snowmelt or summer thunderstorms).

- The energy associated with water throughout the site. Are episodic or periodic flows of running water capable of eroding the site? Is there enough fetch to generate wave action?

- A determination of the depth to the water table, the annual fluctuation in the water table, and the amount of capillary rise. If the water table or capillary zone does not reach the rooting zone of riparian-wetland plants, then the riparian communities will depend entirely on surface water for their growth and sustenance.

- Where appropriate, a study of geologic maps to determine where geologic structures (e.g., faults) and lithologies (aquifers, aquitards, and aquicludes) are likely to produce groundwater-dependent lentic areas.

Sources of hydrologic information and useful classification data include the Wetlands Delineation Manual (USACE 1987), the BLM's TR 1737-7 (Leonard et al. 1992), and the Forest Service's groundwater-dependent ecosystem protocol (USDA Forest Service 2012a and 2012b), which describe rigorous, science-based procedures to characterize the functions and processes of a riparian-wetland site and to address items in the hydrology section of the assessment form.

The ID team should review the sources of hydrologic and climatic information provided in chapter 4 to define site potential, as this same information will be useful in assessing the hydrology items.

Many riparian-wetland classifications have been developed and used by federal and state agencies and nongovernmental organizations. Some have important regional applications (e.g., Stewart and Kantrud 1971; Weixelman et al. 2011) and might be the preferred classification for some field offices and some types of management. In addition, in some situations, there may be a need to classify springs into specific form and functional groups using the classification system of Springer and Stevens (2009).

The most common national-level riparian-wetland classifications in use in the United States include the Cowardin classification system (Cowardin et al. 1979) and the hydrogeomorphic model (Brinson 1993; Smith et al. 1995; Brinson et al. 1995; and Walton et al. 1995). Classification systems provide a shorthand to communicate concepts, functions, attributes, and processes in an efficient manner. ID teams should review and gain fluency with the concepts presented and terminology used in these seminal works. Basic information about these two classification systems is provided in appendices F and G, respectively.

Item 1: Riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events

Purpose

Water is the essential ingredient that creates and maintains all riparian-wetland areas. Cowardin et al. (1979) stated, "In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface." The purpose of item 1 is to document that inundation or saturation is long enough in duration and occurs frequently enough to maintain riparian-wetland characteristics consistent with site potential. For example, a fen or peatland requires soil saturation at or very near the surface to maintain peat.

Note that there is some overlap between items 1 and 17 (saturation of soils is sufficient to compose and maintain hydric soils). However, when evaluating item 1, the ID team should focus on evidence of riparian-wetland *hydrology* (i.e., ponding, flooding, and saturation). In contrast, when evaluating item 17, the ID team should focus on *soil features* that are used to determine the presence or absence of hydric soils. Because water levels can change throughout the growing season, it is possible that evidence of ponding, flooding, or saturation may not exist at the time of a PFC assessment, in which case the persistence of hydric soil indicators can provide a reliable and alternative source of evidence to determine the existence, extent, and condition of a riparian-wetland area.

Observational Indicators and Examples

Primary indicators are those that can be relied upon by themselves to determine if riparian-wetland hydrology is present (USACE 1987). Only one primary indicator needs to be present to support a "yes" response to item 1. Item 1 would be answered "yes" if evidence of inundation or saturation is apparent.

- **Inundation:** The primary indicator of inundation is visual observation of standing water above the ground surface. Standing water is the most obvious indicator of inundation; however, surface water may be a temporary phenomenon in wetland sites and may be present on nonwetland sites as a result of seasonal conditions and recent weather conditions (USACE 1987).

- **Saturated soil:** The primary indicator of saturation is visual observation of free water accumulating in a shallow soil pit (figure 5). The ID team should excavate a soil pit to a depth of 40 centimeters (16 inches). If water drains into the hole, then the soils are saturated to at least the height of the water in the pit. The time required for water to drain into a soil pit varies by soil texture; therefore, the soil pit should be excavated immediately upon arrival at the site to provide enough time for water to accumulate in the pit. In soils with very low rates of hydraulic conductivity, it may be impractical to wait until water has filled the soil pit to the level of the water table. Alternatively, the team may observe water weeping from the wall or face of the soil pit. Because of the capillary fringe, saturated soils can extend above the water table. Observation of inundation and/or saturated soil conditions may depend on the seasonal climate and recent weather conditions (USACE 1987).

NOTE: An auger hole may be inaccurate or misleading for confirming saturation in clayey soils when only macropores are filled with water. Macropores may have filled during a recent rain while the soil matrix remained unsaturated. Tightly sealed piezometers or tensiometers are recommended to confirm saturation. These instruments should be sealed with clay (e.g., bentonite) to prevent surface water from running down the sides of the instruments (Vepraskas 2015).

Figure 5. The depth to the water table or saturated soil conditions can be determined by the depth to standing water in a soil pit.

- **Hydric soil indicators:** These indicators will show that wetland hydrology is present or has been present at some time. A comprehensive list of hydric soil indicators is provided in Field Indicators of Hydric Soils in the United States (USDA-NRCS 2017, or latest version). Additional information may be found in regional supplements and Vepraskas (2015) (see item 17 in chapter 7). In general, hydric soil indicators include:
  - Horizons enriched in organic matter.
  - The formation of gleyed soils.
  - The formation of redoximorphic features.
  - The formation of hydrogen sulfide gas (detectable by a rotten egg odor).

- **Sediment deposits:** These include deposition of suspended sediment or formation of mud-cracked sediment (figure 6) on the ground surface. Generally, this sediment is finely laminated and finely textured. It will commonly coat litter, leaves, or plant material that is on the ground surface. It may also coat fence posts, rocks, woody vegetation, and bridge footings up to the high-water stage of a recent flood.

- **Mud cracks:** Fine-textured deposits commonly form mud cracks when they undergo desiccation (figure 6).

Figure 6. Mud cracks and algal crusts provide evidence of inundation in seasonally flooded wetlands.

- **Organic deposits/drift lines:** Deposition of vegetation debris or plant matter in a linear drift line or high-water mark indicates the height of a recent flood stage or inundation of the ground surface (figure 7). The plant matter might include small twigs, litter, seeds, and branches that are washed, transported, and sorted into a drift line, differentiating it from litter that has formed in situ.

NOTE: The ID team must be careful when using sediment, mud cracks, and vegetation debris as evidence of recent and relatively frequent inundation. Some flood features from large-magnitude, low-frequency floods may persist for years and decades. The sediment and vegetation debris should be studied to distinguish recent from relict and infrequent deposits. Older sediments may not retain well-defined mud cracks or depositional lamination. Eventually, soil-forming processes will obliterate depositional features of sediment at the ground surface, and vegetation debris will lose color and show signs of weathering and decomposition.

- **Algal flakes or crusts:** Remains of algal crusts are present in areas of former standing water. Algae can form in the presence of surface water and then form a mat as surface water evaporates or infiltrates and eventually disappears from a site (figure 6).

- **Macroinvertebrates:** Nadeau (2011) provides a list of macroinvertebrates that are associated with perennial and intermittent streamflow. Though that paper was intended to determine duration of streamflow (i.e., lotic systems), it is also relevant to lentic systems with standing water.

- **Watermarks:** Watermarks on woody vegetation, stationary rocks, and other fixed objects (e.g., buildings, fences, staff gages) indicate the maximum height of recent inundation.

  NOTE: This evidence should be corroborated with other evidence, as a single water stain can persist for a long time and may not qualify as "recent" and may not be readily interpreted by itself as evidence of "relatively frequent" events.

- **Drainage patterns:** Drainage patterns commonly occur in wetlands adjacent to streams and on slopes and consist of drainage flow features into or through a lentic riparian-wetland area.

  NOTE: Drainage patterns may by observed in upland areas following considerable precipitation; therefore, these features must be evaluated with respect to landscape position (USACE 1987).

  The drainage patterns may be evident as:

  - Scour channels or drainageways carved into soil or sediment.
  - Pathways where leaf litter has been washed away.
  - Vegetative matter (organic debris) piled against thick vegetation or aligned perpendicularly to the direction of flow along the upstream side of woody stems (USACE 1987; figure 7).

Figure 7. Organic debris accumulates in an arranged fashion along the high-water level or along the upstream side of woody stems.

- **Vegetation:** A perennial riparian-wetland site with relatively frequent inundation or saturated soils should show a dominance of OBL and/or FACW species. Dryer lentic sites often have more FAC species in the community. Additional information on how vegetation is used as a wetland indicator is provided in the vegetation section (chapter 6, item 10).

- **Recorded data:** This may include lake-gage data, tidal-gage data, water-table/well data, historical data (figure 8). Recorded data may be available online or at U.S. Army Corps of Engineers district offices, USGS offices, the National Oceanic and Atmospheric Administration, state engineer's offices, or state water departments. Also, a growing volume of remote-sensing data permits analysis of surface-water occurrence in relatively fine spatial and temporal resolution. An ID team could easily supplement "snapshot in time" field observations with time-series analysis of satellite imagery to determine periods and durations of flooding and ponding.

Figure 8. Staff gage (A) provides an inexpensive way to document changes in water stage. Stilling wells (B) and piezometers (C) also provide records of surface and groundwater stages. Many gages are outfitted with electronic recording devices to provide real-time, seasonal, and annual records of water-level fluctuations.

Secondary indicators are those that cannot be relied upon by themselves to determine if riparian-wetland hydrology is present. *At least two secondary indicators* must be present to support a "yes" response to item 1. Secondary indicators include:

- **Oxidized rhizosphere:** A zone of soil where living plant roots and microorganisms occur, associated with living plant roots in the upper 30 centimeters (12 inches) of the soil. Oxidized rhizosphere refers to the iron oxide (rustlike minerals) that commonly precipitates in and along the root pore or root channel when oxygen comes into contact with reduced iron.

- **Water-stained leaves:** Water stains on leaf litter indicate areas that have been inundated with water (more useful in the eastern United States than in the western United States).

- **Soil survey hydrologic data:** Soil survey data provide climatic information, soil classifications, and wetness characteristics of soils, such as frequency, duration, and timing of inundation and saturation.

The "yes" indicators above are mostly from the USACE (1987) Wetlands Delineation Manual with some additional information drawn from Nadeau (2011). For nonjurisdictional riparian-wetland areas, the water table and wetland soil criteria may occur at a greater depth than observed in jurisdictional wetlands.

Item 1 would be answered "no" if the site lacks evidence of saturation or inundation. A "no" response would occur if:

- *There is no recent evidence of inundation.*

- *There is no recent evidence of saturated soils.*

- *Relict hydric soils occur in areas with no current evidence of or potential for soil saturation or inundation.* If the soil contains hydric soil properties, but the site presently lacks periods of inundation or saturation, the site may be dewatered due to alteration of the hydrologic regime. If the water supply to the riparian-wetland area appears to be declining, then the ID team should examine the contributing area for any corroborating evidence of water extraction, diversion, or drainage related to irrigation ditches, levees, road prisms, tiled fields, or groundwater wells. Clues to relict hydric soils are included in item 17 in chapter 7.

- *Upland vegetation is encroaching on the site.* Where UPL and FACU species are encroaching on OBL and FACW species, the site may be drying due to a loss of hydrology (figure 9).

Figure 9. A gully is draining the site, and the surface is no longer saturated. FAC and FACU species are encroaching on landscape positions where OBL and FACW species are expected.

Item 1 is always applicable and will never be answered "NA."

Supporting Science

Indicators of riparian-wetland hydrology are discussed in the Wetlands Delineation Manual (USACE 1987). The Wetlands Delineation Manual states that "an area has wetland hydrology if it is inundated or saturated to the surface continuously for at least 5 percent of the growing season in most years (50 percent probability of recurrence)" (USACE 1987). Hydric soil indicators are described in Field Indicators of Hydric Soils in the United States (USDA-NRCS 2017, or latest version).

The NRCS provides hydrologic data for soils in ecological site descriptions and in electronic databases (such as the Soil Survey Geographic Database and Web Soil Survey, or SSURGO). These data include information on the runoff potential, infiltration rate, hydric soil indicators, drainage properties, soil-moisture regimes, frequency and depth of flooding and ponding, and seasonal depth to water table.

The NRCS defines flooding as temporary inundation caused by overflowing streams, runoff from adjacent slopes, or tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding. The frequency classes of flooding (and ponding), as defined by the NRCS, are provided in table 3. For the purposes of this protocol, a "yes" answer applies to those lentic sites that exhibit "frequent" or "very frequent" flooding or ponding as well as some sites on the more frequent end of the "occasional" class.

Table 3. Flooding/ponding frequency as defined by NRCS.

Frequency Class	Description	Annual Chance of Flooding/Recurrence Interval	Item 1 Interpretation
None	Flooding/ponding is not probable.	Nearly 0 percent in any year. Flooding occurs less than once in 500 years.	"No"
Very rare	Flooding/ponding is very unlikely but possible under extremely unusual weather conditions.	Less than 1 percent in any year.	
Rare	Flooding/ponding is unlikely but possible under unusual weather conditions.	1-5 percent in any year.	
Occasional	Flooding/ponding occurs infrequently under normal weather conditions.	5-50 percent in any year.	Case-by-case evaluation required; may be "yes" or "no"
Frequent	Flooding/ponding occurs often under normal weather conditions.	More than 50 percent in any year but less than 50 percent in all months in any year.	"Yes"
Very frequent	Flooding/ponding occurs very often under normal weather conditions.	More than 50 percent in all months of any year.	

Additional flood-frequency regimes are defined in Cowardin et al. (1979) and FGDC (2013) and included in table 4. The Fish and Wildlife Service uses the Cowardin system in the NWI, an online resource of the abundance, characteristics, and distribution of wetlands in the United States. For the purposes of item 1, a "yes" answer applies to sites that exhibit permanently flooded, intermittently exposed, semipermanently flooded, seasonally flooded, and saturated flood-frequency regimes. Those sites that are temporarily flooded may or may not be flooded frequently enough to suffice for a "yes" response.

Table 4. Nontidal water-modifier terms (FGDC 2013).

Flood-frequency Regime	Definition	Interpretation
Permanently flooded	Water covers the substrate throughout the year in all years. Vegetation is composed of obligate hydrophytes.	Generally lentic habitat – Perennial
Intermittently exposed	Water covers the substrate throughout the year except in years of extreme drought.	Generally lentic habitat – Intermittent
Semipermanently flooded	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.	
Seasonally flooded	Surface water is present for extended periods (generally 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 depth to substrate saturation may vary considerably among sites and among years.	
Seasonally flooded-saturated	Surface water is present for extended periods (generally 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.	
Seasonally saturated	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.	
Continuously saturated	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.	
Temporarily flooded	Surface water is present for brief periods (from a few days to a few weeks) 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.	May or may not be lentic habitat
Intermittently flooded	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 regime may change as soil-moisture conditions change. Some areas exhibiting this regime do not fall within this protocol's definition of wetlands because they do not have hydric soils or support hydrophytes.	Usually not lentic habitat

Flood-frequency Regime	Definition	Interpretation
Artificially flooded	The amount and duration of flooding are controlled by means of pumps or siphons in combination with dikes or dams. The vegetation growing on these areas cannot be considered a reliable indicator of water regime. Examples of artificially flooded wetlands are some agricultural lands managed under a rice-soybean rotation, and wildlife management areas where forest, crops, or pioneer plants may be flooded or dewatered to attract wetland wildlife. Neither wetlands within, or caused by leakage from, constructed impoundments nor irrigated pasture lands supplied by diversion ditches or artesian wells are included under this modifier. This modifier should not be used for impoundments or excavated wetlands unless both water inputs and outputs are controlled to achieve a specific depth and duration of flooding.	May or may not be lentic habitat

Correlation with Other Assessment Items

Item 1 may be correlated with item 3 (riparian-wetland area is enlarging or at potential extent), item 6 (disturbances or features that negatively affect surface- and subsurface-flow patterns are absent), item 10 (species present indicate maintenance of riparian-wetland soil-moisture characteristics), and item 17 (saturation of soils is sufficient to compose and maintain hydric soils). If item 1 is answered "no," then it is possible that item 3, 6, 10, or 17 may be answered "no" as well.

Item 2: Fluctuation of water levels is within a range that maintains hydrologic functions and riparian-wetland vegetation

Purpose

Riparian-wetland vegetation plays an important role in the stability of most lentic riparian-wetland areas. Periodic flooding or saturation of these areas is necessary to promote and sustain this vegetation; however, these water-level changes must be within the range of plant tolerance. The purpose of item 2 is to determine if water-level changes in standing water systems (e.g., lakes, ponds, reservoirs, swamps, and marshes) as well as groundwater-supported systems are within the limits that will sustain riparian-wetland vegetation.

Observational Indicators and Examples

A "yes" response would be expected where:

- Riparian-wetland vegetation is dominated by OBL and FACW plants (see item 10 in chapter 6 for details of wetland indicator categories or wetland ratings of plants), *or*

- FAC species dominate in riparian-wetland sites that have the potential for only FAC species, *or*

- OBL, FACW, and FAC species are produced during wet years even though the sites can support only UPL species during dry years, when this variability is the norm and related to natural variability in precipitation and surface runoff events (e.g., in surface-water supported riparian-wetland sites such as playas), *and*

- Ponding/flooding or soil saturation is adequate to form and maintain organic soils (such as peat, mucky peat, and muck) consistent with site potential.

Visual evidence of a "no" answer includes:

- An expanse of bare ground (e.g., a "bathtub ring" of bare ground) or annual species between the seasonal high- and low-water stages in a standing-water system (e.g., reservoir, lake, pond, swamp, or marsh), as shown in figure 10. The bare ground results when the drop in water level is too fast for water-dependent riparian-wetland plants to grow roots to keep up with the retreat in water levels.
  - These bathtub rings and vegetation patterns occur in many regulated reservoirs where control of water discharge produces large and rapid fluctuations in water level.
  - These features also occur if the natural supply of water is diverted suddenly and in large proportion for irrigation or other offsite applications.

  NOTE: The formation of a bathtub ring is noteworthy only during the growing season. During the dormant season, plant growth is not expected to keep pace with declining water levels.

- Oxidation of peat as a result of water-table decline or dewatering of soil material.

This item cannot be addressed properly without an understanding of the hydrologic potential of the site, particularly the natural climatic and hydrologic variability of the site. The ID team should have an appreciation for the natural range of fluctuation in inundated sites that are supported by surface water and the natural seasonal fluctuation of the water table in sites supported by groundwater.

An "NA" answer would apply to those rare riparian-wetland areas that do not require riparian-wetland vegetation to function properly, such as shorelines armored with coarse rock.

Supporting Science

Riparian-wetland plants living along the edges of standing water bodies have adapted so that during drying periods, as long as water levels do not drop too rapidly, the plants will expand and occupy the newly exposed sites. During wetter periods, as the water body refills, some plants may be drowned around the edges. If the elevation of the water level changes faster than the plants can respond, a bathtub ring effect occurs where riparian-wetland plants cannot survive, leaving bare ground (figure 10). Excessive groundwater fluctuations or the combination of excessive groundwater and surface-water changes can cause similar vegetation effects. The bathtub ring effect can be obvious on aerial photos.

Where fluctuations in water level are large and lead to the formation of bathtub rings of unvegetated ground (figure 10), the ID team should examine possible causes of this effect. For example, is the condition related to the management of water storage and releases from a dam, from seasonal diversion of surface water for irrigation or other purposes, from groundwater pumping that results in depletion of an aquifer and a sudden drop in the water table, or from other practices that generate or exacerbate the natural seasonal fluctuation in water level?

Figure 10. A bathtub ring of bare ground between the seasonal high-water and seasonal low-water levels suggests drawdown of the water surface at a rapid rate that exceeds the ability of wetland plants to keep pace.

Correlation with Other Assessment Items

There is a strong relation between item 2 and item 1 (riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events), item 10 (species present indicate maintenance of riparian-wetland soil-moisture characteristics), item 12 (riparian-wetland plants exhibit high vigor), and item 17 (saturation of soils is sufficient to compose and maintain hydric soils). In addition, items 2 and 4 (riparian-wetland impairment from the contributing area is absent) may correlate if it is determined that diversion of water in the contributing area is responsible for the conditions that caused item 2 to be answered "no." If item 2 is answered "no," then one or more related items will often be answered "no" as well.

Item 3: Riparian-wetland area is enlarging or has achieved potential extent

Purpose

The purpose of item 3 is to determine if a riparian-wetland area is enlarging or has reached its potential extent. Degradation of a lentic area commonly results in contraction of the riparian-wetland area. Degradation may be caused by:

- Accelerated sedimentation rates.
- Loss of water-storage capacity related to a decrease in the volume of surface storage.
- Chronic trampling and compaction of sensitive soils, resulting in a loss of soil porosity and soil-moisture holding capacity (particularly in the mesic fringe bordering lentic areas).
- Dewatering of a riparian-wetland area through gully incision, headcut expansion, ditching, drain-tiles, or channelization.
- A loss or lowering of the water table by decreased water inputs.

These processes can have detrimental effects on the health and extent of riparian-wetland vegetation. Some riparian-wetland areas may appear to be enlarging initially as they fill with sediment, because deposition around the shoreline may provide more shallow water area where emergent vegetation can establish. However, over the long-term, there is a decrease in extent as the circumference of the riparian-wetland area shrinks. Chronic trampling and compaction of lentic soils can increase soil bulk density, sever roots, impede root development, expose soil to excessive drying, and decrease water-storage capacity of soils, all of which results in lower plant vigor and less available plant moisture. Finally, a loss or lowering of the water table can result in water stress (loss of vigor), lowered biomass production, and eventually a shift from hydric plants to mesic or even xeric (upland) plant species.

Item 3 has two parts. One is to determine if a riparian-wetland area is expanding. Recovery of degraded sites is expressed by an increase in amount and extent of riparian-wetland vegetation. The other is to determine if a riparian-wetland area has achieved potential extent. Either condition may result in a "yes" answer.

Observational Indicators and Examples

This item can be evaluated through an investigation of field observations and a time series of aerial imagery and photography. There are now many online sources of aerial imagery. A couple of the most relevant time-lapse imagery programs include Google Earth Engine and Global Surface Water Explorer. Prichard et al. (1999) recommend the use of color infrared photography to assess this item, because riparian-wetland vegetation appears bright red in this type of photography in contrast to the greenish to bluish colors of upland vegetation. Ideally the aerial imagery and the field observations should be collected at the same time of year so data are more readily interpreted.

Evidence supporting a "yes" answer includes:

- **Hydric vegetation:** An increase in cover and extent of riparian-wetland species (i.e., OBL and FACW species, particularly many of the sedge, rush, and willow species).
- **Plant community shifts:** Replacement of older, upland (UPL or FACU) species by younger, riparian-wetland species on locations where there is the possibility for expansion. The riparian-wetland vegetation should be vigorous and regenerating, whereas the upland species should appear to be dying or showing decline in vigor.
- **Rising water table/water surface:** Upland or riparian trees and shrubs that established at one water level are dead, dying, or in a state of declining vigor related to a rising water table and increased soil moisture or water stage (figure 11).
- **Aerial imagery of stable or expanding extent:** Extent of vigorous riparian-wetland vegetation can be evaluated in a time series of aerial images or photographs (figure 12). Preferably comparisons are made at approximately the same time of the year, as the apparent extent of a riparian-wetland area can change throughout the growing season.
- **Maximum topographic extent:** The riparian-wetland area occupies its maximum potential topographic extent; that is, the riparian-wetland area occupies the entire valley bottom or topographic depression that could be in contact with a shallow water table.
- **Lake-stage or water-table data:** Hydrologic data, such as lake-stage data or water-table data measured in gage staffs, piezometers, or observation wells (figure 8) can document the rise in lake levels or water tables and the extent of riparian-wetland areas. As with photographs, it is important to compare water-table and lake-stage data from approximately the same time of the year, since stage can change seasonally.

Figure 11. Numerous dead upland plants (juniper trees identified by arrows) along the margin of a riparian-wetland area and expansion of sedge and cattail community into the sites occupied by dead trees provide evidence of a rising water table and an enlarging riparian-wetland area.

Figure 12. Progressive dewatering of a wet meadow is evident in relation to the headward expansion of gullies from 2009 to 2017. Notice the conversion of green vegetation (hydric species) to brown vegetation (xeric or upland species) along the expanding gully system. The pink-colored pins indicate the position of headcuts in 2009; the yellow-colored pins, the position of headcuts in 2017. (Photos courtesy of Dennis Doncaster, Bureau of Land Management.)

Evidence supporting a "no" answer may include:

- A vegetation pattern in which younger, upland (UPL or FACU) species are establishing and regenerating in areas where older, riparian-wetland (OBL or FACW) species are dying or losing vigor. This pattern includes the establishment of mesic plants on mounds and hummocks in sites that should support hydric vegetation.
- Soil compaction, especially in the mesic fringe, which leads to a loss of soil-moisture storage with concomitant shift in plant composition and/or plant vigor.
- Gully incision, channelization, or headcut migration through a riparian-wetland area with demonstrable dewatering of lentic habitat (figure 12).
- A decline in the water table with a resulting loss of riparian-wetland (OBL or FACW) vegetation and replacement by more drought-tolerant or upland (UPL or FACU) vegetation.
- A decline in the water table with a resulting decline in the vigor of riparian-wetland vegetation. For example, there may be noticeable mortality in tree canopy related to a loss of water supply (figure 13).

  NOTE: Tree-canopy contraction may also result from insect infestations or plant disease. In these circumstances, the condition of the canopy is addressed under item 12 (riparian-wetland plants exhibit high vigor). Water-table depth, surface-water stage, and precipitation data can help to differentiate hydrologic from pathogenic changes to tree canopy.
- Persistence of relict hydric soil indicators in landscape positions that are no longer capable of forming hydric soils.

For areas with no potential for riparian-wetland vegetation (for example, a hot spring surrounded by travertine), an "NA" answer would be given, as landform dictates functionality.

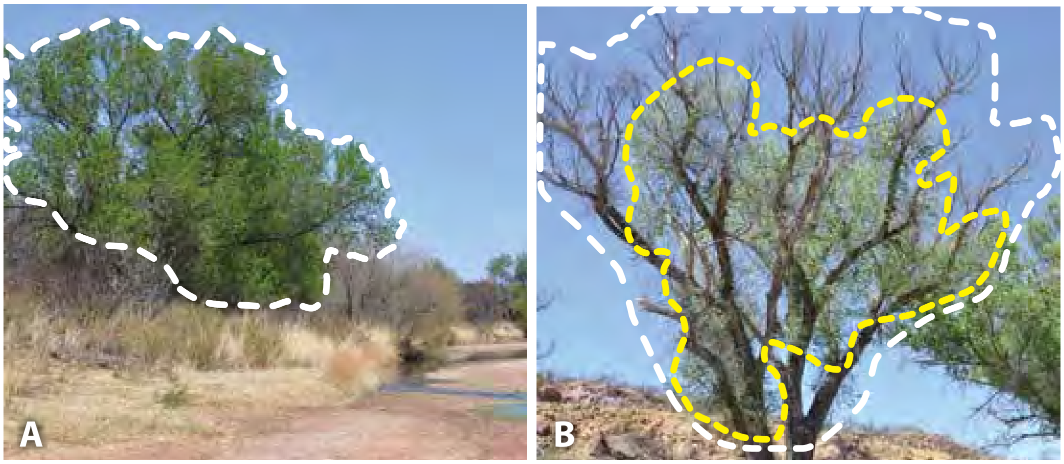


Figure 13. When roots of trees and shrubs are in direct contact with a stable water table, the canopy is full (white dashed lines) and extends to the end of branches (A). In contrast, where the water table has declined, trees may have limited access to groundwater; the canopy may be contracted (yellow dashed line) from its maximum possible extent (white dashed line), and many branches may be devoid of leaves as a result of limited water supply (B).

Supporting Science

Hydric soil indicators, riparian-wetland vegetation, the elevation of surface water, and the height of the water table and capillary fringe in relation to the ground surface are all clues to soil-moisture conditions and key forms of evidence used to determine the potential extent of riparian-wetland areas. The Wetlands Delineation Manual (USACE 1987) provides detailed instructions on how to determine the extent of wetlands.

Hydric soils are indicators of reducing, anaerobic, or saturated soil conditions. However, some hydric soil indicators can persist in the soil even after a water table drops, indicating that the extent of a riparian-wetland area has been reduced. Additional information on hydric soil indicators is provided in Field Indicators of Hydric Soils in the United States (USDA-NRCS 2017, or most recent version) as well as Vepraskas (2015), and Vepraskas and Craft (2016). More information on so-called “relict” hydric soil indicators is included in the chapter 7, item 17 discussion.

Each plant has a certain affinity or preference for a certain level of soil moisture. The comparative soil-moisture adaptations are described as wetland indicator categories (WICs). Additional information on WICs is provided under the chapter 6 discussion of item 10 (species present indicate maintenance of riparian-wetland soil-moisture characteristics) and online in the National Wetland Plant List (Lichvar et al. 2016).

Correlation with Other Assessment Items

There is a strong relation between item 3 and item 1 (riparian-wetland area is saturated at or near the surface or inundated in “relatively frequent” events), item 10 (species present indicate maintenance of riparian-wetland soil-moisture conditions), item 12 (riparian-wetland plants exhibit high vigor), and item 17 (saturation of soils is sufficient to compose and maintain hydric soils). If item 3 is answered “no,” then these related items will often be answered “no” as well.

Item 4: Riparian-wetland impairment from the contributing area is absent

Purpose

Item 4 addresses if there has been a change in the water or sediment delivered to a riparian-wetland area from the contributing area and if that change is resulting in impairment to the riparian-wetland area. The contributing area is that part of the drainage basin in which overland flow and stream flow would reach the assessed riparian-wetland area. *In addition, the contributing area includes the aquifer that delivers groundwater to the assessed riparian-wetland area.* This item provides the opportunity to differentiate, if possible, between causal factors from the contributing area versus direct impacts to the riparian-wetland area being assessed.

A "yes" answer provides a positive indication of proper upland functionality. A "no" answer means that the explanation or probable cause of observable riparian-wetland impairment is directly related to some condition or activity in the contributing area. The ID team should support "yes" and "no" responses with detailed notes and observations of impairment, location of impairment, and likely cause-and-effect relations.

Observational Indicators and Examples

Using a step-by-step evaluation process (figure 14), an ID team would first determine if there is any evidence of impairment in the riparian-wetland area. If evidence of impairment is absent, then the answer to item 4 would be "yes." However, if the ID team determines that there is impairment of some sort to the riparian-wetland area, then the team would have to determine the source or cause of the impairment:

- If the cause of riparian-wetland impairment is in situ (i.e., within the riparian-wetland area itself), item 4 could still be answered "yes." For example, if livestock or wildlife are chronically concentrating within the riparian-wetland area and the level of trampling is the source of impairment, then the cause is local (in situ) and not from the surrounding uplands or contributing area. A similar response would be noted if the impairment was related to a road or trail located within the riparian-wetland area, or a drainage ditch constructed in the riparian-wetland area, etc. In other words, when there is in situ impairment, that impairment is addressed in one or more of the other 19 items.

- If the cause of riparian-wetland impairment is from a factor or activity located outside the riparian-wetland area and in the adjacent uplands or contributing area, then item 4 would be answered "no." For example, if there is an activity located outside of the riparian-wetland area that has an observable impact to conditions or functions in the riparian-wetland area, then the cause is from the contributing area. Examples of "no" responses could include activities in the watershed that:

- **Produce excess sediment:** Due to, for example, logging, cultivated agricultural lands, concentrated livestock use, or wildfires that result in excessive deposition in the riparian-wetland area.

- **Generate excess runoff:** Due to, for example, poor road design or maintenance or interbasin transfer of water into the watershed that results in accelerated and diverted runoff to and sediment deposition in the riparian-wetland area.

- **Alter natural water quality:** Due to, for example, discharge of poor-quality water (derived from acid-mine drainage, irrigation return flows, or from leakage of brackish well water) into the riparian-wetland area. Evidence of low water quality might include declining plant vigor, water-quality measurements, and water odor or discoloration.

- **Deplete natural surface runoff:** Due to, for example, subtraction of natural surface runoff to the riparian-wetland area by surface-water alterations related to road construction, dikes, levees, dams, irrigation withdrawals, interbasin transfer of water out of the watershed, or drainage ditches.

- **Deplete natural subsurface discharge:** Due to, for example, subtraction of natural subsurface water to the riparian-wetland area by groundwater pumping or interception of throughflow by roads.

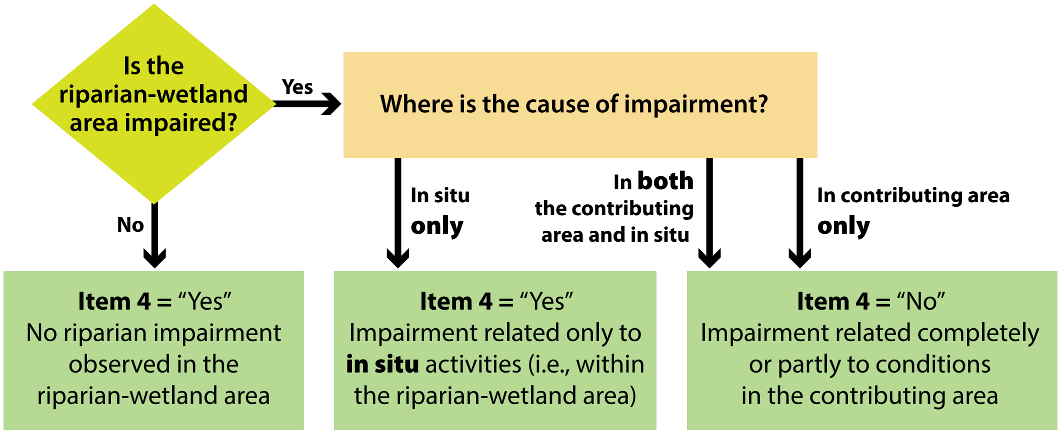


Figure 14. Step-by-step evaluation process to determine if watershed factors contribute to riparian-wetland impairment.

Possible upland/watershed causes of impairment should be identified. The ID team should consider changes in the contributing area that affect (1) the source(s) of water (surface, groundwater, or throughflow), (2) the hydrodynamics (or pathways) of water movement into, through, and out of the riparian-wetland area, and (3) the supply and mobility of sediment into the riparian-wetland area. Sediment sources in the watershed could be investigated through analysis of aerial photography, either when preparing for the assessment (gathering and reviewing existing information) or after the field portion of the assessment. The cause-and-effect relationship between upland conditions and riparian-wetland area impairment should also be identified. Although conditions in the contributing area may be impaired, the purpose of this item is to determine whether that impairment is having a direct and demonstrable impact on the riparian-wetland area being assessed.

The visual indicators for item 4 are generally not subtle. If the watershed is contributing to riparian-wetland impairment, excessive sediment or increased surface water may be routed to the assessed area. This might be the result of a natural event in the watershed, such as a wildfire and subsequent sediment delivery to the riparian-wetland area, and would result in a "no" answer with an explanation of the severity of the "no" for that system. Clearcut logging, wildfire, or overgrazing could potentially alter surface water hydrology and sediment delivery. Interbasin water transfer or discharge of pumped water (e.g., from coal-bed methane production) could also alter hydrology and sediment delivery.

As the ID team evaluates observational indicators of impairment, it should consider:

- **Volume:** The amount of water and/or sediment. Volume might increase or decrease in response to human activities, poor land management, or poor watershed conditions.

- **Time:** The travel time or residence time of water and sediment movement through different parts of the watershed. Water and sediment typically move more quickly from hillslopes into riparian-wetland areas, as resisting forces decrease in the contributing uplands. Resisting forces typically decrease as vegetation and litter cover decrease.

- **Energy:** As with travel time, energy increases as resistance decreases. Watersheds with greater stability (i.e., more resistance) have more effective buffers to dampen the erosive effects of runoff events than those watersheds with diminished resistance.

Item 4 will always be answered "yes" or "no," as it is always applicable.

Supporting Science

The natural characteristics and the land-managed condition of watersheds influence the hydrologic regime, sediment supply, water quality, and plant community composition of riparian-wetland areas. Areas with high topographic relief, low vegetation cover, and high bare ground would have greater fluctuations in water surface elevation, higher sediment supply, and lower water qualities than areas with lower relief, higher vegetation cover, and lower bare ground, all other factors being equal. These relationships were established in a study by Euliss and Mushet (1996), in which they compared wetlands in tilled agricultural watersheds and uncultivated, grassland watersheds.

Water enters and moves through the watershed as precipitation, overland flow, and groundwater discharge; water leaves the watershed through groundwater infiltration, runoff, and evapotranspiration, as summarized by the water-balance equation:

$$P + (R_i + Q_i) + G_i = ET + Q_o + G_o$$

where P is direct precipitation on the riparian-wetland area, R_i and Q_i are surface-water flows from overland runoff (R_i) and streamflow (Q_i) into the riparian-wetland area, G_i

is groundwater discharge to the riparian-wetland area, ET is evapotranspiration from the riparian-wetland area, Q_o is surface-water flow out of the riparian-wetland area, and G_o is groundwater recharge from the riparian-wetland area. The simplified water-balance equation provides a conceptual model in which to discuss relative changes to the water-sediment budget as a function of land use practices and resource conditions (see figure 15). Generally, sediment mobility is increased by lower amounts of litter and vegetation cover and is decreased by the converse.

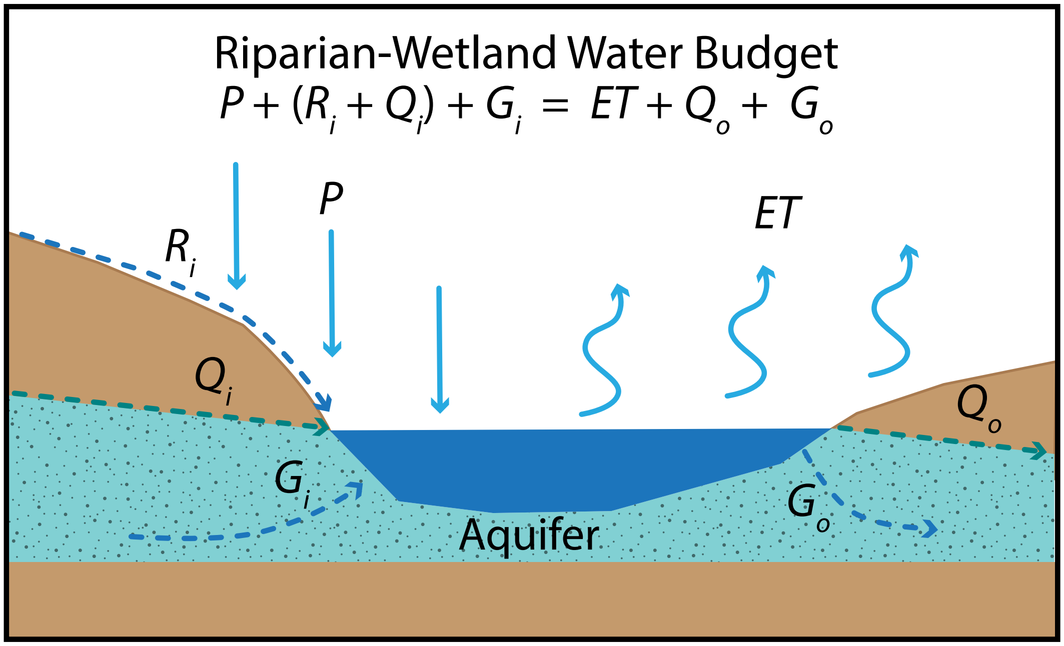


Figure 15. Schematic water budget depicts the generalized inputs and losses of water in a riparian-wetland area.

Natural phenomena, such as drought and wildfire, affect the water and sediment budgets within a natural range of conditions. These natural processes can be exacerbated or driven to an unnatural and unstable condition by land management practices (e.g., improper grazing, conversion of uplands to cultivated agricultural fields, urbanization, poor road construction and maintenance), which can lead to impairment of upland hydrologic processes and increased rates of soil erosion in the uplands with corresponding accelerated rates of sedimentation within riparian-wetland areas. For more information on water budgets (also referred to as water balance), see USDA-NRCS (1997) and chapter 8 of Dunne and Leopold (1978).

Roads exert much influence on the generation of sediment and the alteration of surface and subsurface water movement in watersheds. This topic has been studied extensively by the USDA Forest Service (Zeedyk 1996; Lewis 2000; Luce and Wemple 2001) among others. Detrimental changes in water supply come from constraining or diverting surface and/or subsurface flows. An example would be upslope road prisms that act as dikes, intercepting flow, or road ditches and cross-drainage structures installed in a manner that diverts overland flows away from the riparian-wetland area, causing desiccation of meadow soils (Zeedyk 1996).

Correlation with Other Assessment Items

Item 4 is related to item 19 (riparian-wetland area is in balance with the water and sediment being supplied by the watershed).

Item 5: Water quality is sufficient to support riparian-wetland plants

Purpose

The purpose of item 5 is to determine if water quality is being maintained, thereby allowing these sites to produce and sustain the kind of riparian-wetland vegetation necessary for proper function. When addressing item 5, it is imperative to differentiate the natural sources of water constituents from those that are increased, added, or concentrated because of land management actions and disturbances to the contributing area. The ID team must bear in mind the potential of sites and note that groundwater-dependent sites can *naturally* have unusual water chemistry due to the variability in pH, metals and metallic salts, sulfur compounds, and even water temperature, which affects the ability to transmit and deposit water-soluble constituents. Also, ID teams should note that item 5 is specific to water quality, whereas item 16 addresses soil chemistry. Sometimes the two items are related because water quality can affect soil chemistry and vice versa.

Observational Indicators and Examples

A “yes” answer would be given when the riparian-wetland vegetation is vigorous and the species present are consistent with site potential. Situations that might elicit a “yes” response include:

- Riparian-wetland vegetation appears to be vigorous. (See chapter 6, item 12 discussion for details concerning plant vigor.)

- The assemblage of riparian-wetland species is adapted to the natural pH and alkalinity of a site.

In addition, a “yes” response may be anticipated when and where:

- There is an odor that is related to natural anaerobic conditions (i.e., rotten egg odor related to hydrogen sulfide gas) where anaerobic conditions are expected.

  NOTE: The ID team should recognize situations where odor is natural (e.g., a rotten egg odor in areas with anaerobic conditions, or an odor in areas of hydrothermal activity or hot springs).

- Salt-tolerant species occur in a riparian-wetland site that has *naturally* brackish water (0.5 to 30 g/kg or parts per thousand (ppt)) or saline water (more than 30 g/kg (or ppt)).

> NOTE: Salinity of water is commonly indicated by total dissolved solids or electrical conductivity (EC). Measurement of EC of aqueous solutions will yield different values than the EC of saturated soil paste extracts described in item 16. Consequently, EC should note whether the measurement was made on an aqueous solution or a saturated soil paste.

In contrast, a "no" response would be given where the riparian-wetland vegetation has poor vigor due to poor water quality, or where it exhibits a community type that is the result of poor water quality. For example, a "no" response might be related to poor plant health and vigor resulting from:

- Algal bloom that is occurring during an off-season for algal blooms or that has been exacerbated by an accumulation of nutrients from fertilizers or manure in runoff. Comparison with the algal growth in a reference site can help ID teams discriminate between natural seasonal growth and algal blooms that are unnatural and exacerbated by adjacent land practices.

- Direct discharge of brackish and saline "produced" water (typically resulting from the extraction of coal-bed methane or oil) to surface water bodies. In addition, produced waters may enter riparian-wetland areas as a result of accidental spills and leaks from holding ponds, storage tanks, pipelines, and injection wells (figure 16).

- Acid-mine drainage, especially where there is an increase in the concentration of dissolved metals or the pH of water is substantially altered (figure 17).

- Runoff from cultivated agricultural fields that contains herbicides.

- The lack of plant diversity where high diversity is expected. If the only plants in the community are nutrient- or contaminant-tolerant and the intolerant plants have been lost from the community, it is likely that there is a water-quality issue. For example, in areas with coal-bed methane production, it is possible that highly brackish and saline groundwater has been discharged, pumped, and/or improperly stored or accidentally leaked to surface water bodies. The high salinity of these produced waters can kill many riparian-wetland plants (figure 16) or reduce the plant community to one or few highly salt-tolerant species.

- A foul odor or discolored water. Water-quality tests should be made to determine if the discoloration or odor is natural or related to poor management practices. Acid-mine drainage and acid-rock drainage are examples of where water can be contaminated by heavy metals and discolored.

- High turbidity, caused by a high concentration of suspended sediment, which reduces light availability to inundated, emergent vegetation.

An "NA" answer would be given for areas with no potential for riparian-wetland vegetation.

Figure 16. Highly saline produced waters killed a cattail community when the waters leaked from a pipeline and drained into riparian-wetland areas. (Photo courtesy of North Dakota Department of Mineral Resources, Oil & Gas Division.)

Figure 17. Effluent from buried mine tailings discharged acidic and metal-laced water into surface water. (Photo courtesy of Jon Kaminsky, Bureau of Land Management.)

Supporting Science

Many lentic areas are natural sinks or repositories where water, nutrients, sediments, and other water-soluble or water-borne components accumulate. Pollutants in any water body, including groundwater, can cause problems with the health, productivity, vigor, and composition of plant life. For example:

- Freshwater aquatic plants are negatively affected by cadmium (a heavy metal) at concentrations ranging from 2 to 7,400 micrograms per liter (µg/l) and cyanide at concentrations from 30 to 26,000 µg/l.

- Abnormal accumulations of salts or dissolved solids can stress some plants or change the composition to plants that are salt-tolerant.

- Inorganic suspended materials reduce light penetration in the water body and can lead to the formation of films on plant leaves, which block sunlight and impede photosynthesis (USEPA 1986).

- Nutrients from fertilizers or manure can induce an algal bloom and eutrophication of water bodies. Although the initial response of added fertilizers might be an increase in biomass production, the eventual result is commonly the loss of dissolved oxygen, with life-threatening consequences to aquatic fauna.

The geology of some watersheds can produce surface waters and groundwaters that are naturally high in salts, carbonates, acid, or other components that can inhibit plant growth.

Correlation with Other Assessment Items

There is a strong relation between item 5 and items 8-13 (vegetation items related to plant diversity, plant vigor, age class diversity, soil-stabilizing capabilities, soil moisture, and adequacy of vegetation cover). If water quality is so poor that it will not support riparian-wetland vegetation, then many or all of items 8-13 would usually be answered “no.”

Also, items 5 and 16 (accumulation of chemicals affecting plant productivity/composition is absent) may be correlated, as water movement through soil can dissolve soil constituents that affect water quality. Water quality can affect soil quality and vice versa.

Item 6: Disturbances or features that negatively affect surface- and subsurface-flow patterns are absent. These disturbances/features include but are not limited to hoof action, dams, dikes, levees, spring boxes, diversions, trails, roads, rills, gullies, drilling activities.

Purpose

The purpose of item 6 is to determine if surface- or subsurface-flow patterns (including water inflow, storage, and outflow) are being maintained. Alteration of surface- or subsurface-flow patterns may affect the functionality of riparian-wetland areas where riparian-wetland vegetation is important. A change in flow patterns may mean a change in vegetation type (e.g., replacement of riparian-wetland species with upland species) or may create a site unable to dissipate energies or withstand physical stressors. For other sites, it may mean a change in extent of the riparian-wetland area or a complete loss of riparian-wetland area.

The ID team should note that the focus of item 6 is the impact to surface- and subsurface-flow patterns. Sometimes the same features (e.g., hummocks or pedestals) can be used to answer both items 6 and 14 (abnormal frost or hydrologic heaving is absent), but the processes addressed by each item are different. The focus of item 14 is the degree of frost action.

NOTE: If features/human-made structures exist, it is important that the ID team use appendix D—ensuring that relatively permanent altered sites are distinguished from modified sites and that estimated potential is accurate—in order to address this item correctly.

Observational Indicators and Examples

A key concept for a "yes" answer is whether a riparian-wetland area is receiving, storing, and transmitting an acceptable range of surface and subsurface flows. The impact of disturbances should be evaluated with respect to changes to the volume, timing, intensity, duration, or frequency of surface or subsurface flows. A "yes" answer may be given for a riparian-wetland assessment area if:

- Hoof prints, footprints, and vehicle wheel tracks are few, faint, and shallow and do not contribute to overall dewatering, flow alteration, soil pugging (deformation that results in the formation of pugs, voids, or "postholes"), soil poaching (elastic deformation in which soils lose their structure when in a slurry-like condition), or soil compaction of the site.

- Roads, dikes, levees, and other infrastructure are properly designed with pipes, culverts, or similar features to permit transmission of a near-natural volume of water to the riparian-wetland area. These infrastructure features should adequately maintain high-flow and low-flow discharges and the hydroperiod of flow such that the function and condition of the riparian-wetland area are not adversely impaired.

- Range improvements and water developments, such as spring boxes, are properly designed to maintain the height of the water table and protect riparian-wetland plant communities and maintain hydrologic functions (Gurrieri 2020).

A "no" response would be expected if there are disturbances/features that have changed the timing, rate, direction, or volume of water inflow, storage, or outflow. Such changes might result when:

- Livestock, wild horses and burros, wild ungulates, foot traffic, or vehicles have created trails, compacted soils, pugged soils, or poached soils (figure 18), which has led to a discernible, long-term impairment such as:

    - Interception and redirection of surface water along the trails, paths, or tracks.

    - Increased runoff and/or lost soil-moisture storage capacity.

    - Increased erosion and delivery of sediment to the riparian-wetland area, or dewatering of soil moisture by drainage into pugs and ruts and loss through increased rates of evaporation.

    - Oxidation and corresponding loss of organic soil horizons at the ground surface, resulting in a smaller and less effective organic sponge to store plant-available water.

    NOTE: Heavy and continuous trampling through weakened root systems (i.e., less dense, less deep) may result in soil pugging or "postholing" in which large ungulates can sink 30 centimeters or more into poorly vegetated soils (figures 18 and 19). In saturated soil, repeated trampling may result in soil poaching. In severe cases, pugging results in dewatering of the soil profile and oxidation of organic matter. Loss of organic matter reduces the soil-moisture storage capacity of soils and leaves them susceptible to drought.

- Dams, dikes, levees, roads, and other infrastructure have ponded, diverted, or altered flow patterns, resulting in a reduction in water volume and a noticeable decrease in riparian-wetland extent or drop in water table.

- Construction of upstream dams or irrigation diversions have decreased water supply and/or altered water period, leading to overall desiccation of a riparian-wetland area.

- Construction of a dugout or similar watering reservoir either has perforated an impermeable layer, leading to the loss of perched water, or has caused a drop in the water table related to drainage and accelerated evaporation. See also item 18 (underlying geologic material/soil material/permafrost is capable of restricting water percolation).

- Human-made ditches, gullies, or headcuts have resulted in a drop in water table, dewatering of the riparian-wetland area, or contraction in the extent of the riparian-wetland area (figure 12).

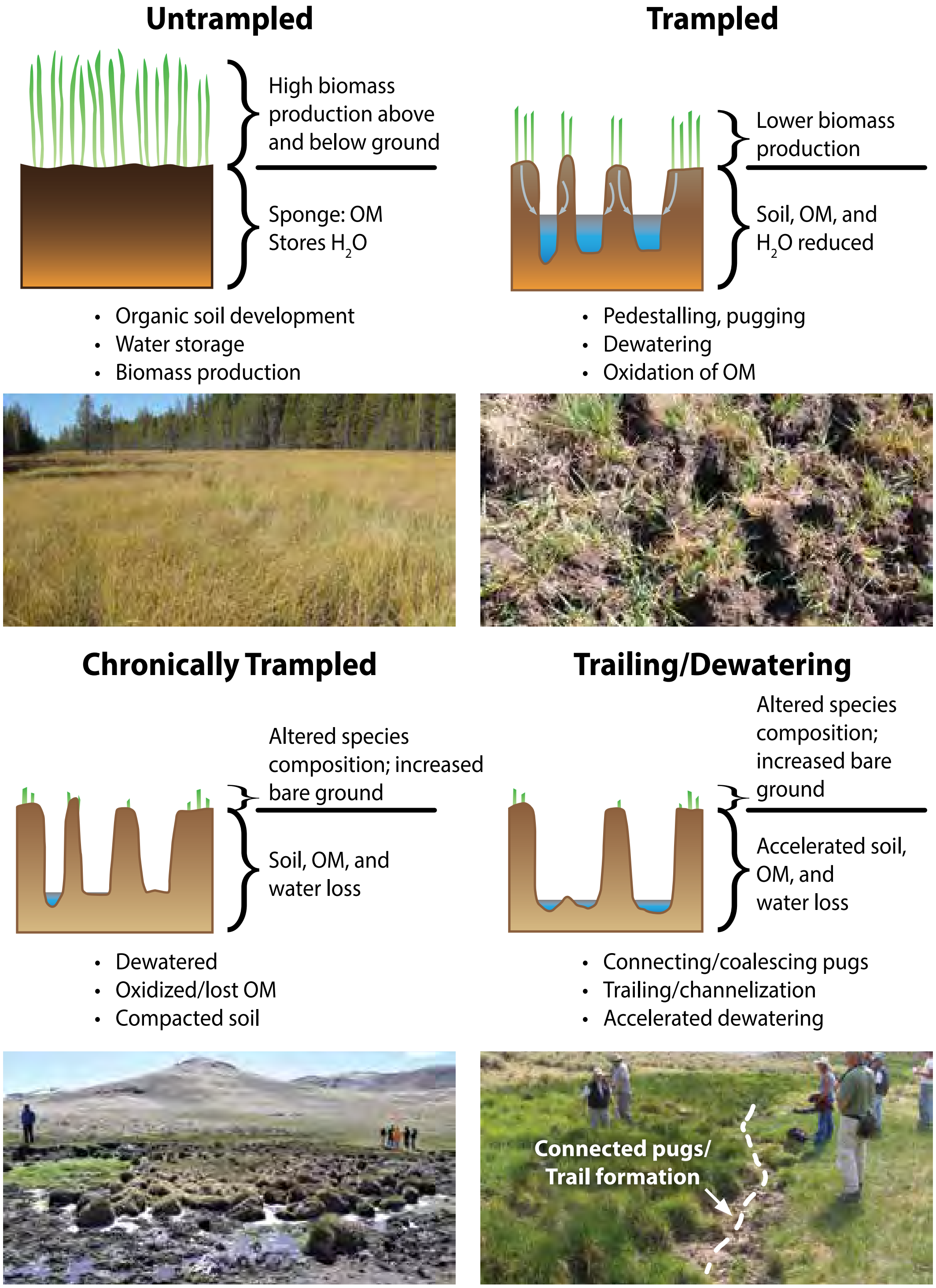


Figure 18. Schematic illustration of progressive vegetation impacts, soil impacts, and dewatering resulting from intensive and chronic trampling. Trampling leads to breakage of root masses below ground, which leads to lost vigor and productivity above ground. OM = organic matter.

Figure 19. Large ungulates commonly sink in wet soils and leave deep void spaces (pugs) in the ground. The voids can fill with water, resulting in drainage of soils and overall loss in soil moisture. (Photo courtesy of Sherman Swanson, University of Nevada, Reno.)

- Drop in water table or surface-water elevations has resulted in a change in plant composition to more drought-tolerant species or to a loss of vigor in hydric species.
  - Canopies of riparian trees show dieback or reduction in total canopy volume due to the decline in water table (e.g., Scott et al. 1999, Cooper and Merritt 2012; see figure 13).
  - Drought-intolerant, riparian-wetland species (e.g., Fremont cottonwood (*Populus fremontii*) and Goodding's willow (*Salix gooddingii*)) are replaced by drought-tolerant species (e.g., tamarisk (*Tamarix* spp.); Lite and Stromberg 2005).
  - Change from OBL and FACW herbaceous species (e.g., spikerush and bulrush species) to FAC, FACU, or UPL species (e.g., big sacaton (*Sporobolus wrightii*) or velvet mesquite (*Prosopis velutina*); Stromberg et al. 1996).
- Drop in water table has led to the mortality of hydric (OBL and FACW) saplings of cottonwood and willow (e.g., Shafroth et al. 2000) even though older, more mature trees with deeper root systems may persist.
- Groundwater extraction from the contributing aquifer has resulted in a drop in the water table or decrease in the extent of the riparian-wetland area.

Item 6 will always be answered "yes" or "no," as it is always applicable.

Supporting Science

If the functional surface- or subsurface-flow patterns of lentic areas are altered, the timing, frequency, magnitude, and duration of inundation or saturation can be affected with corresponding changes to the soils and vegetation. Examples include: when a riparian-wetland area is not inundated because a dike keeps floodwater out; roadways alter surface flow leading to a loss of water or an increase in sediment delivered to the riparian-wetland area; a lentic area is drained by diverting surface or subsurface flow away from the site; or an area has compacted soils, which reduces the infiltration rate and increases runoff.

Changes in plant assemblages provide evidence of a dewatered site. A number of recent publications describe the water requirements of different hydric plants and riparian-wetland communities (e.g., Stromberg et al. 1996; Scott et al. 1999; Stromberg et al. 2007; Cooper and Merritt 2012; Aldous and Bach 2014; Aldous et al. 2014).

Correlation with Other Assessment Items

There is a strong relation between item 6 and item 1 (riparian-wetland area is saturated at or near surface or inundated in "relatively frequent" events), item 3 (riparian-wetland area is enlarging or has achieved potential extent), item 10 (species present indicate maintenance of riparian-wetland soil-moisture characteristics), item 12 (riparian-wetland plants exhibit high vigor), and item 17 (saturation of soils is sufficient to compose and maintain hydric soils). Also, items 6 and 14 (abnormal frost or hydrologic heaving is absent) may correlate if the formation of abnormal frost-heave hummocks leads to observable dewatering of a riparian-wetland site. If item 6 is answered "no," then one or more of these items may be answered "no."

Item 7: Impoundment structure accommodates safe passage of flows (e.g., no headcut affecting dam or spillway)

Purpose

Some lentic riparian-wetland areas have been altered through the addition of structures designed to capture and store runoff, thus creating a more permanent or larger riparian-wetland area. However, when structures are used to alter a riparian-wetland area, they need to be designed and maintained to accommodate safe passage of flows (i.e., in a way that does not create erosion or otherwise impair the site). Item 7 applies only to riparian-wetland areas that have a structure (i.e., dam and associated parts) that is meant to control or regulate the volume, stage, or flow of surface water.

Observational Indicators and Examples

The ID team should inspect any water-control structures in or affecting the assessment area. These might include the:

- Spillway or other outlets.
- Dam or embankment.
- Foundation and abutments.
- Headgate(s).
- Drainpipes.

If the structures are stable and are accommodating flows with no evidence of erosion or riparian-wetland impairment, the answer to item 7 would be "yes." Examples of stability include:

- The spillway is properly engineered in width and gradient and adequately vegetated, rocked, or lined with intact, erosion-resistant materials to transmit flows safely.
- The dam is not eroding and has not lost material to wave action, land sliding, mass wasting, overtopping flows, or seepage.
- Large tree roots or animal burrows have not compromised the integrity of the dam.
- Drainpipes are properly installed, and water is not escaping around these structures.
- Debris is regularly removed to prevent blockage of spillways, drainpipes, and other outflow structures.
- The headgate is operational and fully functional.

If there is erosion, leakage, or a headcut affecting the integrity of the dam or spillway, the answer to item 7 would be "no." Examples of unstable structures include:

- Debris jams. Improper maintenance or upkeep may lead to blockage of the spillway or drains with debris, which could cause water stages to rise and to overtop the dam.
- Cracks, slumps, and shifting pieces of ground or lining in the foundation, abutments, embankment, spillway, or outlet (figure 20).
- Headcut erosion or gullying in the spillway (figure 21).
- Erosion and loss of material in a dam (figure 22).

- Sediment-filled reservoirs. When reservoirs fill with sediment, they lose their capacity to accommodate and store flood flows. Under this reduced functionality, ordinary-sized storms could exceed the designed flood-control capacity of the reservoir and could lead to overtopping of the dam, a very serious and dangerous condition that can erode and breach a dam (figure 22).

- The headgate is nonfunctional, resulting in uncontrollable drainage of the reservoir.

- Piping (internal erosion caused by seepage). Piping results when seepage through the dam removes soil particles, creating void spaces or sinkholes in the dam. Piping commonly develops along a penetration in the dam, such as a drainage pipe (figure 23). Because piping is created by internal erosion, it can be difficult to detect. Some observations that can provide early warning of potential piping include:

    - Seepage around hydraulic structures, such as drainpipes, spillways, or outlets.

    - Seepage through animal burrows and tree roots.

    - Dead trees, because rotted roots can become conduits of seepage.

    - Seepage through cracks in the dam's embankment, foundation, or abutment.

    - Visible corrosion of drainpipe or other structures that penetrate the dam (figure 23).

    - Formation of sand boils downstream of the dam.

    - Formation of sinkholes anywhere on the dam.

    - Discharge of muddy water on the downstream slope of the dam or a short distance downstream of an earthen dam (ASDSO 2019).

Figure 20. A cracked, slumped, and broken concrete spillway may be unstable, as discharge can access and undermine the soil and sediment beneath and adjacent to the spillway.

Figure 21. A 3-5 m deep headcut migrating through the spillway threatens the integrity of a dam.

Figure 22. Water overtopping a dam can cause dangerous erosion of the dam.

A prompt examination by a qualified dam inspector is recommended for any structure that is deemed to be unstable.

Item 7 applies only to those lentic riparian-wetland areas that have water-control infrastructure, such as those created or maintained by dugouts or dams. If no structure is present, item 7 would be answered "NA."

Figure 23. Cavities (or soil piping) in a dam. Piping may occur along improperly backfilled structures or from leakage through corroded metal pipes.

Supporting Science

The integrity of spillways and dams is threatened by gully erosion, loss of floodwater storage, and piping. Gully erosion occurs when headcuts form in a stream channel or drainageway, and the channel or drainageway incises, or downcuts. Gullies typically grow or enlarge by downcutting and by headcutting (i.e., upstream/upvalley migration of the headcut). Growth of gullies results in: generation of large volumes of sediment, potential drop in water table, and high-energy runoff events in which surface water is confined to the gully and unable to access a floodplain where stream energy can be dissipated. It is imperative that spillways are properly engineered so energy is dissipated. Spillways also need maintenance so gullies do not form; if they do form, it is critical to control gully erosion promptly. A variety of gully control methods are described by Heede (1976, 1980).

Sedimentation of reservoirs, ponds, and dugouts eventually leads to a loss of floodwater storage, which can increase discharge volume, depth, and duration through the spillway and the potential for water in the reservoir to overtop a dam. Poor upland watershed conditions can accelerate the natural rates of sedimentation and lead to premature filling of reservoirs with sediment. Management actions must either prevent accelerated upland erosion or periodically dredge sediments from dugouts, stock ponds, and reservoirs. Sedimentation rates can be adversely affected when the amount of upland vegetation that protects soil is reduced and overland flow is increased. This may be the result of:

- Improper grazing or harvesting of vegetation by livestock, wild horses and burros, or wildlife.
- Roads, which commonly concentrate runoff, which in turn provides energy to erode and transport sediment.
- Wildfires, which devegetate hillslopes and leave them vulnerable to runoff events.
- Deforestation related to timber harvest.

Sedimentation rates can be altered and generally increased by road construction, urban development, oil/gas field development, gully formation and channel incision, and conversion of rangeland to cultivated agricultural fields.

Piping (internal erosion of dams) is another major threat to water-control structures, such as dams, especially in expandable soils (soils rich in expandable clays such as smectite), saline and sodic soils, and acidic soils. The processes that lead to piping are described in detail in ASDSO (2019).

Correlation with Other Assessment Items

Item 7 correlates with item 4 (riparian-wetland impairment from the contributing area is absent), as factors that accelerate reservoir filling may be caused by factors in the contributing area.

6. Assessing Vegetation Attributes and Processes

Items 8-15 address vegetation attributes and processes that need to be in working order for a lentic riparian-wetland area to function properly. Factors such as the kind, proportion, and amount (cover or density) of vegetation in the riparian-wetland community contribute to riparian-wetland function. There is a progression in plant density and plant community development, from the complete absence of stabilizing riparian-wetland vegetation species to the development of stabilizing plant communities throughout a riparian-wetland area, approximating ecological potential. *Thus, items 8-13 are closely correlated with one another because they represent different stages in this progression:*

- Items 8-10[1] address the kinds of plants in the riparian-wetland area and if there is recruitment of young plants and maintenance of other age classes. These three items seek to determine if the appropriate plants are present and if they are reproducing. These items do not address how many plants are there, just whether the plants are present, because the presence of key riparian-wetland plants is the first step in the recovery process.

- Item 11 relates to whether the riparian-wetland plants identified in items 8-10 have progressed to the point that stabilizing species are forming recognizable and distinct communities. This phase is the next logical development after vegetation establishment and is key to determining whether recovery is imminent. Item 11 also does not address whether the amount of stabilizing plants is adequate, only whether stabilizing plant communities are present.

- Item 12 focuses on whether the plants present (addressed by the previous items) are vigorous. This is another critical attribute for plant community establishment, expansion, and persistence necessary for recovery and maintenance of a riparian-wetland area.

- Item 13 is important for synthesizing the vegetation items assessed, as its intent is to determine if there is an adequate *amount* of stabilizing vegetation to protect soil surfaces and shorelines, to dissipate energy from overland flows and wind and wave action, and to resist physical alteration. The amount of vegetation is expressed by the distribution of stabilizing riparian-wetland plants present. The amount is the last item in this sequence of recovery—vegetation must first become established, reproduce, and form communities before there is enough cover to protect the site.

Completion of a riparian-wetland plant list (appendix A) is an important step before addressing the vegetation items. Dominant vegetation, stabilizing species, and diagnostic species for ecological site descriptions or other classifications should be recorded to help indicate or refine potential. The wetland indicator category (Lichvar et al. 2016) and the greenline stability rating (Winward 2000; Burton et al. 2011; Lorenzana et al. 2017) for each plant should be recorded.

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[1] The order of items 8 and 9 has been reversed on the lentic assessment form from previous versions to create a more logical flow to the assessment process. This reversal will need to be considered in database management.

Recording plant species, although important, is not sufficient to address the vegetation items on the PFC assessment form accurately. The plant specialist(s) on the ID team must understand plant attributes, such as the growth, distribution, and reproductive habits of those species, and how each species or functional vegetation group influences riparian-wetland function.

ID teams must understand not only the differences in potential across sites, but also how different vegetation functional groups and species are adapted to specific elevation surfaces (or geomorphic/topographic positions) and water-table depth across a single riparian-wetland site, as in the following examples:

- Groundwater discharge point(s) around springs and seeps.
- High spots or microtopographic high points associated with ridges, strings, mounds, and tops of hummocks and pedestals.
- Low spots or microtopographic low points, such as depressions, swales, troughs, drainageways, flarks (linear, water-filled depressions in a peatland).
- The mesic fringe or transition area from OBL and FACW plant communities to FAC, FACU, and UPL plant communities.
- Shorelines of lakes and ponds.
- Thalweg (the line of lowest elevation within a valley or watercourse).

The occurrence of particular plants and plant communities is tied to the moisture zone and moisture gradient and disturbance zones at the site. For example, water sedge (*Carex aquatilis*) would not be expected in the mesic fringe above the groundwater discharge point. Understanding this concept is important so that appropriate expectations are set for where to look for certain plants and plant communities within the riparian-wetland area.

Riparian-wetland vegetation may also include invasive species or noxious weeds. Water is an excellent dispersal agent for seeds, and weeds can become established, especially on bare ground or early in the recovery process. Because the PFC assessment focuses on the physical function of the site, the presence of nonnative invasive or noxious weeds (although undesirable) does not necessarily preclude the achievement of PFC. Some invasive species possess reasonably good site-stabilizing properties (e.g., reed canarygrass (*Phalaris arundinacea*) has moderately high soil-stabilizing properties). The effects of noxious weeds in the riparian-wetland area may be symptomatic of other problems in the system and would be addressed in the appropriate assessment items. For example, monocultures of tamarisk tend to impact the natural hydrologic regime (item 6), geomorphic stability (item 19), and vegetation diversity (item 8) negatively. Nonnative invasive species and noxious weeds should be noted in appropriate detail on the assessment form.

Vegetation items are designed both to help diagnose the functional rating and to interpret recovery potential. As an example, there may be a situation in which item 11 (stabilizing plant communities are present that are capable of withstanding overland flows, and wind and wave actions, and can resist physical alteration) is answered "yes," and item 13 (an adequate amount of stabilizing riparian-wetland vegetation is present to protect soil surfaces and shorelines, to dissipate energy from overland flows and wind and wave actions, and to resist physical alteration) is answered "no." If the trend is upward, management is allowing for stabilizing riparian-wetland plant community formation, so improvement is likely imminent by either continuing current management or by making some modifications. A downward trend can be a red flag. In a different site where items 11 and 13 are both answered "no," recovery is not evident, the problem is likely severe, and a different management approach may be necessary. Although both of the sites described in these examples would likely be rated as FAR, the management approach might be very different for each site.

- Items 14 (abnormal frost or hydrologic heaving is absent) and 15 (favorable microsite condition is maintained by adjacent site characteristics) are stand-alone assessment items that are explained under those items.

Although most lentic riparian-wetland areas affected by management activities require vegetation to function, some landform-controlled lentic sites (although rare) may not (e.g., hillside springs on steep slopes, lakes and ponds with rocky shorelines). On those sites, many of the vegetation items are "NA."

Item 8: There is adequate diversity of stabilizing riparian-wetland vegetation for recovery/ maintenance

Purpose

Recovery or maintenance of most lentic riparian-wetland areas requires the presence of plant communities that contain stabilizing riparian-wetland vegetation. Item 8 addresses whether a sufficient number of stabilizing plant species are present (not whether all the stabilizing species an area can support are present).

Stabilizers are plant species that (1) become established along the edges of and in streams, ponds, and lakes, seeps, springs, marshes, swamps, bogs, fens, muskegs, prairie potholes, wet and moist meadows, vegetated drainageways, etc., (2) commonly have strong, cordlike rhizomes as well as deep, fibrous root masses, and (3) have coarse leaves and strong crowns, which, along with their massive root systems, protect riparian-wetland areas and facilitate function (Winward 2000). Stabilizers are able to buffer these sites against the erosive force of moving water caused by snowmelt, precipitation events, overland flows, and wind and wave action, and they protect the soil surface from direct physical human and animal impacts that can shear plant root crowns and rhizomes, compact soils, reduce infiltration and soil-moisture storage, and disrupt surface flow/drainage patterns.

Although they generally require hydric settings for establishment, some stabilizers may persist in drier conditions once they have become firmly established (Winward 2000). Many of the sedges, rushes, and riparian-wetland shrubs are considered stabilizers (common examples include Nebraska sedge (*Carex nebrascensis*) and Geyer willow (*Salix geyeriana*)). In contrast, species such as brookgrass (*Catabrosia aquatica*), watercress (*Nasturtium officinale*), redtop (*Agrostis stolonifera*), and Kentucky bluegrass (*Poa pratensis*) and most forbs have shallow roots and relatively weak stems and are much less able to buffer shorelines and protect soil surfaces.

The presence of only one stabilizing species often makes a site vulnerable to disease or extreme changes in climate, which may result in impairment of an area. A diversity of stabilizers allows riparian-wetland areas to adjust to changing environmental factors. *However, some lentic riparian-wetland areas are dominated by a single stabilizing species, particularly if they are small and have a consistent and homogenous moisture zone across the site. Larger sites with more variability in moisture zones are generally composed of a complex of multiple plant communities.* Understanding site potential is key to making this determination.

Observational Indicators and Examples

Although thresholds for diversity of stabilizing plant species are not firmly established, in most cases more than one stabilizing species must be present for the site to maintain adequate resiliency. If the site needs both herbaceous and woody vegetation for function, two of each plant life-form (herbaceous and woody) are generally needed for function. The following examples should be considered when addressing this item:

- If it is determined that a site has the potential for and needs woody vegetation for function and is found to have planeleaf willow (*Salix planifolia*) and Wolf's willow (*Salix wolfii*), the answer to item 8 would be "yes," as this is sufficient composition to recover or maintain this site. If this same site contained only planeleaf willow, the answer to item 8 would be "no."

  Some sites can function with *either* herbaceous *or* woody vegetation. For example, on a site where this is the case and Nebraska sedge and Arctic rush (*Juncus arcticus*) are present (with one or fewer woody species), the answer to item 8 would be "yes." If the same site contained Geyer willow and Booth's willow (*Salix boothii*) and one or fewer herbaceous species, the item would also be "yes."

- Some sites may have the potential and the requirement for *both* herbaceous and woody riparian-wetland vegetation to dissipate energy and protect the soil surface. In these instances, two stabilizing species of each plant life-form (herbaceous and woody) are required for a "yes" answer. Item 8 can be answered both "yes" and "no" if both herbaceous and woody vegetation are required and one plant life-form has two or more species but the other does not (e.g., Nebraska sedge and Arctic rush are present, but only one willow species is present). If this is the case, sufficient rationale must be provided to explain the different answers.

- *Caution must be used when assessing sites that* naturally *lack a diversity of stabilizing species.* The presence of only one stabilizing species is not uncommon—especially in hydric zones where the water table is shallow and stable. Rhizomatous stabilizing sedges can form rather extensive homogenous swards of the same species. If that species is present, then the answer would be "yes." Mesic areas (moderately moist areas) that are further away from the hydric zone and where the water table is somewhat deeper, tend to have greater species diversity. At potential, some fens with low pH values and a shallow water table have an extensive moss cover with patchy graminoid cover (Weixelman and Cooper 2009); it is not uncommon for these sites to lack a diversity of riparian-wetland stabilizers. Understanding the site potential will greatly assist the ID team in making this determination.

As mentioned in the chapter 6 introduction to the vegetation indicators, the ID team should understand how different vegetation functional groups and species are adapted to specific elevation surfaces (or geomorphic/topographic positions) and water-table depth across the riparian-wetland area as described. The occurrence of particular plants and plant communities is tied to the moisture gradient and disturbance zones at the site. The majority of stabilizing plant species are OBL or FACW plants and will occur in the wettest zones within the riparian-wetland area (although not all OBL and FACW plants are stabilizers).

"NA" would apply for those lentic sites that do not require vegetation to function properly.

Supporting Science

Riparian-wetland vegetation is usually extremely heterogeneous, as evidenced by many riparian-wetland classification documents. In general, ecosystem stability is characterized by an increase in species diversity, structural complexity, and organic matter (Kormondy 1969). Monocultures are susceptible to disease, herbivory, insect infestations, and extreme temperature fluctuations.

Riparian-wetland communities must be able to adapt to extremes in water availability and stresses associated with anaerobic/aerobic conditions occurring in the rooting zone. Climatic changes, including drought and wet cycles, continue to occur throughout the United States. However, the period between successive drought (or wet) years is completely unpredictable and variable. Streamflow, aquifer recharge, and attendant water tables may vary considerably over time in conjunction with fluctuations in precipitation and runoff. Therefore, the diversity of stabilizing plant species within the riparian-wetland area must be enough to accommodate substantial shifts in the water table or zone of saturation or to sustain these species under varying conditions.

Supporting science for the importance of heterogeneity can be found in the many riparian-wetland classifications available. If local classifications exist, it is critical to consult them. Regional riparian-wetland classifications, even those from adjacent states or regions, are a good resource. They provide descriptions of types that may also occur across the western United States (due to the presence of water, regardless of their location), making it possible to refer to classifications from adjacent states if one does not exist in the local area. For example, many classifications have a Geyer willow/beaked sedge (*Carex utriculata*) type that is very similar for major species and site characteristics from Montana (Hansen et al. 1995) to Nevada (Manning and Padgett 1995). These classifications have been helpful in evaluating sites in adjoining states where no current classification existed. The type descriptions, along with the constancy/average cover tables, help describe the range of characteristics in terms of site, location, hydrology, and species composition and structure. Without these classifications, it would be difficult to assess potential and determine the number of species that should be present.

Correlation with Other Assessment Items

This item specifically addresses the presence of stabilizing species, while item 11 (stabilizing plant communities are present that are capable of withstanding overland flows, and wind and wave actions, and can resist physical alteration) and item 13 (an adequate amount of stabilizing riparian-wetland vegetation is present to protect soil surfaces and shorelines, to dissipate energy from overland flows and wind and wave actions, and to resist physical alteration) help determine if recognizable and distinct stabilizing plant communities have started to develop and if there is an adequate amount of stabilizing riparian-wetland vegetation.

Item 9: There are adequate age classes of stabilizing riparian-wetland vegetation for recovery/maintenance

Purpose

For a riparian-wetland area to recover or maintain itself, it must have recruitment of stabilizing plant species necessary for recovery or replacement. Item 9 addresses if the age classes that provide recruitment to maintain an area or to allow an area to recover are present (not whether all possible age classes are present).

Most woody riparian-wetland plant communities can recover or maintain themselves with two age classes, as long as one of the age classes is young (recruitment) and the other is middle-aged (replacement). The presence of current-year seedlings (germination) does not necessarily indicate recruitment (establishment of young plants), as there are many sites where germination is common and widespread, but the plants have difficulty advancing into older age classes due to site-specific dynamics or other factors. Older age classes (mature) usually persist, as they are well-connected to existing water tables, even with degraded conditions. Recruitment of herbaceous stabilizers is indicated by maintenance of dense sod where it exists, presence of young shoots around established plants in sparse communities, or apparent expansion of shoots into pioneering/colonizing riparian-wetland vegetation. It is important to note that it is sometimes difficult to ascertain the true age of shrubs (e.g., it is not uncommon to observe stems sprouting from an old root crown that is below the soil surface). As a result, this item is more appropriately addressing "apparent age" than actual age in some instances.

Observational Indicators and Examples

The following factors will influence whether item 9 is answered "yes" or "no."

- For riparian-wetland areas that require woody vegetation to achieve function, the ID team would answer "yes" if there are both young (recruitment) and middle-aged (replacement) classes present. If either of these two age classes are absent, the answer would be "no."

- Herbaceous riparian-wetland communities are typically dominated by grasslike (graminoid) plants that regenerate vegetatively by tillering, rhizomes, or stolons. In these herbaceous communities, it can be more difficult to distinguish between age classes. However, if the ID team understands the habit of these species (i.e., if they are dense, mat-forming sedges such as Nebraska sedge), continuous, robust cover composed of many stems and blades would be expected. In this case, the answer to this item would be "yes." However, if the cover of stabilizing plants is clumped or there are only scattered individuals (figure 24), or rhizomatous plants have failed to expand or fill in bare soil patches, the answer would be "no."

- Some riparian-wetland areas have potential for both woody and herbaceous vegetation. If a combination of woody and herbaceous plants is required, there should be evidence of recruitment for both woody and herbaceous plants for a "yes" response.

- Item 9 can be answered both yes and no if both herbaceous and woody vegetation are required and one plant life-form has adequate age classes but the other does not. The rationale for both answers should be documented in the comments on the assessment form.

- The ID team needs to recognize changes over time that affect potential for recruitment, especially in recovering systems. For example, willow species that require a depositional or erosional surface for germination and establishment may initially be recruited in a degraded vegetated drainageway. The extent of exposed, aerated soils then declines over time with recovery. Progression towards saturated, anaerobic conditions can decrease continued willow regeneration and favor sedge, rush, or other species adapted to anaerobic soils. Item 9 would still be "yes" in this situation even though willows are present but not recruiting. Again, the rationale for the answer should be noted on the assessment form.

- Judgment is required for plant communities that establish as even-aged stands as a result of episodic events, which is a common occurrence. These stands may persist at an even age until disturbances open parts of them for additional recruitment. Episodic recruitment scenarios (such as postflood or postfire) or communities at potential natural condition may not have a diversity of age classes. Sites that are in an advanced ecological status have limited opportunity for recruitment, but small patches of disturbance usually exist. If species are present that have an episodic recruitment tendency or the site is in an advanced ecological status, most often a "yes" response would be indicated.

"NA" would apply for those lentic sites that do not require vegetation to function properly.

As mentioned earlier, it is important for the ID team to understand how different vegetation functional groups and species are adapted to specific elevation surfaces (or geomorphic/topographic positions) and water-table depth across the riparian-wetland area (as described in the chapter 6 introduction to vegetation indicators). As a result, the recruitment of new plants and plant communities is tied to the moisture gradient and disturbance zones. For example, water sedge would not be expected in the mesic fringe above the groundwater discharge point. Understanding this concept is important so that appropriate expectations are set for *where* to look for recruitment within the riparian-wetland area.

Because individual plant species are tied to moisture regimes, recent changes in the water table usually promote changes in plant composition. In those cases, observers should look closely at herbaceous plants, since there will be newly established (younger) plants present in response to the changed moisture regime.

Figure 24. Scattered individual Nebraska sedge shoots and leaves (silver plants) not reproducing adequately are evidence for a "no" response to the herbaceous component of item 9.

Supporting Science

Cooper and Merritt (2012) summarize the soil-water needs of riparian-wetland vegetation, including plant recruitment, growth, and maintenance that can affect age class distribution. Recruitment is further affected by physiological and mechanical stresses, such as defoliation, mechanical damage, and fire. The interrelationships of age structure can be quite complex, but general characterizations can be made of expanding, episodic, stable, and diminishing populations (Kormondy 1969) (figure 25).

Expanding populations can generally be described by a pyramid shape of age class distribution, with many young plants forming a wide base, fewer middle-aged plants in the middle, and very few old plants at the top. Stable populations have more of a bullet-shaped distribution, with rather equal numbers of young and middle-aged individuals forming the base and middle, and a gradually diminishing number of the oldest individuals at the top. Diminishing populations display more urn-shaped distributions, with a narrow base of young plants that widens towards the older age classes, then often sharply narrows with the oldest individuals (figure 25).

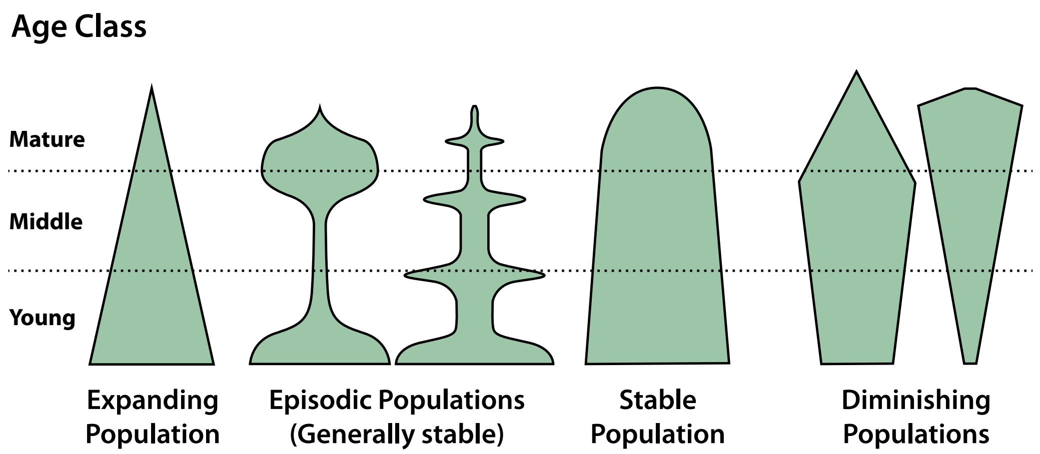

Figure 25. Age class population distribution shapes (modified from Kormondy 1969).

Plant species with an episodic recruitment tendency may exhibit the shape of a diminishing population, waiting for an event to induce recruitment. For example, even though a seed source is present, site conditions may be present only periodically for germination and establishment. Willow and cottonwoods have many seeds that are viable for only about 2 weeks. If the mineral soil is too dry, the seeds will desiccate. A dense layer of sedges also limits establishment because the seeds cannot come in contact with wet mineral soils. The seed source is always present, but the site conditions are not always favorable for seedling establishment.

Populations of woody plants with episodic recruitment tendencies also may be hourglass-shaped with large numbers in the young and old age classes and with few middle-aged individuals; or they may have populations that are more bimodal or multimodal, with larger numbers spread in a few age class groups, reflecting pulses of recruitment episodes (figure 25). Hourglass-shaped populations would be characterized as generally stable due to the presence of many young plants. Bimodal- or multimodal-shaped populations would also be stable if there is a reasonably large number of young plants represented. Of particular concern are indicators of diminishing populations, such as those with few or no individuals in the young or middle-aged classes where apparently suitable niches for recruitment are vacant.

For herbaceous species, the term "age class distribution" is somewhat misleading, but the intent to identify indicators of expanding, stable, or diminishing populations through recruitment/reproduction is the same. Dahl and Hyder (1977) discuss developmental morphological attributes that have implications pertinent to plant recruitment and maintenance. Indicators include the ratio of vegetative to reproductive culms (for plants reproducing by seed), amount and degree of lateral shoot development or tillering, and types of vegetative shoots.

Correlation with Other Assessment Items

This item can correlate with item 3 (riparian-wetland area is enlarging or has achieved potential extent), as newly established (younger) plants may be present in response to the changed moisture regime. It also correlates with item 12 (riparian-wetland plants exhibit high vigor) for herbaceous species, since it is common for scattered herbaceous plants that are not reproducing to exhibit low vigor.

Item 10: Species present indicate maintenance of riparian-wetland soil-moisture characteristics

Purpose

Item 10 focuses solely on assessing the vegetation present to determine if soil moisture is being maintained (regardless of the vegetation's other ecological/functional properties). To answer item 10, the ID team should look for evidence that the level of the water table is being maintained or is moving towards its potential extent as indicated by the wetland indicator category of existing riparian-wetland vegetation. Maintenance or recovery of an existing water table is vital to the maintenance or recovery of a riparian-wetland area.

Riparian-wetland areas by definition are a transition between the aquatic and upland areas, so care should be taken to evaluate the wet and dry vegetation components relative to appropriate positions on the landscape. As mentioned earlier, it is important for the ID team to understand how different vegetation functional groups and species are adapted to specific elevation surfaces (or geomorphic/topographic positions) and water-table depth across the riparian-wetland area (as described in the chapter 6 introduction to vegetation indicators). The occurrence of particular plants and plant communities is tied to the moisture gradient and disturbance zones at the site.

A loss of soil-moisture characteristics caused by a decline in groundwater can initiate a shift from riparian-wetland plants to more upland plants if (1) the water table drops below the root zone, and (2) the duration of drawdown is long enough that riparian-wetland vegetation becomes stressed or dies. Short-term declines in groundwater levels (3-4 months) will generally affect only some shallow-rooted or very young plants or species that are particularly sensitive to water-level declines; most of the time, a short-term decline will not stress vegetation enough to trigger a significant change in species composition.

Observational Indicators and Examples

To assess the vegetation present for item 10 correctly, knowledge of riparian-wetland plant species is essential. The ID team must accurately identify specific plant species and understand the nature of their occurrence on the landscape. Plants that primarily occur in wetlands are called hydrophytes. Hydrophytes are adapted to growing in the low-oxygen/anaerobic conditions associated with prolonged saturation or flooding, which is why they can be used as indicators of soil-moisture characteristics. The term "hydrophytes" is generally restricted to OBL and FACW plants but is sometimes used to describe FAC plants, which can occur as hydrophytes or nonhydrophytes. Plants are divided into categories relative to the likelihood of their occurrence in wetlands or nonwetlands (table 5) (Lichvar et al. 2016). Individual plant ratings can be found on the National Wetland Plant List (USACE 2014) and online at the USDA PLANTS Database (USDA-NRCS 2019).

- A "yes" response would be given for item 10 when OBL or FACW plants are present on appropriate geomorphic positions of a perennial site as determined by expected wetland soil characteristics, including depth and duration of plant-available water. Knowledge of individual species' soil-moisture requirements and tolerance is also required. A "no" response would be given if FACU or UPL plants occupy positions expected to be occupied by hydrophytes (OBL and FACW plants), indicating a change in flow or groundwater-related variables (soil-water availability).

- Some intermittent and common perennial systems could be somewhat different, depending on flow or groundwater-related characteristics, as their potential may be primarily FAC plants. If this is the case, and the riparian-wetland area is dominated by FAC plants, item 10 would be "yes." A riparian-wetland area in an intermittent or perennial site with the potential for FAC vegetation would be given a "no" answer if the hydric zone is dominated by FACU or UPL plants.

Table 5. Wetland indicator categories based on ecological descriptions.

Wetland Indicator Category (Abbreviation)	Ecological Description (Lichvar et al. 2016)
Obligate (OBL)	Almost always is a hydrophyte, rarely in uplands
Facultative Wetland (FACW)	Usually is a hydrophyte but occasionally found in uplands
Facultative (FAC)	Commonly occurs as either a hydrophyte or nonhydrophyte
Facultative Upland (FACU)	Occasionally is a hydrophyte but usually occurs in uplands
Upland (UPL)	Rarely is a hydrophyte, almost always in uplands

Mature OBL and FACW plants by themselves may not always indicate that soil-moisture characteristics are being maintained. When there is a long-term drop in the water table, the shallow-rooted vegetation will decline first, and there may be a composition change to more upland species. Mature plants that established contact with the water table long ago are often able to maintain contact with a declining water table for a long time due to deep roots, but current soil-water characteristics preclude regeneration of these species. However, in the "flashy" systems of the southwestern United States, OBL and FACW plant species recruitment is often in the bottom of a vegetated drainageway. In other instances, OBL and FACW plants may occur well above the riparian-wetland area in nonhydric soils because they are connected to the riparian-wetland area by roots or rhizomes (e.g., Arctic rush).

When completing this item, the ID team should evaluate recovering systems with care. Depositional events may initiate a temporary shift towards upland plants during the lag time required for a rising water table to "catch up." Such events should be noted so that the rating is appropriate and reflective of current conditions and trend.

Item 10 would be answered "NA" for riparian-wetland areas that have no potential to produce vegetation.

Supporting Science

The relative affinity that specific plant species have for moisture is well-documented by the wetland indicator categorization work in Lichvar et al. (2016). Myers (1989) and most of the classification literature mentioned under item 8 cite an increase in upland plants as an indicator of a declining water table.

Correlation with Other Assessment Items

Item 10 correlates with item 3 (riparian-wetland area is enlarging or has achieved potential extent). The expansion of OBL and FACW plants may be an indication of a rising water table or reconnection with the floodplain. There is also a strong correlation with item 1 (riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events) and item 17 (saturation of soils is sufficient to compose and maintain hydric soils). Item 10 also correlates with item 6 (disturbances or features that negatively affect surface- and subsurface-flow patterns are absent), as plant species and plant communities have the capacity to respond rapidly to changes in water-flow patterns.

Item 11: Stabilizing plant communities are present that are capable of withstanding overland flows (e.g., storm events, snowmelt), and wind and wave actions, and can resist physical alteration

Purpose

Item 11 focuses on whether there are stabilizing plant *communities* present at the site to support recovery and maintenance. The intent of this item is to document that soil surfaces/shorelines have developed *communities* of the stabilizing plants described in item 8. Whereas item 8 is designed to determine if stabilizing species are simply present in the riparian-wetland area, this item is asking if those plants have formed *recognizable and distinct communities*. However, item 11 does not address adequacy (amount) and is not intended to determine if *enough* vegetation or *enough* communities are present (the purpose of item 13).

Riparian-wetland sites lacking stabilizing plants that have not yet formed recognizable plant communities are prone to rilling, concentrated flow patterns, headcuts, pedestalling, soil compaction, soil pugging, etc. Most stabilizing riparian-wetland plant communities are dominated by specific OBL and FACW plants that have deep, strong root masses capable of withstanding overland flows (e.g., storm events, snowmelt), wind and wave action, and direct physical impairment/alteration. In some geographic areas, some FAC plants may also function as stabilizers. Most plant communities dominated by FACU and UPL species do not have stabilizing root characteristics. The presence of stabilizing plant communities, even if they do not dominate the site, has additional interpretive value for recovery or maintenance potential of a site over the presence of stabilizing species alone.

Observational Indicators and Examples

The following factors will influence whether item 11 is answered "yes" or "no."

- If stabilizing plants have formed distinct and recognizable communities, the answer to item 11 would be "yes." For some intermittent systems (and some perennial systems, as noted above), the presence of recognizable communities of FAC plants may be all that is required for a "yes" response, as this may be all these systems can produce.

- A "yes" response is possible on item 11 if there are well-developed patches at the site that contain deep-rooted plant communities. In such conditions, it is likely that reproduction of additional deep-rooted vegetation will occur and eventually fill in the gaps at the site. If deep-rooted riparian-wetland plants occur only as scattered individual plants at a site, item 11 would be answered "no."

- Plant communities such as Kentucky bluegrass, redtop, and blue grama (*Bouteloua gracilis*) do not have root masses capable of withstanding high-energy events or the forces generated from hoof action. If these communities exist *in lieu of* communities of stabilizing riparian-wetland plants, the answer to item 11 would be "no."

- As mentioned earlier, at potential, some fens with low pH values and a shallow water table have an extensive moss cover with only patchy graminoid cover (Weixelman and Cooper 2009); it is not uncommon for these sites to lack distinct plant communities. In instances such as this, when site potential limits development of communities, the answer to item 11 would be "yes."

Again, it is important for the ID team to understand how different vegetation functional groups and species are adapted to specific elevation surfaces (or geomorphic/topographic positions) and water-table depth across the riparian-wetland area (as described in the chapter 6 introduction to vegetation indicators). The occurrence of particular plants and plant communities is tied to the moisture gradient and disturbance zones at the site. Most stabilizing plant species are OBL and FACW plants and will occur in the wettest zones within the riparian-wetland area (although not all OBL and FACW plants are stabilizers).

There are situations, such as with high mountain lakes surrounded by boulder fields, where vegetation has no influence on shoreline stability. For these, the answer would be "NA."

Supporting Science

Stabilizing riparian-wetland species, such as willow, alder, aspen, birch, and cottonwood, or deep-rooted herbaceous species, such as sedges, rushes, bulrush, and some riparian-wetland grasses, are very effective in armoring soil surfaces and shorelines against overland flows, wave action, ice damage, undercutting, and bank collapse (figure 26). Herbaceous riparian-wetland species, particularly rhizomatous graminoids, such as cattails, bulrush, sedges, rushes, and some riparian-wetland grasses, have dense, fibrous root systems that create a stable soil, bound together by an extensive network of fine roots. These roots and rhizomes have such a strong stabilizing effect on the soils that they can protect soil surfaces and shorelines. They are particularly effective in protecting against ice damage, which removes unvegetated soil away from the shoreline and exposes more shoreline to further damage. The ice crystals cannot break apart the root network. It is important to understand that rhizomes (belowground stems) are stronger than roots and have growing points. Therefore, rhizomatous plants are more effective stabilizers than plants without rhizomes.

Figure 26. Stabilizing vegetation exhibits highly developed roots and rhizomes.

In general, graminoids with rhizomes or stolons are the best soil binders, since they form a continuous, interwoven mat of rhizomes and large, medium, and fine roots. It is the high proportion (both in mass and density) of fine roots (more than 90 percent in Nebraska sedge) within this mat, however, that aids in aggregate formation, root turnover, and inputs of organic matter into the soil (Manning et al. 1989). These properties aid in soil development, which in turn creates a more favorable environment for riparian-wetland plant establishment.

Many lentic riparian-wetland sites are composed of fine-textured soils that are susceptible to physical impacts from human and animal traffic—particularly when they are moist or wet (Manning and Padgett 1995; Padgett et al. 1989). Heavy trampling can degrade lentic riparian-wetland communities as shorelines and slopes fracture, slump, or erode; plant tussocks and roots are sheared; hummocks form; soils are compacted, pugged, and poached; infiltration and groundwater storage declines; flow patterns are disrupted; and trampling-resistant mesic or xeric species (adapted to disturbed/compacted soils) replace less-resistant ones (Lynch 2012; Middleton 2016; Bauer and Burton 1993; Platts 1991; USDA-NRCS 2001; Martin and Butler 2017) (figure 27). Because of their unique morphology and robust nature, stabilizing riparian-wetland vegetation (described above) not only binds soil particles and stabilizes shorelines, slopes, and soil surfaces, but also protects soils from deformation and compaction caused by physical human and animal activities more effectively than do communities of weakly or shallow-rooted nonstabilizing plants. Tensile strength provided by root masses of riparian-wetland vegetation may be the primary source

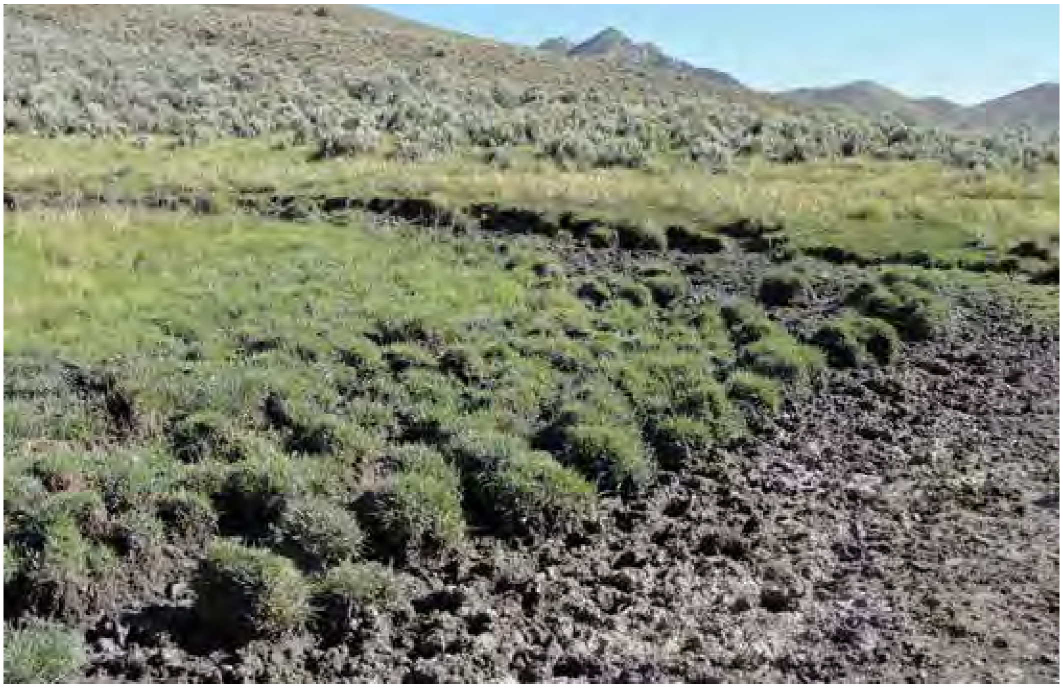

Figure 27. Pugged, hummocked, and trampled soil surface in a mesic meadow. Lack of stabilizing plant communities makes this site more prone to physical alteration.

of resistance in the soil of many riparian-wetland areas. Tensile strength will depend on both the kind of vegetation present and the extent and density of root masses in the soil. All other things being equal, sites with communities of stabilizing plant species can better withstand more physical human and animal traffic without degrading than sites that lack stabilizing communities.

Based on the authors' experience with hundreds of lentic sites in the United States, riparian-wetland areas with communities of stabilizing plants are less prone to hoof shear and hoof slide than those composed of weakly rooted species. Pugging (or "postholing") occurs when the hooves of ungulates penetrate wet soil surfaces, causing damage to plants and the soil structure (Teutsch 2019). Pugging from domestic and wild ungulates is often shallower and less severe in riparian-wetland meadows dominated by herbaceous stabilizers (e.g., sedges and rushes, due to their extensive, dense root systems) than on sites dominated by brookgrass, redtop, Kentucky bluegrass, and weedy forbs (i.e., nonstabilizers). In addition, concentrated animal trailing on sites dominated by weakly or shallow-rooted species can easily create paths of bare soil—resulting in concentrated flow patterns and the formation of rills and headcuts.

Excessive soil compaction in riparian-wetland areas reduces infiltration and soil-moisture storage and changes plant communities from hydric stabilizing plants to mesic and xeric plants (most of which are nonstabilizers) adapted to those conditions. Riparian-wetland soils with high levels of organic matter tend to resist compaction better, facilitate infiltration, and store more water in the profile than those lacking organic matter (Wolkowski and Lowery 2008; Hoorman et al. 2011). The contribution of organic matter into surface horizons from robust aboveground and belowground biomass produced by most stabilizing plants helps protect the site from soil compaction by improving the formation of stable soil aggregates that resist compaction (Wheeler et al. 2002; Wolkowski and Lowery 2008; Hoorman et al. 2011). Because of their root density and mass and their generally robust structure, stabilizing species contribute more biomass into the soil to produce organic matter than more diminutive, weakly or shallow-rooted nonstabilizers. Riparian-wetland communities of stabilizing plants also promote site conditions and soil physical characteristics that allow them to recover quickly from heavy grazing events as long as adequate soil moisture is still available (Wheeler et al. 2002).

Assessment of erosion control potential is based on rooting habits of individual species (Lewis 1958; Manning et al. 1989; Kleinfelder et al. 1992; Lorenzana et al. 2017) or preferably on ratings of or discussions about both species and plant communities, such as in Weixelman et al. (1996), Hansen et al. (1995), Manning and Padgett (1995), USDA Forest Service (1992), and Kovalchik (1987). Even though these publications are geographically specific, similar species and plant communities occur broadly across various geographic regions. Certain species, such as Nebraska sedge, beaked sedge, and Arctic rush, are common throughout the western United States.

Stability ratings have been developed for plant communities and individual plant species and other features (barren areas, rock, woody material) that help characterize how well the sites may resist erosion (Winward 2000; Burton et al. 2011; Crowe and Clausnitzer 1997; Lorenzana et al. 2017). Many OBL and FACW species, and some FAC species, have high erosion control potential.

Correlation with Other Assessment Items

This item correlates with item 13 (an adequate amount of stabilizing riparian-wetland vegetation is present to protect soil surfaces and shorelines, to dissipate energy from overland flows and wind and wave actions, and to resist physical alteration) and is particularly useful for cases where item 13 is answered "no." In those instances, a "yes" answer on item 11 indicates that the site has an adequate source of the kind of plant communities that support recovery and progress towards an adequate amount of stabilizing vegetation if provided an opportunity to do so.

Item 12: Riparian-wetland plants exhibit high vigor

Purpose

Item 12 refers to whether riparian-wetland plants are healthy and robust or are weakened and stressed. Plants that are in an unhealthy state have a diminished ability to grow (expand), reproduce, or contribute to function and can be at risk of mortality. The loss of key riparian-wetland plants can subject the riparian-wetland area to impairment. The aboveground expression reflects belowground condition and the ability of riparian-wetland species to stabilize an area.

Observational Indicators and Examples

Reduced height, root growth, leaf width, leaf area (production), and signs of stress, such as chlorosis, have traditionally been used as indicators of reduced vigor on herbaceous species. Growth form (morphology), leader length, and the amount of dead or dying limbs (Cole 1958; Keigley and Frisina 1998) are also long-standing indicators of shrub vigor. However, dead and dying limbs are common in willows with a cyclic life history. Clump willows, such as Geyer willow, Lemmon's willow (*Salix lemmonii*), and Booth's willow, are examples of species that replace their limbs approximately every 20 years. The dead limbs remaining serve to protect the new shoots that emerge from the base (Elmore undated).

- Emphasis should be placed on stabilizing species when addressing this item. If stabilizing riparian-wetland species are of low vigor and nonstabilizing riparian-wetland plants (brookgrass, shallow-rooted forbs, etc.) are of high vigor, the answer to this item would be "no."

- Woody plants should be distinguished from herbaceous plants when assessing vigor. For most riparian-wetland areas, plant size, shape, and leaf color during the growing season can be used to discern vigor. For example, if willows are well-rounded and robust, item 12 would be answered "yes." If these same plants have altered growth forms (e.g., if they are hedged, highlined, or clubbed) or have suppressed leader growth (figure 28), item 12 would be answered "no."

- This item could also be answered both "yes" and "no" if, for example, herbaceous species appear healthy and vigorous ("yes") and woody species appear diseased, stressed, or otherwise unhealthy ("no"), or vice versa.

- Chlorosis occurs when leaves produce insufficient chlorophyll. If willow leaves are turning yellow during the growing season, often water is being removed or added to a system, which stresses the plants. However, change in color can also indicate a disease, nutrient problem, or climatic factors. Plants turning yellow during the growing season would result in a "no" response to this item.

- The abundance of herbaceous plants along with other indicators, such as leaf width or height, can be used to assess vigor. For example, if Nebraska sedge occurs as a dense mat with adequate leaf width, item 12 would be answered "yes." If Nebraska sedge occurs as narrow-leafed, isolated plants or as broken clumps that are not forming communities (interspaces between sedge plants are occupied by upland species or bare ground (figure 24)), item 12 would be answered "no."

- This item is specific to vigor, not annual use. The ID team must use caution and look carefully at grazed/browsed plants to avoid being influenced by the current year's herbivory.

- Caution should be used when assessing sites early in the season or during years of delayed leaf-out, as plants in those instances may only appear to lack vigor.

- In some instances, narrow-leafed plants may be healthy but young and in the process of expanding by rhizomes from more robust individuals or patches.

- In fens with low nutrient availability (e.g., poor fens), plants will naturally look less vigorous. Again, the need to understand site potential is critical.

Declines in groundwater can cause plants to appear weakened and stressed. However, riparian-wetland vegetation that exhibits low vigor or appears stressed is not always a reliable early-warning indicator of declining groundwater levels. Other factors, such as disease, drought, or temperature extremes, can also influence vigor. The most reliable approach for detecting changes in shallow groundwater conditions is to combine a detailed assessment of riparian-wetland vegetation composition and vigor with observations of groundwater levels in wells.

For riparian-wetland areas that have no potential to produce vegetation, this item would be answered "NA."

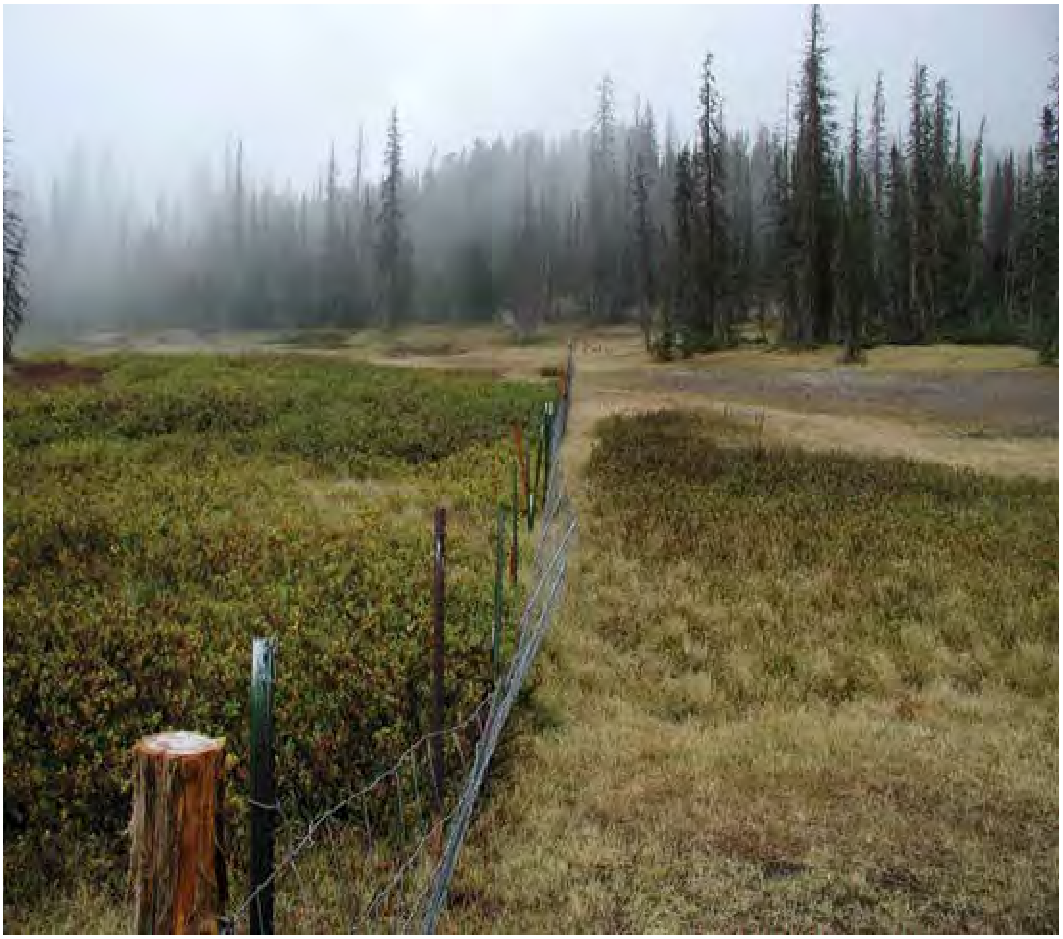

Figure 28. The short willow shrubs on the left side of the fence show high vigor (and high cover), whereas those to the right of the fence do not. The right side is grazed/browsed by wildlife and sheep, and the left side exhibits only wildlife use. Neither side was grazed during the season when the photo was taken. The shrubs on the right exhibit suppressed leader growth, a hedged appearance, and less cover than those on the left side of the fence.

Supporting Science

The relative health of plants within a community can be expressed in many morphological and physiological forms. The reproductive indicators for herbaceous species discussed under item 9 (there are adequate age classes of stabilizing riparian-wetland vegetation for recovery/maintenance) are associated with relative plant health or vigor (unhealthy plants do not reproduce as well). Plant size, leaf area and size, and root growth are also associated with relative plant health or vigor. When healthy and vigorous, some stabilizing riparian-wetland plant communities have up to a 3:1 ratio of belowground to aboveground growth, whereas upland plant communities are closer to a 1:1.5 ratio (Dwire et al. 2004).

Correlation with Other Assessment Items

There is a correlation between this item and item 9 (there are adequate age classes of stabilizing riparian-wetland vegetation for recovery/maintenance). If there is a "no" response on item 9, a "no" response may be likely on item 12, depending on the reason for the lack of age classes. This item also correlates with item 10 (species present indicate maintenance of riparian-wetland soil-moisture characteristics), in that a drop in the water table would result in a decrease in vigor before an actual shift in species composition.

Item 13: An adequate amount of stabilizing riparian-wetland vegetation is present to protect soil surfaces and shorelines, to dissipate energy from overland flows and wind and wave actions, and to resist physical alteration

Purpose

Item 13 pertains to whether there is an adequate *amount* of vegetative cover of stabilizing riparian-wetland plant communities present at the site to protect soil surfaces and shorelines, to dissipate energy from overland flows and wind and wave actions, and to resist direct physical alteration. This item is important for areas where vegetation is required for proper function. For a riparian-wetland area to recover, stabilizing plant communities, vigor, and recruitment are necessary, but until an adequate *amount* of vegetation is present, the riparian-wetland area is vulnerable to impairment.

NOTE: It is important to understand that all lentic sites are subject to the energy of moving water and physical impacts in varying degrees. A site may have energy from both overland flows *and* wind and wave actions, or it may have energy from only one of these sources (e.g., a wet meadow with no open water would not have wave action but would experience overland flows). In addition, at some point all lentic sites are subject to some degree of physical alteration. For these reasons, this item should be addressed on all lentic sites with vegetation; it would never be answered NA for such sites.

Item 13 addresses the amount of cover, while items 8-12 address species diversity, recruitment (age classes), wetland indicator status, the presence and location of communities, and vigor—not the amount of cover.

Observational Indicators and Examples

The following factors will influence whether item 13 should be answered "yes" or "no."

- If a site has the potential to be dominated by riparian-wetland plants but is presently dominated by upland plant communities, the answer to item 13 would be "no." If this same site has 50 percent stabilizing riparian-wetland plant cover and 50 percent upland plant cover, the answer to item 13 would still be "no."
- Although there are exceptions, from a practical assessment standpoint, a "yes" answer would be indicated if there is at least 70-75 percent stabilizing cover. This amount of cover is usually sufficient to protect most sites and dissipate energy. Practitioners may use a higher value for particularly sensitive sites or a lower value for resistant sites if a rationale is provided. Exceptions include poor fens with low pH values, as they are commonly characterized by an extensive moss cover with patchy graminoid cover (Weixelman and Cooper 2009); these sites often do not have the potential for 70 percent stabilizing cover.

For lentic sites *without open water* or distinct shorelines (moist and wet meadows, fens, etc.) or on sites with a riparian-wetland area located away from the shoreline:

- Rills, concentrated flow patterns, headcuts, etc. throughout the site, *combined* with a limited amount of stabilizing riparian-wetland vegetation, provide a clear indication of inadequate cover. Although these instability features are good indicators, some sites that lack adequate cover may not have yet experienced the timing and magnitude of storm or snowmelt events sufficient to degrade the site; when energies associated with water movement do occur, there is a high likelihood for site degradation if adequate stabilizing cover is not present.

For lentic sites *with open water* and distinct shorelines (lakes, ponds, marshes, etc.):

- Where a perennial wetland receives periodic wind and wave action, the shoreline opposite the direction of the prevailing winds may require 90 percent cover for a "yes" response. For other wetland types with different site potential, the shoreline may need only 70 percent cover for the answer to be "yes."
- Shoreline failures/slump blocks, bare-vertical banks on shorelines, etc. throughout the site, *combined* with a limited amount of stabilizing riparian-wetland vegetation, provide a clear indication of inadequate stabilizing cover (figure 29). Although these instability features are good indicators, some sites that lack adequate cover may not have yet experienced the timing and magnitude of storm or wind events sufficient to degrade the site; when energies associated with these events do occur, there is a high likelihood for site degradation if adequate cover is not present.

Again, it is important for the ID team to understand how different vegetation functional groups and species are adapted to specific elevation surfaces (or geomorphic/topographic positions) and water-table depth across the riparian-wetland area (as described in the chapter 6 introduction to vegetation indicators). The occurrence of particular plants and plant communities is tied to the moisture gradient and disturbance zones at the site. For example, water sedge would not be expected in the mesic fringe above the groundwater discharge point. Understanding this concept is important so that appropriate expectations are set for where to look for the various plants and plant communities within the riparian-wetland area.

Many intermittent and some perennial systems may not have the potential for OBL and FACW stabilizing plant communities and have FAC plant communities that stabilize the site.

Item 13 would be answered "NA" for riparian-wetland areas that do not need vegetation to achieve PFC.

Figure 29. Shoreline not covered with an adequate *amount* of stabilizing riparian-wetland vegetation to protect the soil surface and dissipate energy from overland flows, and wind and wave actions, or to resist physical alteration.

Supporting Science

The best protection against lentic area impairment (excessive erosion, compaction, etc.) from overland flows, wind and wave action, and physical alteration is maintaining adequate vegetative cover of stabilizing plants. Although there is little detailed research to validate how much cover different lentic areas need to maintain function, a great amount of empirical evidence by PFC developers suggests that 70 percent is a reasonable minimum stabilizing cover necessary for function absent site-specific information. This corresponds to similar percentages suggested in the literature to protect other riparian-wetland functions. For example, Weixelman and Cooper (2009) suggest a minimum of 75 percent peat-forming species is needed to maintain peat formation and soil moisture at a site.

The supporting science information presented under item 11 provides the details about the functional attributes of stabilizing riparian-wetland vegetation and applies to this item as well. As indicated, stability ratings have been developed for plant communities and individual plant species and other features (barren areas, rock, woody material) that help characterize how well a site may resist erosion (Winward 2000; Burton et al. 2011; Crowe and Clausnitzer 1997; Lorenzana et al. 2017). Winward (2000) and Burton et al. (2011) provide total vegetation cover and vegetation stability class metrics derived from greenline vegetation data. Stability class values of 7 and above (on a scale with 1 being lowest and 10 being highest) are considered high to very high by Winward, while values of greater than 6 are considered high (the highest class in a scale of low, medium, and high) by Burton et al. (2011) (table 6). High stability class values calculated by either method are generally considered adequate for PFC.

Table 6. Relative stability class values based on general rooting characteristics assigned by Burton et al. (2011); numerical values generally conform to Winward (2000) and Lorenzana et al. (2017).

Forbs	
Taproot or most roots, shallow (<15 cm)	Low (2)
Fibrous roots, usually up to 30 cm	Medium (5)
Rhizomatous roots, with little indication of extensive fibrous roots	Medium (5)
Rhizomatous roots, with extensive fibrous roots	High (8.5)
Graminoids	
Annual, biennial, and short-lived perennials	Low (2)
Stoloniferous, cespitose, tufted, or short rhizomatous perennials (<1 m tall)	Low (2)
Slender or thin creeping rhizomes	Medium (5)
Long, stout, well-developed creeping rhizomes	High (8.5)
Woody Species	
Taprooted species	Low (2)
Short shrubs (<1 m tall) with shallow root systems	Low (2)
Shallow to moderate root systems	Medium (5)
Rhizomatous root system, generally shallow (<15 cm)	Medium (5)
Root crown with spreading roots	High (8.5)
Widespread root systems	High (8.5)

Correlation with Other Assessment Items

Item 2 (fluctuation of water levels is within a range that maintains hydrologic functions and riparian-wetland vegetation) is related to item 13, as fluctuating water levels can influence the amount of stabilizing cover on a site. Item 3 (riparian-wetland area is enlarging or has achieved potential extent) is determined by evaluating the presence of stabilizing riparian-wetland vegetation on the site as well.

Items 8-12 can all have “yes” responses with item 13 having a “no” response. This is because it is possible to have a diversity of stabilizers (item 8), various age classes (item 9), riparian-wetland plants (item 10), distinct and recognizable stabilizing communities (item 11), and high vigor (item 12) but simply not enough stabilizing cover on the site (item 13). If items 8-12 all have “no” responses, it is not possible for item 13 to be answered “yes.” Also, if stabilizing riparian-wetland vegetation is of low vigor (item 12), there may not be enough cover for a “yes” answer to this item.

Item 14: Abnormal frost or hydrologic heaving is absent

Purpose

Frost or hydrologic heaving occurs when soil pores contain free water conducive to the development of segregated ice lenses or crystals when temperatures drop below freezing. Expansion when water changes from a liquid to a solid state and continued growth of ice crystals or lenses over time can push or heave the soil surface upward, creating cryogenic (freeze-formed) mounds commonly described in North America as hummocks. This is a natural process that can occur in the following situations:

- High-elevation (subalpine to alpine zone) or high-latitude (polar) areas.
- Frost pockets affected by cold-air drainage.
- Fine-textured soils that are typically high in clay (e.g., clay, clay loam, silty clay loam).

This natural process can be exacerbated by impacts that do any of the following:

- Compact or seal parts of the soil surface, which restricts water infiltration between plants.
- Reduce pore space by compaction of soil.
- Result in an excess or complete removal of protective and insulating vegetation to produce deep and differential frost in the soil profile (Grab 2005).

Over time, vegetated hummocks of increasing height develop between the sealed or compacted interspaces. Riparian-wetland vegetation on the hummocks may be reduced or replaced by upland vegetation as the soil surface becomes elevated above the water table. Root shearing becomes a problem, and interspace areas are exposed to increased erosional forces. With the development of irregular surfaces, ungulates are more likely to walk in the depressions between hummocks, leading to yet more differential compaction, destruction of soil structure, and the potential for greater differential frost heave. Slope wetlands may become dewatered as hummocks increase in height and inter-hummock depressions concentrate runoff and drain riparian-wetland soils. *The intent of this item is to determine whether frost or hydrologic heaving is occurring, and if so, whether it is occurring at a normal or exacerbated degree that creates excess loss of water, soil, or organic matter.*

The ID team should note that the focus of item 14 is the degree of frost action, which can be observed in places by the formation of frost-heave hummocks. In contrast, the impact to surface- and subsurface-flow patterns is the focus of item 6. In some situations, ID teams will be examining the same features (hummocks or pedestals), but the evaluation of proper function will be focused on different processes (frost action for item 14 versus alteration of flow patterns for item 6).

Observational Indicators and Examples

Before addressing this item, the ID team should determine that frost or hydrologic heaving can occur on the site. Many riparian-wetland areas will not experience this process. For frost or hydrologic heaving to occur, the right amount of moisture, soil texture and composition, and freezing temperatures must be present to allow water in the soil to form ice crystals or discrete ice lenses. For areas that do not meet these requirements, item 14 would be answered "NA."

If frost heaving is present, the ID team must determine if the degree of frost heaving is normal or exacerbated. A "yes" response is suggested if any one of the following circumstances is observed:

- The height and density of frost heaves is normal relative to reference sites.
- Soils have fine texture (i.e., silt or nonplastic clay) and/or high organic content (i.e., peat) and have abundant soil moisture with little evidence of differential soil compaction, no apparent increase in bulk density, or no visible trailing or soil trampling.
- Vegetation cover is dense across the hummock and inter-hummock spaces. Dense vegetation should provide a degree of insulation to decrease the depth of frost formation and degree of frost heave in soils.

In contrast, if hummocks are taller or denser than normal, then the appropriate response would be "no." This is likely when:

- There is a loss of vegetative cover. Low vegetative cover can cause a loss of thermal insulation, which can lead to deeper frost formation in the soil.
- Patches of bare ground develop as a result of high grazing levels or excessive hoof action and soil alteration.
- Vegetation on the tops of hummocks converts from hydric (OBL and FACW) species to mesic (FAC/FACU/UPL) species.
- Ungulate trailing leads to the compaction of soil or changes in bulk density, leading to the differential frost heaving of the site.
- Inter-hummock depressions become conduits of runoff, resulting in dewatering of riparian-wetland soils and differential frost formation.

Figure 30 provides examples of three riparian-wetlands with frost heaving. The frost heaving displayed in photos (A) and (B) is more columnlike, with more frequent and often narrower, steeper-sided hummocks. These hummocks are also slightly higher or "abnormal" and reflect exacerbated frost heave resulting from livestock grazing and hoof action. Frost heaving displayed in photos (C) and (D) shows broader hummocks with low-angle sides. These hummocks and the interspaces are completely devoid of ungulate hoof action, pugging, or compaction. Item 14 would be answered "no" for the areas in photos (A) and (B) and "yes" for the area in photos (C) and (D), which is considered to be "natural."

An "NA" response would apply to all those riparian-wetland environments that are not affected by frost or hydrologic heaving. This is true of regions that are frost-free or that have very mild frost action, as well as sites with well-drained, coarse-textured soils (e.g., sand and gravel), which typically are not prone to frost heave.

Supporting Science

Hummock formation has been attributed to repeated freeze-thaw processes and differential frost heave (Mackay 1980; Lewis et al. 1993; Van Vliet-Lanoë 2004) and develops by cryoturbation (soil churning through frost action) in fine-grained, frost-susceptible soils (Verret et al. 2019). Frost heaving does not typically occur in clean sands and gravels but does occur as the silt and nonplastic clay content in the soil increases. The proper moisture content and freezing temperatures are also necessary for frost heaving to occur (Hough 1957).

The National Soils Handbook (USDA 1983) describes the basic processes and engineering significance of frost heaving. Empirical evidence indicates that severity of the frost action can be exacerbated by management practices, such as improper livestock grazing. However, there is little additional literature on the precise mechanisms leading to exacerbated frost action. The hummock topography in wet meadows is different than other frost-heave situations. Fahey (1974) observed that unvegetated hummocks (termed "frost boils" in this work) were raised or heaved by frost action higher than vegetated hummocks. Similarly, Gatto (1997) observed that areas compacted by vehicles seemed to have greater frost heave and subsequent subsidence than the uncompacted areas. Differential frost heave (Fowler and Noon 1997) may have some bearing on the differences observed. The National Range and Pasture Handbook (USDA-NRCS 2003) also describes frost heaving of forage plants. Our suggestion is that this process is sufficiently common to warrant additional research on management impacts in natural settings subject to frost heave.

Correlation with Other Assessment Items

Item 14 is closely related to item 6 (disturbances or features that negatively affect surface- and subsurface- flow patterns are absent), as abnormal frost-heave hummocks commonly have disrupted surface-flow patterns. It is not uncommon for frost action to affect flow patterns as well.

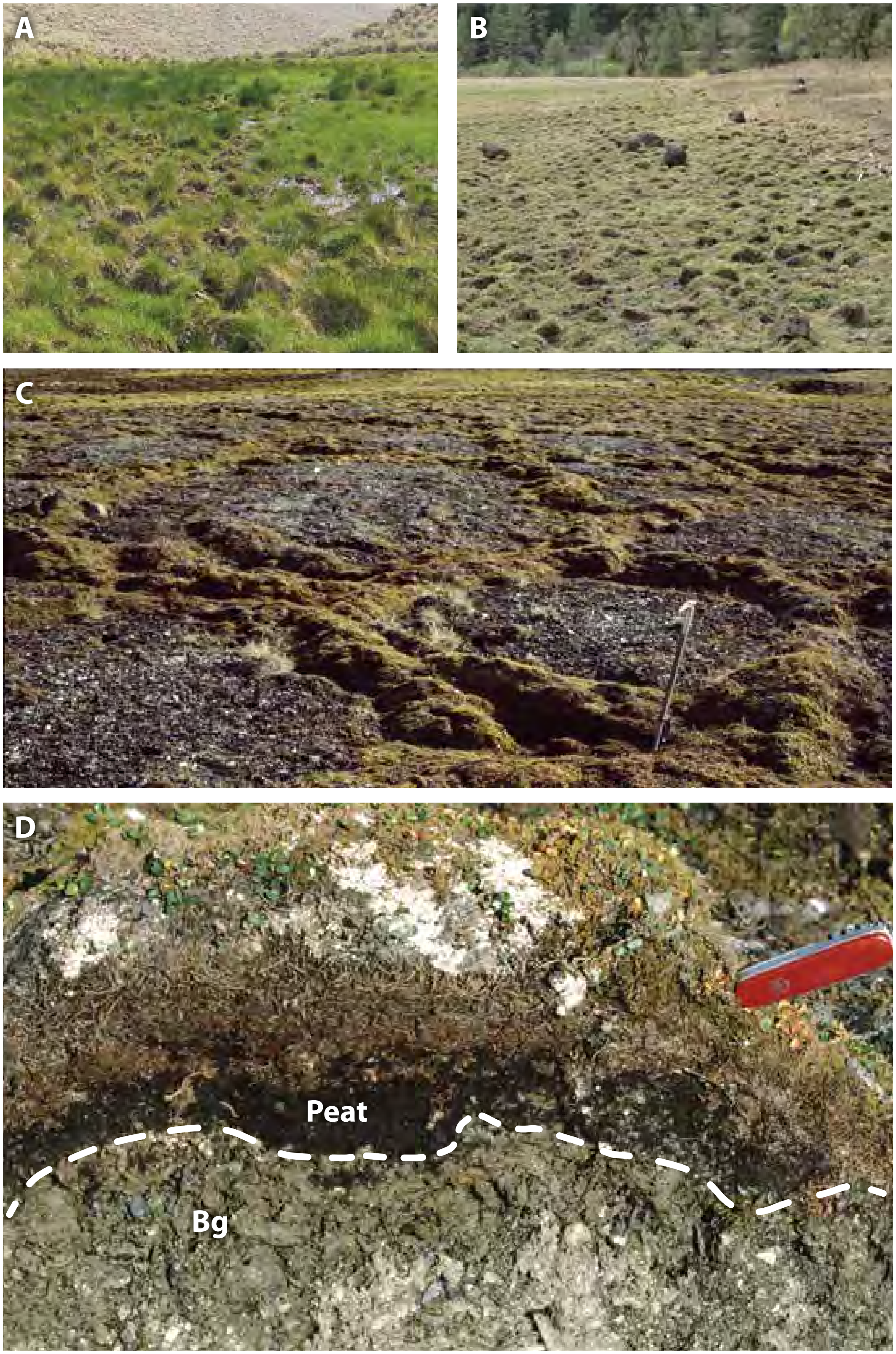

Figure 30. Abnormal hydrologic heaving (hummocks) (A) and (B). Normal frost heaving (C) and (D). Hummocks in (C) have formed in an area with permafrost but no grazing by domesticated livestock. Hummocks contain peat and moss. (D) Cross-section through frost-heaved hummock shows a surface layer of peat that has been undisturbed by any hoof action, pugging, or compaction. "Bg" represents a subsurface soil horizon with gley features.

Item 15: Favorable microsite condition (e.g., woody material, water temperature) is maintained by adjacent site characteristics

Purpose

Some riparian-wetland areas require very specific conditions to sustain temporal water budgets. If seasonal inflows, outflows, and/or evapotranspiration characteristics are significantly altered, the type and extent of the riparian-wetland area can also be altered. Adjacent site characteristics can directly influence both inflow and outflow by buffering surface runoff. Changes in the type of vegetation can also change evaporation versus transpiration rates. Increases or decreases in one may not be proportional to changes in the other, thus affecting annual patterns of soil-water states.

In some riparian-wetland areas, adjacent site characteristics can affect vegetation recruitment potential onsite by shading, temperature modification, availability of seed germination sites, etc. If functionality depends on these particular species, then the adjacent site characteristics must also be maintained. The intent of this item is to determine whether microsite conditions are necessary for proper functioning, and if so, whether adjacent site characteristics are maintaining those conditions.

Observational Indicators and Examples

Forested depressional wetland areas in the Pacific Northwest require the presence of nursery logs that provide sites for some plants, such as western red cedar (*Thuja plicata*), to establish. The decaying logs must also maintain adequate moisture and temperature for germination. Trees on adjacent sites can buffer inflows to these sites to prevent excessive inundation. Probably more important, a certain density of tall trees provides shade that prevents surface drying during germination. The mature trees surrounding the site are also a greater source of nursery logs than the trees onsite.

The absence of large trees for shade and nursery logs within falling distance of the riparian-wetland area would result in a "no" answer for item 15 (figure 31). If there is a mixed age class of trees on adjacent sites with sufficient canopy to provide adequate shade to the site, item 15 would be answered "yes." If they are not present or being maintained, then item 15 would be answered "no."

Maintaining favorable microsite conditions may also be necessary for retention of permafrost for some areas, such as black spruce wetlands in Alaska (Post 1996).

Other riparian-wetland areas depend on adjacent vegetation communities to trap snow, which supplies the riparian-wetland areas with water. Sagebrush communities can trap winter snow throughout much of the sagebrush steppe, but loss of sagebrush from fire, chaining, herbicide, or other treatments can alter the hydrology of these riparian-wetland communities. Similarly, residual grass cover can trap snow through the northern Great Plains, but overgrazing can diminish the snow-trapping effects of grass communities and may alter local hydrology. Item 15 applies to sites that depend

Figure 31. Dense forest cover adjacent to a small riparian-wetland area has been removed by fire, causing decreased shading/increased solar radiation, which in turn is promoting drier conditions. Also, the fire has removed any nursery logs that might have fallen into the riparian-wetland area, decayed, and increased water storage onsite. These circumstances would warrant a "no" response to item 15.

on local snowpack or that are fed by seasonal, shallow, proximal sources of water, not by regional aquifers or distal sources of water.

When addressing item 15, it is important to determine if microsite conditions must be present for the site to function properly and then to identify what these conditions are. Most riparian-wetland areas do not require these special conditions. In sites that do not require these conditions to be present to function properly, the answer to item 15 would be "NA."

Supporting Science

Brinson (1993) and Walton et al. (1995) describe wetland hydraulic and hydrological processes, including those that may be influenced by adjacent sites. Daily water stage can be measured as a direct indicator. However, distinguishing between the effects of overall watershed conditions versus adjacent site and evapotranspiration characteristics is difficult to determine. Surface-level solar radiation and daily maximum and minimum temperatures can also be measured as direct indicators for sites such as the forested wetland described above. There may be other microsite conditions that affect different types of wetlands and their function.

An Approach for Assessing Wetland Functions Using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices (Smith et al. 1995) describes a procedure for characterization, assessment, and analysis that should help in identifying and modeling relationships of adjacent sites to microsite conditions where they exist.

Correlation with Other Assessment Items

In many cases, the effects associated with adjacent site characteristics will have already been considered in item 4 (riparian-wetland impairment from contributing area is absent) or item 6 (disturbances or features that negatively affect surface- and subsurface-flow patterns are absent).

7. Assessing Soil and Geomorphic Attributes and Processes

Items 16-20 address soil and geomorphic attributes and processes that must be in working order for a lentic riparian-wetland area to function properly. Some of the documents referenced in the introductions to the sections on hydrology and vegetation are also appropriate here.

Landscape position and landforms are important considerations in understanding water sources and water movement into, through, and out of riparian-wetland areas. Landscape position is also referred to as watershed position. A thorough understanding of hydrogeomorphic processes (see Brinson 1993) will facilitate interpretation of soil and geomorphology attributes and processes.

Wetland delineation skills will also assist in interpreting soil, geomorphology, and hydrogeomorphic relations. Background information on wetland delineation includes Tiner (2017) and USACE (1987). Finally, a good understanding of hydric soil indicators will help practitioners decipher information about riparian-wetland areas, including hydroperiod, depth to water table, and the frequency and duration of saturation, flooding, or inundation. Wetland soils and hydric soil indicators are described in detail in USDA-NRCS (2017), Vepraskas and Craft (2016), Vepraskas (2015), and Lewis et al. (2003).

Knowledge of riparian-wetland soils is essential in most lentic PFC assessments. However, soil expertise has been historically limited or missing in many federal land management offices. If an ID team does not have a resource specialist with knowledge of riparian-wetland soils, alternatives for securing these skills are to add a soil specialist from a nearby NRCS office or a soil and water conservation district or to contract with an outside party.

Item 16: Accumulation of chemicals affecting plant productivity/composition is absent

Purpose

The intent of item 16 is to determine if vegetation is being adversely affected by the accumulation of chemicals in riparian-wetland soils. Maintenance of a chemical balance in a lentic riparian-wetland area is necessary for functionality. The accumulation of harmful chemicals could affect plant composition and/or productivity.

Item 16 addresses the accumulation of chemicals in the soil, whereas item 5 (water quality is sufficient to support riparian-wetland plants) addresses water quality. Sometimes the two items are related, because water quality can affect soil chemistry and vice versa. When addressing item 16, *the ID team must bear in mind the potential of the site and note that soils can naturally have unusual chemistry due to the natural variability in the properties of the soil parent material.*

Observational Indicators and Examples

Many chemicals can affect plant productivity and composition when they accumulate in the soil. Some of the most common chemicals that affect the vegetation of riparian-wetland areas include:

- Soluble salts found in saline and sodic soils.
- Metals and metallic salts.
- Sulfur compounds.
- Acids and bases, which affect pH.

If a riparian-wetland area requires vegetation to function properly, the answer to item 16 would be "yes" if:

- There is no visible accumulation of harmful chemicals (e.g., soluble salts or flocculated metal salts) on the soil surface, within the soil profile, or within the capillary fringe above the water table.
- Visible accumulations of possibly harmful chemicals are present; however, plant composition, productivity, and vigor are consistent with site potential (as determined by local geology and soil parent materials).
    - For example, some alkaline fens can have calcium carbonate, or marl, visible on the soil surface at potential. The ID team must differentiate natural chemical constituents, consistent with site potential, from chemical accumulations that are the result of management practices.

A "no" answer could apply when:

- Accumulation of chemicals (soluble salts, flocculated metal salts) is visible as salt crystals or mineral crusts on the soil surface, in the soil profile, or within the capillary fringe above the water table.
    - Saline soils typically contain white minerals in the soil profile or white crusts on the soil surface (figure 32).
    - Sodic soils commonly contain dark minerals in the soil profile or dark crusts on the soil surface and a dense clay pan on the soil surface or in the subsurface. Sodic soils commonly have coarse to very coarse columnar structure in the subsurface (figure 33); alternatively, high sodium content can lead to the loss of soil structure.
- Soil pH has been altered by acid-mine drainage.
- Plant composition lacks diversity and indicates a shift to salt-tolerant species (table 7).

- Plant productivity and vigor are stunted and demonstrably related to an accumulation of harmful chemicals.
    - Blackening or yellowing along leaf margins is common in vegetation growing in saline soils, especially in plants that are intolerant of moderate to very high saline conditions.
    - Plant production, stature (figure 34), and root growth (figure 35) of plants are reduced in plants that are intolerant of alkaline conditions or other chemically laden soils.

Figure 32. Saline soils commonly display salt crystals and crusts on the surface (A) or in the soil profile (B).

Figure 33. Columnar structure (indicated by white arrow and the horizontal row of rounded grayish column tops) is common in sodic soils. (Photo courtesy of The Marbut Memorial Slide Collection, Soil Science Society of America 1993.)

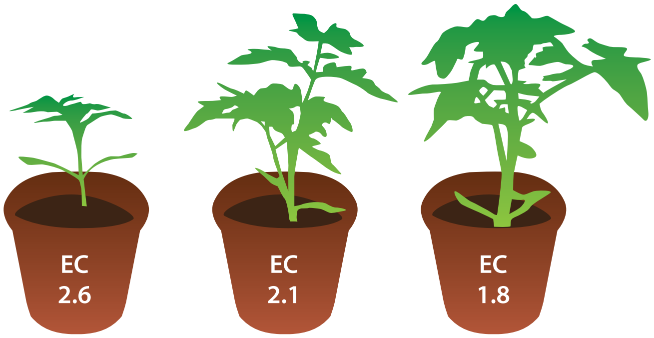

Figure 34. Plant growth generally varies inversely with soil alkalinity, which is commonly measured by electrical conductivity. The smallest tomato plant is growing in a soil with an electrical conductivity of 2.6 dS/m, and the largest plant is in a soil with an electrical conductivity of 1.8 dS/m. (Modified from USDA-NRCS 2014.)

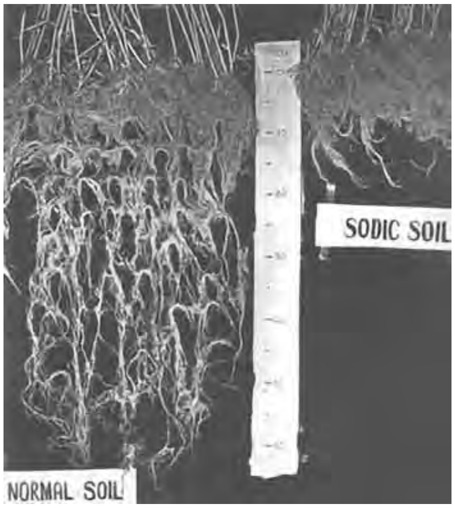

Figure 35. The root structure of wheat plants grown in different soils is shown. The roots in normal soil are 60 cm long, whereas the roots in the sodic soil are dense to only 10 cm depth and sparse to 20 cm (Food and Agriculture Organization of the United Nations, Abrol et al. 1988, photo reproduced with permission).

- EC is elevated above natural soil levels due to run-on of irrigation return water that is high in dissolved salts. Plant productivity is affected by soils with an EC of 2 dS/m or more (figure 34). Table 7 includes a list of common riparian-wetland, salt-tolerant vegetation.
- EC is elevated in discharge wetlands (e.g., saline seepage areas) where there is discharge of shallow groundwater that is high in total dissolved solids due to altered local hydrology (figure 36).
    - Groundwater may become unnaturally elevated in dissolved load due to particular land management practices (Seelig 2000). For example, where cultivation practices (e.g., leaving fields fallow) or heavy grazing in recharge sites has severely depleted upland vegetation cover, soil moisture moves out of the root zone, through subsoil and geologic materials, and then reemerges at the surface, where soluble salts precipitate (figures 36 and 37).

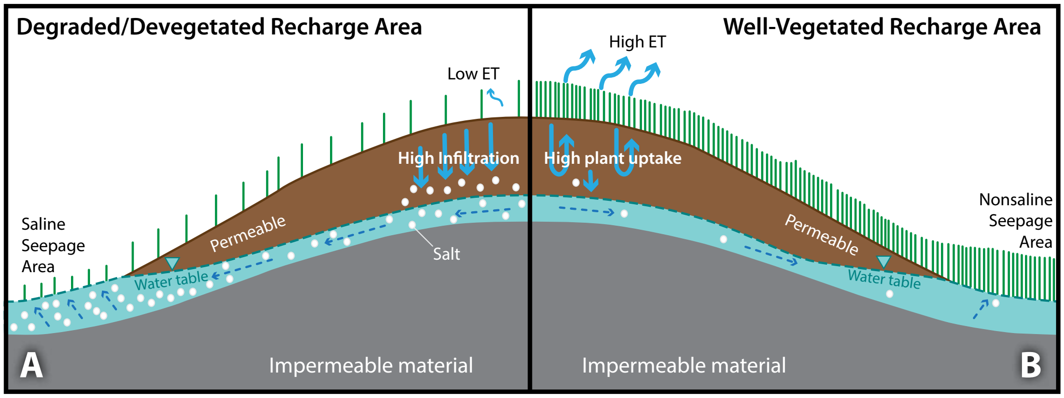

Figure 36. Sparsely vegetated recharge areas can induce the formation of saline seeps by increasing the proportion of precipitation that infiltrates and dissolves soluble salts (A), whereas plants in well-vegetated recharge areas will use much of the precipitation while it is in the soil profile and off-gas it as evapotranspiration (ET), with comparatively less infiltration and lower soluble salt discharge to seeps (B).

Figure 37. Multiple prairie potholes in one field (left/center of view) exhibit formation of saline seeps, whereas potholes in adjacent fields with the same parent material have little to no visible salt accumulation. This field-specific formation of saline seeps is related to vegetation management in the recharge areas, as illustrated in figure 36.

Table 7. Common riparian-wetland plants found in salt-affected soils, from Ogle and St. John (2010), Lair (undated), and USDA-NRCS (2019).

Common Name	Scientific Name	WIC	Common Name	Scientific Name	WIC
Salt tolerance level very high (>12 dS/m)					
Common spikerush	*Eleocharis palustris*	OBL	Nuttall's alkaligrass	*Puccinellia nuttalliana*	FACW-OBL
Glasswort	*Salicornia* spp.	OBL	Scratchgrass	*Muhlenbergia asperifolia*	FACW
Hardstem bulrush	*Schoenoplectus acutus*	OBL	Common reed	*Phragmites australis*	FACW
Chairmaker's bulrush	*Schoenoplectus americanus*	OBL	Pursh seepweed	*Suaeda calceoliformis*	FACW
Common threesquare	*Schoenoplectus pungens*	OBL	Saltcedar/ tamarisk	*Tamarix* spp.	FACW
Softstem bulrush	*Schoenoplectus tabernaemontani*	OBL	Saltgrass	*Distichlis spicata*	FAC
Seaside arrowgrass	*Triglochin maritima*	OBL	Canada wildrye	*Elymus canadensis*	FAC
Narrowleaf cattail	*Typha angustifolia*	OBL	Beardless wildrye	*Leymus triticoides*	FAC
Broadleaf cattail	*Typha latifolia*	OBL	Black greasewood	*Sarcobatus vermiculatus*	FAC
Salt tolerance level high (>8-12 dS/m)					
Beaked spikerush	*Eleocharis rostellata*	OBL	Big sacaton	*Sporobolus wrightii*	FAC-FACW
Knotgrass	*Paspalum distichum*	FACW	Saltbush species	*Atriplex* spp.	FAC
Alkali cordgrass	*Spartina gracilis*	FACW	Russian olive	*Elaeagnus angustifolia*	FAC
Creeping meadow foxtail	*Alopecurus arundinaceus*	FAC-FACW	Foxtail barley	*Hordeum jubatum*	FAC
			Alkali sacaton	*Sporobolus airoides*	FAC
Salt tolerance level moderate (4-8 dS/m)					
Arctic rush	*Juncus arcticus*	FACW-OBL	Burningbush	*Bassia prostrata*	FAC
Meadow foxtail	*Alopecurus pratensis*	FAC-FACW	Povertyweed	*Iva axillaris*	FAC
Switchgrass	*Panicum virgatum*	FAC-FACW	Curly dock	*Rumex crispus*	FAC

WIC = wetland indicator categories, where OBL = obligate; FACW = facultative wetland; FAC = facultative. Additional details provided with item 10.

As is true with all assessment items, this item should be interpreted relative to site potential. The ID team should have adequate knowledge of the local geology, regional and local aquifers, and soil parent materials. Plant composition is naturally sparse or limited to salt-tolerant species, where:

- Soils are *naturally enriched* in soluble salts due to the type of soil parent materials, such as marine shales or glacial deposits containing marine shale. Saline soils are common throughout the range of Cretaceous marine shales deposited in the Western Interior Seaway, which extended from northern Canada, through the Great Plains provinces, Montana, and the Dakotas and extended south through Texas. Also, soils located near coastlines, natural salt lakes, or evaporite deposits (e.g., some playas) may be naturally enriched in soluble salts through mist deposition and wind transport of evaporite minerals.

- There are closed basin systems, where evaporate minerals become naturally concentrated.

- There is discharge of brackish or saline groundwater with high total dissolved solids that infuse the soils of lentic riparian-wetland areas.

Also see item 5 (water quality is sufficient to support riparian-wetland plants) for examples of "yes" and "no" responses. In many instances, water quality is affected by soil chemistry and vice versa.

"NA" would apply for those riparian-wetland areas that do not require vegetation to function properly.

Supporting Science

The effect of chemical accumulations in soil on plant growth depends on soil texture, distribution and type of chemicals, and plant species (Schoeneberger et al. 2012). One of the most common chemical accumulations in soil is salt, including salts of sodium, calcium, and magnesium with chloride, sulfate, and bicarbonate being the most common. Singer and Magnus (1987) found that drainage and high evaporation promote the accumulation of salts. Some mechanisms for accumulation of soil salts include:

- Excessive evaporation and capillary rise that bring salts into the root zone (figure 38), particularly during periods of seasonally high water tables or when the soil surface is fallow or lacks vegetation (figure 36; Kwiatkowski and Pittman 1997; Tober et al. 2007). These processes form "discharge soils"; that is, soils in which the subsoil is high in calcium carbonate, usually as a product of dominant upward movement of water in the soil column. Discharge soils are common around and near wetlands (Tober et al. 2007). Management of saline discharge soils can be accomplished by establishing permanent vegetation with deep-rooted plants to reduce surface evaporation and to use excess water effectively (Tober et al. 2007). Proper management of vegetation, litter, and organic matter in both recharge and near discharge wetlands is key to maintaining proper salinity levels in discharge soils.

- Saline seeps that develop when excess water from precipitation moves through soils in upland recharge areas, dissolves salts as it percolates, and then re-emerges at the surface in a discharge area (Seelig 2000; McCauley and Jones 2005). Prevention of saline seeps can be accomplished by promoting healthy vegetation cover in upland recharge areas, thereby preventing discharge of toxic levels of salts in saline seeps (Tober et al. 2007).

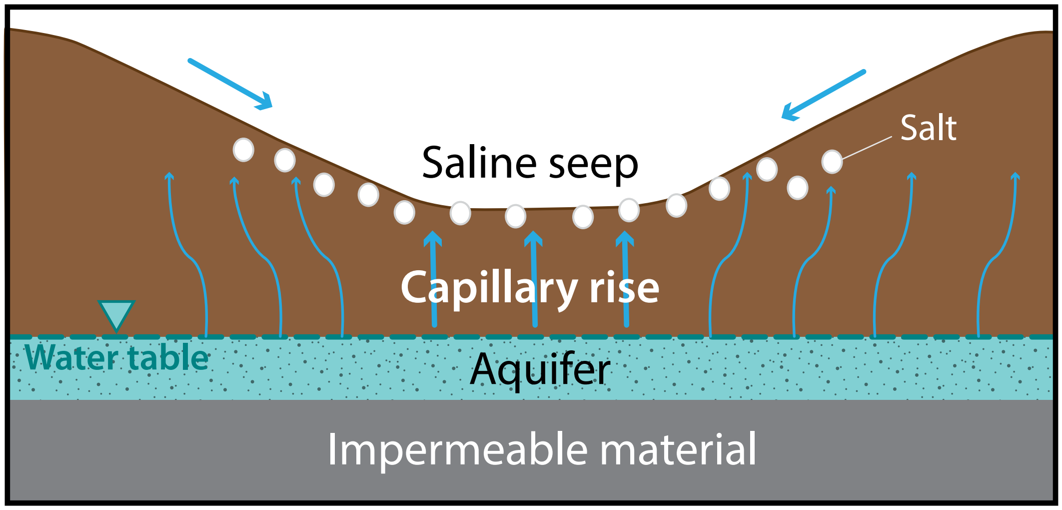

Figure 38. Capillary rise can introduce dissolved salts to the root zone, where plant uptake of soil moisture and evapotranspiration can lead to accumulation of salt on or near the soil surface.

Chemicals (salts and heavy metals) are delivered to the soil surface and soil profile by capillary action, ponded water and subsequent evaporation, and discharge of groundwater. The amount of salt accumulation depends on the soil texture, depth of the water table, evaporation rates, and depth of restricting layers. The height of capillary rise above the water table depends on the pore size and shape, which are related to soil texture or particle size. The predicted height of capillary rise varies from 750 centimeters (~300 inches) for fine silts to 1.5 centimeters (<1 inch) for fine gravel (Fetter 1994). Evaporation from the pond surface concentrates salts in the remaining water, and these salts can precipitate along the shoreline as the surface area of the pond decreases (figures 39 and 40). In these evaporation zones, salts accumulate and lower the osmotic component of the soil moisture. For a plant to grow in an environment of increased salts, the plant must change the concentration of solute in its cells. This process of osmotic regulation costs the plant energy and decreases its growth (Singer and Magnus 1987). Plant growth also decreases in response to toxicity of one or more ions of salt. In addition to changing the osmotic component, high levels of salt alter the pH of soils, thus changing the availability of such micronutrients as iron (Fe), manganese (Mn), copper (Cu), and zinc (Zn).

Saline and sodic soils are common chemically affected soils that can limit plant growth and affect plant composition. Soil salinity is commonly measured with an electrical conductivity meter, which provides an estimate of the concentration of soluble salts in saturated soil extract. Most plants exhibit a reduction in growth when the EC of soil is more than 2 dS/m (Tober et al. 2007). Saline soils are characterized by high EC, low exchangeable sodium percentage (ESP), and pH that is not high (table 8; Seelig 2000; Ogle and St. John 2010).

Soil sodicity is calculated from the ESP and/or the sodium adsorption ratio, both of which examine the percentage of sodium (Na^+) cations in the soil. Sodic soils are characterized by low EC, high ESP, and high pH (table 8; Seelig 2000; Ogle and St. John 2010). Sodic soils generally have poor soil structure due to their propensity to disperse clay particles. In addition, when sodium-clay particles settle out, they form layers that are impenetrable to plant roots and seedling emergence (Seelig 2000) and, therefore, can create patches devoid of vegetation.

Saline-sodic soils have properties of both saline and sodic conditions, including high EC, high ESP, and pH that is not high (table 8; Seelig 2000; Ogle and St. John 2010). Knowledge of plant tolerances to salinity can help identify those soils and riparian-wetland sites that are affected by salinity. Some common, riparian, salt-tolerant plant species are listed in table 7.

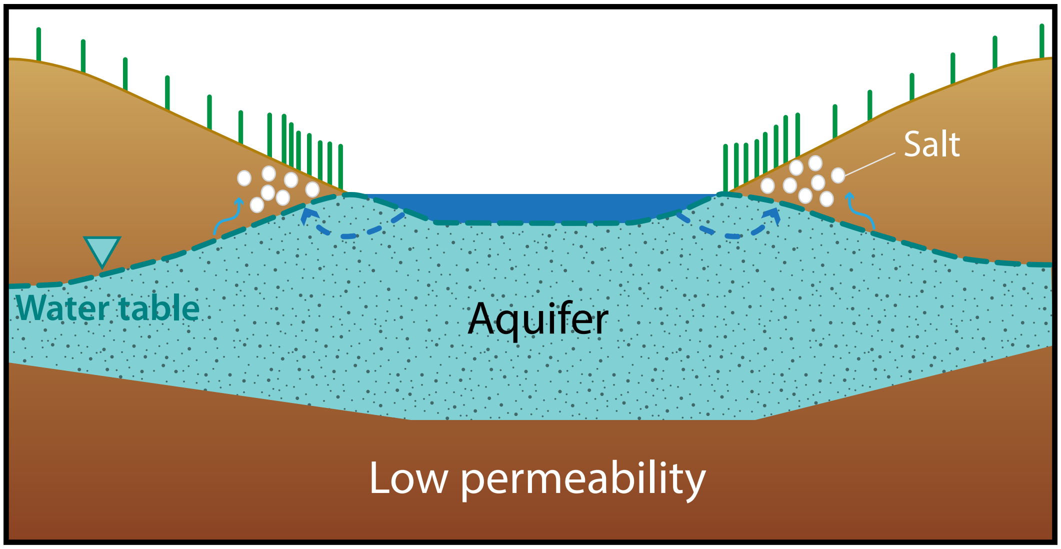

Figure 39. Capillary rise from the water table and groundwater flow from a surface water body to the soil can lead to accumulation of salt on or near the soil surface.

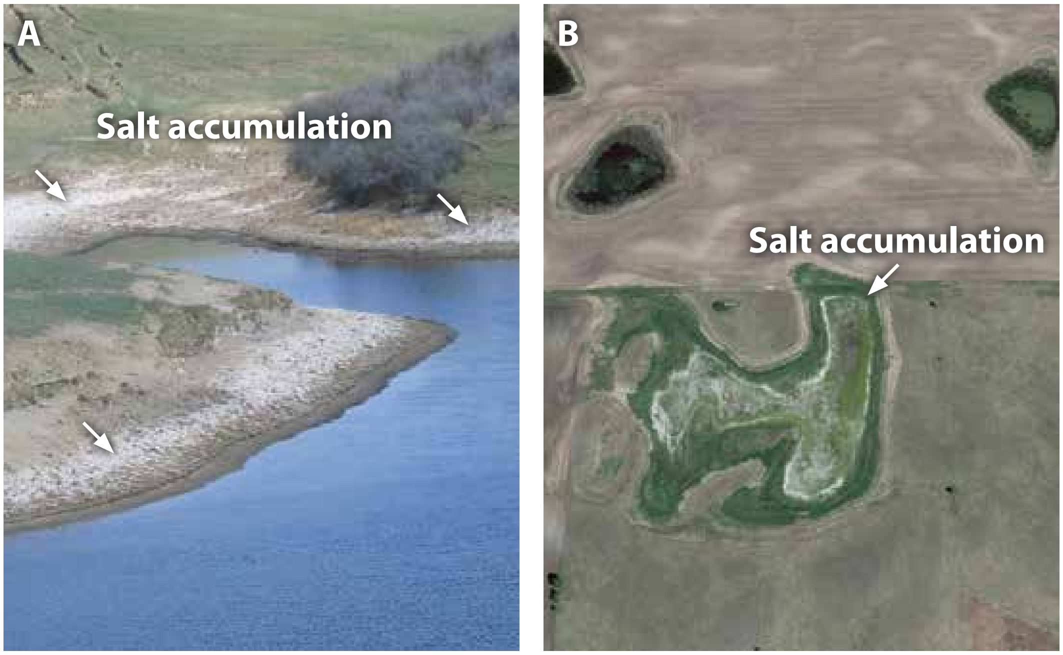

Figure 40. Artificial water bodies, such as stock ponds and reservoirs (A), and natural wetlands (B) can also experience capillary rise and groundwater flow leading to the accumulation of salt on or near the soil surface.

Correlation with Other Assessment Items

Item 16 is correlated with item 8 (there is adequate diversity of stabilizing riparian-wetland vegetation for recovery/maintenance) and item 12 (riparian-wetland plants exhibit high vigor). Item 16 may also correlate with item 4 (riparian-wetland impairment from the contributing area is absent) because upland conditions can affect recharge sites, which in turn can affect the condition of discharge soils or seepage areas. Item 16 may also correlate with item 5 (water quality is sufficient to support riparian-wetland plants) because contamination of water may also manifest as contamination of soil and vice versa. If item 16 is answered "no," then one or more of items 4, 5, 8, and 12 would be answered "no," too.

Table 8. Characteristics of saline, sodic, and saline-sodic soils, summarized from Seelig (2000) and Ogle and St. John (2010).

Soil Type	Electrical Conductivity* (dS/m)	Sodium Adsorption Ratio*	Exchangeable Sodium Percentage (%)	pH
Saline	> 4	< 13	< 15	< 8.5
Sodic	< 4	> 13	> 15	> 8.5
Saline-sodic	> 4	> 13	> 15	< 8.5

* Determined from saturated extract.

Item 17: Saturation of soils (i.e., ponding, flooding frequency, and duration) is sufficient to compose and maintain hydric soils

Purpose

The purpose of item 17 is to determine whether hydric soils are being created or maintained in those areas that should have hydric soils. Hydric soils develop and are maintained through frequent flooding, ponding, or saturation (typically during the growing season) of long enough duration for anaerobic conditions to develop.

Items 17 and 1 (riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events) can have some overlap. However, when evaluating item 17, the ID team should focus on soil features that are used to determine the presence or absence of hydric soils. In contrast, item 1 focuses on field evidence of riparian-wetland hydrology (i.e., ponding, flooding, and saturation). Because water levels can change throughout the growing season, it is possible that evidence of ponding, flooding, or saturation may not exist, in which case the persistence of hydric soil indicators can provide a reliable and alternative source of evidence to determine the existence, extent, and condition of riparian-wetland area.

Observational Indicators and Examples

The formation of hydric soils is not a prerequisite of a riparian-wetland area; however, in those environments where hydric soils can form, it is essential to determine if the conditions that create hydric soils persist. If they do not, then the riparian-wetland area is likely drying, its extent will contract, and plant communities will shift to those adapted to drier conditions.

General types of hydric soil indicators are summarized in table 9. A "yes" response to item 17 is indicated by:

- Production of hydrogen sulfide gas, which is noticeable as a rotten egg odor. The detection of hydrogen sulfide is most likely immediately after the soil has been excavated, as the odor can dissipate quickly. Hydrogen sulfide is commonly produced in salt marshes and in marshes and swamps with organic soils (Tiner 2017).
- Reduction, translocation, and accumulation of iron and manganese:
    - Gleyed matrix – reduced iron to form matrix with gley color (characteristically bluish gray or greenish gray; see Munsell gley color charts and specific color requirements in USDA-NRCS 2017).
    - Redox concentrations – accumulation of iron and manganese oxides in the form of nodules, concretions, soft masses, and ped and pore linings.
    - Redox depletions – loss of iron species, or stripping of coatings from mineral grains to leave a bleached and bare mineral grain (e.g., gray stripped mineral grain).
    - Reduced matrix – in situ formation of matrix that has low chroma color.
- Accumulation of organic matter, including:
    - Formation of a histic epipedon; peat, mucky peat, or muck; mucky mineral soil; or dark, organic-rich mineral surface layers.
    - Formation of organic coatings on mineral grains.

Consult Field Indicators of Hydric Soils in the United States (USDA-NRCS 2017 or latest version) for a complete list of hydric soil indicators. Some hydric soil indicators are specific to major land and resource areas, so the ID team should know in which one the assessment area is located.

In addition to the evidence listed in item 1, a "no" response might apply if:

- An organic horizon shows signs of oxidation at the ground surface related to drying of a site.
- Plant composition shows evidence of converting from OBL or FACW species to drier (FAC, FACU, or UPL) species (see item 10).

Table 9. Hydric soil processes and hydric soil indicator types.

Hydric Soil Process	Hydric Soil Indicator Types*
Sulfate Reduction	• Microbial conversion of sulfate (SO_4^{2-}) to hydrogen sulfide gas (H_2S); rotten egg odor
Iron and Manganese Reduction Translocation Oxidation	• Ferric (Fe^{3+}) to ferrous (Fe^{2+}) iron forms • Manganic (Mn^{3+} or Mn^{4+}) to manganous (Mn^{2+}) manganese forms • Gleying • Redoximorphic features – Redox matrix – Redox depletions – Redox concentrations
Organic Matter Accumulation	• Peat or muck • Fibrist (peat) • Hemic (mucky peat) • Sapric (muck) • Mucky mineral soil • Dark, organic-rich mineral surface layers

* This list does not represent official hydric soil indicators. Consult USDA-NRCS (2017 or latest version) for a complete list of hydric soil indicators.

"NA" would apply to those riparian-wetland areas where hydric soil conditions do not form; for example, soils that have no iron or manganese minerals or along a rocky shore or gravel beach.

CAVEATS: When interpreting hydric soil indicators, the ID team should recognize some *specific limitations and complications,* including (1) the relation between hydric soils and riparian-wetland areas, (2) the occurrence of relict redoximorphic features, (3) parent materials that can mask hydric soil indicators, and (4) conditions that prevent the formation of hydric soil indicators.

Hydric soils and riparian-wetland areas. Hydric soils form under conditions that exist in wetlands, but not all riparian-wetland areas have the conditions that are required to form hydric soils. In addition, there are artificial (agricultural irrigated fields) and newly formed riparian-wetlands (e.g., beaver-impounded areas) that may be so recently formed that they do not yet exhibit hydric soil indicators.

Relict redoximorphic features. Conversely, hydric soil indicators are known to persist in the soil environment long after hydric soil-forming conditions have ceased to exist (see additional information under "Supporting Science"). Therefore, the ID team should research site history and determine if conditions promoting saturated soils or surface inundation still exist (see item 1). This is particularly true where soil morphology seems inconsistent with the landscape setting, existing vegetation, or observable site hydrology (USDA-NRCS 2017). This disconnect between hydric soil features and necessary hydric soil conditions may be due to human manipulation of the water table or flood regime or to dewatering of the site from any other natural or human cause.

Problematic parent materials. Soils formed with black, gray, or red parent materials can be difficult to interpret, as are soils with high pH, soils high or low in organic-matter content, recently developed hydric soils, and soils with high iron inputs (USDA-NRCS 2017). Finally, hydric soil indicators commonly are best expressed in areas where saturated anaerobic conditions alternate with periods of aerobic conditions. In soils that are permanently saturated and anaerobic, hydric soil indicators may not form (USDA-NRCS 2017).

Inability to form hydric soils. Many riparian-wetland sites cannot establish or maintain hydric soils. Some soils are naturally devoid of iron and manganese minerals, so there is little to no chance of exhibiting redoximorphic features. Whereas hydric soil indicators provide evidence of a riparian-wetland soil, the lack of a hydric soil indicator is not evidence that a soil is not part of a riparian-wetland site. Many riparian-wetland sites do not have hydric soils and, therefore, the overall importance of item 17 must be considered relative to site potential.

Supporting Science

Hydric soil forms under conditions of saturation, flooding, or ponding long enough during the growing season to form anaerobic conditions in its upper part. Hydric soils are formed by biogeochemical processes that promote the accumulation of organic matter and the reduction, translocation, and accumulation of iron, manganese, sulfur, and carbon compounds. Hydric soil indicators are described in detail in Field Indicators of Hydric Soils in the United States (USDA-NRCS 2017, or most recent version; also see Vepraskas 2015, and Vepraskas and Craft 2016).

The presence of a hydric soil indicator is the easiest way to demonstrate that soil saturation is sufficient to develop and maintain hydric soils. In cases where hydric soil indicators are not present, other, more complicated measures can be taken to determine soil saturation. Certainly, if long-term hydrologic data are available, saturation can be determined. Also, weather data, measurement of redox potential, and dyes, such as α, α′-dipyridyl, can be used to identify the presence and formation of redoximorphic features (Vepraskas 2015).

Hydric soils may be difficult to identify or interpret in the field if (1) they are derived from grayish or reddish parent materials, (2) they are Mollisols or Vertisols, (3) they have relict redoximorphic features, or (4) they have been disturbed, as in cultivated and filled areas. Artificially drained or protected soils are considered hydric if they have at least one of the indicators. Furthermore, redoximorphic features are not found in soils with:

- Low amounts of soluble organic carbon.
- High (more than 7) pH.
- Low temperatures.
- Low amounts of Fe (e.g., siliceous sands).
- Aerated groundwater (Vepraskas 2015).

Relict redoximorphic features. Another problem is the recognition and proper identification of relict redoximorphic features. The basic assumption is that redoximorphic features represent current condition of saturation and Fe/Mn reduction; however, because these features are persistent, it is possible for them to have formed in the past under conditions that no longer exist. Vepraskas (2015), Vepraskas and Craft (2016), and Vasilas (2019) indicate that relict redoximorphic features may be distinguished from contemporary ones by several characteristics (see table 10), including:

- **Feature boundary characteristics:** Actively forming redoximorphic nodules and concentrations typically have a "halo-like" appearance or gradual or diffuse boundaries with the soil matrix and may have an irregular surface. In contrast, degrading or relict redoximorphic features commonly display sharp boundaries with the soil matrix and may show many grains protruding from the surface.

- **Location of certain features in relation to macropores:** In environments that actively support the formation of and maintenance of hydric soil indicators, anaerobic water moves repeatedly along the macropores (in which roots repeatedly grow). In hydric soil, clay depletions occur along stable macropores, and there are no Fe-rich clay coatings. In contrast, where hydric soil conditions no longer exist, Fe-rich clay coatings on macropores indicate that Fe is no longer being stripped from around the macropore.

- **Mineralogy and color hue:** Hydric soils typically have Fe concentrations consisting of such minerals as ferrihydrite, lepidocrocite, goethite, and jarosite with hues ranging from 2.5Y to 10YR. In contrast, Fe concentrations in relict hydric soils typically consist of hematite, which occurs in redder hues of 10R, 5R, and 2.5YR.

Table 10. Characteristics used to differentiate between contemporary and relict redoximorphic features (from Vepraskas 2015).

Characteristic	Contemporary/Actively Forming Redoximorphic Features	Relict Redoximorphic Features
Boundary characteristics of Fe/Mn nodules and concretions	Gradual or diffuse boundaries with soil matrix; may have irregular surface; "halos"	Degraded with sharp boundaries with the soil matrix; show many grains protruding from the surface
Location of features to macropores	Clay depletions occur along stable macropores (in which roots repeatedly grow) and must not be overlain by Fe-rich clay coatings	Overgrowth of Fe-rich clay coatings indicate that Fe is no longer being stripped from around the macropore
Feature mineralogy and color hue*	Concentrations (masses, pore linings) consist of the following minerals and color hues: Ferrihydrite – 5YR Lepidocrocite – 7.5YR Goethite – 7.5YR, 10YR Jarosite – 2.5Y	Concentrations (nodules, concretions, masses) consist of the following mineral and color hue: Hematite – 10R, 5R, 2.5YR

*Hues are not considered to be reliable indicators when values and chromas are ≤ 3.5

ID teams should observe the following steps when identifying hydric soils (USDA-NRCS 2017):

1. All organic materials (leaves, needles, bark, etc.) should be removed to expose the surface.

2. Several holes should be dug to a depth of 50 centimeters (20 inches) or as deep as needed to make an accurate soil description. Multiple holes will ensure that the soil profile description is representative of the site and will remove variations caused by small changes in elevation.

3. From the soil description, field indicators that have been met should be specified.

4. Measurements should be made from muck or mineral soil surface unless instructed otherwise.

5. All colors refer to moist Munsell colors. Soil chroma should not be rounded to meet an indicator. A soil matrix with a chroma between 2 and 3 should be listed as having a chroma of 2+. (If the indicator has a chroma of 2 or less, a chroma of 2+ would not meet the requirements.) Values should be rounded to the nearest color chip. Methods of characterizing redoximorphic features, such as quantity, class, size, contrast, color, and moisture state, should be based on established field techniques (Schoeneberger et al. 2012).

Correlation with Other Assessment Items

There is a strong relation between item 17 and item 1 (riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events), item 3 (riparian-wetland area is enlarging or has achieved potential extent), and item 10 (species present indicate maintenance of riparian-wetland soil-moisture characteristics). Item 17 also correlates with item 6 (disturbances or features that negatively affect surface- or subsurface-flow patterns are absent). Any decrease in water supply or soil saturation, riparian-wetland extent, or water-flow patterns may result in a loss of hydric soil features. If item 17 is answered "no," then one or more of these related items would also be answered "no."

Item 18: Underlying geologic material/soil material/permafrost is capable of restricting water percolation

Purpose

Item 18 is relevant only in those lentic riparian-wetland areas where a restrictive layer (geologic material, soil material, or permafrost) is required to maintain ponded or saturated conditions. The intent of item 18 is to determine whether this underlying restrictive layer is being maintained.

Many lentic riparian-wetland areas have an underlying material that causes water to persist and sustain the lentic characteristics of a site. This underlying material restricts water percolation, producing permanent or seasonal ponding, saturation, or inundation. This underlying material must be maintained for a lentic area to function properly.

The best way to describe the importance of maintaining this underlying material is to compare a riparian-wetland area to a bathtub with a plug. As long as the plug stays in place, the tub can retain water, but as soon as the plug is pulled, the tub can no longer retain water. When something similar happens in a riparian-wetland area, the area can no longer maintain existing hydrology and associated vegetation because it is being drained, and riparian-wetland properties will eventually be lost.

Observational Indicators and Examples

Because the restrictive layers are typically subaqueous or subterranean, they are commonly not directly visible in a field inspection. A "yes" answer would be provided when there is evidence that a restrictive layer is causing and maintaining the pooling and storage of water (figure 41). These restrictive layers may include:

- Impermeable, lithified geologic material (aquiclude), such as unfractured igneous rock or shale.
- Relatively impermeable geologic material (aquitard) or soil types with very low rates of hydraulic conductivity, such as clay-rich till, bentonite, and other types of unconsolidated clay and silt deposits.
- Permafrost.

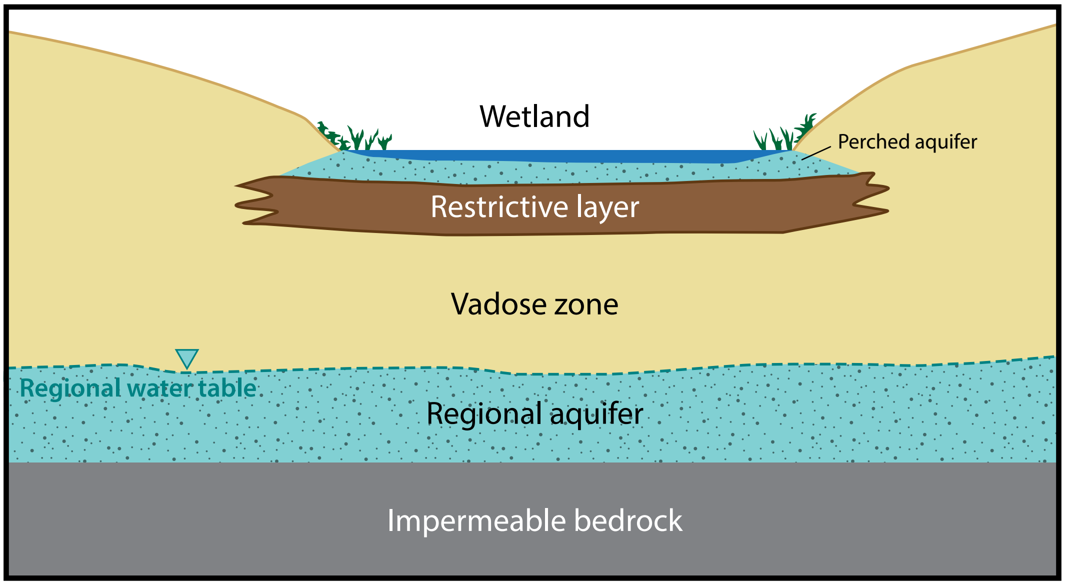

Figure 41. Perched aquifer is maintained by an impermeable or restrictive layer with low hydraulic conductivity. Perforation or damage to the restrictive layer may cause the dewatering and loss of the perched aquifer and associated riparian-wetland areas. (Modified from Melly et al. 2017.)

Evidence that the restrictive layer may not be functioning properly includes visible evidence of some ground penetration or disturbance capable of reaching and disrupting the restrictive layer. A "no" answer is suggested when there is a restrictive layer, but it is incapable of pooling and storing water for sufficient time at or near the surface to form and maintain lentic riparian-wetland conditions. A compromised restrictive layer might result from:

- Excavations, dredging, drilling, or other operations that perforate the restrictive layer and cause accelerated drainage of a riparian-wetland area. For example, some playas have had shallow "dugouts" excavated with bulldozers and backhoes to create stock-watering facilities. In a case where the excavation extended completely through the restrictive layer, the dugout would not be able to retain water in the volume and for the time that an operational dugout could. Therefore, it might be necessary to evaluate the adequacy of one perched system with the condition of similar sites to determine the natural water-holding capacity and to differentiate sites with compromised restrictive layers.

- Formation of piping that leads to internal erosion and drainage conduits through the restrictive layer.

- Formation of a headcut or gully that grows upvalley and eventually cuts through the restrictive layer. The headcut or gully can lead to the partial or complete loss of a riparian-wetland area.

- Melting or loss of permafrost.

The answer "NA" would be used for those riparian-wetland areas that are not dependent on a restrictive layer for their existence, such as groundwater-dependent ecosystems.

Supporting Science

Riparian-wetland systems that form as a result of a restrictive layer may be natural or artificial. Natural sites have a geologic material, soil material (e.g., a fine-texture material, such as clay, that has very low hydraulic conductivity), or permafrost that can restrict the rate of water percolation. An artificial site may have a synthetic fabric, constructed and installed clay layer, or chemical application that acts as a restrictive layer. In natural systems, the ponded water is sometimes referred to as a perched aquifer, which is a laterally discontinuous aquifer that forms within the vadose zone (unsaturated zone above the regional water table). The perched aquifer is created by an impermeable (aquiclude) or relatively impermeable (aquitard) layer that restricts the movement of groundwater. Consequently, perched aquifers are generally the result of precipitation and surface runoff that is pooled and stored above the restrictive layer.

Vernal pools are seasonal depressional wetlands that form above a restrictive layer. These are common in environments with a Mediterranean climate, in which wet winters generate the moisture that fills the depressions, and then dry summers lead to desiccation of the depressions.

Correlation with Other Assessment Items

Item 18 may correlate with item 3 (riparian-wetland area is enlarging or has achieved potential extent) and item 17 (saturation of soils is sufficient to compose and maintain hydric soils). If a restricting layer is compromised, then the extent of the lentic area is likely to decrease, as water levels, water volume, and duration of water impoundment cannot be maintained relative to potential. Likewise, if the restricting layer does not function properly, then the processes required to form and maintain hydric soils may not function either.

Item 19: Riparian-wetland area is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Purpose

The intent of item 19 is to determine if the water and sediment are being supplied to the lentic riparian-wetland area at a nearly natural rate and the lentic area can function properly, or if the supply of either water or sediment has been altered to a degree that the proper functioning of the lentic area is affected.

Over geologic time, lentic riparian-wetland areas typically fill with sediment and may even convert to an upland area type, which is natural. However, this conversion rate can be accelerated by land management activities within a watershed, such as road building and maintenance, logging, water diversions, farming, urbanization, or grazing, if not done properly. For example, too many roads, or roads in the wrong location, or roads poorly designed to manage runoff may accelerate erosion within a watershed. These activities may not only accelerate the rate of erosion but also generate excessive amounts of sediment, causing riparian-wetland areas to fill at rates that greatly exceed natural rates of sedimentation. When this happens, an area will no longer function properly.

Also, increased energy associated with an increase in surface flows into a riparian-wetland area may form rills, gullies, or headcuts, which in turn can generate additional sediment that can rapidly fill lentic riparian-wetland areas.

Observational Indicators and Examples

A "yes" response is suggested when there is no evidence of excessive deposition in the riparian-wetland area as a result of sediment from the watershed. Likewise, if there is no evidence of a change in water supply to the riparian-wetland area, then the response would be "yes." "Yes" responses are suggested when:

- The area of open water in a pond or lake system is being maintained, the margins of the water body are relatively stable over time, and the water body is not filling in rapidly with sediment.

- Water depth of ponds or lakes is being maintained.

- Vegetation buffers are effective at controlling runoff and trapping sediment before they enter riparian-wetland areas.

- Aerial extent of riparian-wetland area is staying constant over time.

A "no" response could result from:

- Rapid growth of a delta extending into a wetland.

- Fluctuations in water level greater than expected. See Euliss and Mushet (1996), who demonstrated that water-level fluctuations are greater in watersheds with accelerated runoff and erosion than in watersheds with more natural rates of runoff because more water infiltrates into the soil and enters lakes and ponds via groundwater.

- Conversion of open-water habitat to emergent habitat (or conversion of emergent habitat to seldom inundated/permanently exposed habitat) as sedimentation fills in shallow water bodies (figure 42; Clemmer 2001; Prichard et al. 1999).

- Nearby presence of roads with visible erosion feeding sediment from the road towards or into the riparian-wetland area.

- Erosion that has removed soil from the riparian-wetland area, resulting in a decrease in site fertility or water-storage capacity.

- Unstable shorelines.

- Burial of fence posts or other human structures, which can provide documented rates of historical sedimentation.

- Field evidence of rill, gully, or flow-path erosion from adjacent hillslopes with transport direction to the riparian-wetland area. These erosion features should be in excess of natural site potential to justify a "no" response.

- Documented interbasin transfer of water or water diversions that have changed the water balance and transport capacity of sediment to the riparian-wetland area.

Item 19 will never be answered "NA"; it will always have a "yes" or "no" answer.

Supporting Science

Riparian-wetland areas are constantly adjusting to the water and sediment being supplied by the watershed. Changes in watershed condition can affect both additions and subtractions to water and sediment supply. Understanding riparian-wetland areas requires an understanding of changes in overland flows and sediment production upslope (upgradient) from the riparian-wetland areas. Guidance on water and sediment budgets is provided under item 4 and is applicable to item 19 as well.

Correlation with Other Assessment Items

Because water and sediment are supplied from the watershed, item 19 is closely tied to item 4 (riparian-wetland impairment from the contributing area is absent).

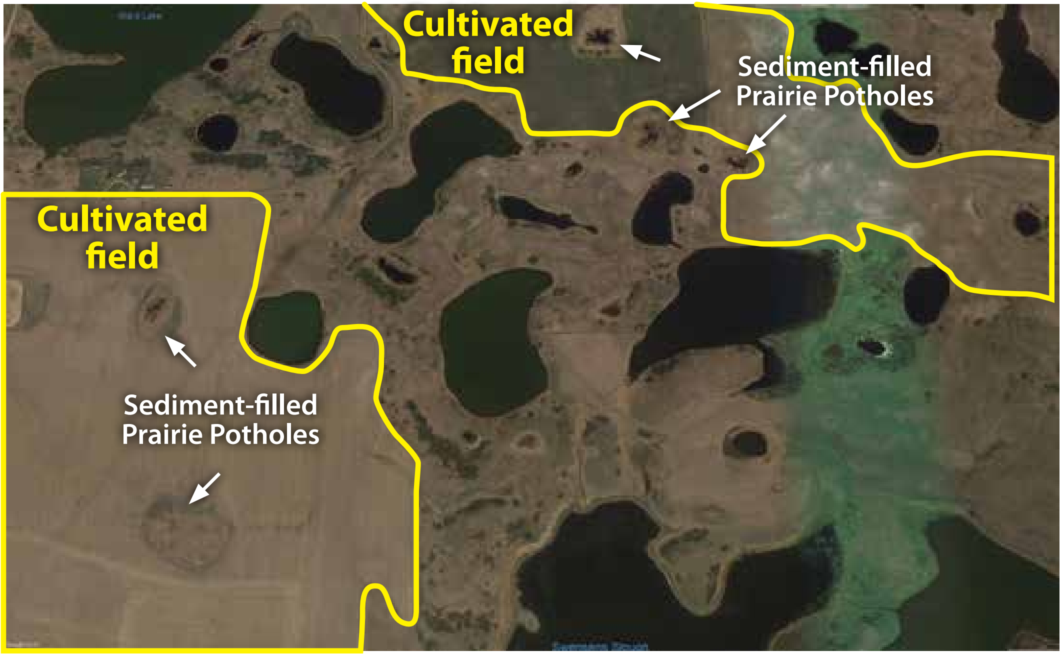

Figure 42. Depressional wetlands (prairie potholes) within or adjacent to cultivated fields (outlined in yellow) show evidence of high sedimentation rates. Open-water habitat of potholes in cultivated fields is either absent or greatly reduced in comparison with equally sized prairie potholes in unplowed grassland.

Item 20: Islands and shoreline characteristics (i.e., rocks, coarse and/or large woody material) are adequate to dissipate wind- and wave-event energies

Purpose

The intent of item 20 is to address those systems that do not require vegetation or that require a combination of rock, wood, and vegetation to dissipate energy (figure 43). Item 20 applies only to open-water (i.e., lake, pond, marsh, swamp) wetland systems.

Riparian-wetland areas with islands and shorelines must be able to dissipate energy during wind- and wave-action events (including waves generated by boat wakes) to function properly. These islands and shorelines need characteristics that are resistant to wind and wave action. Although most lentic riparian-wetland areas require riparian-wetland vegetation along islands and shorelines to do this, some do not. The presence of rocks and/or woody material can dissipate energies associated with wind and wave action, thereby providing the elements necessary for a system to function properly.

Observational Indicators and Examples

A "yes" response is indicated when rock and large and coarse woody material are in abundance and adequate to dissipate wind and wave energy along the shoreline.

A "no" response is indicated when:

- Shorelines are eroded and have wave-cut benches, exposed tree roots, slump blocks, or fractured shorelines over a substantial length.
- Shorelines exhibit recession and are wave-scalloped or -scoured with an appreciable loss of fine sediment, soil, and organic matter.
- Near-shore sediment is reworked and accumulates in the shallow margins of the wetland area.

An "NA" response applies to:

- All riparian-wetland areas that do not have open water and hence do not have the potential for islands or shorelines.
- Those riparian-wetland areas that are entirely dependent on vegetation along islands or shorelines for stability. (These sites are addressed in item 13 and not item 20.)

Supporting Science

When evaluating the adequacy of rock or wood to dissipate wind and wave energy, the ID team should consider the following: (1) the amount, kind, and size of rock along shorelines, (2) the size and depth of water sources, (3) frequency, timing, direction, and duration of event energies, (4) slope of the shoreline, (5) uses of the area, (6) adjacent topography, (7) availability of wood from adjacent plant communities, and (8) the fetch (i.e., the distance traveled by wind or waves across open water).

Erosion of shorelines affects lentic areas by (1) lowering water quality, (2) reducing the capacity to hold and store water, and (3) altering the plant community.

Figure 43. The near shoreline contains fine sediment, delivered by a stream inlet, and is stabilized by riparian-wetland vegetation. In contrast, the far shoreline intersects a talus slope and is entirely dependent on the caliber and amount of rock for stability. Both items 13 and 20 should be addressed during the assessment of this particular riparian-wetland area.

Correlation with Other Assessment Items

Item 20 examines the adequacy of rock and woody material to dissipate energy, whereas item 13 examines the adequacy of vegetation to dissipate energy. Note that items 20 and 13 do not actually correlate and consequently must be assessed independently. Therefore, to address items 13 and 20 properly, the ID team must determine the potential of each site and determine if the site requires vegetation (item 13) or nonvegetation attributes (i.e., rock and wood for item 20), or a combination of vegetation, rock, and wood (items 13 and 20) to dissipate energy.

Note that some lakes, ponds, and reservoirs may have rocky shorelines in one part and fine-textured shorelines (that support vegetation) elsewhere. For example, many natural lakes and reservoirs accumulate fine sediment where streams enter them, sometimes leading to the formation of a delta. Deltas or lake inlets may have the soils and sediments that promote growth of riparian-wetland vegetation. In contrast, lake outlets and dam embankments may be lined with rock. Elsewhere a talus slope may form part of a shoreline in a mountain lake.

8. Finalizing the PFC Assessment

Determine the Functional Rating

General Guidance

After documenting their observations on the assessment form, *ID team members collectively determine a functional rating based on a review and discussion of their "yes" and "no" responses and their documented comments for each item on the form.* The ID team assigns the rating that most appropriately corresponds with how the assessment items were evaluated: proper functioning condition (PFC), functional–at risk (FAR), or nonfunctional (NF).

Proper functioning condition (PFC): A lentic riparian-wetland area is considered to be in PFC, or "functioning properly," when adequate vegetation, soil and landform, or woody material is present to:

- Dissipate energies associated with overland flows (e.g., storm and snowmelt events) and wind and wave action, thereby reducing erosion.
- Protect/stabilize shorelines, islands, and soil surfaces from erosion and direct physical alteration from human and animal activities.
- Improve floodwater retention as well as ponding, storage, and retention of surface water.
- Saturate soil and retain soil moisture.
- Maintain or improve groundwater recharge.
- Capture sediment.
- Maintain soil attributes (e.g., organic matter, pore space, structure, soil chemistry).

The definition of PFC includes "adequate vegetation, soil and landform, *or* woody material" because not all lentic riparian-wetland areas process the energy of moving water or resist physical impacts in the same way—nor do they have the same potential plant community. For example, some vegetated drainageways have the potential for a near monoculture of hydric herbaceous species (OBL and FACW plants) while others have the potential to produce only FAC plants with limited hydric species isolated to zones or small areas within the site.

The PFC assessment is designed to assess whether the physical elements (abiotic and biotic) are in working order relative to potential. When these physical elements are in working order, site characteristics develop that can provide associated values, such as wildlife habitat, recreational opportunities, and good water quality. *Functionality must come first and then may lead to the achievement of desired conditions.*

Because of the variability in types of lentic riparian-wetland areas (based on differences in climatic setting, geology, landform, hydrology, and soils) and variability

in the severity of individual factors relative to an area's ability to withstand overland flows, wind and wave action, and direct physical alterations from human and animal activity, there is no set number of "no" responses required to determine whether an area is rated as FAR or NF. If a riparian-wetland area has the necessary elements, then it has a *high probability of withstanding the actions and impacts described above.* If all the responses on the assessment form are "yes," the site is undoubtedly meeting these criteria and would be rated as PFC. If some responses are "no," the site may still meet the definition of PFC, depending on the nature and severity of the "no" responses. ID team discussion and documentation of conditions are critical to making these determinations.

Functional–at risk rating (FAR): If a riparian-wetland area is rated as FAR, it is in limited functional condition; however, one or more existing hydrologic, vegetative, or soil/geomorphic attributes make it susceptible to impairment. A FAR riparian-wetland area may possess some or even most of the elements in the PFC definition, but at least one of its attributes/processes gives it a high probability for impairment from overland flows, wind and wave action, and direct physical alterations from humans and animals. Most of the time, several "no" responses will be evident because of the correlation among items on the assessment form. If these "no" responses, in the ID team's opinion, collectively provide a high probability for impairment from the actions described above, then the area would be rated as FAR. If there is disagreement among team members after all comments have been discussed, it is advisable to be conservative in the rating (e.g., if the discussion is between PFC and FAR, then the rating should be FAR). One situation where only one "no" answer indicates a lentic riparian-wetland area is at risk is when a structure is not accommodating safe passage of flows because a headcut is starting to affect the dam or spillway. If a riparian-wetland site has a headcut within or moving upgradient from below the site, then the riparian-wetland area above the headcut (to a point where there is some geologic or structural grade control) would be rated as FAR or NF regardless of other factors.

Trend towards or away from PFC *must* be described when a rating of FAR is given. Trend is the direction of change in one or more attributes over time and can be addressed two ways. If trend is determined using photos, monitoring data, detailed inventories, and any other measurement or documentation to compare past conditions with present conditions, it is defined as "monitored trend." Monitored trend is described as upward, downward, or static. If this information is not available, indicators of "apparent trend" may be used to estimate trend during the assessment process. Apparent trend is defined as "an interpretation of trend based on observation and professional judgment at a single point in time" (Society for Range Management 1998) and is described as upward, downward, or not apparent. Observation and professional judgment to ascertain apparent trend may incorporate review of past PFC assessments for a site. Caution should be used in these instances to ensure that something tangible has changed; the ID team should avoid making a trend determination based simply on a comparison of different ratings. ID teams need to indicate which trend method (monitored or apparent) was used and provide their rationale for the selected trend determination on the assessment form.

Nonfunctional rating (NF): Riparian-wetland areas rated as NF *clearly lack the elements listed in the PFC definition.* If a riparian-wetland area is rated as NF, it is clearly not providing adequate vegetation, soil and landforms, or woody material to dissipate energies associated with overland flows and wind and wave action, and thus is not reducing erosion, improving water quality, protecting soil surfaces, and stabilizing the site from physical alterations, or otherwise supporting PFC. Usually NF ratings translate to a preponderance of "no" responses on the assessment, but not necessarily all "no" responses. For example, a riparian-wetland area may still be saturated at or near the surface or inundated in "relatively frequent" events but be clearly nonfunctional because it lacks vegetation to protect the area from erosion or physical alteration.

Although it may appear that the selection of a final rating category is the primary objective of the PFC assessment, *the observations and comments for each item provide specific, critical information that is useful for subsequent management, restoration, and monitoring efforts and for estimating the recovery trajectory and rate. This information may reveal important opportunities and is a key benefit of the PFC assessment.*

Example of a System Progressing towards PNC

Riparian-wetland areas can function properly before they achieve potential. The PFC definition does not mean that potential or optimal conditions for a particular species must be achieved for an area to be considered functioning properly. Figure 44 provides a hypothetical example of the relationship between PFC and landform/vegetation succession for one kind of lentic riparian-wetland area; *the relationship may be different for other areas because of differences in potential and the way specific systems progress/regress.*

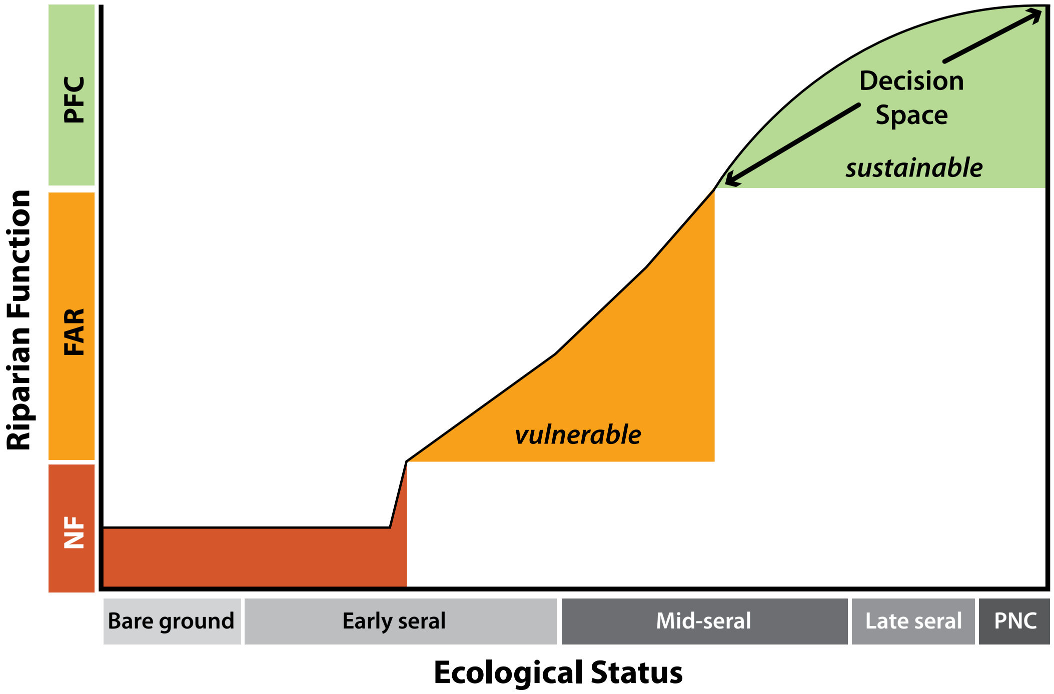

Figure 44. An example of succession as it relates to riparian-wetland recovery and physical function. Riparian-wetland areas rated functional–at risk are vulnerable to impairment from overland flows, wind and wave action, and physical alteration by humans or animals. Lentic areas in PFC are better able to withstand impairment from these events and thereby can sustainably produce certain values. *Not all lentic riparian-wetland areas will follow this successional progression.*

In the hypothetical example shown in figure 44, assuming riparian-wetland recovery continues uninterrupted, the riparian-wetland area will evolve from bare ground to its potential natural condition (PNC). The riparian-wetland area will progress through phases of NF, FAR, and PFC. *In this example, PFC occurs at the mid-seral state (moderate similarity to PNC).*[2] *This is not always the case.* Depending on which attributes and processes are required for function, it may occur from early-seral (low similarity to PNC) to late-seral states or high similarity to PNC (although PFC occurs less commonly at sites at an early-seral state than those that are in a more advanced state).

"States" represent distinct conditions at a defined point in time. A riparian-wetland area may remain at one state or condition for an undetermined length of time because of coinciding circumstances of management and climate.

Progress towards a higher state or condition may at times be impeded by greater natural stresses associated with flooding, drought, fire, etc. within the natural range of variability. Regression towards a lower condition may depend on exceeding a threshold of stability, progressing slowly at first, and then rapidly declining as the threshold is crossed. In any condition, from FAR to PNC, an event, either human-induced or natural (fire, volcanic eruption, floods, dewatering, etc.), can cause the area to regress to a lower condition. A much greater disturbance event is necessary to cause the condition to regress in areas that are in PFC than in areas that are FAR. Not all lentic riparian-wetland areas will follow this same progression. Impairment can occur quickly, and recovery can often be slow, depending on site-specific attributes and processes. In general, this is why it is desirable to maintain lentic riparian-wetland areas in PFC. Sites in PFC are more resistant to change and resilient after disturbance.

As a system progresses towards potential natural condition, a number of physical changes begin to occur. These include reduced erosion and improved floodwater retention and groundwater recharge (when adequate vegetation, soil and landform, or woody material are present to dissipate energy associated with overland flows, wind and wave action, or human and animal disturbances). As the physical aspects of a system begin to function, the process of developing habitat characteristics—such as diverse ponding features and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses—is initiated. The physical aspects must be in working order to sustain the site characteristics that provide habitat and other resource values (Fischenich 2006).

The threshold for any goal is at least PFC because riparian-wetland areas with any rating below PFC are not sustainable. Until PFC is attained, the "decision space"—the parameters within which management decisions can be made—that is available to managers to emphasize one resource value over another may be limited. This does not imply that sites rated FAR or NF cannot accommodate management actions such as grazing; it only means that management options can be limited because they must provide for recovery. After the site is at PFC, any number of management options can be considered because the site is much more resilient.

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[2] There are different models used to describe successional processes occurring at a site. Linear models have been used for several years to describe ecological succession and the various "states" occurring at a site. More recently, state-and-transition models (nonlinear) have been presented to describe ecological changes in response to site characteristics and common disturbances. The simple successional model described in this technical reference is presented to illustrate (in a simple manner) how riparian-wetland function changes as ecological community attributes change. Readers should consult the literature for detailed models of ecological site dynamics.

As lentic riparian-wetland areas recover and attain PFC, they will generally continue to progress towards some advanced condition unless management actions are implemented to modify the process. The decision space in figure 44 does not imply that management has unlimited control over every riparian-wetland attribute or process, nor does it imply that it is always easy to manipulate riparian-wetland attributes to feature one value over another (McBain and Trush 1997).

Complete the Assessment

Riparian-Wetland Area Information and PFC Assessment Forms

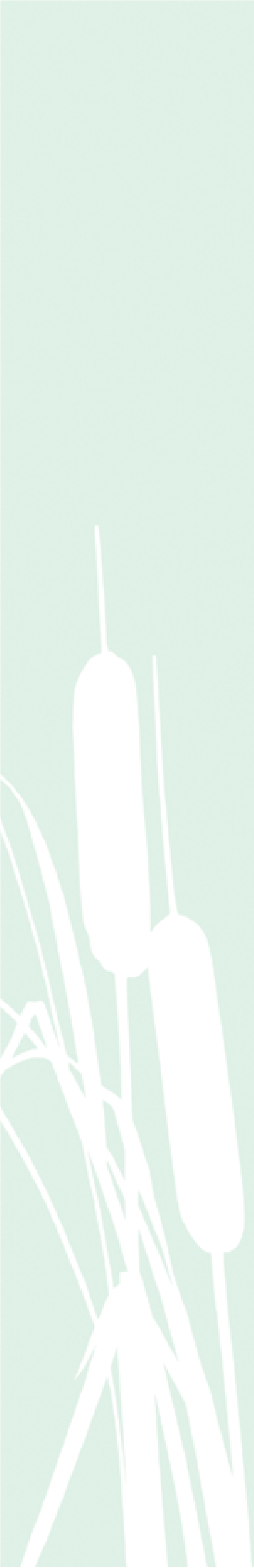
For a PFC assessment to be finalized, the ID team completes the following *for each site*:

1. Riparian-wetland assessment area information form (including map).
2. PFC assessment form.
3. Riparian plant list form or similar list (strongly recommended).
4. Photographs supporting the PFC assessment (with documentation).
5. Assessment results entered into the appropriate agency database (as needed).

The forms, as well as detailed instructions for completing them, are included in appendix A.

Photo Documentation

Photographs to support key observations are an important component of PFC assessment documentation. Taking photos throughout the assessment area is recommended. In addition, photos that illustrate or support observations and "yes/no" answers on the PFC assessment form are helpful. Each photograph may have readily apparent meaning to one or more ID team members immediately after the assessment, but time, change in personnel, retirements, and poor memories may quickly obscure the location, meaning, and importance of photographs. A brief description of the key feature should be recorded for each photograph. The date of photographs should also be noted, as conditions can change throughout the growing season and in response to such management actions as grazing. Preferably, the location of photographs will be determined by a global positioning system (GPS) and marked on an attached aerial photograph or topographic map. Storage of GPS photopoints in a GIS database will facilitate electronic storage and retrieval of photographs in a site-by-site manner.



Summary of Results

In addition, if multiple areas are completed, the ID team can summarize its findings in a comprehensive report. A report provides helpful information for future projects and analyses. A suggested outline for the report is shown below:

I. Introduction

II. PFC assessment results
    A. Description of assessment area
    B. Delineation/stratification
    C. Description of potential(s)
    D. Riparian-wetland area narratives (summary of PFC assessment results in narrative form)
    E. Observations/findings
    F. Issue identification and management recommendations

III. References (soils surveys, classification, etc.)

IV. Appendices

Appendix 1: Site information, plant list, and PFC assessment forms

Appendix 2: Photos and captions

Appendix 3: Maps with reach/site breaks and photo waypoints

Appendix 4: Waypoint/photopoint log

Depending on complexity, a table of contents, executive summary, methods summary, and details of riparian-wetland classification may also be included.

Appendix A—Assessment Forms and Instructions

The "Lentic Riparian-Wetland Assessment Area Information Form" and "PFC Assessment Form (Lentic)" must be filled out for each assessment area. Completion of the "Lentic PFC Riparian-Wetland Plant List Form" is also strongly recommended to facilitate recordkeeping and documentation; this form may be customized based on local needs. Photographs should be cataloged to ensure that important information, such as location, date taken, and purpose, is retained over time.

Lentic Riparian-Wetland Assessment Area Information Form – Instructions

Background Information

- Provide pertinent background information.

- List all members of the core ID team by name and discipline. Include others not on the core ID team, and identify their role as extended team members. Extended team members may include nonagency individuals, such as permittees, members of other user groups, or members of nongovernmental organizations, provided they have local knowledge that can inform the assessment.

- Indicate the nature of the assessment method (i.e., complete ground reconnaissance, ground inspection of selected representative areas, or a combination using drone (unmanned aerial vehicle) imagery or remote imagery and selective field inspections).

- Attach an aerial image, USGS 7.5-minute topographic map, or GIS map showing the location of the riparian-wetland assessment area.

Location

Record the location of the lentic riparian-wetland assessment area with one or more geographic systems (latitude and longitude in degrees, minutes, and seconds or in decimal degrees, or Universal Transverse Mercator (UTM) coordinate system). Provide the datum (e.g., North American Datum 1927 (NAD27), North American Datum 1983 (NAD83), or World Geodetic System 1984 (WGS84)). Omission of the datum can result in aberrations whenever the geographic data are projected in a different coordinate system than the one used to fix the location originally. If UTM coordinates are used, also indicate the UTM zone.

Description of Potential and Rationale

Describe the potential natural condition for the riparian-wetland assessment area and account for the hydrologic regime and the plant communities that should exist at potential. Describe the soils and geomorphic setting and how these properties may affect potential natural condition. Give the rationale used for determining potential. Refer to chapter 4 for additional information on potential.

Other Assessment or Monitoring Data

- Indicate if the riparian-wetland area was assessed previously. If it was assessed, include the date(s), previous functional rating(s), and any trend information. Place a copy of the previous assessment in the project file, and make a copy for use in the field.

- Indicate if a DMA or other monitoring site was established within the assessment area and when monitoring occurred.

- Indicate if a reference site was used to make comparisons with the assessed site.

- Include copies of existing data to inform the current assessment effort.

Altered Potential Attachment

If an altered potential exists, use the guidance in appendix D to populate the answers to questions posed on the attachment to the "Lentic Riparian-Wetland Assessment Area Information Form."

Lentic Riparian-Wetland Assessment Area Information Form

I. Background information: Date:__________________

Riparian-wetland area name:__________________________________Area ID:_________________________

Management unit (allotment/pasture, other):____

Administrative unit/state:____

ID team members:____

____

Areal extent of riparian-wetland assessment area:_________________________(acres/hectares – circle one)

Assessment method:

☐ Complete ground reconnaissance

☐ Ground inspection of selected representative areas

☐ Remote imagery with selective ground inspection of representative or other areas requiring closer inspection

II. Location of riparian-wetland assessment area:

Location: Attach aerial image, USGS 7.5-minute topographic map, or GIS map with the riparian-wetland assessment area delineated. Use GIS in the office or GPS in the field to obtain a representative location to affix a point to the riparian-wetland assessment area.

GIS/GPS point location of riparian-wetland assessment area

Latitude:___________________________________N Longitude:_______________________________ W

or

UTM E____________________________________ m UTM N________________________________ m

Datum: ☐ NAD27 ☐ NAD83 ☐ WGS84 ☐ Other (specify):__________________________

UTM Zone (required for UTM coordinates):____

III. Description of potential and rationale: Should include description of hydrologic regime, geomorphic setting, important soil properties, and riparian-wetland plant communities at potential (if altered potential is present, use the "Altered Potential Attachment" below):

____

____

____

IV. Other assessment or monitoring data or information about the riparian-wetland assessment area:

Lentic Riparian-Wetland Assessment Area Information Form – Altered Potential Attachment

See appendix D for instructions and examples for addressing these questions.

1. **Have the alterations created artificial conditions for a substantial part of the site (and riparian-wetland functions are not present or expected)?**

2. **Are alterations present, but the potential of the site remains unchanged?**

3. **Has a new lentic riparian-wetland area been created in a former upland area?**

4. **Are alterations present that have changed the potential of an existing lentic site (but have not created artificial site conditions described in question #1 for a substantial part of the site)?**

PFC Assessment Form (Lentic) – Instructions

1. Before completing the form, examine the assessment area using the selected approach (complete ground reconnaissance; ground inspection of selected representative areas; or inspection of remote sensed imagery with selective ground inspections of representative or other areas requiring closer scrutiny). Take notes and photographs and discuss key attributes observed throughout the assessment area.

2. Occasionally the ID team may encounter assessment areas that have both lentic and lotic features (e.g., a spring brook, beaver complex embedded in a lotic setting, or wet meadow with an incised channel). In such situations, the ID team may need to blend the lotic and lentic assessment forms to best capture the processes, attributes, and functions of the riparian-wetland area.

3. Complete the "PFC Assessment Form (Lentic)" after examining each assessment area. Examining multiple areas and then completing several forms at once is not advised. The ID team should complete one assessment form upon examining each assessment area so as not to confuse features and observations among sites.

4. Mark the "yes," "no," or "NA" box for each item on the form unless the ID team concludes that there is strong evidence that neither a conclusive "yes" or "no" is appropriate or that both apply: if this is the case, mark both the "yes" and "no" boxes for that item. Marking both "yes" and "no" because there is not a conclusive answer should be done sparingly, and the ID team should work to make a conclusive determination of a "yes" or "no" for each item. The "NA" box is provided for assessment areas that do not have the potential for that item.

5. Document the response to each item with a short narrative describing the ID team's rationale. Because PFC is a qualitative assessment, providing the rationale for each item is important. As the assessment form is being completed, refer to chapters 5-7 for each item's purpose and useful observational indicators.

6. After completing all 20 assessment items, read the definitions of the three functional categories, discuss how the assessment items were rated, and determine the functional rating category of the assessment area. Provide a short narrative describing the rationale used for the selected rating. See chapter 8 for a detailed discussion.

7. Address trend for FAR ratings. Trend can be addressed by using "monitored trend" (using supplemental information) or "apparent trend" (based on a one-time observation of indicators). Provide a short narrative describing the rationale used for ascertaining trend. See chapter 8 for a detailed discussion.

8. Based on the condition of the assessment area, estimate the status of the area within the PFC and FAR categories on the thermometer scale to the nearest third of the category.

    - **For the PFC range,** the upper third is for those assessment areas where the vegetation community is at or approaching PNC and the site exhibits high stability. In contrast, the lower third of the PFC range represents assessment areas where the vegetation communities, soils, and geomorphic conditions are adequate for dissipating energy and maintaining site stability, but there are appreciable opportunities for increased stabilization and maturation of riparian-wetland plant communities. The middle third is for all conditions in between.

    - **For the FAR range,** the upper third represents riparian-wetland sites that are a small step away from PFC. In contrast, the lower third is just a step above the NF range. The middle third is for all conditions in between.

- **NF is nonfunctional,** so there is no need to subdivide this category. NF riparian-wetland areas are severely degraded and incapable of functioning properly under the current conditions.

  The purpose of using this scale on the thermometer is to provide additional information for decisionmaking. For example, FAR sites at the bottom of the scale may be managed differently than those almost at PFC.

9. If the assessment area is rated FAR or NF, determine if there are factors contributing to those conditions that are outside the control of the manager. If the riparian-wetland area is rated PFC, document any factors that may affect the achievement of desired condition for other values. Indicate "yes" or "no" to the question about whether factors outside the manager's control are influencing the achievement of PFC, and describe any such factors in the remarks section.
10. Complete summary remarks, and use additional space if needed. Written observations provide solid documentation of items that drive the functional rating. A photo log can provide a visual rationale.

PFC Assessment Form (Lentic)

Riparian-wetland area name:______________________________Date:______________

Assessment ID team members:____

____

____________________________________Riparian-wetland area ID:________________

Yes	No	NA	HYDROLOGY
		▨	1. Riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events.
Rationale:			
			2. Fluctuation of water levels is within a range that maintains hydrologic functions and riparian-wetland vegetation.
Rationale:			
			3. Riparian-wetland area is enlarging or has achieved potential extent.
Rationale:			
		▨	4. Riparian-wetland impairment from the contributing area is absent.
Rationale:			
			5. Water quality is sufficient to support riparian-wetland plants.
Rationale:			

		▨	6. Disturbances or features that negatively affect surface- and subsurface- flow patterns are absent. These disturbances/features include but are not limited to hoof action, dams, dikes, levees, spring boxes, diversions, trails, roads, rills, gullies, drilling activities.
Rationale:			
			7. Impoundment structure accommodates safe passage of flows (e.g., no headcut affecting dam or spillway).
Rationale:			

Yes	No	NA	VEGETATION
			8. There is adequate diversity of stabilizing riparian-wetland vegetation for recovery/maintenance.
Rationale:			
			9. There are adequate age classes of stabilizing riparian-wetland vegetation for recovery/maintenance.
Rationale:			
			10. Species present indicate maintenance of riparian-wetland soil-moisture characteristics.
Rationale:			

			11. Stabilizing plant communities are present that are capable of withstanding overland flows (e.g., storm events, snowmelt), and wind and wave actions, and can resist physical alteration.
Rationale:			
			12. Riparian-wetland plants exhibit high vigor.
Rationale:			
			13. An adequate amount of stabilizing riparian-wetland vegetation is present to protect soil surfaces and shorelines, to dissipate energy from overland flows and wind and wave actions, and to resist physical alteration.
Rationale:			
			14. Abnormal frost or hydrologic heaving is absent.
Rationale:			
			15. Favorable microsite condition (e.g., woody material, water temperature) is maintained by adjacent site characteristics.
Rationale:			

Yes	No	NA	SOILS/GEOMORPHOLOGY
			16. Accumulation of chemicals affecting plant productivity/composition is absent.
Rationale:			
			17. Saturation of soils (i.e., ponding, flooding frequency, and duration) is sufficient to compose and maintain hydric soils.
Rationale:			
			18. Underlying geologic material/soil material/permafrost is capable of restricting water percolation.
Rationale:			
		▨	19. Riparian-wetland area is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition).
Rationale:			
			20. Islands and shoreline characteristics (i.e., rocks, coarse and/or large woody material) are adequate to dissipate wind- and wave-event energies.
Rationale:			

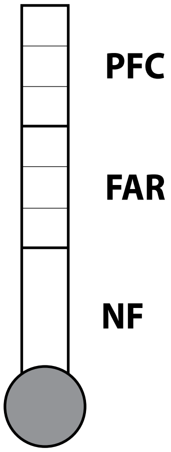
Summary Determination

Functional rating (check one)

☐ Proper functioning condition

☐ Functional–at risk

☐ Nonfunctional



Trend for FAR rating (check one)

Monitored trend	Apparent trend
☐ Upward	☐ Upward
☐ Downward	☐ Downward
☐ Static	☐ Not apparent

Rationale for rating: ____

____

____

____

____

____

____

____

Rationale for trend (for FAR rating): ____

____

____

____

____

____

____

____

Are there factors present preventing the achievement of PFC or affecting progress towards desired condition that are outside the control of the manager?

☐ Yes ☐ No

If yes, what are those factors? Check all that apply.

☐ Flow regulation
☐ Mining activity
☐ Watershed condition
☐ Land ownership
☐ Dewatering
☐ Dredging activity
☐ Road encroachment
☐ Oil field water discharge
☐ Augmented flows
☐ Other (specify): ____________________

Explain factors preventing achievement of PFC: ____________________

Lentic PFC Riparian-Wetland Plant List Form – Instructions

The ID team should record the riparian-wetland plant species commonly found in the assessment area on the "Lentic PFC Riparian-Wetland Plant List Form." Minor or inconsequential plants do not have to be recorded. Instead, the ID team should note all species that are important to the function of the riparian-wetland area; for example, those that colonize shorelines, provide soil stability, trap sediment, provide shade, or indicate abundance and depth of soil moisture.

Similarly, when an ID team has numerous assessment areas, it is generally most efficient to develop a riparian-wetland plant list that is customized to the overall project area and populated with the most common riparian species (see appendix E for an example). A detailed riparian-wetland plant list includes an identification of the U.S. Army Corps of Engineers plant region, plant symbols, common and/or scientific name(s) of plants, their relative abundance (column AB), geomorphic/topographic position (column G/T), wetland indicator category (column WIC), stability class (column SC), and whether they are nonnative, invasive species (column IN).

U.S. Army Corps of Engineers Plant Regions

Plant regions in the United States are mapped and delineated on the National Wetland Plant List website. The wetland indicator class of individual species can change from one region to another, so ID teams should identify the plant region for each assessment area. The plant regions include:

AGCP	Atlantic and Gulf Coastal Plain
AK	Alaska
AW	Arid West
CB	Caribbean
EMP	Eastern Mountains and Piedmont
GP	Great Plains
HI	Hawaii
MW	Midwest
NCNE	Northcentral and Northeast
WMVC	Western Mountains, Valleys, and Coast

Plant Symbol

Document the plant symbol, as found online in the USDA PLANTS Database (USDA-NRCS 2019, or latest version).

Presence/Relative Abundance (AB)

Document the riparian-wetland species observed in the assessment area to answer item 8 on the PFC assessment form (there is adequate diversity of stabilizing riparian-wetland vegetation for recovery/maintenance). The ID team may choose to indicate the presence of a plant with a checkmark in the left-hand column and then to note the relative abundance of each species observed using a numerical scale of 1 to 4 in column AB. The scale is not based on plant-cover data collected from quadrats but on a crude visual estimation of the abundance of a species in the assessment area.

Geomorphic/Topographic Position (G/T)

Identifying the geomorphic/topographic location of riparian-wetland plants with different wetland indicator statuses helps in addressing item 1 (riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events), item 3 (riparian-wetland area is enlarging or has achieved potential extent), and item 10 (species present indicate maintenance of riparian-wetland soil-moisture characteristics) on the PFC assessment form. The ID team can learn much about the depth to a shallow water table by noting which surfaces have hydric plants and which have upland plants.

Wetland Indicator Category (WIC)

The ID team can address item 10 (species present indicate maintenance of riparian-wetland soil-moisture characteristics) by noting the WIC (Lichvar et al. 2012) of individual species throughout the riparian-wetland assessment area. See item 10 for a detailed discussion of determining the WIC of plants. As previously stated, the WIC of plants can change from one region to another, so it is important to identify the plant region for each assessment area.

Stability Class (SC)

Item 11 asks if the right plants/plant communities (i.e., those with strong, stabilizing root systems) are present to protect shorelines and soils and to withstand overland flows and wind and wave events. Strong, stabilizing root systems are also necessary to protect soils from hoof action by ungulates. A few studies (e.g., Winward 2000, Lorenzana et al. 2017) have attempted to quantify the relative rooting strength of common riparian-wetland plants. Winward (2000) used a numerical scale from 1 (weakest) to 10 (strongest) to denote relative rooting strength of various community types. However, when ID teams conduct PFC assessments, they are not making the quantified measurements to justify use of highly detailed numerical scales. Also, the plant list typically includes individual species and not community types. Therefore, a broad, three-tiered scale of "low," "medium," and "high" rooting stability is recommended for PFC assessments. The MIM data analysis module (Burton et al. 2011) contains stability classes for the most common perennial riparian-wetland plants in the Great Plains; Arid West; and Western Mountains, Valleys, and Coast plant regions.

Nonnative, Invasive Species (IN)

Although nonnative, invasive species may provide riparian stability, they may not be desirable in terms of habitat or ecological goals. The ID team should note whether these species are present, as they commonly dictate management actions.

Lentic PFC Riparian-Wetland Plant List Form

Assessment area name:____**ID:**____________________

Region (USACE or other):____**Date:**__________________

√	Plant Symbol	Common Name	Scientific Name	AB	G/T	WIC	SC	IN
Trees/Shrubs								
Graminoids/Grasses								
Forbs								

Notes:

Explanation of Plant List

√ Check species present.

Abundance (AB): Use a scale of 1 to 4, where:

1 = Species present but with only one to a few individuals found in the assessment area.
2 = Species found intermittently or occasionally throughout the assessment area.
3 = Species generally common and missing in comparatively small parts of the assessment area.
4 = Species abundant and found throughout the entire assessment area.

Geomorphic/Topographic Surface (G/T):

DP	Groundwater discharge point(s) of springs/seeps
H	High spots, microtopographic high points, such as ridges, strings, mounds, tops of hummocks, and pedestals
L	Low spots, microtopographic low points, such as depressions, swales, troughs, drainageways, flarks
MF	Mesic fringe near the transition from OBL and FACW plant communities to FAC, FACU, and UPL plant communities
S	Shoreline of lakes and ponds
T	Thalweg (lowest path through vegetated drainageway or other types of depressions)
W	Widespread occurrence

ID teams should specify and define additional geomorphic/topographic positions of riparian-wetland plants if needed.

Wetland Indicator Category (WIC): See most recent National Wetland Plant List at the U.S. Army Corps of Engineers website.

OBL (obligate plants)—Almost always occur in wetlands

FACW (facultative wetland plants)—Usually occur in wetlands, but may occur in nonwetlands

FAC (facultative plants)—Occur in wetlands and nonwetlands

FACU (facultative upland plants)—Usually occur in nonwetlands, but may occur in wetlands

UPL (upland plants)—Almost never occur in wetlands

Stability Class/Rooting Strength (SC): Relative values based on general rooting characteristics assigned by Burton et al. (2011); numerical values conform to Winward (2000) and Lorenzana et al. (2017).

Forbs	
Taproot or most roots, shallow (<15 cm)	Low (2)
Fibrous roots, usually up to30 cm	Medium (5)
Rhizomes with little indication of extensive fibrous roots	Medium (5)
Rhizomes with extensive fibrous roots	High (8.5)
Graminoids	
Annual, biennial, and short-lived perennials	Low (2)
Stoloniferous, cespitose, tufted, or short rhizomatous perennials (<1 m tall)	Low (2)
Slender or thin creeping rhizomes	Medium (5)
Long, stout, well-developed creeping rhizomes	High (8.5)
Woody Species	
Taprooted species	Low (2)
Short shrubs (<1 m tall) with shallow root systems	Low (2)
Shallow to moderate root systems	Medium (5)
Rhizomes, generally shallow (<15 cm)	Medium (5)
Root crown with spreading roots	High (8.5)
Widespread root systems	High (8.5)

Nonnative, Invasive Species (IN): Note nonnative, invasive species by marking this column.

Appendix B—Matrix of Correlated Items

The correlation matrix provided in table B-1 summarizes the "Correlation with Other Assessment Items" sections from each of the 20 lentic PFC items. NOTE: These are generalized, potential correlations, but in practice any given correlation may or may not be present for a given site. A "yes" or "no" response to one item does not necessitate a similar response in the highly correlated item(s). Therefore, the correlation of items is meant to be read by rows and not by columns. The correlation is limited to those primary assessment items with the strongest correlations in the majority of lentic sites. Other correlations may exist that are considered of minor importance or of limited application based on decades of PFC assessments across a wide variety of riparian-wetland types. Also, some correlations are reciprocal because the items commonly are interdependent, whereas other correlations are not reciprocal because one item may be the dependent variable and the other is an independent variable.

Table B-1. Summary of the most common correlations among assessment items.

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
HYDROLOGY																				
1 – Riparian-wetland area is saturated or inundated relatively frequently.			*			*				*							*			
2 – Fluctuation of water levels is within a suitable range.	*			*						*		*					*			
3 – Riparian-wetland area is enlarging or at potential extent.	*									*		*					*			
4 – Impairment from the contributing area is absent.																			*	
5 – Water quality supports riparian-wetland plants.								*	*	*	*	*	*			*				
6 – Disturbances negatively affecting flow patterns are absent.	*		*							*		*		*			*			
7 – Structure safely accommodates flow.				*																
VEGETATION																				
8 – Diversity of stabilizing riparian-wetland vegetation is adequate.											*		*							
9 – Age classes of stabilizing riparian-wetland vegetation are present.			*									*								

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
10 – Species present indicate soil moisture.	*		*			*				🟩							*			
11 – Stabilizing plant communities are present.											🟩		*							
12 – Riparian-wetland plants exhibit high vigor.									*	*		🟩								
13 – Amount of stabilizing riparian-wetland vegetation is adequate to dissipate energy and to resist physical alteration.		*	*					*	*	*	*	*	🟩							
14 – Abnormal frost or hydrologic heaving is absent.						*								🟩						
15 – Favorable microsite condition is maintained.				*		*									🟩					
SOILS/GEOMORPHOLOGY																				
16 – Accumulation of chemicals does not affect plant productivity/ composition.				*	*			*				*				🟧				
17 – Saturation composes and maintains hydric soils.	*		*			*				*							🟧			
18 – Geologic/soil layer restricts water percolation.			*														*	🟧		
19 – Riparian-wetland area is in balance with the water and sediment supply.				*															🟧	
20 – Shoreline characteristics dissipate wind and wave energy.																				🟧

Appendix C—Quantitative and Semiquantitative Techniques for Validating or Monitoring Assessment Items

The PFC protocol is a qualitative assessment of various attributes and processes. There will be times, however, when items from the assessment need to be quantified. Quantitative techniques are encouraged in conjunction with the PFC assessment for individual calibration where answers are uncertain (to validate a particular assessment item) or where experience is limited. In addition, the use of quantitative techniques is necessary to monitor the change in a particular attribute over time accurately and precisely.

Although quantitative techniques can be used to help address most of the assessment items, those items with exclusively observational indicators will be difficult to quantify; for example, item 12 (riparian-wetland plants exhibit high vigor) and item 14 (frost or abnormal hydrologic heaving is absent). Table C-1 provides a summary of techniques that can be used to quantify the PFC assessment items. These are the most commonly used and accepted procedures to date, and the list is by no means exhaustive. Some procedures are universal and applied in lotic and lentic systems. Others were initially developed and applied in lotic systems but can be modified and used in lentic systems. At the time of publication of this technical reference, the Bureau of Land Management was drafting a lentic monitoring protocol (Reynolds et al., 2020 working draft) that can be used to help quantify some of the PFC items.

Table C-1. Techniques for quantifying PFC assessment items.

Quantitative Item	Measurement (References)	Interpretation, Notes
Item 1: Riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events.		
Wetland delineation	USACE 1987; Tiner 2017.	Many of the wetland delineation indicators are pertinent to the determination of relatively frequent soil saturation and surface inundation.
Water-depth changes (using surface-water staff gages)	 USDA-NRCS 1997.	Lake-level records are maintained by numerous state and federal agencies, including the USGS, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, state engineers' offices, and other state water departments. Long-term records should be examined to determine if a change in water depth reflects a change in riparian-wetland extent.
Water-table position (using monitoring wells/piezometers)	USEPA 1991; USDA-NRCS 1997; Sprecher 2008; Cooper and Merritt 2012.	Information on water-table position throughout the growing season can provide information on the frequency, duration, and timing of surface inundation and soil saturation.

Quantitative Item	**Measurement (References)**	**Interpretation, Notes**
Evidence of hydric soil indicators (using soil pit or soil core)	See USDA-NRCS 2017; Vepraskas 2015; Vepraskas and Craft 2016; USDA Forest Service 2012b; Reynolds et al. (2020 working draft).	Many soil properties (e.g., color, horizon thickness, organic-matter content) must be quantified to qualify as hydric soil indicators.
Visual evidence of surface inundation or habitat extent (using aerial and satellite imagery)	Clemmer 2001; Prichard et al. 1999.	Aerial and satellite imagery can provide repeated visual documentation of surface inundation or the extent of riparian-wetland area.
Depth to water table and reducing conditions (using steel rods/rebar)	Bridgham et al. 1991.	The depth to the water table may be determined by driving rebar in the riparian-wetland soil. The oxidation/reduction process that occurs during saturation will change the color of the steel rod and can be measured to indicate the depth to the water table. Oxidized horizons will appear as rust on the rebar; anaerobic horizons will not induce rusting on the rebar. This technique works better in some soils than others. Process may take 2 or more weeks to develop adequate signs of oxidation.
Item 2: Fluctuation of water levels is within a range that maintains hydrologic functions and riparian-wetland vegetation.		
Water-level changes (using monitoring wells/piezometers)	USEPA 1991; USDA-NRCS 1997; Sprecher 2008; Cooper and Merritt 2012.	Water-level measurements should be taken at least four times a year, more often if possible. For a greater understanding of the groundwater/surface-water interactions, surface-water measurements should be made and correlated with fluctuations in groundwater levels in monitoring wells. The most reliable indicator for changes in shallow groundwater conditions supporting riparian vegetation is that of monitoring well measurements in the riparian area combined with detailed assessments of vegetative health.
Water-depth changes (using surface-water staff gages)	 USDA-NRCS 1997.	Lake-level records are maintained by numerous state and federal agencies, including the USGS, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, state engineers' offices, and other state water departments. Long-term records should be examined to determine if a change in water depth reflects a change in riparian-wetland extent.

Quantitative Item	**Measurement (References)**	**Interpretation, Notes**
Evidence of "bathtub ring" (using remote sensing products, such as aerial photographs, LIDAR, and satellite imagery)	Clemmer 2001; Prichard et al. 1999. Imagery products are available from the USDA Farm Service Agency, Aerial Photography Field Office. Increasingly, ID teams are collecting or have access to high-resolution, low-elevation aerial photography collected by UAVs (drones).	Riparian-wetland area should be inspected for evidence of a "bathtub ring" devoid of perennial riparian-wetland vegetation, and width changes over time should be mapped/measured.
Wetland delineation	USACE 1987; Tiner 2017.	Many of the wetland delineation indicators are pertinent to the determination of the range of fluctuation of water levels.
Item 3: Riparian-wetland area is enlarging or has achieved potential extent.		
Wetland delineation	USACE 1987; Tiner 2017.	Many of the wetland delineation indicators are pertinent to the determination of whether a riparian-wetland area is enlarging or has achieved potential extent.
Visual evidence of vegetation and water stages (using remote sensing products, such as aerial photographs, LIDAR, and satellite imagery)	Clemmer 2001; Prichard et al. 1999. Imagery products are available from the USDA Farm Service Agency, Aerial Photography Field Office. Increasingly, ID teams are collecting or have access to high-resolution, low-elevation aerial photography collected by UAVs (drones).	Riparian-wetland area changes should be mapped/measured over time. Commonly, a bird's-eye view can quickly reveal what is not immediately apparent from ground surveys. The photos should be taken at an appropriate time of the year when vegetation characteristics are most readily interpreted and seasonally high water stages or extent occur. In many places these conditions exist from mid- to late summer (Prichard et al. 1999). Color infrared is a preferred medium for aerial photography of riparian-wetland areas, as it permits more accurate interpretations of geomorphic features and vegetation than color or black-and-white photos (Clemmer 2001; Prichard et al. 1999).
Plant composition and cover	Burton et al. 2011; USDA Forest Service 2012b; Reynolds et al. (2020 working draft).	Burton et al. (2011) and USDA Forest Service (2012b) are quadrat methods for plant composition and cover. Comparison of different years' data of plant composition can help determine if hydric riparian-wetland vegetation is expanding or contracting at the site. Burton et al. (2011) described how to measure plant composition and cover in low-flow areas where perennial vegetation occupies the entire vegetated drainageway. Reynolds et al. (2020 working draft) is a line-point intercept (LPI) method for plant composition and cover.
Ecological type identification and ecological status determination	Weixelman et al. 1996.	This is an analytical method for classifying ecological types using a rooted frequency procedure.

Quantitative Item	Measurement (References)	Interpretation, Notes
Water-level changes (using monitoring wells/piezometers)	USEPA 1991; USDA-NRCS 1997; Sprecher 2008; Cooper and Merritt 2012.	Water-level measurements should be taken at least four times a year, more often if possible. For a greater understanding of the groundwater/surface-water interactions, surface-water measurements should be made and correlated with fluctuations in groundwater levels in monitoring wells. The most reliable indicator for changes in shallow groundwater conditions supporting riparian-wetland vegetation is that of monitoring well measurements in the riparian-wetland area combined with detailed assessments of vegetative health.
Redox potential	USDA Forest Service 2012b; Cooper and Merritt 2012.	Redox potential is a measure of the soil oxidation-reduction potential, which can be measured with a millivolt meter.
Item 4: Riparian-wetland impairment from the contributing area is absent.		
Visual evidence of watershed conditions (using aerial and satellite imagery)	Clemmer 2001; Prichard et al. 1999.	Commonly, a bird's-eye view can quickly reveal what is not immediately apparent from ground surveys. Aerial and satellite imagery can provide visual documentation of watershed conditions that may affect riparian-wetland conditions. Analyses should focus on evidence of erosion or runoff from roadways, burned areas, logged areas, cultivated areas, or other disturbances throughout the watershed, whether on federal public lands or adjacent lands of other ownership. In addition, the ID team should look for such features as dikes, levees, and ditches, which can alter the amount and pathway of water supplies.
Site equilibrium versus disequilibrium (using water budget models)	Dunne and Leopold 1978 (chapter 8); USDA-NRCS 1997.	Modeling the inputs, outputs, and storage of water through a riparian-wetland area may differentiate sites that are in equilibrium from those in disequilibrium.
Rate of sedimentation	Kleiss 1993.	Various methods can be used to determine if the rate of sedimentation is near a natural rate or accelerated due to human causes.
Watershed condition (using dendrogeomorphic methods)	Hupp and Morris 1990.	Cores and cross sections of specific trees are taken to obtain the age relative to geomorphic processes and recent deposition.
Watershed condition (using hydrogeomorphic methods)	Brinson et al. 1995; DeBano and Schmidt 1989.	This refers to a variety of quantitative methods to determine condition of watersheds and riparian-wetland areas.

Quantitative Item	**Measurement (References)**	**Interpretation, Notes**
Changes in groundwater extraction (using groundwater records)	Groundwater records (including location and number of wells and pumping volumes) are maintained by numerous state and federal agencies, including the USGS, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, state engineers' offices, and other state water departments.	Long-term records should be examined to determine if changes in groundwater extraction are tied to changes in water supply, water-table depth, and condition of riparian-wetland areas.
Item 5: Water quality is sufficient to support riparian-wetland plants.		
Electrical conductivity, cation exchange capacity, and pH	Moore et al. 2008. See instruction manuals for specific techniques and proper use of individual EC meters or multiprobe meters.	Direct measurement can indicate if there is high alkalinity, high salinity, or plant-limiting pH in the soil or water.
Level of key nutrients (phosphorous, nitrogen)	See instruction manuals for specific techniques and proper use of individual probes or multiprobe instruments.	Nutrient load can provide indications of contamination from surface-water runoff. Agricultural fertilizers and concentrated animal feeding operations are a common source of nutrients in water.
Water quality (using state and federal measurements)	Varied state and federal procedures.	U.S. Environmental Protection Agency and individual state procedures for each contaminant or substance evaluated should be followed.
Plant composition and cover	Burton et al. 2011; USDA Forest Service 2012b; Reynolds et al. (2020 working draft).	Burton et al. (2011) and USDA Forest Service (2012b) are quadrat methods for plant composition and cover that can be used to determine wetland status and tolerance of species to different levels of salinity, pH, or other chemical limitations. Burton et al. (2011) described how to measure plant composition and cover in low-flow areas where perennial vegetation occupies the entire vegetated drainageway. Reynolds et al. (2020 working draft) is an LPI method for plant composition and cover.
Ecological type identification and ecological status determination	Weixelman et al. 1996.	This is an analytical method for classifying ecological types using a rooted frequency procedure.
Item 6: Disturbances or features that negatively affect surface- or subsurface-flow patterns are absent. These disturbances/features include but are not limited to hoof action, dams, dikes, levees, spring boxes, diversions, trails, roads, rills, gullies, drilling activities.		
Bare ground	USDA Forest Service 2012b; Reynolds et al. (2020 working draft).	USDA Forest Service 2012b is a quadrat method that records a point-intercept estimate of bare ground. Reynolds et al. (2020 working draft) is an LPI method that records bare ground.

Quantitative Item	Measurement (References)	Interpretation, Notes
Soil/streambank alteration	Burton et al. 2011.	This is a quadrat method that records the presence of human- and animal-caused soil disturbance. Burton et al. (2011) described how to apply streambank alteration to low-flow areas where perennial vegetation occupies the entire vegetated drainageway.
Visual evidence of disturbances/features (using aerial and satellite imagery)	Clemmer 2001; Prichard et al. 1999.	Aerial and satellite imagery can provide visual documentation of watershed conditions that may affect surface-flow patterns. Analyses should focus on evidence of features that can act as hydrologic modifiers, such as roadways, dikes, levees, drainages tiles, and ditches that can alter the amount and pathway of water supplies.
Visual evidence of disturbances/features (using very low elevation photogrammetric techniques)	Booth et al. 2015; Cox et al. 2016, 2018.	Use of unmanned aerial vehicles (drones) and boom-mounted cameras can provide high-resolution images suitable for detailed, three-dimensional analysis.
Surface-water elevation (using surface-water records)	Sauer and Turnipseed 2010. Surface-water records are maintained by numerous state and federal agencies, including the USGS, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, state engineers' offices, and other state water departments.	Surface-water elevation can be monitored in a great variety of ways, including a staff gage; pressure transducer to measure the depth of a water column above the pressure sensor; or acoustic, radar, or optical (laser) water-level sensors, which determine lake stage by measuring the travel time from the sensor to the target (lake surface) and back (Sauer and Turnipseed 2010).
Changes in groundwater extraction (using groundwater records)	Groundwater records (including location and number of wells and pumping volumes) are maintained by numerous state and federal agencies, including the USGS, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, state engineers' offices, and other state water departments.	Long-term records should be examined to determine if changes in groundwater extraction are tied to changes in water supply, water-table depth, and flow patterns to riparian-wetland areas.

Quantitative Item	**Measurement (References)**	**Interpretation, Notes**
Water-level changes (using monitoring wells/piezometers)	USEPA 1991; USDA-NRCS 1997; Sprecher 2008; Cooper and Merritt 2012.	Water-level measurements should be taken at least four times a year, more often if possible. For a greater understanding of the groundwater/surface-water interactions, surface-water measurements should be made and correlated with fluctuations in groundwater levels in monitoring wells. The most reliable indicator for changes in shallow groundwater conditions supporting riparian-wetland vegetation is that of monitoring well measurements in the riparian-wetland area combined with detailed assessments of vegetative health.
Item 7: Impoundment structure accommodates safe passage of flows (e.g., no headcut affecting dam or spillway).		
This is a qualitative/observational indicator with no specific measurement procedure.		
Item 8: There is adequate diversity of stabilizing riparian-wetland vegetation for recovery/maintenance.		
Plant composition and cover	Burton et al. 2011; USDA Forest Service 2012b; Reynolds et al. (2020 working draft).	Burton et al. (2011) and USDA Forest Service (2012b) are quadrat methods for plant composition and cover that can be used to assess diversity. Burton et al. (2011) described how to measure plant composition and cover in low-flow areas where perennial vegetation occupies the entire vegetated drainageway. Reynolds et al. (2020 working draft) is an LPI method for plant composition and cover.
Ecological type identification and ecological status determination	Weixelman et al. 1996.	This is an analytical method for classifying ecological types using a rooted frequency procedure.
Item 9: There are adequate age classes of stabilizing riparian-wetland vegetation for recovery/maintenance.		
Plant composition and cover	Burton et al. 2011; USDA Forest Service 2012b.	Burton et al. (2011) and USDA Forest Service (2012b) are quadrat methods for plant composition and cover to help assess herbaceous plant reproduction status. Burton et al. (2011) described how to measure plant composition and cover in low-flow areas where perennial vegetation occupies the entire vegetated drainageway.
Woody species height class	Burton et al. 2011.	Woody species height class is used in conjunction with plant composition to characterize the height and structural diversity of woody plants. Burton et al. (2011) described how to measure the height of woody species in low-flow areas where perennial vegetation occupies the entire vegetated drainageway.

Quantitative Item	**Measurement (References)**	**Interpretation, Notes**
Woody species age class	Burton et al. 2011.	This is a quadrat method to quantify woody age classes. Burton et al. (2011) described how to quantify age classes of woody (riparian) species in low-flow areas where perennial vegetation occupies the entire vegetated drainageway.
Ecological type identification and ecological status determination	Weixelman et al. 1996.	This is an analytical method for classifying ecological types using a rooted frequency procedure.
Item 10: Species present indicate maintenance of riparian-wetland soil-moisture characteristics.		
Relative abundance of hydrophytic plants	USACE 2008.	The prevalence index described in USACE (2008) is used to determine the relative abundance of hydrophytic plants.
Plant composition and cover	Burton et al. 2011; USDA Forest Service 2012b; Reynolds et al. (2020 working draft).	Burton et al. (2011) and USDA Forest Service (2012b) are quadrat methods for plant composition and cover used to determine wetland status. Burton et al. (2011) described how to measure plant composition and cover in low-flow areas where perennial vegetation occupies the entire vegetated drainageway. Reynolds et al. (2020 working draft) is an LPI method for plant composition and cover.
Ecological type identification and ecological status determination	Weixelman et al. 1996.	This is an analytical method for classifying ecological types using a rooted frequency procedure.
Also see the National Wetland Plant List (which is periodically updated), available on the U.S. Army Corps of Engineers website and the USDA PLANTS Database. The wetland indicator categories (Lichvar et al. 2012, 2016) may be used to interpret the soil-moisture characteristics of individual plant species.		
Item 11: Stabilizing plant communities are present that are capable of withstanding overland flows (e.g., storm events, snowmelt), and wind and wave actions, and can resist physical alteration.		
Plant composition and cover	Burton et al. 2011; USDA Forest Service 2012b; Reynolds et al. (2020 working draft).	Burton et al. (2011) and USDA Forest Service (2012b) are quadrat methods for plant composition and cover used to assess plant communities. Burton et al. (2011) provided a metric for vegetation stability rating (Winward greenline stability rating). Burton et al. (2011) described how to measure plant composition and cover in low-flow areas where perennial vegetation occupies the entire vegetated drainageway. Reynolds et al. (2020 working draft) is an LPI method for plant composition and cover.
Ecological type identification and ecological status determination	Weixelman et al. 1996.	This is an analytical method for classifying ecological types using a rooted frequency procedure.

Quantitative Item	Measurement (References)	Interpretation, Notes
Item 12: Riparian-wetland plants exhibit high vigor.		
Weixelman et al. (1996) established procedures for documenting mean rooting depth and expected ranges of rooting depth associated with various ecological conditions of specific herbaceous riparian-wetland plant communities. Shallower rooting depths associated with declining status can be, in part, a quantitative measure of the vigor of the community.		
Item 13: An adequate amount of stabilizing riparian-wetland vegetation is present to protect soil surfaces and shorelines, to dissipate energy from overland flows and wind and wave actions, and to resist physical alteration.		
Plant composition and cover	Burton et al. 2011; USDA Forest Service 2012b; Reynolds et al. (2020 working draft).	Burton et al. (2011) and USDA Forest Service (2012b) are quadrat methods for plant composition and cover used to determine if enough stabilizing riparian-wetland species are present. Burton et al. (2011) provided a metric for vegetation stability rating (Winward greenline stability rating). Burton et al. (2011) described how to measure plant composition and cover in low-flow areas where perennial vegetation occupies the entire vegetated drainageway. Reynolds et al. (2020 working draft) is an LPI method for plant composition and cover.
Ecological type identification and ecological status determination	Weixelman et al. 1996.	This is an analytical method for classifying ecological types using a rooted frequency procedure.
Item 14: Abnormal frost or hydrologic heaving is absent.		
NOTE: Differentiation of normal from abnormal frost heaving is difficult even with quantitative measurements. The best approach is to have a reference site of the same riparian-wetland complex as the assessed site. Comparisons between reference and assessed sites can be made for (1) hummock height and density, (2) bulk density, (3) vegetation cover and percent bare ground, and (4) geometry/shape of hummocks.		
Soil texture and organic-matter content	Grab 2005.	Frost heave is unlikely in sand and gravel; in contrast, it commonly occurs in soils with high silt and nonplastic clay content as well as peat, which has high soil-moisture holding capacity.
Soil-temperature and soil-moisture regimes	Hough 1957; Grab 2005.	Abnormal or not, frost-heaved soils occur only where there is sufficient soil moisture and soil freezing.
Bulk density	Blake and Hartge 1986; Howard and Singer 1981; ASTM 2015.	There is speculation that compacted soil in the inter-hummock depression exhibits less heave than noncompacted soil in the hummock.
Vegetation cover	Grab 2005.	Differential frost in the soil profile can be produced by differential vegetation cover. Lower cover (both in terms of absolute cover and of biomass) is hypothesized to generate deeper frost formation in the soil profile.

Quantitative Item	Measurement (References)	Interpretation, Notes
Surface roughness	Booth et al. 2015; Thomsen et al. 2015.	Erosion-bridge, digital photogrammetry, laser scanner, or similar means should be used to create a digital elevation model to characterize surface roughness and compare to the control site within the same riparian complex (i.e., stratum). Surface roughness is hypothesized to increase when hummock topography is exaggerated by livestock activity (Booth et al. 2015).
Surface roughness (using very low elevation photogrammetric techniques)	Booth et al. 2015; Cox et al. 2016, 2018.	Use of unmanned aerial vehicles (drones) and boom-mounted cameras can provide high-resolution images suitable for detailed, three-dimensional analysis.
Item 15: Favorable microsite condition (e.g., woody material, water temperature) is maintained by adjacent site characteristics.		
This is a qualitative/observational indicator with no measurement procedure other than measurement of water temperature with a thermometer. Smith et al. (1995) described a procedure for characterization, assessment, and analysis that may help identify and model relations of adjacent sites to microsite conditions where they exist.		
Item 16: Accumulation of chemicals affecting plant productivity/composition is absent.		
Electrical conductivity, pH	Measurement of soil salinity and soil sodicity can be determined by saturated soil paste extracts (USDA Salinity Laboratory 1954; USDA-NRCS 1996). Soil salinity, soil sodicity, and pH can also be measured in the field with a multimeter, commonly using a 1:1 soil to distilled water solution. See instruction manuals for use of individual EC meters or multiprobe meters.	Soil salinity is determined by EC. Sodicity is measured by calculating the exchangeable sodium percentage or the sodium adsorption ratio (McCauley and Jones 2005).
Plant composition and cover	Burton et al. 2011; USDA Forest Service 2012b; Reynolds et al. (2020 working draft).	Burton et al. (2011) and USDA Forest Service (2012b) are quadrat methods for plant composition and cover used to determine ecological status, wetland status, and salt or alkalinity tolerance. Burton et al. (2011) described how to measure plant composition and cover in low-flow areas where perennial vegetation occupies the entire vegetated drainageway. Reynolds et al. (2020 working draft) is an LPI method for plant composition and cover.
Ecological type identification and ecological status determination	Weixelman et al. 1996.	This is an analytical method for classifying ecological types using a rooted frequency procedure.

Quantitative Item	Measurement (References)	Interpretation, Notes
Item 17: Saturation of soils (i.e., ponding, flooding frequency, and duration) is sufficient to compose and maintain hydric soils.		
Evidence of hydric soil indicators (using soil pit or soil core)	USDA-NRCS 2017; Vepraskas 2015; Vepraskas and Craft 2016; USDA-Forest Service 2012b; Reynolds et al. (2020 working draft).	Many soil properties (e.g., color, horizon thickness, organic-matter content) must be quantified to qualify as hydric soil indicators.
Wetland delineation	USACE 1987; Tiner 2017.	Many of the wetland delineation indicators are pertinent to the determination of relatively frequent soil saturation and surface inundation.
Depth to water table	USEPA 1991; USDA-NRCS 1997; Sprecher 2008; USDA Forest Service 2012b; Cooper and Merritt 2012.	A soil pit or an installed piezometer or monitoring well can be used to determine depth to saturated soils and/or the water table.
Visual evidence of surface inundation or habitat extent (using aerial and satellite imagery)	Clemmer 2001; Prichard et al. 1999.	Aerial and satellite imagery can provide repeated visual documentation of surface inundation or the extent of riparian-wetland area.
Item 18: Underlying geologic material/soil material/permafrost is capable of restricting water percolation.		
Evidence of an intact restrictive layer (using local geology or soil information)		Soil pits, bore hole logs, stratigraphic logs, or trenches can be examined to determine if a layer restrictive to water movement occurs at a depth below any ground disturbances and therefore is likely to be intact.
Visible evidence of wet conditions (using aerial imagery)	Clemmer 2001; Prichard et al. 1999.	Wet conditions (moist/saturated soils; surface inundation) may be visible in photographs taken during the wet time of the year.
Local disturbances versus regional responses to climate (using direct comparison of sites within the same riparian complex stratum)		Where disturbance to a restricted layer is suspected, the ID team can compare conditions of assessed site with similar sites (i.e., within the same type of riparian complex) in the vicinity to distinguish local disturbances from regionwide responses to climatic fluctuations.
Geologic faults	Soil maps for small areas can be obtained online from the USDA-NRCS Web Soil Survey.	Geologic maps should be examined to determine the trace of mapped faults. Minor faults may be visible from aerial imagery, LIDAR, or field exposures. Soil maps should also be consulted.
Item 19: Riparian-wetland area is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition).		
The riparian-wetland balance of water and sediment can be evaluated and quantified with some of the methods described under item 4 (riparian-wetland impairment from the contributing area is absent). In particular, water budget models (Dunne and Leopold 1978; USDA-NRCS 1997) and visual evidence of watershed conditions from aerial imagery (Clemmer 2001; Prichard et al. 1999) may be used to evaluate erosion and deposition at the watershed or riparian-wetland site scales.		

Quantitative Item	**Measurement (References)**	**Interpretation, Notes**
Item 20: Islands and shoreline characteristics (i.e., rocks, coarse and/or large woody material) are adequate to dissipate wind- and wave-event energies.		
Plant composition and cover	Burton et al. 2011; USDA Forest Service 2012b; Reynolds et al. (2020 working draft).	Burton et al. (2011) and USDA Forest Service (2012b) are quadrat methods used to determine total rock and wood cover and frequency. Burton et al. (2011) developed an approach to measure composition and cover on the lotic greenline, but the same rules can be applied to a shoreline. Reynolds et al. (2020 working draft) is an LPI method for plant composition and cover.
Visual evidence of shoreline stability (using aerial and satellite imagery)	Clemmer 2001; Prichard et al. 1999.	Aerial and satellite imagery can provide repeated visual documentation of shoreline stability and possible retreat.
Shoreline changes (using erosion pins and scour chains)	Rosgen 1996.	Erosion pins and scour chains may be used to measure the sedimentation/aggradation or retreat/erosion of a shoreline. Measurements of shoreline change should be evaluated with weather data on the magnitude and duration of recent storm events and snowpack.
Shoreline changes (using photopoints with reference points)		The ID team may use photopoints to document shoreline changes from multiple points and measure distances from multiple reference points to shoreline over time.

Appendix D—Applying Potential to the Assessment of Altered Lentic Areas

The need to assess lentic riparian-wetland areas that have experienced human alteration occurs frequently. Addressing how human alterations can affect site potential requires a common definition of "altered potential" and an analysis of the type, spatial extent, and degree of the alteration.

Altered lentic riparian-wetland sites are defined here as those with relatively permanent human alterations that can directly and substantially affect lentic area function. **Relatively permanent human alterations** are those that have legal, economic, or social constraints such that *changing or removing them would generally be prohibitive or very difficult.*

Examples of relatively permanent human alterations that can change site potential and function in lentic areas include dams/impoundments, dikes, levees, permanent diversions, channelization, roads, groundwater pumping, and related alterations. In addition to the physical permanency of most of these structures, legal water rights, special status species issues, costs, etc. associated with many of these structures represent constraints that can serve to further restrict the possibility for changing or removing them. Also, many of these alterations can occur on lands owned and managed by other entities, creating additional restrictions on the possibility or type of changes that can be realistically considered.

Developed lentic riparian-wetland sites that have structures but that lack the aforementioned permanency and constraints are not considered "altered lentic riparian-wetland sites" in accordance with the above definition. Rather, they are **"modified" lentic riparian-wetland sites.**

An example of a modified lentic riparian-wetland site would be a spring at a slope wetland that, although it features a spring box, pipeline, and a trough or small stock pond, lacks the relatively permanent alterations that define an altered lentic site; consequently, changing, moving, or removing the structures would be possible if desired. In this example, the ID team would describe the original site potential, and the assessment would document the degree to which the (nonpermanent) structures may affect function (figure D-1); the team would then address the assessment items considering this potential. This scenario is very common on public lands in the western United States. For modified lentic sites (as defined here), function may be substantially affected, but potential remains similar to an unaltered site, which is assessed in accordance with that potential.

The distinction between altered lentic sites (relatively permanent) and modified lentic sites (nonpermanent) is important to estimating potential correctly. It is key that the ID team clearly understands that not every developed lentic site is an altered lentic site (figure D-1), nor is every developed lentic site only a modified lentic riparian-wetland site. The determination of whether a developed lentic site has a relatively permanent human alteration, or is just modified, must be made and documented on a site-specific basis by the ID team.

By definition, distinguishing the permanency of alterations must include the criteria of how feasible it is to change, move, or remove the alteration. *This does not imply that developments/structures must always be changed, moved, or removed in order to achieve PFC, however.* Potential is applied to the PFC assessment by considering each item on the assessment form relative to what it can possibly attain in order to ensure an accurate assessment. A lentic area does not have to be at potential for any item to be answered "yes." Potential just needs to be considered when addressing the assessment items. *Both altered lentic sites and modified lentic sites can achieve PFC.*

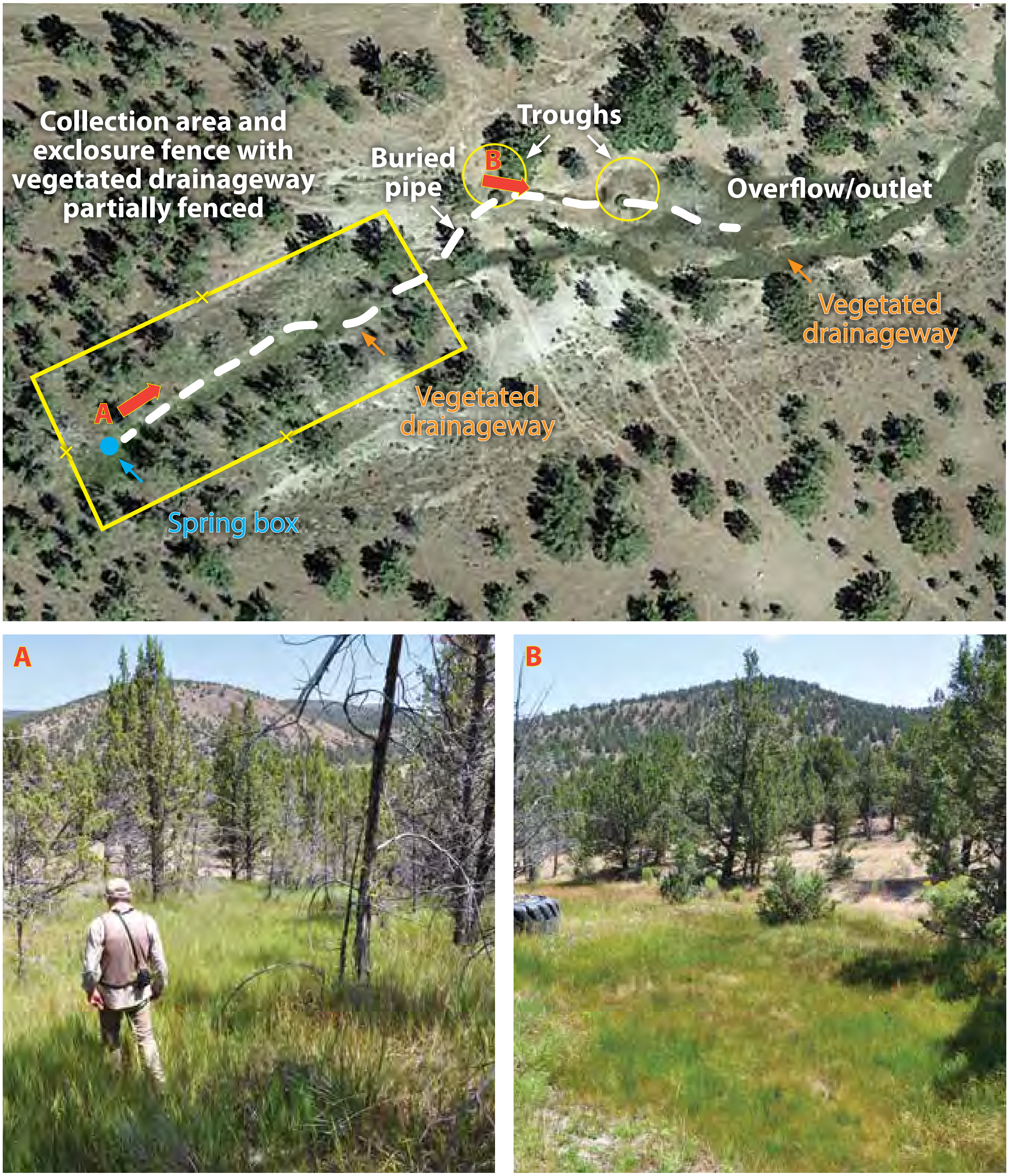


Figure D-1. Developed spring/seep with a vegetated drainageway that is partially fenced. This spring development is *not* a relatively permanent human alteration, as there are no legal, economic, or social constraints present and the structures can be modified, moved, or removed. Although function has been affected (the pipeline ditch depression and trough overflows have modified flow patterns and have created "new" riparian-wetland area outside of the original vegetated drainageway), the overall potential of the site has not changed. The original site potential would be used for the PFC assessment. ➡ = Location and direction of photos A and B.

Another example of a nonpermanent alteration could be a vegetated drainageway located within a sole land ownership, where OBL plants (sedges and bulrushes) were once dominant and two or three small earthen dams were constructed in the drainageway to store intermittent, low-volume surface water. In this example, vegetation in the drainageway quickly changed to primarily FAC plants with some FACW plants, the riparian-wetland area in the drainageway became narrower, and the downvalley extent of the riparian-wetland zone retracted further up the drainage. Thus, the ID team would use the original site potential as a gauge for the PFC assessment because these small earthen dams could be removed. However, in different circumstances—for example, if the impoundments were large and/or numerous or located on another ownership, or if some other constraining economic, social, or legal issue was tied to the area—it might not be feasible to remove them and they would be considered relatively permanent human alterations. In that case, the ID team would describe an altered potential (see question #4 below). If some possibility existed for them to be removed in the future, though, the original potential would be used.

Management activities (e.g., livestock grazing, logging, forest stand treatments, and recreation) are human-induced actions that can also affect and alter the condition of the site; however, they *are generally not relatively permanent human alterations.* For example, some slope wetlands impacted by grazing or recreation may have formed a headcut that caused them to incise to the point that they change from lentic systems to lotic systems (as depicted in chapter 4). Although the potential was changed (at least for many years without active restoration), it was not due to a relatively permanent human alteration but was the result of either poor management or natural processes or a combination of both. *This example of responses to stressors is neither a modified system nor a relatively permanent human alteration.*

Determining potential for human-altered systems can be challenging. The ID team must carefully consider the type, spatial extent, and degree of the alteration to determine if and in what manner the potential has actually changed. If necessary, the ID team should describe the altered potential, including the most appropriate attributes of hydrology, vegetation, and soil/landform that can be attained under permanent human alterations.

Because there are many unique alteration scenarios, and because the PFC assessment is a universal tool, creating detailed instructions applicable to all altered lentic sites would be impractical.

The following questions are provided to guide ID teams as they determine the potential of human-altered lentic areas. The answers to these questions should be documented on the "Lentic Riparian-Wetland Assessment Area Information Form – Altered Potential Attachment." See also flowchart figure D-2.

1. **Have the alterations created artificial conditions for a substantial part of the site (and riparian-wetland functions are not present or expected)?**

In most instances, determining if the site is altered so extensively that it is largely artificial will require the professional judgment of the ID team. This question is intended to eliminate from consideration those sites that are completely artificial or have been altered so substantially that, for the most part, they are no longer expected to provide natural lentic riparian-wetland area functions.

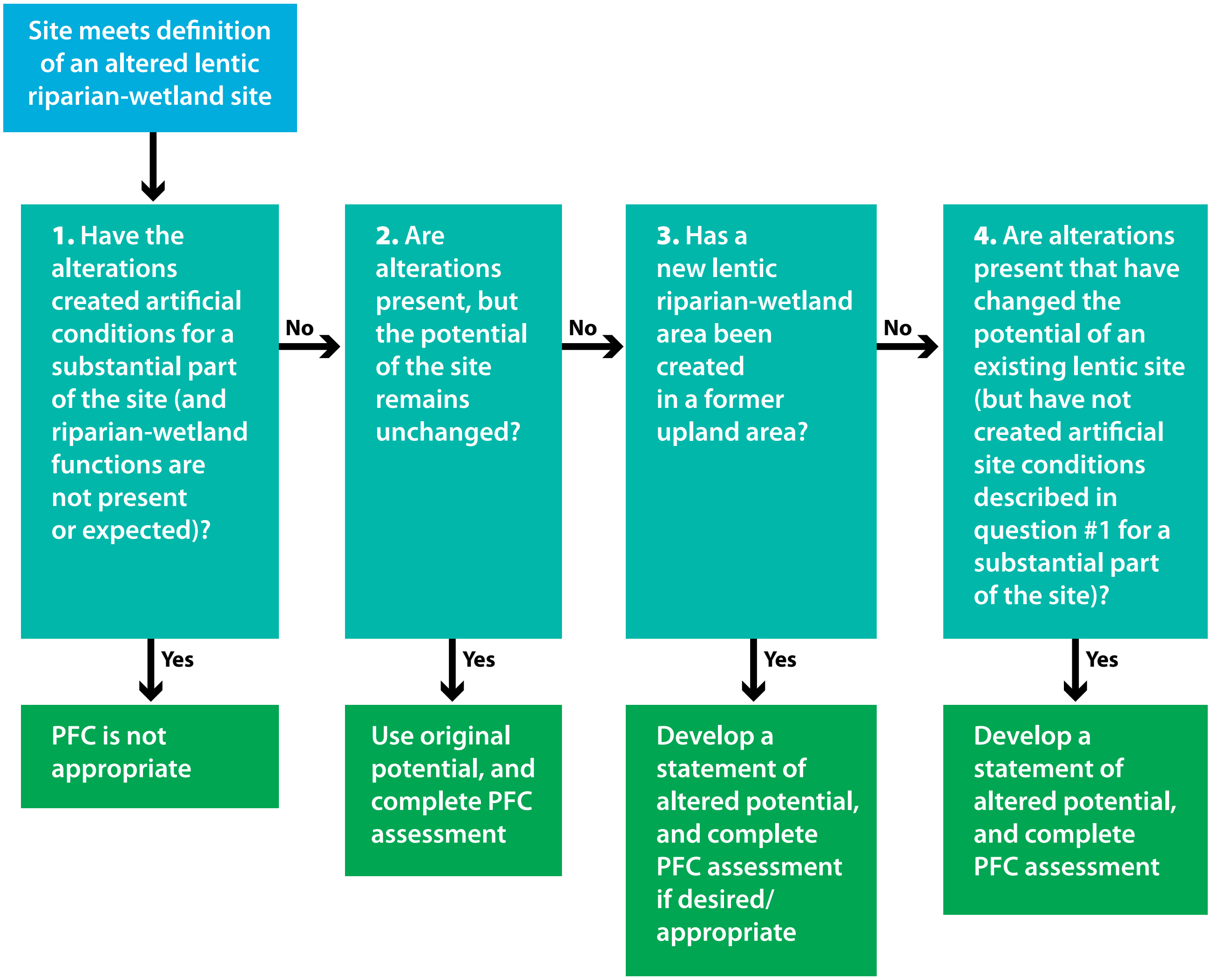


Figure D-2. Altered potential process diagram.

- If the lentic area is largely artificial, if riparian-wetland functions are not present or expected, and if the structures or activities are not expected to be changed or removed, PFC is generally not an appropriate tool for assessing the site (see example in figure D-3).

- A common example of an artificial lentic site is a reservoir or stock pond specifically designed to store water and/or to provide livestock and/or wildlife water onsite. These structures were not intended to provide riparian-wetland functions or values, nor are riparian-wetland functions present or expected. As a result, PFC is generally not an appropriate tool for assessing such a site (see figure D-3). If the reservoir or pond created new riparian-wetland area (i.e., riparian-wetland functions are present), the ID team would move on to question #3 below.

- Spring systems that have been almost completely dewatered by a permanent structural diversion at the source are common. In many of these instances, the associated riparian-wetland zone either has significantly retracted or has been eliminated. The ID team would first have to determine if the development was a relatively permanent human alteration and not just a simple water development (without the described constraints) that could be changed or removed without considerable difficulty (as described above).

- If the relatively permanent human alteration (structure) has permanently and completely dewatered a site and vegetation is largely UPL plant species, it is no longer a riparian-wetland area, and PFC is obviously not appropriate. The ID team would document that the riparian-wetland zone had been eliminated due to the permanent human alteration, describe the probability of water ever returning, and ensure that this information was tracked in the appropriate database. If some of the riparian-wetland zone is still intact, the altered potential would be described in accordance with question #3 below.

- If the development is scheduled for removal, the ID team would determine what effect the removal would have on the potential of the site. (The site may or may not be able to return to its original potential.)

- If artificial conditions exist but not for a substantial part of the site, the ID team would answer "no" to this question, provide a statement of rationale, and move on to questions #2, #3, and #4.

Figure D-3. Artificial stock pond constructed for livestock water. A vegetated drainageway feeds the pond and is mostly fenced. Water rights and social and economic factors likely prohibit this pond from being removed; therefore, it is relatively permanent. This structure was not intended to provide riparian-wetland values. For this site, question #1 would be answered "yes," and PFC would not be done. However, potential would be estimated, and PFC would be completed for the vegetated drainageway. In this instance, if a PFC assessment is done on the drainageway, the pond (not assessed) may have the potential to impair the drainageway (e.g., headcut moving up into the assessed drainageway).

2. Are alterations present, but the potential of the site remains unchanged?

If this is the case, the ID team would assess the condition of the site using the original potential. The mere presence of a relatively permanent human alteration does not necessarily change the potential of a site.

- An example would be a developed spring similar to the one described above under #1, except that the permanent development does not appreciably affect overall water volume enough to eliminate or measurably contract or alter the riparian-wetland zone. This situation is common.

- Another example would be where natural lakes and ponds have been modified or "artificially enhanced" to increase water storage capacity—usually by installing a dam and/or by excavating additional material. Many of these water bodies retain their original natural functions and have riparian-wetland vegetation along their shorelines. In such instances, the potential may not have changed whatsoever (figure D-4). If the structure/alteration *has* changed the potential, the ID team would proceed to question #3.

Figure D-4. Artificially enhanced pond where the installation of a dam structure enlarged the pond storage and riparian-wetland area along the banks. Economic and social factors prohibit this pond from being removed; therefore, it is relatively permanent. If those factors did not exist, it would not be relatively permanent. The potential of this site has not changed, and the original potential is used. This is an example of a "yes" response to question #2.

3. Has a new lentic riparian-wetland area been created in a former upland area?

Some human alterations/structures have created new riparian-wetland areas in former upland sites. Examples are well or spring outflow/overflow areas, water development overflows, mining activities that release groundwater to the surface, road building/modifications that change overland flow patterns, and the construction of reservoirs and ponds. Although these kinds of sites are technically "artificial," they may create sites that are effectively riparian-wetland areas. Therefore, these sites can be evaluated with the PFC protocol.

"Created" lentic riparian-wetland sites that are providing riparian-wetland functions and, subsequently, values could be evaluated for their functional attributes using the PFC assessment. The land use plan, goals, and policy of the management agency or landowner will dictate if PFC should be completed on these kinds of systems and exactly how the assessment information should be used.

- A common example is the construction of reservoirs and ponds that were initially intended for some utility purpose, such as water storage or livestock watering facilities, but that have developed riparian-wetland attributes and functions (figure D-5).

- The PFC assessment can be used for all human alterations that create new riparian-wetland areas. It will be challenging to develop a statement of potential for these kinds of systems. The ID team would have to do a careful analysis of the attributes and processes that had created the riparian-wetland area while documenting potential—which would be an altered potential. Once the altered potential was identified, the ID team would document that the potential of the site had changed because of a human alteration (upland to riparian), (2) describe the altered potential, (3) provide a rationale for how it determined the altered potential, and (4) assess the site in terms of this altered potential.

Figure D-5. This small reservoir was specifically designed for storage and livestock watering and was not intended to provide riparian-wetland values. However, it has developed riparian-wetland vegetation on the shoreline. This is an example of a "yes" response to question #3, and potential must be estimated if a PFC assessment is to be completed.
➡ = Location and direction of the photo.

4. Are alterations present that have changed the potential of an existing lentic site (but have not created artificial site conditions described in question #1 for a substantial part of the site)?

If this is the case, the ID team would have to determine the altered potential. The ID team would need to use professional judgment to answer these questions and to provide a rationale for how these guidelines were used to determine if PFC was appropriate and, if so, how potential was established for the altered site.

An example of a site that has an altered potential ("yes" to this question) would be a permanent spring development that did not eliminate the riparian-wetland zone as did the one described in the example under #1 (e.g., a small, wet meadow still exists). However, the development did alter the water regime enough to change the potential of the site (in contrast with the example in #2). The collection structure is concrete, and water is diverted offsite via a steel pipe that provides culinary water to a small residential home area. The water rights are not held by the landowner where the spring is located, and there is no reasonable chance for the structure to be removed or modified. Both the volume and frequency of surface inundation is less than before the development was constructed. Vegetation has shifted from a dominance of OBL plants (hydric plants) to primarily FAC and UPL plants (xeric), with scattered FACW plants (mesic) and some OBL species confined to the area very near the discharge point. (See figure D-6.)

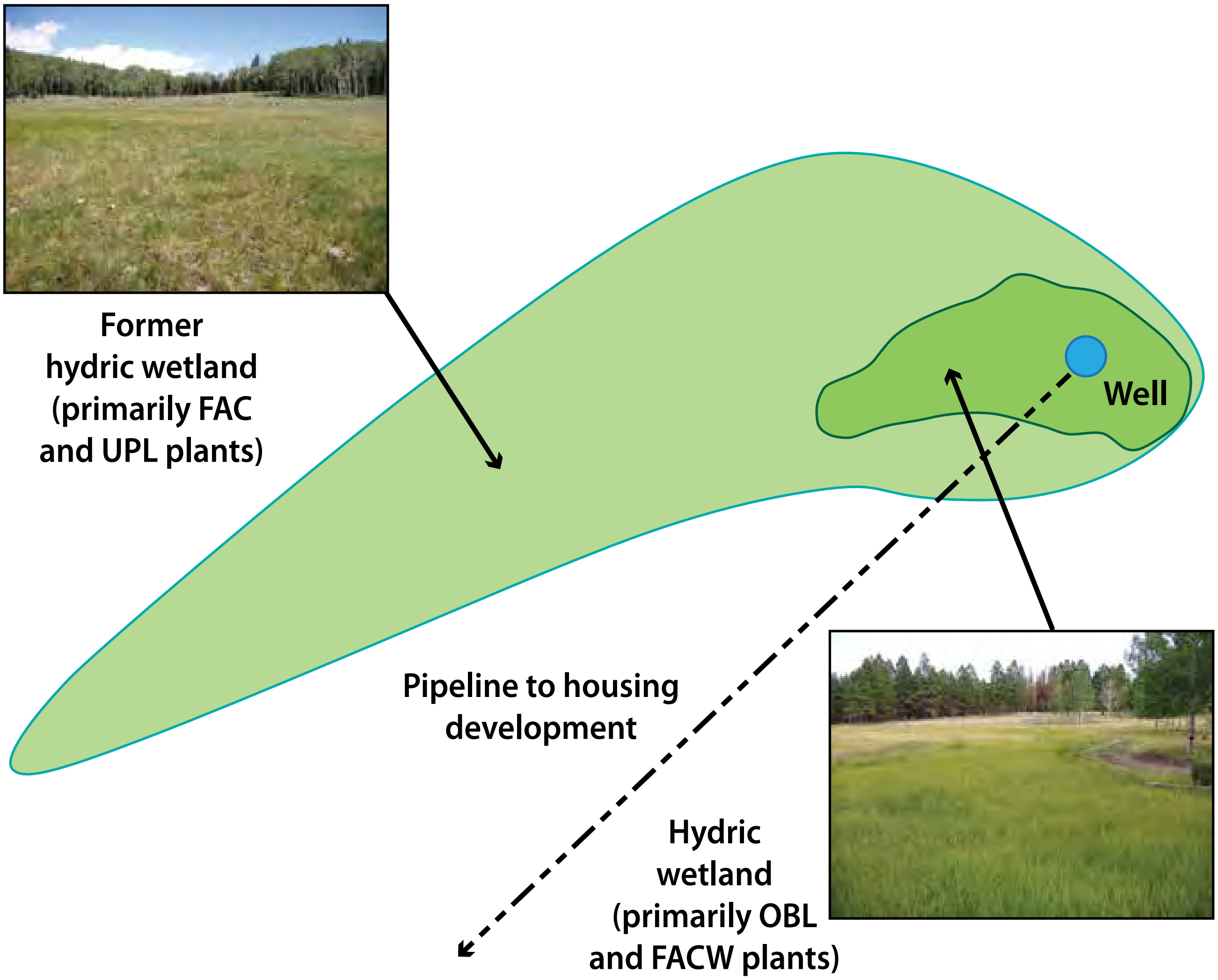


Figure D-6. Permanently altered site where an altered potential description is developed and used as the gauge for a PFC assessment.

Potential for the altered site in figure D-6 would be addressed as follows:

1. **Have the alterations created artificial conditions for a substantial part of the site (and riparian-wetland functions are not present or expected)?**

   No. While the volume and frequency of surface inundation has been reduced, the wet meadow associated with the spring can still produce riparian-wetland attributes that will allow it to meet the definition of PFC.

2. **Are alterations present, but the potential of the site remains unchanged?**

   No. The potential has changed.

3. **Has a new lentic riparian-wetland area been created in a former upland area?**

   No.

4. **Are alterations present that have changed the potential of an existing lentic site (but have not created artificial site conditions described in question #1 for a substantial part of the site)?**

   Yes, due to the construction of the water development, both the volume and frequency of surface inundation are less than before the structures were installed. Vegetation has shifted from a dominance of OBL plants to primarily FACW and FAC species with OBL plants isolated to very near the discharge point. The site is still able to function properly but cannot be expected to exhibit the same surface inundation regime and vegetation conditions possible before construction of the development.

For lentic areas without any development or relatively permanent human alteration, the site's (unaltered) potential applies to the volume and frequency of surface inundation and the type of wetland species that should be present. However, for sites with development or relatively permanent human alteration, the ID team must define a new/altered potential for evaluating the extent, volume, and frequency of inundation and the type of plant communities possible given the changed water regime. In the scenario described above, the associated wet meadow must now provide riparian-wetland function with a different suite of plant species. Therefore, the altered potential of this site is wet/mesic meadow dominated by FACW and FAC plants, and the site should be evaluated with this new potential. Finally, the ID team would *(1) document that the potential of the site had changed because of a relatively permanent human alteration, (2) describe the altered potential, (3) provide a rationale for how it determined the altered potential, and (4) assess the site in terms of this altered potential.* Doing so would ensure an adequate record of the process and rationale used to address an altered potential.

Appendix E—Example Assessments

Slope Wetland, Northern Rocky Mountains

Potential: This spring-fed slope wetland has the potential for water to be at or near the surface season-long. Multiple discharge points are present, and surface-water movement should be characterized by dispersed flow. Soils are loamy with a relatively thin organic surface horizon. Vegetation should be dominated by hydric meadow graminoid species that are OBL or FACW.

Rating and Key Factors: This riparian-wetland area was rated as FAR with a downward trend due to a number of factors that make it susceptible to further impairment. Items 6, 13, and 14 received "no" responses. Natural surface-flow patterns (item 6) have been altered by hoof action, and dispersed flow across the riparian-wetland area has been displaced with concentrated flow paths with excess bare ground between the hummocks. This is creating small channels that coalesce into a single channel at the downslope end of the riparian-wetland area (see arrow). In addition, there is not an adequate amount of stabilizing riparian-wetland vegetation present to protect the soil surface and dissipate energy during overland flows and to resist physical alteration (item 13). Abnormal frost/hydrologic heaving is present (item 14).

Functional–at risk with a downward trend

Artificially Enhanced Pond, Columbia Plateau

Potential: These photos show an artificially enhanced pond where a dam was constructed to increase surface-water storage. This pond was likely originally created by a beaver dam and is fed by a perennial spring complex characterized by both dispersed flow and a small spring brook (inflow and water volume are stable). Subsoil is clayey, thereby restricting water percolation, and soils along the shoreline are loamy with a high organic content. Shoreline vegetation should be dominated by hydric meadow graminoid species that are OBL or FACW. Aquatic emergent plants may be present in the potential natural community.

Rating and Key Factors: This pond was rated as PFC. All items received a "yes" or "NA" response. Water levels are stable (item 2); the structure (spillway) is accommodating safe passage of flows because it is well vegetated with stabilizing plants and no headcuts are present (item 7); and an adequate amount of stabilizing riparian-wetland vegetation is present to protect soil surfaces and shorelines, to dissipate energy from overland flows and wind and wave actions, and to resist physical alteration (item 13). There is a dense community of Nebraska sedge along the shoreline. Although this site has been grazed somewhat heavily, with visible trampling on the shoreline, livestock have not created deep pugging and significant hoof shear on the shoreline given the rooting properties of the stabilizing community of Nebraska sedge (demonstrating its ability to resist alteration). Also, no excessive erosion or deposition is occurring (item 19).

Proper functioning condition

Slope Wetland (Vegetated Drainageway), Colorado Plateau

Potential: This spring-fed slope wetland in a low-order vegetated drainageway has the potential for water to be at or near the surface season-long. Multiple discharge points along the drainageway are present and maintain saturated soil conditions throughout. Organic soil dominates the site. Deep-rooted OBL sedges dominate the plant community.

Rating and Key Factors: This riparian-wetland area was rated as PFC, primarily because there was ample evidence that water is abundant (item 1) and readily available to sustain riparian-wetland vegetation (item 8) and hydric soils (item 17), the vegetation is vigorous (item 12) and abundant, and the organic soils are in good condition with little evidence of trampling, hoof action, or oxidation of organic matter or soil erosion in general. Dense swards of strongly rooted sedges (item 11) create a resilient habitat that can withstand hoof action of ungulates without creating the soil pugging and soil poaching (item 6) that easily result in the absence of dense, strongly rooted swards.

Proper functioning condition

Slope Wetland (Vegetated Drainageway), Great Basin

Potential: A very shallow water table that is at and above the ground surface for parts of the growing season can produce saturated, anaerobic soils. This is a discharge groundwater-dependent site. Vegetation is adapted to anaerobic conditions and includes cattail, hardstem bulrush (*Schoenoplectus acutus*) and softstem bulrush (*Schoenoplectus tabernaemontani*), fewflower spikerush (*Eleocharis quinqueflora*), and American speedwell (*Veronica americana*) in the small aquatic pools that are fed by cool groundwater discharge. Mineral soils are gleyed to the surface. Although there is accumulation of organic matter, there is high sediment input from overland flows generated during frequent winter season frontal storm events and summer convective storms.

Rating and Key Factors: This vegetated drainageway was rated as FAR due to the chronic ground and flow-path disturbance (item 6), loss of stabilizing communities (item 11), loss of plant vigor (item 12), and inadequacy of riparian-wetland plant cover (item 13). Past grazing periods have resulted in chronic heavy to severe grazing in the vegetated drainageways, resulting in a loss of the palatable and strongly rooted riparian-wetland plants. The desired plants either exist in stunted and weakened condition or are being replaced with weakly rooted graminoids, such as redtop, Kentucky bluegrass, and toad rush (*Juncus bufonius*). The soil surface has much bare ground as a result of chronic ungulate trampling leading to soil pugging and soil poaching. Ground disturbance further weakens plants by shearing root systems.

The reference condition was a multidecadal grazing exclosure. The assessment area was immediately upvalley of the reference exclosure and in the same riparian complex. The exclosure and assessment areas share similar hydrologic, vegetation, and soil potential.

Reference Condition

Functional–at risk Assessment Area

Slope Wetland (Spring), Great Plains

Potential: This riparian-wetland area is a groundwater-dependent ecosystem that receives year-round groundwater discharge from a shallow alluvial aquifer. The abundance of water maintains a year-round water table that is at, near, and sometimes above the ground surface during the growing season. Soils are saturated, anaerobic, and organic. A mixed shrub/sedge community dominates the site. Shrubs typically occur along the mesic fringe of the slope wetland and on slightly drained, microtopographic highs (the product of either past hoof shear or frost-heave hummocks or both). Dominant shrubs include alder and water birch. Dominant grasses include American mannagrass (*Glyceria grandis*) and switchgrass (*Panicum virgatum*). The reference condition photo illustrates PNC. Dense, continuous swards of sedges provide ground cover and a resilient, protective root mat.

Rating and Key Factors: The assessed site was rated as FAR. It suffers from livestock trailing due to a lack of developed water in the pasture. Lack of herding has allowed livestock to loaf and concentrate near springs during the heat of summer. Livestock and wildlife have sought water from dispersed springs, commonly pawing at the ground to create small drinking pools (item 6). Soil loss is apparent by the elevated hummock microtopography of shrub-stemmed mounds (item 6), which average 30-45 centimeters (12-18 inches) high. Bare ground is extensive (item 6), and saturated soils are thoroughly poached by chronic soil trampling (item 6). Vegetation swards are small, broken, and patchy (item 11).

The reference condition was an adjacent pasture with offsite water development and a multipasture deferred rotation.

Reference Condition

Functional–at risk Assessment Area

Slope Wetland (Wet Meadow), Basin and Range

Potential: This wet meadow site is supported by groundwater discharge and a year-long high water table. Organic soil and anaerobic conditions promote the dominance of OBL sedges and rushes, including water sedge, analogue sedge (*Carex simulata*), beaked sedge, Nebraska sedge, and swordleaf rush (*Juncus ensifolius*). Woody plants are not expected under a high water table in the presence of saturated anaerobic soils.

Rating and Key Factors: This meadow was rated as FAR due to a headcut, which is having a demonstrable effect dewatering the site (item 3), oxidizing organic soils (item 17), and converting the plant community from one dominated by hydric plants (sedge/rush community) to mesic plants (item 10) (in particular, basin wildrye (*Leymus cinereus*), which is rated FAC in the Arid West region of the Great Basin). There are grayish, oxidized epipedons. Channelized flow and drainage of the meadow is not expected at potential. This lentic site has been altered functionally to a lotic site with formation and migration of a knickpoint (item 16 in the lotic PFC protocol).

Functional–at risk

Depressional Wetland (Prairie Pothole), Great Plains

Potential: This site is a natural riparian-wetland pothole. There is a seasonally high water table that intersects the ground surface and then subsides throughout the growing season in most years. Much of the water comes from ponded snowmelt and ponded precipitation and run-on from summer convective storms.

Hansen et al. (1995) describe a common spikesedge community type for many semipermanently to seasonally flooded wetlands. The dominant vegetation includes common spikerush (*Eleocharis palustris*), needle spikerush (*Eleocharis acicularis*), tufted hairgrass (*Deschampsia cespitosa*), and Nuttall's alkaligrass (*Puccinellia nuttalliana*). In deeper parts where there is standing water for a prolonged time, emergent vegetation, such as hardstem bulrush, alkali bulrush (*Scirpus maritimus*), and water smartweed (*Polygonum amphibium*) are common.

The fluctuating water table suggests redoximorphic features should be evident throughout the soil profile.

Rating and Key Factors: This site was rated as FAR with a downward trend (though currently at the upper range of the FAR scale). Notably, livestock use has led to soil compaction and soil pugging (item 6), particularly through the mesic fringe. These physical soil disturbances and chronic high levels of use have in turn altered the plant community to more weakly rooted (item 11) and early-seral plants, such as Kentucky bluegrass, foxtail barley (*Hordeum jubatum*), curlycup gumweed (*Grindelia squarrosa*), and curlydock (*Rumex crispus*).

Because of the presence of all desired species and good upland conditions and hydrologic processes, the ID team placed this site at the uppermost range of FAR; it appears the desired plant community could be restored with a few years of better livestock control and lighter use, particularly during the hot-season period, or shorter duration of use and more recovery time.

Functional–at risk with a downward trend

Example Assessment

Slope Wetland (Vegetated Drainageway)

Northern Rocky Mountains

Lentic Riparian-Wetland Assessment Area Information Form

I. Background information: Date: 8/8/18

Riparian-wetland area name: Bobcat Spring Area ID: BSDO-BOB-02

Management unit (allotment/pasture, other): Hard Scrabble Allotment

Administrative unit/state: Big Sky District Office

ID team members: Crystal Waters (hydrology), Sandy Plains (range), Robin Vogelsong (wildlife), Curly Dock (botany), Pete Moss (soils/geomorphology); also Buck and Kittie Hereford (permittees)

Areal extent of riparian-wetland assessment area: 4-5 ([✓ acres]/hectares – circle one)

Assessment method:

☒ Complete ground reconnaissance

☐ Ground inspection of selected representative areas

☐ Remote imagery with selective ground inspection of representative or other areas requiring closer inspection

II. Location of riparian-wetland assessment area:

Location: Attach aerial image, USGS 7.5-minute topographic map, or GIS map with the riparian-wetland assessment area delineated. Use GIS in the office or GPS in the field to obtain a representative location to affix a point to the riparian-wetland assessment area.

GIS/GPS point location of riparian-wetland assessment area

Latitude: xx.12345678 N Longitude: -xxx.12345678 W

or

UTM E ________ m UTM N ________ m

Datum: ☐ NAD27 ☒ NAD83 ☐ WGS84 ☐ Other (specify): ________

UTM Zone (required for UTM coordinates): ________

III. Description of potential and rationale: Should include description of hydrologic regime, geomorphic setting, important soil properties, and riparian-wetland plant communities at potential (if altered potential is present, use the "Altered Potential Attachment" below):

Groundwater-dependent ecosystem, Slope wetland (HGM) system

Hydrology - This spring-fed slope wetland has the potential for water to be at or near the surface throughout the growing season. Multiple discharge points are present along the length of the vegetated *drainageway. Surface water is seasonally expressed at the surface and held within the rooting zone of hydrophytic plants throughout the growing season.*

Vegetation - Hansen et al. (1995) describe a beaked sedge (i.e., formerly C. rostrata community, which today is identified as C. utriculata community) for these well-watered sites. These sites tend to form a monoculture of beaked sedge at potential. Other common plants (at potential) in this community include Geyer and Booth's willow along the mesic fringe; with Nebraska sedge, tufted hairgrass, Arctic (Baltic) rush, and swordleaf rush in the hydric zone.

Soils - High water table, anaerobic conditions, and cool growing season promote the formation of organic epipedons and histosols (e.g., cryofibrists, cryohemists). Organic horizons provide high soil-moisture holding capacity for hydric plants at potential.

IV. Other assessment or monitoring data or information about the riparian-wetland assessment area:

PFC assessment completed in 1998. This was a 20-year redo as part of a permit renewal. The information from the 1998 assessment was deemed "stale," and a new assessment was justified in accordance with the guidance on when to repeat a PFC assessment. 1998 assessment suggested much less impact to vegetated drainageway, probably because the water development had been installed in the 1970s and range files indicate it had been maintained and was operational throughout the 70s, 80s, and 90s.

No monitoring data were collected at this site, because for decades it had been in good shape and didn't rise to the level of management concern that would have necessitated monitoring.

Regular repeat photography available starting in 1964 at approximately 3 to 6 year intervals. Most photos taken at or near end-of-season, so plant expression is limited, but they do provide opportunity to see what pasture/riparian-wetland conditions were like at the end of a grazing period.

PFC Assessment Form (Lentic)

Riparian-wetland area name: Bobcat Spring Date: 8/8/18

Assessment ID team members: Crystal Waters (hydrology), Sandy Plains (range), Robin Vogelsong (wildlife), Curly Dock (botany), Pete Moss (soils/geomorphology); also Buck and Kittie Hereford (permittees) Riparian-wetland area ID: BSDO-BOB-02

<table>
<tr><th>Yes</th><th>No</th><th>NA</th><th>HYDROLOGY</th></tr>
<tr><td>X</td><td></td><td>▨</td><td>1. Riparian-wetland area is saturated at or near the surface or inundated in “relatively frequent” events.</td></tr>
<tr><td colspan="4">Rationale:
Multiple springs are present along the length of the vegetated drainageway. Evidence of seasonal soil saturation with mud-cracked ground and gleyed soils.</td></tr>
<tr><td>X</td><td></td><td></td><td>2. Fluctuation of water levels is within a range that maintains hydrologic functions and riparian-wetland vegetation.</td></tr>
<tr><td colspan="4">Rationale:
Hydrophytic vegetation suggesting adequate water during critical growing season. Because this is a groundwater discharge system, water availability does not seem to be limiting.</td></tr>
<tr><td></td><td>X</td><td></td><td>3. Riparian-wetland area is enlarging or has achieved potential extent.</td></tr>
<tr><td colspan="4">Rationale:
Margins have compacted soils, and hydric vegetation is replaced with upland species adapted to drier soil conditions. Riparian-wetland vegetation does not occupy the full extent of the vegetated drainageway, as margins appear to be drying out due to trailing and soil compaction.</td></tr>
<tr><td>X</td><td></td><td>▨</td><td>4. Riparian-wetland impairment from the contributing area is absent.</td></tr>
<tr><td colspan="4">Rationale:
Uplands are not the issue here. Uplands seem to be in good condition. No evidence of excessive erosion or runoff in uplands.</td></tr>
<tr><td>X</td><td></td><td></td><td>5. Water quality is sufficient to support riparian-wetland plants.</td></tr>
<tr><td colspan="4">Rationale:
The plants present are consistent with a freshwater spring system. No indication of high salinity or other plant-limiting water chemistry.</td></tr>
</table>

<table>
<tr><td></td><td>X</td><td></td><td>6. Disturbances or features that negatively affect surface- and subsurface- flow patterns are absent. These disturbances/features include but are not limited to hoof action, dams, dikes, levees, spring boxes, diversions, trails, roads, rills, gullies, drilling activities.</td></tr>
<tr><td colspan="4">Rationale:
Extensive hoof action and livestock trailing in the vegetated drainageway has had major alteration to surface-flow patterns, evidence of localized erosion/gullying in the drainageway, compaction of soils along the margin of the drainageway, and pugging in the wetter soils in the drainageway.</td></tr>
<tr><td></td><td></td><td>X</td><td>7. Impoundment structure accommodates safe passage of flows (e.g., no headcut affecting dam or spillway).</td></tr>
<tr><td colspan="4">Rationale:
NA - no dams or hydrologic infrastructure at this site.</td></tr>
</table>

<table>
<tr><th>Yes</th><th>No</th><th>NA</th><th>VEGETATION</th></tr>
<tr><td>X</td><td></td><td></td><td>8. There is adequate diversity of stabilizing riparian-wetland vegetation for recovery/maintenance.</td></tr>
<tr><td colspan="4">Rationale:
Multiple hydrophytic willow, sedge, and grass species. Many forb species (see plant list).</td></tr>
<tr><td></td><td>X</td><td></td><td>9. There are adequate age classes of stabilizing riparian-wetland vegetation for recovery/maintenance.</td></tr>
<tr><td colspan="4">Rationale:
Woody plants: Large clump willows do not have any recruitment. Only mature plants on site.
Herbaceous plants: Lots of bare ground where there should be mat-forming swards of sedges.</td></tr>
<tr><td></td><td>X</td><td></td><td>10. Species present indicate maintenance of riparian-wetland soil-moisture characteristics.</td></tr>
<tr><td colspan="4">Rationale:
Although OBL and FACW plants (see plant list) occupy the well-watered parts of the vegetated drainageway, they are clearly not found in all the geomorphic and topographic positions where they are expected.</td></tr>
</table>

X			11. Stabilizing plant communities are present that are capable of withstanding overland flows (e.g., storm events, snowmelt), and wind and wave actions, and can resist physical alteration.

Rationale:

Plenty of medium to high stabilizing sedges (see plant list).

	X		12. Riparian-wetland plants exhibit high vigor.

Rationale:

Many mature willows have heavily hedged appearance, indicating chronically heavy to severe browse levels up to about 5 feet height. Graminoid species are not mat-forming, indicating chronic breakage and disruption of root systems from soil pugging.

	X		13. An adequate amount of stabilizing riparian-wetland vegetation is present to protect soil surfaces and shorelines, to dissipate energy from overland flows and wind and wave actions, and to resist physical alteration.

Rationale:

Vegetated drainageway is at least 50 percent bare ground, considerably higher in some patches. Evidence of soil erosion and incipient gullying in places. The bare ground and gullying both suggest inadequate vegetative cover.

	X		14. Abnormal frost or hydrologic heaving is absent.

Rationale:

Ground disturbance from pugging is very high. Clearly the uniform mounds indicate frost heaving that would be considered abnormal.

		X	15. Favorable microsite condition (e.g., woody material, water temperature) is maintained by adjacent site characteristics.

Rationale:

This is not the type of site that requires or depends on microsite conditions. Groundwater discharge maintains riparian-wetland conditions.

<table>
<tr><th>Yes</th><th>No</th><th>NA</th><th>SOILS/GEOMORPHOLOGY</th></tr>
<tr><td>X</td><td></td><td></td><td>16. Accumulation of chemicals affecting plant productivity/composition is absent.</td></tr>
<tr><td colspan="4">Rationale:
No visible accumulations of chemicals on the surface or in the soil profile. No unusual assemblage of plants to indicate a concentration of chemicals.</td></tr>
<tr><td></td><td>X</td><td></td><td>17. Saturation of soils (i.e., ponding, flooding frequency, and duration) is sufficient to compose and maintain hydric soils.</td></tr>
<tr><td colspan="4">Rationale:
There is ample evidence that groundwater discharge is seasonally saturating some soils in the vegetated drainageway. However, the organic epipedon is also quite oxidized, indicating that the site is being desiccated to an extent that cannot maintain the organic epipedon under the current levels of pugging and trampling, which are probably contributing to some dewatering of the site.</td></tr>
<tr><td></td><td></td><td>X</td><td>18. Underlying geologic material/soil material/permafrost is capable of restricting water percolation.</td></tr>
<tr><td colspan="4">Rationale:
This is a groundwater discharge system, so item 18 is not applicable.</td></tr>
<tr><td></td><td>X</td><td></td><td>19. Riparian-wetland area is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition).</td></tr>
<tr><td colspan="4">Rationale:
Another difficult item to assess given the level of disturbance to the vegetated drainageway. The source of water is groundwater, and there is nothing to suggest that the water supply to the site has been altered. However, there is evidence of dewatering and soil erosion related to soil compaction and pugging and incipient gully formation (see, in particular, items 6 and 17).</td></tr>
<tr><td></td><td></td><td>X</td><td>20. Islands and shoreline characteristics (i.e., rocks, coarse and/or large woody material) are adequate to dissipate wind- and wave-event energies.</td></tr>
<tr><td colspan="4">Rationale:
This is a vegetated drainageway, and it does not have islands or shorelines that result from open, standing water. Therefore, item 20 is not applicable to this type of system.</td></tr>
</table>

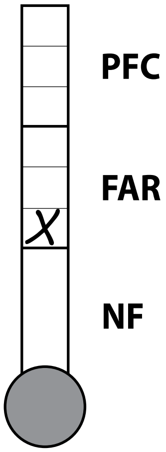
Summary Determination

Functional rating (check one)

☐ Proper functioning condition

☒ Functional–at risk

☐ Nonfunctional



Trend for FAR rating (check one)

Monitored trend	**Apparent trend**
☐ Upward	☐ Upward
☐ Downward	☒ Downward
☐ Static	☐ Not apparent

Rationale for rating: As commonly occurs, this assessment was somewhat more challenging to complete because it was done after the site had been recently grazed. This forced the ID team to shift its focus from the annual-use impacts to the specific long-term attributes and functions addressed in each assessment item. This riparian-wetland area is clearly not providing adequate vegetation, soil and landform, or woody material to dissipate energies and is not reducing erosion, improving water quality, and stabilizing the site from physical alterations. Therefore, it was rated functional–at risk with a downward trend due to a number of factors: “no” responses to item 3 (riparian-wetland area expanding or at potential extent) and item 6 (natural surface- and subsurface-flow patterns) in the hydrology section; item 9 (various age classes), item 12 (plants with high vigor), and item 13 (adequate riparian-wetland vegetative cover) in the vegetation section; and item 17 (saturation of soil to maintain hydric soils) and item 19 (riparian-wetland area is in balance with the water and sediment supply) in the soils section.

The overall desiccation of the site due to a loss of soil-moisture holding capacity, compaction, pugging and poaching, and accelerated drainage from the site means hydrologic function has been seriously impaired. Chronic trampling and heavy to severe levels of grazing have converted the plant community from deep-rooted, soil-stabilizing hydrophytic sedges to a sparse cover of shallow and weakly rooted facultative and upland plants with large patches of bare soils. Soil loss from erosion and oxidation of organic matter is high.

Rationale for trend (for FAR rating): Active gully erosion in the lower end of vegetated drainageway is moving headward and threatens integrity of entire site.

Are there factors present preventing the achievement of PFC or affecting progress towards desired condition that are outside the control of the manager?

☐ Yes ☒ No

If yes, what are those factors? Check all that apply.

☐ Flow regulation
☐ Mining activity
☐ Watershed condition
☐ Land ownership
☐ Dewatering
☐ Dredging activity
☐ Road encroachment
☐ Oil field water discharge
☐ Augmented flows
☐ Other (specify):

Explain factors preventing achievement of PFC: Current management is not providing adequate period of rest and recovery for riparian-wetland vegetation. In addition, the offsite water development is inoperable, and so livestock are seeking water in the drainageway instead of getting clean water from a trough. Need to fix water development and develop a better allotment rotation so livestock do not loaf and use this site for so long that plants and soil suffer and impact hydrology irreparably.

Lentic PFC Riparian-Wetland Plant List Form

Assessment area name: Bobcat Spring **ID:** BSDO-BOB-02

Region (USACE or other): Western Mountains, Valleys, and Coast (WMVC) **Date:** 8/8/18

√	Plant Symbol	Common Name	Scientific Name	AB	G/T	WIC	SC	IN
Trees/Shrubs								
	ALIN2	Gray alder	*Alnus incana*			FACW	H	
	AMAL2	Saskatoon serviceberry	*Amelanchier alnifolia*			FACU	M	
	BEOC2	Water birch	*Betula occidentalis*			FACW	H	
	COSE16	Redosier dogwood	*Cornus sericea*			FACW	H	
√	DAFR6	Shrubby cinquefoil	*Dasiphora fruticosa*	1	MF	FAC	M	
	POTR5	Quaking aspen	*Populus tremuloides*			FACU	H	
	PRVI	Chokecherry	*Prunus virginiana*			FACU	H	
	RIAU	Golden currant	*Ribes aureum*			FAC	M	
	RIHU	Northern black currant	*Ribes hudsonianum*			FACW	M	
	RILA	Prickly currant	*Ribes lacustre*			FAC	M	
	ROWO	Woods' rose	*Rosa woodsii*			FACU	M	
	SABE2	Bebb willow	*Salix bebbiana*			FACW	H	
√	SABO2	Booth's willow	*Salix boothii*	1	MF	FACW	H	
	SADR	Drummond's willow	*Salix drummondiana*			FACW	H	
	SAEX	Coyote willow	*Salix exigua*			FACW	M	
√	SAGE2	Geyer willow	*Salix geyeriana*	1	MF	OBL	H	
	SALU	Whiplash willow	*Salix lucida*			FACW	H	
	SALU2	Yellow willow	*Salix lutea*			OBL	H	
	SASC	Scouler's willow	*Salix scouleriana*			FAC	H	
√	SYAL	Common snowberry	*Symphoricarpos albus*	1	MF	FACU	M	
Graminoids/Grasses								
√	AGST2	Creeping bentgrass (redtop)	*Agrostis stolonifera*	4	W	FACW	L	
	ALPR3	Meadow foxtail	*Alopecurus pratensis*			FAC	M	
	CAAQ3	Water whorlgrass (brookgrass)	*Catabrosa aquatica*			OBL	L	
	CAAQ	Water sedge	*Carex aquatilis*			OBL	H	
	CAMI7	Smallwing sedge	*Carex microptera*			FACU	M	
√	CANE2	Nebraska sedge	*Carex nebrascensis*	2	W	OBL	H	
	CAPE42	Woolly Sedge	*Carex pellita*			OBL	H	
√	CAUT	Beaked sedge	*Carex utriculata*	2	L	OBL	H	
√	DECE	Tufted hairgrass	*Deschampsia cespitosa*	1	L	FACW	L	
	ELPA3	Common spikerush	*Eleocharis palustris*			OBL	M	
√	ELQU2	Fewflower spikerush	*Eleocharis quinqueflora*	1	T	OBL	M	
	GLYCE	Mannagrass	*Glyceria* sp.			OBL	M	

√	Plant Symbol	Common Name	Scientific Name	AB	G/T	WIC	SC	IN
Graminoids/Grasses (continued)								
	HOBR2	Meadow barley	*Hordeum brachyantherum*			FACW	L	
	HOJU	Foxtail barley	*Hordeum jubatum*			FAC	L	
√	JUAR2	Arctic rush	*Juncus arcticus*	3	W	FACW	H	
	JUEN	Swordleaf rush	*Juncus ensifolius*			FACW	M	
	LECI4	Basin wildrye	*Leymus cinereus*			FAC	M	
	PHAR3	Reed canarygrass	*Phalaris arundinacea*			FACW	M	√
	PHPR3	Timothy	*Phleum pratense*			FAC	L	
√	POPR	Kentucky bluegrass	*Poa pratensis*	3	W	FAC	L	
Forbs								
√	CIAR4	Canada thistle	*Cirsium arvense*	3	W	FACU	L	√
√	CIVU	Bull thistle	*Cirsium vulgare*	2	W	FACU	L	√
	EPILO	Willowherb	*Epilobium* spp.			FACW	L	
	FRVI	Virginia strawberry	*Fragaria virginiana*			FACU	L	
√	IRMI	Rocky Mountain iris	*Iris missouriensis*	3	MF	FACW	M	
	MEAR4	Wild mint	*Mentha arvensis*			FACW	L	
	MIGU	Seep monkeyflower	*Mimulus guttatus*			OBL	L	
	RAAQ	White water crowfoot	*Ranunculus aquatilis*			OBL	L	
√	TAOF	Common dandelion	*Taraxacum officinale*	3	W	FACU	L	
	THMO6	Mountain goldenbanner	*Thermopsis montana*			FAC	M	
	TRRE3	White clover	*Trifolium repens*			FAC	L	
	TYLA	Broadleaf cattail	*Typha latifolia*			OBL	H	
√	URDI	Stinging nettle	*Urtica dioica*	2	MF	FAC	H	
	VEAM2	American speedwell	*Veronica americana*			OBL	M	
√	CEST8	Spotted knapweed	*Centaurea stoebe*	3	W	UPL	L	√

Notes: ____________________

Appendix F—Cowardin Classification System

Adapted from Cowardin et al. 1979, USDI-FWS 2019, and FGDC 2013

In the 1970s the Fish and Wildlife Service embarked on an effort to inventory the wetlands (water depth less than or equal to 2 meters) and deepwater (water depth more than 2 meters) habitats of the United States. The Cowardin system (Cowardin et al. 1979) (see figure F-1) was developed to classify and describe different types of wetlands and deepwater habitats. The National Wetlands Inventory (NWI) uses the Cowardin classification system to produce a national inventory of the distribution and amount of these habitats as well as the status and trend of the nation's wetland habitats. This inventory is periodically revised.

The Cowardin classification system is the formal classification system of the Fish and Wildlife Service, and in 1996 it became the national standard for mapping wetlands and deepwater habitats (FGCD 2013). The Cowardin classification system is hierarchical with systems, subsystems, classes, subclasses, and modifiers. This hierarchical system provides progressively more refined stratification groups that can aid ID teams with stratification of the riparian-wetland sites of a project area. Initial mapping efforts were at a small scale (1:100,000 to 1:250,000), but currently much mapping is conducted at a larger scale of 1:24,000. A working knowledge of the NWI is valuable in obtaining broad-scale inventory of wetlands throughout a project area and in stratifying wetlands and riparian habitat.

Cowardin Classification System

Palustrine (P). This modifier describes all nontidal wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 parts per thousand (ppt). It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 hectares (20 acres), (2) active wave-formed or bedrock shoreline features, (3) water depth in the deepest part of basin less than 2 meters (6.6 feet) at low water, and (4) salinity due to ocean-derived salts less than 0.5 ppt.

Lacustrine (L). This modifier includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel, (2) lacking trees, shrubs, persistent emergent, emergent mosses or lichens with 30 percent or greater areal coverage, and (3) total area of at least 8 hectares (20 acres). Similar wetlands and deepwater habitats totaling less than 8 hectares are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin equals or exceeds 2 meters (6.6 feet) at low water. Lacustrine waters may be tidal or nontidal, but ocean-derived salinity is always less than 0.5 ppt. The Lacustrine System includes permanently flooded lakes and reservoirs, intermittent lakes (e.g., playa lakes), and tidal lakes with ocean-derived salinities below 0.5 ppt.

Riverine (R). All wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 ppt or greater. A channel is "an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water."

Estuarine (E). Deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The salinity may be periodically increased above that of the open ocean by evaporation. Along some low-energy coastlines there is appreciable dilution of sea water. Offshore areas with typical estuarine plants, such as red mangroves (*Rhizophora mangle*), are included in the Estuarine System. The Estuarine System includes both estuaries and lagoons.

Marine (M). Marine habitats are exposed to the waves and currents of the open ocean, and the water regimes are determined primarily by the ebb and flow of oceanic tides. Salinities exceed 30 ppt with little or no dilution except outside the mouths of estuaries.

Cowardin Classes

Rock Bottom (RB). All wetlands and deepwater habitats with substrates having an areal cover of stones, boulders, or bedrock 75 percent or greater and vegetative cover of less than 30 percent.

Unconsolidated Bottom (UB). Wetlands that have a muddy or silty substrate with at least 25 percent cover.

Aquatic Bed (AB). Wetlands with vegetation that grows on or below the water surface for most of the growing season.

Reef (RF). Ridgelike or moundlike structures formed by the colonization and growth of sedentary invertebrates.

Streambed (SB). All wetlands contained with the Intermittent Subsystem of the Riverine System and all channels of the Estuarine System or of the Tidal Subsystem of the Riverine System that are completely dewatered at low tide.

Rocky Shore (RS). All wetland habitats characterized by bedrock, stones, or boulders, which singly or in combination have an areal cover of 75 percent or more and an areal coverage by vegetation of less than 30 percent.

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

Moss-Lichen Wetland (ML). Areas where mosses or lichens cover substrates other than rock and where emergent plants, shrubs, or trees alone or in combination cover less than 30 percent.

Emergent Wetland (EM). Wetlands with erect, rooted herbaceous vegetation present during most of the growing season.

Scrub-Shrub Wetland (SS). Wetlands dominated by woody vegetation that is less than 6 meters (20 feet) tall. Woody vegetation includes tree saplings and trees that are stunted due to environmental conditions.

Forested Wetland (FO). Wetlands dominated by woody vegetation that is greater than 6 meters (20 feet) tall.

Cowardin Water Regime Modifiers

Permanently Flooded (H). Water covers the land surface throughout the year in all years. Vegetation is composed of obligate hydrophytes. This modifier is mostly applied to deepwater habitats, such as lakes where there is no chance of drying.

Intermittently Exposed (G). Surface water is present throughout the year except in years of extreme drought. This modifier is applied to large ponds and shallow lakes where the water does not appear likely to dry up.

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.

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. When surface water is absent, the water table is often near the land surface.

Seasonally Flooded-Saturated (E). Surface water is present for an extended period (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.

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.

Continuously 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.

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.

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.

Artificially Flooded (K). The amount and duration of flooding are controlled by pumps or siphons in combination with dikes, berms, or dams. The vegetation growing on these areas cannot be considered a reliable indicator of water regime. Examples of artificially flooded wetlands are some agricultural land managed under a rice-soybean rotation, and wildlife management areas where forests, crops, or pioneer plants may be flooded or dewatered to attract wetland wildlife. Neither wetlands within, or caused by leakage from, human-made impoundments nor irrigated pasture lands supplied by diversion ditches or artesian wells are included under the modifier. The artificially flooded water regime modifier should not be used for impoundments or excavated wetlands unless both water inputs and outputs are controlled to achieve a specific depth and duration of flooding.

Cowardin Special Modifiers

Beaver (b). This modifier describes wetlands that are formed within and adjacent to streams by beaver activity.

Excavated (x). This modifier describes wetlands that were created through the excavation of soils.

Partially ditched/drained (d). This modifier describes human alterations to wetlands, including ditches.

Diked/impounded (h). This modifier describes human alterations to wetlands where impoundments or dikes have been added.

Farmed (f). This modifier describes wetlands that have been altered due to farming practices.

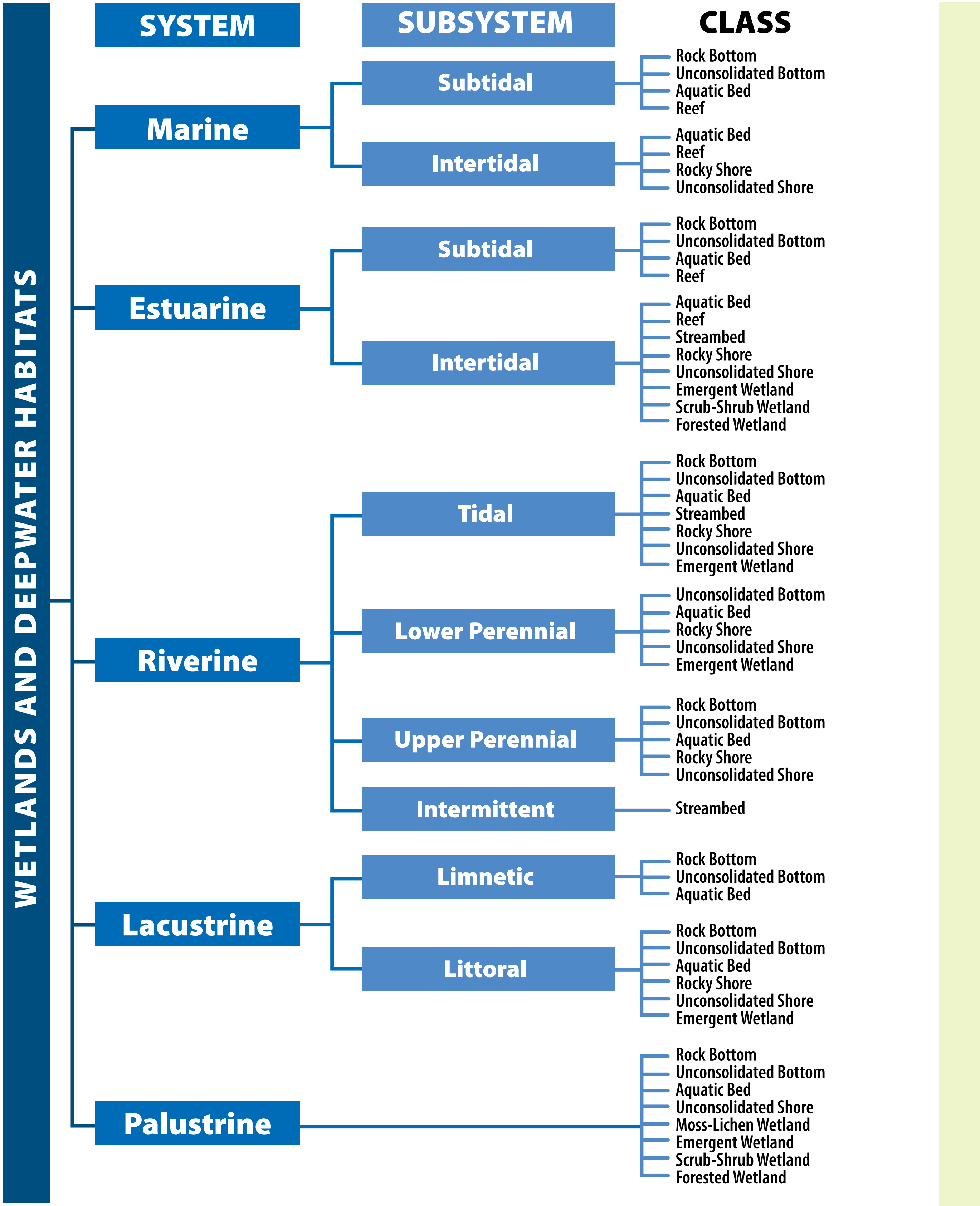


Figure F-1. Cowardin hierarchical classification system for wetland and deepwater habitats (from Cowardin et al. 1979).

There is an additional system recognized by USDI-FWS (2019):

> ***Riparian (Rp):*** The Fish and Wildlife Service used the principles and hierarchical structure of the Cowardin classification to develop a Riparian System for arid and semiarid areas of the western United States where mean annual evaporation exceeds mean annual precipitation by 10 inches or more. Riparian areas are plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainageways). 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.

The Riparian System is divided into two subsystems—lotic (denoted as "1") and lentic (denoted as "2")—which in turn are divided into three classes (Forested (FO), Scrub-Shrub (SS), Emergent (EM)), which have four subclasses (Dead (5), Deciduous (6), Evergreen (7), and Mixed (8)). Various dominance types are assigned to the different subclasses (table F-1).

Table F-1. Dominance types in the riparian system.

Deciduous Subclass	Evergreen Subclass	Mixed Subclass
• SY-Sycamore • CW-Cottonwood • SC-Salt Cedar • MQ-Mesquite • AS-Aspen • AL-Alder • RO-Russian Olive • WI-Willow • BB-Buckbrush • GW-Greasewood • RB-Rabbitbrush • MD-Mixed Deciduous	• JU-Juniper • WS-White Spruce • EO-Emory Oak • BS-Blue Spruce • SB-Sagebrush • ME-Mixed Evergreen	• AK-Alkali Sacaton • WW-Western Wheatgrass • GB-Great Basin Wild Rye

Examples (Palustrine System)

To classify Palustrine wetlands, 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 wet only at the beginning of the growing season: **PEMA**

3. A fen in the subalpine zone: **PEMB**

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 percent 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 only periodically flooded: **PSSA**

7. Dry cottonwood gallery forest along the floodplain: **Rp1FO**

Appendix G—Hydrogeomorphic Classification

Brinson (1993) developed the hydrogeomorphic classification to identify groups of wetlands that function similarly. The HGM classification is based on three factors that affect wetland functions: geomorphic setting, water source, and hydrodynamics. Additional modifiers (e.g., water chemistry, hydroperiod, plant communities) are used to define subclasses. HGM classes and subclasses can be used to stratify wetlands throughout a project area for purposes of PFC assessments and monitoring.

In the HGM approach, geomorphic setting encompasses the geologic setting, geologic evolution, landscape setting, landform, and topographic position of a wetland. Water source refers to the process by which water enters the wetland. It might be direct precipitation, overland flow or overbank flow, subsurface interflow or throughflow, groundwater discharge, or any combination of these. Hydrodynamics relates to the energy level and direction of moving water in the wetland. It can be unidirectional or bidirectional (or oscillating), and vertical or horizontal (table G-1; Smith et al. 1995). Much of the content in this section is taken directly from Brinson (1993), Smith et al. (1995), or Smith et al. (2013).

Table G-1. Fundamental factors that affect wetland function and are incorporated into the HGM classification.

Factor	Components: Examples
Geomorphic setting	Geologic setting: structural terrain; lithology Geologic evolution: eroded or constructed landforms Landscape setting: subwatershed headwater or watershed valley Landform: terrace, floodplain, hillslope, interdune, moraine Topographic position: top, middle, toe of hillslope
Water source	Direct precipitation onto/into wetland Surface flow: overland flow, overbank flow Subsurface flow: soil interflow, throughflow Groundwater flow: baseflow, groundwater discharge
Hydrodynamics	Directional: unidirectional (e.g., streamflow) or bidirectional/oscillating (e.g., tidal) Directional: vertical or horizontal.

Slope wetlands normally are found where there is a discharge of groundwater to the land surface. They normally occur on sloping land; elevation gradients may range from steep hillsides to slight slopes. Slope wetlands are usually incapable of depressional storage because they lack the necessary closed contours. Principal water sources are usually groundwater discharge and interflow from surrounding uplands, as well as precipitation. Hydrodynamics are dominated by downslope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by subsurface saturation, surface flows, and evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland.

Regional subclass examples: fens, vegetated drainageways, avalanche chutes

Depressional wetlands occur in topographic depressions. Dominant water sources are precipitation, groundwater discharge, and both interflow and overland flow from adjacent uplands. The direction of flow is normally from the surrounding uplands towards the center of the depression. Elevation contours are closed, thus allowing the accumulation of surface water. Depressional wetlands may have any combination of inlets and outlets or lack them completely. Dominant hydrodynamics are vertical fluctuations, primarily seasonal. Depressional wetlands may lose water through intermittent or perennial drainage from an outlet, by evapotranspiration, and, if they are not receiving groundwater discharge, by slowly contributing to groundwater. Peat deposits may develop in depressional wetlands. Prairie potholes are a common example of depressional wetlands.

> Regional subclass examples: Open groundwater; open surface water; prairie pothole marshes (subdivided by hydroperiod—ephemeral, temporary, seasonal—and by salinity—fresh, slightly brackish, moderately brackish), Nebraska rainbasins, California vernal pools, High Plains playas, Midwest and New England kettles, cypress domes

Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. In some cases, these wetlands consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface-water flow is bidirectional, usually controlled by water-level fluctuations, such as seiches in the adjoining lake. Lacustrine fringe wetlands are indistinguishable from depressional wetlands where the size of the lake becomes so small relative to fringe wetlands that the lake is incapable of stabilizing water tables. Lacustrine fringe wetlands lose water by flow returning to the lake after flooding, by saturation surface flow, and by evapotranspiration. Organic matter normally accumulates in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are a common example of lacustrine fringe wetlands.

> Regional subclass examples: Great Lakes marshes, Flathead Lake marshes

Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are often overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. However, sources may be interflow and return flow from adjacent uplands, occasional overland flow from adjacent uplands, tributary inflow, and precipitation. At their headwater, riverine wetlands often are replaced by slope or depressional wetlands where the channel morphology may disappear. They may intergrade with poorly drained flats or uplands. Perennial flow in the channel is not a requirement.

> Regional subclass examples: Upper perennial, lower perennial, nonperennial bottomland hardwood forests, riparian forested wetlands, headwater stream, perennial stream

Mineral soil flats are most common on interfluves, extensive relict lake bottoms, or large historic floodplain terraces where the main source of water is precipitation. They receive no groundwater discharge, which distinguishes them from depressional and slope wetlands. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, saturation overland flow, and seepage to underlying groundwater. They are distinguished from flat upland areas by their poor vertical drainage, often due to spodic horizons and hardpans, and low lateral drainage, usually due to low hydraulic gradients.

> Regional subclass examples: playas, wet pine flatwoods

Organic soil flats, or extensive peatlands, differ from mineral soil flats, in part because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by saturation overland flow and seepage to underlying groundwater. Raised bogs share many of these characteristics but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peatlands are common examples of organic soil flat wetlands.

Regional subclass example: peat bogs

Tidal fringe wetlands occur along coasts and estuaries and are under the influence of sea level. They intergrade landward with riverine wetlands where tidal currents diminish and river flow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. The interface between the tidal fringe and riverine classes is where bidirectional flows from tides dominate over unidirectional flow controlled by floodplain slope of riverine wetlands. Because they frequently flood and because water-table elevations are controlled mainly by sea-surface elevation, tidal fringe wetlands seldom dry for significant periods.

Regional subclass examples: Chesapeake Bay marshes, San Francisco Bay marshes; salt marshes

Glossary

Advanced ecological status – A community with a high coefficient of similarity to a defined or perceived PNC for an ecological site, usually late seral or PNC ecological status.

Aerobic – A condition in which molecular oxygen is a part of the environment.

Altered potential – The best possible ecological status that can be attained under relatively permanent human alterations.

Anaerobic – A condition in which molecular oxygen is absent (or effectively so) from the environment (USDA-NRCS 2017). The condition typically occurs in a soil environment experiencing continuously saturated conditions, during which time microbial respiration consumes any available oxygen.

Aquiclude – Zone or lithology that is completely impermeable (see also *Aquitard*). Aquicludes do not transmit groundwater.

Aquifer – Lithology or unconsolidated material that is permeable, contains and transmits groundwater, and has moderate to high rates of hydraulic conductivity, typically at rates that can support groundwater pumping and extraction.

Aquitard – Zone or lithology within the Earth that restricts or retards the flow of groundwater from one aquifer to another. Aquitards have low hydraulic conductivity. Typically, aquitards occur in clay and nonporous rock.

Capillary zone – Zone of negative water pressures immediately above the water table. The capillary zone is a region that is saturated or nearly saturated as a result of capillary rise (i.e., where surface-tension forces draw water into the pore spaces above the water table).

Community type – A repeating classified and/or recognizable assemblage or grouping of plant species. Community types often occur as patches, stringers, or islands and are distinguished by floristic similarities in both their overstory and understory layers.

Compaction – See *Soil compaction.*

Duration – A general descriptive term for the time that inundation lasts per flood occurrence for a geographic area. Categories include the following: very brief (less than 2 days); brief (2 to 7 days); long (7 days to 1 month); very long (more than 1 month); and flash flooding (less than 2 hours).

Ecological site – A conceptual division of the landscape, defined as a distinctive kind of land (based on recurring soil, landform, geological, and climate characteristics) that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances (Caudle et al. 2013).

Ecotone – A transition area of vegetation between two communities that has characteristics of both kinds of neighboring vegetation as well as characteristics of its own. Ecotones vary in width, depending on site and climatic factors.

Ephemeral system – A system that flows or temporarily holds water only in direct response to precipitation. It receives no water from springs and has no long-continued supply from melting snow or other surface sources. Its stream channel or ground surface is always above the water table. The term "ephemeral" may be arbitrarily restricted to streams or stretches of streams that do not flow continuously during periods of as much as 1 month (Meinzer 1923). An ephemeral system does not exhibit the typical biological, hydrological, and in some cases, physical characteristics associated with the continuous or intermittent availability of water (Nadeau 2011). The PFC assessment protocol is not designed for use on ephemeral streams or ephemeral sites.

FAC (facultative plants) – Plants that occur in wetlands and nonwetlands. These plants can grow in hydric, mesic, or xeric habitats. The occurrence of these plants in different habitats represents responses to a variety of environmental variables other than just hydrology, such as shade tolerance, soil pH, and elevation, and they have a wide tolerance of soil-moisture conditions (Lichvar et al. 2012).

FACU (facultative upland plants) – Plants that usually occur in nonwetlands but may occur in wetlands. These plants predominately occur on drier or more mesic sites in geomorphic settings where water rarely saturates the soils or floods the soil surface seasonally (Lichvar et al. 2012).

FACW (facultative wetland plants) – Plants that usually occur in wetlands but may occur in nonwetlands. These plants predominately occur with hydric soils, often in geomorphic settings where water saturates the soils or floods the soil surface at least seasonally (Lichvar et al. 2012).

Fen – An ecosystem with hydric soils, an aquic soil-moisture regime, and an accumulation of peat in the histic epipedon. Organic soil contains a minimum of 40 centimeters (16 inches) of organic horizons within the upper 80 centimeters (32 inches) of the soil profile. The organic horizons contain at least 12 percent to 18 percent organic-carbon content by dry weight, depending upon the percentage of clay in the mineral fraction. Many or most fens have areas of thinner peat soils. These could be on the margins of a basin or the edges of a spring complex. However, all wetland areas connected to the main peat body should be considered part of the fen complex. Compared with other habitats, fens support a disproportionately large number of rare vascular and nonvascular plant species and have importance for regional biological diversity (Weixelman and Cooper 2009).

Flark – Elongated, water-filled depression in a peatland (e.g., bog, fen) commonly occurring as a series of parallel depressions between ridges known as "strings."

Flooding – When the soil surface is temporarily covered with water from any source, such as overflowing streams or rivers, runoff from adjacent slopes, and inflow from high tides.

Frequency – A general descriptive term for the relative annual chance of reoccurrence of a flooding event for a geographic area. Categories include the following: none (0 percent chance); rare (0 to 5 percent chance); occasional (5 to 50 percent chance); and frequent (greater than 50 percent chance).

Frost (or abnormal hydrologic) heaving – The lifting of a surface by the internal action of frost or hydrostatic pressure. It generally occurs after a thaw, when the soil is filled with water droplets and when a sudden drop in temperature below freezing changes the droplets into ice crystals, which involves expansion and consequently causes an upward movement of the soil. The process is exacerbated when there is compaction between plant tussocks (e.g., from hoof action) and/or excessive removal of thermal vegetation cover. The result is the hummocked appearance of plants being elevated above the normal ground surface, root shearing between plants, and exposure of interspaces to increased erosional forces.

Geomorphology – The study of the age and evolution of landforms and the Earth surface processes that shape them.

Gleyed matrix – Soils with a gleyed matrix have the following combination of hue, value, and chroma, and the soils are not glauconitic: 10Y, 5GY, 10GY, 10G, 5BG, 10BG, 5B, 10B, or 5PB with value 4 or more and chroma is 1; or 5G with value 4 or more and chroma is 1 or 2; or N with value 4 or more; or (for testing only) 5Y, value 4, and chroma 1. In some places the gleyed matrix may change color upon exposure to air (reduced matrix). This phenomenon is included in the concept of gleyed matrix (USDA-NRCS 2017).

Greenline – The first perennial vegetation that forms a lineal grouping of community types at or near the water's edge along a stream channel, lake, or pond. Most often it occurs at or slightly below the bankfull stage (Burton et al. 2011; Winward 2000).

Histic epipedon – A thick (20-60 centimeters, or 8-24 inches) organic soil horizon that is saturated with water at some period of the year unless artificially drained and that is at or near the surface of a mineral soil (USDA-NRCS 2017).

Histosols – Organic soils that have organic soil materials in more than half of the upper 80 centimeters (32 inches), or that have organic materials of any thickness if they overlie rock or fragmental materials that have interstices filled with organic soil materials (USDA-NRCS 2017).

Hummock – A general term to describe an elevated mound of 10-100 centimeters (4-40 inches) in height. Hummocks, as a general term, could be further distinguished to reflect growth of sphagnum peat mounds (turf hummocks), vegetation masses (tuffets), frost-heaved ground (frost hummock), or hoof-disturbed ground or erosion pedestals (pedestals). In this document, no effort is made to suggest the genesis or type of hummocks.

Hydraulic conductivity – The rate at which water moves through a porous medium.

Hydric – Characterized by, relating to, or requiring an abundance of moisture.

Hydric soil – A soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in its upper part (USDA-NRCS 2017).

Hydrogen sulfide odor – The odor of H_2S; an odor similar to the smell of rotten eggs (USDA-NRCS 2017). Hydrogen sulfide gas is produced in soils that experience extended periods of saturation and anaerobic conditions. Sulfur compounds must also exist in the soil for H_2S gas to form.

Hydrogeomorphic – Features pertaining to the hydrology and/or geomorphology of a riparian-wetland area.

Hydrologic heaving – The upward and outward movement of the ground surface (or objects on, or in, the ground) caused by the formation of ice in the soil (from Harris et al. 1988).

Hydroperiod – The period during which soils, water bodies, and sites are wet. The seasonal pattern of water-table depth in a riparian-wetland.

Hyporheic zone – A unique hydrochemical and biological region beneath and lateral to a streambed or wetland, where there is mixing of groundwater and surface water.

Incised channel – A stream channel that has cut into the bed of the valley due to erosive lowering of the streambed, which keeps the stream from accessing its floodplain in relatively frequent events.

Intermittent system – A stream or riparian-wetland system that flows or holds water only at certain times when it receives water from springs or gradual and long, continued snowmelt. The intermittent character is generally due to fluctuations of the water table whereby part of the time the streambed or ground surface is below the water table and part of the time it is above the water table. The term "intermittent" may be arbitrarily restricted to streams, stretches of streams, or riparian-wetland areas that flow or hold water continuously during periods of at least 1 month (Meinzer 1923). An intermittent system may lack the biological and hydrological characteristics commonly associated with continuous inundation or saturation (Nadeau 2011).

Inundation – A condition in which water from any source temporarily or permanently covers a land surface.

Lentic – A riparian system characterized by still or very slow-moving water (in contrast to lotic riparian systems). Lentic riparian-wetland systems include but are not limited to seeps, springs, marshes, swamps, bogs, fens, muskegs, prairie potholes, wet and moist meadows, vegetated drainageways, oxbows, beaver complexes, shallow (a depth of 2 meters or less) lakes and ponds, and constructed reservoirs. Lentic systems may be independent of 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 lentic systems are located, water within them generally does not have the requisite energy to form and maintain a scour channel when the systems are functioning properly or at their potential (Prichard et al. 2003). Movement of sediment and organic matter may occur through dissolved or suspended transport, but bedload transport is minor and inconsequential in the development, maintenance, and function of most lentic environments.

Lotic – A riparian system 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.

Mesic – The mesic habitat occurs in a variety of settings, typically with dense vegetation that shades damp or moist soils that are not hydric. In these settings, organic matter, which accumulates as plants decay, moderates soil temperatures and increases the soil's water-holding capacity (Curtis 1959 as used by Lichvar et al. 2012).

Microtopography – A general term to describe topographic variability of the ground surface. In this document the scale of variability is tied to the size of common plants and ranges from a few centimeters to a meter.

Muck – Sapric organic soil material in which virtually all the organic material is so decomposed that identification of plant life-forms is not possible. Bulk density is normally 0.2 g/cm^3 or more. Generally, muck has less than one-sixth fibers after rubbing (USDA-NRCS 2017). (Also see *Mucky peat, Peat,* and *Organic soil material.*)

Mucky peat – Hemic organic material characterized by decomposition that is intermediate between that of peat (fibric material) and that of muck (sapric material). Bulk density is normally between 0.1 and 0.2 g/cm^3. Generally mucky peat does not meet the fiber content (after rubbing) for either peat (fibric material) or muck (sapric material) (USDA-NRCS 2017). (Also see *Muck, Peat,* and *Organic soil material.*)

OBL (obligate plants) – Plants that almost always occur in wetlands. With few exceptions, these plants (herbaceous or woody) are found in standing water or seasonally saturated soils (14 or more consecutive days near the surface (Lichvar et al. 2012)).

Organic soil material – Soil material that is saturated with water for long periods or artificially drained and, excluding live roots, has 18 percent or more organic carbon with 60 percent or more clay or 12 percent or more organic carbon with 0 percent clay. Soils with an intermediate amount of clay have an intermediate amount of organic carbon (USDA-NRCS 2017). Organic soil material includes *Muck, Mucky peat,* and *Peat.*

Peat – Organic matter (the dead remains of plants) deposited under water-soaked conditions as a result of incomplete decomposition. Fibric organic soil material. The plant life-forms can be identified in virtually all the organic material. Bulk density is normally less than 0.1 g/cm^3. Generally, peat has three-fourths or more fibers after rubbing (USDA-NRCS 2017; Chadde et al. 1998). (Also see *Muck, Mucky peat,* and *Organic soil material.*)

Perennial system – A stream or riparian-wetland system that flows or holds water continuously in all or most years. It is generally fed in part by springs, and the streambed/ground surface is often located below the water table for most of the year. Groundwater supplies the baseflow for perennial systems during dry periods, but water is also supplemented by stormwater runoff and snowmelt (Meinzer 1923; Nadeau 2011). A perennial system exhibits the typical biological, hydrological, and physical characteristics commonly associated with continuous inundation or saturation (Nadeau 2011).

Poaching – See *Soil poaching.*

Ponding – A condition in which water stands in a closed depression. The water is removed only by percolation, evaporation, or transpiration. The term is applied to riparian-wetland soils when ponding lasts for more than 7 days (USDA-NRCS 2017).

Potential – The highest ecological status a riparian-wetland area (or stream reach) can attain in the present climate.

Potential natural community – The seral stage the botanical community would achieve if all successional sequences were completed without human interference under the present environmental conditions.

Potential natural condition – The hydrologic regime, the plant communities, and the geomorphic and soil characteristics of the riparian-wetland area that exist at potential (see *Potential*).

Pugging – See *Soil pugging.*

Redox concentration – Bodies of apparent accumulation of Fe/Mn oxides. Redox concentrations include soft masses, pore linings, nodules, and concretions (USDA-NRCS 2017; Vepraskas 2015).

Redox depletions – Bodies of low chroma (less than or equal to 2) having values of 4 or more where Fe/Mn oxides have been stripped or where both Fe/Mn oxides and clay have been stripped. Redox depletions contrast distinctly or prominently with the matrix (USDA-NRCS 2017; Vepraskas 2015).

Redoximorphic features – Soil features formed by the process of reduction, translocation, or oxidation of iron and manganese oxides; formerly called mottles and low-chroma colors (USDA-NRCS 2017; Vepraskas 2015).

Reduced matrix – Soil matrix that has low chroma and high value, but in which the color changes in hue or chroma when the soil is exposed to air (USDA-NRCS 2017; Vepraskas 2015).

Reduction – The gaining of electrons by an atom or ion, thereby reducing its valence. In hydric soils, this is the point when transformation of ferric iron (Fe+++) to ferrous iron (Fe++) occurs (USDA-NRCS 2017).

Riparian-wetland area – An area that is saturated or inundated at a frequency and duration sufficient to produce vegetation typically adapted for life in saturated soil conditions. It is also the transitional area between permanently saturated wetlands and upland areas, often referred to as a riparian area. This transition area has vegetation or physical characteristics reflective of permanent surface- or subsurface-water influence. Wetlands and wetland transitions are usually managed as a unit.

Riparian-wetland ecological site – An area of land with a specific potential plant community and specific physical site characteristics, differing from other areas of land in its ability to produce vegetation and to respond to management. It is distinguished only by the presence of abundant water-driving ecosystem structure and process, which requires special consideration when developing and using ecological site descriptions in wet areas (draft definition, interagency working group on "water" (riparian-wetland and water-dominated) ecological site concept, Jamin Johanson, personal communication, May 22, 2020).

Saturation – A condition that exists when the soil-water pressure is zero or positive. Almost all the soil pores are filled with water (USDA-NRCS 2017).

Soil compaction – Decrease in soil porosity and concomitant increase in soil bulk density as a result of mechanical forces (e.g., from animals, people, and vehicles) applied to the soil. Soil compaction occurs in unsaturated soil (Bilotta et al. 2007).

Soil pH – A numerical expression of the relative acidity or alkalinity of a soil. Soils that have a pH of approximately 6 or 7 generally have the most readily available plant nutrients. Most plants are adapted to soils with neutral or near neutral pH. Few plants can grow in or tolerate low or high pH. The soil pH scale is illustrated below (Soil Science Division Staff 2017).

Soil pH classes.

Ultra acid	< 3.5
Extremely acid	3.5 - 4.4
Very strongly acid	4.5 - 5.0
Strongly acid	5.1 - 5.5
Moderately acid	5.6 - 6.0
Slightly acid	6.1 - 6.5
Neutral	6.6 - 7.3
Slightly alkaline	7.4 - 7.8
Moderately alkaline	7.9 - 8.4
Strongly alkaline	8.5 - 9.0
Very strongly alkaline	> 9.0

Soil poaching – Creation of a slurrylike soil condition in very wet soil and loss of soil structure when soil is trampled by livestock, people, or machinery. Poaching is a type of deformation that occurs, for example, when the animals' load exceeds the load-bearing capacity of a saturated soil and hooves penetrate the soil surface. Poaching can result in the formation of both depressions and mounds where saturated soil is displaced and oozes out from beneath a hoof, foot, tire, or tread. Poaching commonly results in reduced vegetation cover and vigor, reduced porosity, reduced infiltration capacity, and increased soil bulk density below the poached horizon (Bilotta et al. 2007).

Soil pugging – Creation of deep hoof prints on wet, soft soils typically by ungulates. Pugging is a type of plastic deformation (i.e., permanent change in shape) in soils with medium to high soil-moisture content that occurs when load (e.g., the normal stress of an animal's hoof) exceeds the bearing capacity (soil strength) of the soil (Bilotta et al. 2007).

Soil salinity – Commonly determined and indicated by electrical conductivity, which is measured by saturated soil paste in the laboratory. "Electrical conductivity is related to the amount of salts that are more soluble than gypsum in the soil." High concentrations of salts may interfere with the absorption of water by plants and may also interfere with the exchange capacity of nutrient ions. Relative salinity classes as determined by electrical conductivity are shown below (Soil Science Division Staff 2017).

General (i.e., all soil textures) soil salinity classes with corresponding electrical conductivity.

Class	**Electrical Conductivity** (dS/m)
Nonsaline	0 to <2
Very slightly saline	2 to <4
Slightly saline	4 to <8
Moderately saline	8 to <16
Strongly saline	≥16

State-and-transition model – A method to organize and communicate complex information about the relationships among vegetation, soil, animals, hydrology, disturbances (fire, lack of fire, grazing and browsing, drought, unusually wet periods, insects, and disease), and management actions on an ecological site (USDI-BLM et al. 2013).

Thalweg – The line that connects the lowest or deepest (or maximum water depth) points along a vegetated drainageway, wet meadow, or the streambed.

UPL (upland plants) – Plants that almost never occur in wetlands. These plants occupy mesic to xeric nonwetland habitats. They almost never occur in standing water or saturated soils. Typical growth forms include herbaceous, shrubs, woody vines, and trees (Lichvar et al. 2012).

Vernal pool – A seasonal depressional wetland that forms above a restrictive layer (either bedrock or a hard clay layer in the soil) that helps retain water in a pool. These are common in environments with Mediterranean climate conditions of the west coast and in glaciated areas of northeastern and midwestern states, in which wet winters generate the moisture that fills the depressions and then dry summers lead to desiccation of the depressions (adapted from epa.gov/wetlands/vernal-pools). NOTE: In this document, vernal pools *are not* associated with ephemeral systems, which are regarded as nonriparian-wetland areas.

Watershed – A region or area that is bounded peripherally by a drainage divide and that drains ultimately to a particular watercourse or body of water; a drainage basin for a stream or a catchment.

Wetland – See *Riparian-wetland area.*

Woody material – Woody vegetation that enters a riparian-wetland area and is large enough to stay for a period and operate as a hydrologic modifier. Also referred to as woody debris.

Xeric – Nationally, the habitat description "xeric" reflects two different concepts. The xeric habitats of the Arid West typically occur in areas of low rainfall and in what are referred to as desert conditions. The other concept of xeric occurs throughout the remainder of the country in habitats often, but not always, located on hilltops and ridges, on south- or west-facing slopes, or on flatlands with sandy, porous soils. Vegetative cover in xeric habitats is sparser than the vegetation associated with mesic soils. As such, more sunlight reaches the soil surface, creating warmer, drier conditions in the rooting zone. Surface runoff and wind often erode topsoil, maintaining a shallow, excessively well-drained to dry soil profile with a low water-holding capacity (Lichvar et al. 2012).

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